Ocean Trawl Fishery

Environmental Impact Statement
Public Consultation Document

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NSW Department of Primary Industries
Primary Industries Agriculture and Fisheries Division
PO Box 21 Cronulla NSW 2230

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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Details of the public consultation process and contact information are included on page 48 in Chapter A (Volume 1)

Environmental Impact Statement on the Ocean Trawl Fishery in NSW
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DECLARATION

For the purpose of section 115K(4) of the *Environmental Planning and Assessment Act 1979*, the Director-General, NSW Fisheries (now incorporated within the Department of Primary Industries), is the person engaged as responsible for the preparation of this Environmental Impact Statement (EIS). The Director-General, was (until 1 July 2004) Mr Steve Dunn, B.Sc. Hons Fishery Science (Plymouth), Master of Management (Macquarie). A range of Department of Primary Industries staff and stakeholders with expertise and qualifications in fisheries management, environmental science, fisheries science and fisheries compliance assisted in the preparation of the EIS. Where expertise was not available within the Department of Primary Industries, external experts were contracted.

The EIS has been prepared on behalf of the persons who are entitled to operate in the Ocean Trawl Fishery (the proponents). A list of the proponents is contained in Appendix A1 of the EIS.

The address for the Department of Primary Industries and for the proponents is:

Primary Industries Agriculture and Fisheries Division
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PO Box 21
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The location of the proposed activity is described in Chapter D. A description of the proposed activity and proposed controls is provided in Chapter D. An assessment of the environmental impact of the proposed activity as described in the draft Fishery Management Strategy is presented in the EIS in Chapter E. The EIS contains all available information relevant to the environmental assessment of the activity to which the statement relates. The information provided in the EIS is neither knowingly false nor misleading.

MEMBERSHIP ON ADVISORY BOARDS

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Abbreviations

4WD	Four wheel drive
ABS	Australian Bureau of Statistics
ACEC	Animal Care and Ethics Committee (convened by NSW Fisheries)
AFFA	Australian Fisheries Forestry and Agriculture
ALC	Aboriginal Land Council
AQUAPLAN	Australia's National Strategic Plan for Aquatic Animal Health 1998-2003
AQUAVETPLAN	Australian Aquatic Animal Disease Emergency Plan
ARC	Australian Research Council
AS/NZS	Australian/New Zealand Standard
ASFB	Australian Society for Fish Biology
ASL	Above sea level
BIONET	Biodiversity information resource
CAMBA	China-Australia Migratory Bird Agreement
CANRI	Community Access to Natural Resource Information
CARE	Centre for Agricultural and Regional Economics
CBA	Cost-benefit analysis
CMA	Central Map Agency
DEH	Department of Environment and Heritage (Commonwealth)
DIPNR	Department of Infrastructure, Planning and Natural Resources
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	Ecologically Sustainable Development
FM Act	Fisheries Management Act 1994
FMS	Fishery Management Strategy
FRDC	Fisheries Research and Development Corporation
FSC	Fisheries Scientific Committee
GIS	Geographic Information System
IFS	Indigenous Fisheries Strategy
IFWG	Indigenous Fisheries Working Group
IUCN	International Union for the Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
KTP	Key Threatening Process
NHT	Natural Heritage Trust
NP	National Park
NPW Act	National Parks and Wildlife Act 1974
NPWS	National Parks and Wildlife Service
NR	Nature Reserve
NSWF	New South Wales Fisheries
OFTMAC	Ocean Fish Trawl Management Advisory Committee
OH&S	Occupational health and safety
OH&S Act	Occupational Health and Safety Act 2000
OPTMAC	Ocean Prawn Trawl Management Advisory Committee
PDF	Adobe Acrobat © portable document format
SEINS	Self Enforcing Infringement Notice System

Abbreviations continued

SRMPA	The Scientific Research and Miscellaneous Permit Administration of NSW Fisheries
TAP	Threat Abatement Plan
TSBU	Threatened Species and Biodiversity Unit (a section of NSW Fisheries)
TSC Act	Threatened Species Conservation Act 1995
UNESCO	United Nations Educational, Scientific and Cultural Organisation

Glossary

Biodiversity	The variability among living organisms from all sources (including marine and other aquatic ecosystems and the ecological complexes of which they are a part). Includes: diversity within species (genetic diversity), among species (species diversity); and ecosystems (ecosystem diversity).
Cod-end	The rear part of a trawl net where the catch accumulates during fishing operations. Most of the escapement of small fish from the net occurs through the meshes of the cod-end.
Critical habitat	An area or areas of habitat declared under threatened species legislation to be critical to the survival of a threatened species.
Ecological community	The species that occur together (often delimited by a geographic boundary).
Ecologically Sustainable Development (ESD)	Using, conserving and enhancing the community’s resources so that ecological processes on which life depends, are maintained, and the total quality of life, now and into the future, can be increased (CoA, 1992).
Ecosystem	The biotic (living) community and its abiotic (non-living) environment.
Endangered species	Species that is likely to become extinct due to threatening process(es), reduction in population size or available habitat (under the FM and TSC Acts).
Growth overfishing	This occurs when too many small fish are taken, and therefore too few grow to a size that provides the largest yield from the fishery. Growth overfishing generally results when the fishing gear retains significant numbers of fish smaller than the optimum size. [Note that where several fisheries exploit one species, different fishing gears may be used, and not all gears might contribute to the ‘growth overfishing’ of the species.]
Latent effort	Describes that portion of the total potential fishing effort that could be exerted by a fishing fleet, which is not used in the fishery during a given period.
Precautionary principle	A principle of ESD, which states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
Protected species	Species of aquatic organisms protected from commercial fishing, or from all fishing, under the FM Act.
Ramsar Convention	The Convention on Wetlands of International Importance, signed in the Iranian town of Ramsar in 1971. The convention aims to halt the loss of wetlands and to conserve remaining wetlands.
Recovery plan	Plan designed to return a threatened species, population or ecological community to a point where its survival in nature is assured (i.e. it is no longer threatened). Preparation of recovery plans for threatened species is required under the FM Act, TSC Act and EPBC Act.
Recovery program	Measures incorporated in a Fishery Management Strategy to address identified overfishing of a species (including growth or recruitment overfishing).
Recruitment	Describes the process whereby small fish become vulnerable to being caught by the fishing gear, and results from a combination of factors such as growth, migration and selectivity of the fishing gear.
Recruitment overfishing	This occurs when fishing greatly reduces the number of mature (breeding) fish in a population, causing a decline in the reproductive output and leading to a very significant reduction in the number of young fish recruiting to the fished portion of that population.
Risk	The likelihood of an undesired event (or impact) occurring as a result of some behaviour or action.
Risk management	The culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.

Glossary continued

Stock	A defined group of organisms on which a fishery operates. The definition of a stock may be based on genetic or geographic boundaries.
Stock assessment	Describes a process of collection and evaluation of biological and fishery data that leads to an assessment of the status of a fish stock. Stock assessments may be produced to varying levels of detail, depending on the amount of relevant information available.
Threatened species	Species listed under NSW or Commonwealth legislation as endangered or vulnerable. For the purpose of this EIS, also includes species that are listed under the Fisheries Management Act as protected species.
Trophic	Relating to feeding by animals, in particular, the relationships (food-webs) between predators, prey and primary producers.
Validated catch history	The recorded catch history from the period 1986 to 1993 that has been assigned to each fishing business by the NSW Department of Primary Industries.
Vulnerable species	A species that is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate.

Note: The NSW Department of Primary Industries, incorporating NSW Fisheries, was established on 1 July 2004. Any reference in this document to NSW Fisheries is a reference to the NSW Department of Primary Industries.

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ACKNOWLEDGEMENTS

NSW Fisheries would like to thank the many people who contributed substantial amounts of time and effort towards preparing this EIS, often within short timeframes.

The management planning and environmental assessment teams within NSW Fisheries have put in a great deal of dedicated work over the past 12 months, and numerous other departmental staff have made useful comments and suggestions on the drafts.

The members of the various advisory bodies who reviewed drafts of the fishery management strategy and EIS must be acknowledged. They have provided valuable and constructive feedback, although the views expressed within this document are not necessarily those of the advisory bodies. The Management Advisory Committee (MAC) for the Ocean Trawl Fishery in particular has spent several meetings and much of members' personal time reviewing and providing advice on the various drafts of the Fishery Management Strategy and the EIS. Members of the following statutory Ministerial advisory councils (membership is detailed on page *iv*) have also reviewed the draft EIS:

Advisory Council on Commercial Fishing
Advisory Council on Recreational Fishing
Indigenous Fisheries Strategy Working Group (sub-committee)

NSW Fisheries appreciates the timely and committed efforts of the consultants who reported on sections of the environmental assessment guidelines: Dominion Consulting Pty Ltd and Umwelt (Australia) Pty Limited. Thanks are also extended to the peer reviewers for their excellent work: Professor Peter Fairweather from Flinders University, Dr Heather Aslin from the Australian Bureau of Rural Sciences, Associate Professor Stephan Schnierer from Southern Cross University and David Campbell from David Campbell and Associates.

CHAPTER A - EXECUTIVE SUMMARY

Introduction

Trawling off the NSW coast is an important fishery that supplies the Sydney Fish Market and many regional cooperatives and retail outlets with fresh fish. The operation of the current activity poses some key environmental, social and economic risks, particularly impacts on some shark species, species that have been identified as overfished and fish habitats.

These risks must be addressed for the activity to proceed in a sustainable way and for the necessary approvals to be granted. A number of actions have been proposed to address the risks, including implementation of closures and other refuge areas, recovery programs for overfished species, prohibition of trawling on reefs, changes to improve the selectivity of trawl gear, improved bycatch reduction devices and establishment of a scientific observer program. The actions represent a balanced approach to securing the objectives sought for trawling and ecologically sustainable fisheries.

The Environmental Impact Statement for the Ocean Trawl Fishery (covering the Ocean Trawl Share Management Fishery and the Southern Ocean Fish Trawl Fishery) presents a thorough, frank and transparent assessment of the risks associated with the current activity and the measures proposed to address the risks.

Public exhibition of the Environmental Impact Statement for the Ocean Trawl Fishery provides an opportunity for the community to review the environmental performance of the activity of trawling and to have input into its future management.

The Development of Fishery Management Strategies and Environmental Impact Statements

In December 2000, the NSW Government made changes to ensure that fishing activities in New South Wales are managed in an ecologically sustainable way. The changes require the development of fishery management strategies and associated environmental assessments for each major fishing activity, including the ocean trawl fishery.

The draft fishery management strategy and environmental impact assessment for each activity are joined together in an Environmental Impact Statement (EIS). Its structure is based on guidelines issued by the Department of Infrastructure, Planning and Natural Resources.

This overview presents a summary of the EIS, being the first chapter (Chapter A). Chapter B of the EIS reviews the existing operation of the activity, including where it occurs, the methods used, species taken, current management arrangements, and the socio-economics related to the activity. The risks associated with all aspects of the activity are assessed to identify those aspects that require modification by the fishery management strategy. Together these chapters (Chapters A and B) comprise Volume 1 of the EIS.

Chapter C provides an outline of the main alternative management options to those of the existing activity and Chapter D provides details of the proposed management arrangements for the activity (i.e. the draft strategy). Chapter E presents an assessment of the potential impacts of implementing the draft strategy, that is, the extent to which the draft strategy mitigates the risks identified in Chapter B. Chapter F provides a justification for the preferred strategy, taking into account its implications in terms of environmental, social and economic factors.

This overview provides an introduction to the environmental assessment process. It briefly outlines the context within which the activity of ocean trawling currently operates, the management arrangements proposed in the draft FMS, and the findings of the environmental impact assessment.

The Existing Activity of Ocean Trawling

The ocean trawl fishery off NSW has two components, fish trawling and prawn trawling, both of which use a common type of fishing gear (the demersal trawl net). Most trawling for prawns occurs off the north coast and most trawling for fish occurs off the central and southern coasts, however there is overlap of the two methods in the area between Barrenjoey Point and Smoky Cape. There is also considerable overlap between ocean prawn trawling and ocean fish trawling in terms of the species caught and the operators who use each method.

An Offshore Constitutional Settlement (OCS) agreement in December 1990 gave NSW jurisdiction over trawling in depths less than 4000 m (approximately 80 nautical miles from the coast) for waters between Barrenjoey Point (near Sydney) and the Queensland border. The Commonwealth retains jurisdiction for trawling outside 3 nautical miles south of Barrenjoey Point, while NSW currently has jurisdiction for trawling in waters within 3 nautical miles of the NSW coastline.

Approximately 100 fishing businesses hold an entitlement to operate in the fish trawl sector and around 310 fishing businesses hold an entitlement to operate in the prawn trawl sector of the ocean trawl fishery (note: the actual numbers vary over time). However, all endorsed fishing businesses do not operate in the fishery each year, which results in a significant level - about 30 to 40% - of latent (ie. unused or seldom used) fishing effort. Boats used in the fishery are generally 15 to 20 m in length, diesel powered, with modern fish-finding and navigation equipment.

Demersal trawl nets are similar in shape to a large flattened funnel, which is dragged along the seabed on suitable fishing grounds. Trawling cannot be successfully conducted on areas of high rocky reef, or where there are obstacles (such as shipwrecks or undersea cables) that could snag the net or attached gear. The mouth of the net is held open by the shearing action through the water of two ‘otter boards’ (trawl doors), while the catch accumulates in the rear section of the net, termed the ‘cod-end’. Regulations prescribe the mesh size of netting allowed to be used for fish or prawn trawls and other characteristics of the boats and gear, and daily trip limits apply to some species. Trawlers are not permitted to operate within the habitat protection or sanctuary zones within established marine parks and several closures designed to protect juvenile king prawns apply around the mouths of major estuaries.

The ocean trawling fishery produces over 4,000 tonnes of seafood product annually and is valued at about $36 million at first point of sale. The main species taken in prawn trawls are eastern king prawns, school prawns and octopus, while the main species taken in fish trawls are tiger flathead, silver trevally, fiddler shark and southern calamari. Significant quantities of school whiting, sand flathead and cuttlefish are landed by both methods. A large number of species are of secondary importance in the fishery.

Demersal otter trawling is a relatively unselective fishing method, capturing most of the mobile species in the path of the net, and retaining those, which are of a size that cannot escape through the meshes of the net. A significant issue for the NSW ocean trawl fishery has been the level of bycatch (ie. fish that are caught in the net but not retained because they are under the minimum legal length or not commercially valuable), however the introduction of bycatch reduction devices in prawn trawl nets is helping to address the level of incidental capture.

Risk, Response and Predicted Outcome

The following section briefly describes the risks of the ocean trawl fishery as they pertain to environmental, economic and social components (initial risk), the management responses proposed in the draft strategy to mitigate those risks (response), and a predictive assessment of the degree to which those measures may mitigate the risks (predicted outcome). This section is also summarised in Table A1.

In order to address any perceived problems with the existing operation of ocean trawling, it is first necessary to describe and evaluate the potential impacts arising from the manner in which ocean trawling is conducted. It is also necessary to attempt to isolate those elements of the operation that contribute the most to those impacts and to adjust those elements through the draft strategy.

Broadly, the operation of ocean trawling comprises nine component activities that have the potential for a variety of environmental, economic and social impacts. Those activities include:

- Trawling – the deployment, towing and retrieval of a trawl net by a fishing vessel
- Harvesting – the capture and retaining of fish for sale
- Discarding – the returning of unwanted catch to sea
- Contact without capture – the contact of the trawl net with components of the environment whilst being towed but which do not capture any part of the environment
- Loss of fishing gear – the partial or complete loss from vessels of nets, warps, otter boards, ropes or other equipment
- Travel to and from fishing grounds – the steaming of a vessel from port to fishing grounds and the return journey
- Disturbance due to presence in the area – the stationary vessel on the water whilst on-board activities take place
- Boat maintenance and emissions – the tasks that involve fuel, oil or other engine & hull related activities that could be accidentally be spilled or leaked into the sea or air
- Marketing – the sale of fish to an authorised fish receiver

These component activities of trawling can have both direct and indirect impacts on the environment. For example, the activity of harvesting has a direct impact on the abundance and productivity of primary and key secondary species and an indirect impact on oceanic food webs via the removal of some predators.

To address the risks, the draft strategy offers seven major long-term goals for the management of the fishery, which are supported by approximately 25 objectives and 64 management responses. It is important to note that a single management response can mitigate a variety of risks and therefore it is not necessary to formulate direct responses for each risk. The responses with a direct relationship to an environmental, economic or social component are described briefly below and summarised in Table A1.

The risk being assessed was the probability of the retained, non retained, threatened and protected species or the marine habitats and species assemblages becoming ecologically unsustainable within the next 20 years if the current operation of the fishery were to continue unchanged.

At the practical level due to data deficiency the reconciling of fisheries with conservation in the environmental assessments is based on a multi-stage ecosystem risk assessment. A risk matrix is derived based on the multiplication of likelihood and consequence. There is a strong interdependence between and difficulty in quantifying both likelihood and consequence in the data poor fisheries of NSW. Therefore the level of fishery impact (on the y-axis) is used as a surrogate for likelihood and the resilience of the parameter under consideration (on the x-axis) is used as a measure for consequence. A five-step gradient of risk is then defined within the matrix from low risk (high resilience x low fishery impact) to high risk (low resilience x high fishery impact). The risk level determined from the matrix is then related to the type and priority of the fisheries management action required to reduce risk or prevent risk increasing and the required future monitoring.

The fishery impact profile is fishery specific and relates to the activities of the fishery in five broad categories:- how much is caught; how is it fished; how many fishers catch it; what is caught; and where is it fished. This then leads to 12 or more factors such as catch trends, exploitation status, gear selectivity and refuge availability.

In the framework, resilience is described qualitatively based on biological characteristics of species. A suite of biological characteristics such as fecundity, life history strategy, geographic distribution, habitat specificity, population size, growth rate, longevity, age at maturity and diet specificity are used. A set of decision rules are determined for each characteristic that distinguishes between risk prone and risk adverse traits. Then a final resilience is assigned according to the balance of risk prone versus risk adverse characteristics a species possesses.

The individual characteristics or factors, which are used to determine both the resilience and the fishery impact profile for use in the risk matrix are given unequal weights based on their importance.

When dealing with non-biological components (geological habitats) the fishery impact profile remains the same as for the biological components (retained, bycatch, bait and threatened species) but the resilience measures change. As an example hard- ground habitats have medium to high resistance to the physical impact of trawl gear but have zero resilience to the damage caused by fishing gear. The recovery time of a rocky reef is measured in geological time scale and damage to the rocky structure is regarded as permanent.

Ecological impacts

The purpose of this section is to critically evaluate the available information on the ecological impacts of ocean trawling and the underlying mechanisms by which impacts occur. An understanding of these mechanisms is important for the evaluation of future impacts of ocean trawling, and for evaluating the extent and magnitude of existing impacts.

The major potential impacts of the ocean trawl fishery include growth and recruitment overfishing, disruption to ecological processes, impaired recovery of threatened species and damage to habitats. The degree to which these impacts occur varies depending on the resilience of a species or environmental component and the intensity of the fishing activities.

The risk assessment conducted on the existing ocean trawl fishery found that almost all activities of the fishery are likely to pose a risk to most components of the environment. In particular, trawling, harvesting and discarding pose the greatest risk to the components of the environment including primary and key secondary species, non-commercial bycatch species and habitats. Although not all aspects of the activity were found to affect all components of the environment, it was apparent that inappropriate gear selectivity, lack of stock assessments of the primary and key secondary species, poor understanding of discard composition and magnitude, knowledge gaps of biology and ecology of species and ecological interactions, lack of knowledge about the distribution and types of marine habitats with respect to trawling activities all pose a risk to the environment.

It is important to note when reading the following sections that despite a detailed risk assessment on numerous components of the environment, the substantial knowledge gaps about the impacts of the fishery on the oceanic environment leaves a high level of uncertainty surrounding the activity. There are still many aspects that remain uncertain, and in the absence of scientifically rigorous data, this assessment has been necessarily cautious.

Further, the appraisal of the management responses in the draft strategy in the following sections has been made on the basis that the proposed research will be undertaken. Research will remove a high proportion of the uncertainty surrounding the activity and this assessment and allow a retrospective analysis of the accuracy of the assessment and the implementation of new management measures if necessary.

Fish retained by the fishery

Initial risk

Of the 43 species of finfish and shellfish assessed, five were at high risk, nine were moderately high, 12 were intermediate, one was moderately low and 13 were at low risk. All five species at highest risk were sharks due to their low biological resilience, low refuge availability, poor gear selectivity and inadequate stock assessments. Seven finfish and two shellfish made up those with moderately high risk. Some of these species are growth overfished or have declining catch trends, and low availability of refuges from fishing. Those species with intermediate risk include three shark species that have low biological resilience.

Issues Arising

There are nine issues arising from the risk assessment for the species that are retained by the fishery. All the species with the highest level of risk were sharks. This group of species is recognised both nationally and internationally as being at risk from commercial fishing. Sharks are particularly vulnerable to trawling because their slow growth rate, long life span and life history strategy is not conducive to rapid recovery after populations have been depleted. Specific and immediate action should be implemented to reduce the high risk on these species.

Four of the species at moderately high risk are considered growth overfished, i.e. the size at which they are caught is too small. Direct action in the form of changes to gear selectivity is required for these species.

Many of the species that make up a large proportion of the landings of the ocean trawl fishery have either inadequate or no stock assessments. Therefore, there is no quantitative data on which to base more precise management measures. This is a major obstacle to reducing the risk for primary and key secondary species.

There are a number of species in the ocean trawl fishery where size at first capture is below their size at maturity (e.g. silver trevally and tiger flathead). Better selectivity of fish trawl gear should in the longer term improve the yield from the fishery and reduce the catch of small fish for most species.

The bycatch of commercially important species (ie. individuals below the minimum legal length) has received insufficient attention in the ocean trawl fishery, as there is no information on the quantity, composition, frequency and temporal and spatial variability of these discards. This is a source of unaccounted mortality, which means regular assessments of the status of the stocks of some of the key ocean trawl species will be inadequate. It will be important for future stock assessments to take this mortality into account.

While the use of bycatch reduction devices by all ocean prawn trawlers were made mandatory in July 1999, there has been little work done to assess the effectiveness of the devices under normal commercial trawling conditions. There has been no onboard monitoring of ocean prawn trawlers since the compulsory introduction of bycatch reduction devices.

There are a number of key species caught in the ocean trawl fishery that are also taken in large quantities in the Commonwealth, Queensland and Victorian fisheries. There are different management regimes across the Commonwealth and State jurisdictions, with quota management in the South East Fishery and effort control management in NSW and the other States. The differing management regime in the above fisheries increases the risk of species with common stocks becoming ecologically unsustainable because the controls do not complement each other.

The department's catch database has a number of limitations which reduces its capacity to provide reliable information on which to base appropriate management regimes, such as no separate reporting of landings from Commonwealth and State fisheries prior to 1997. This is a major obstacle to reducing the risk of the key species in the ocean trawl fishery. Improving the way information is recorded on the catch returns, coupled with validation of reported landings by independent observers either on vessels and/or at local fish cooperatives would greatly increase the reliability of the database.

There are a number of substantial knowledge gaps that hinder the ocean trawl fishery from being managed and fished in an ecologically sustainable manner. Specific knowledge is needed on the location of trawl grounds for each sector of the fishery, the frequency the grounds are fished and by how many fishers. There is little to no knowledge on the ecology and basic biology of many of the primary and key secondary species. Research on the interactions among fish species and non-target species, interactions of fish with the environment and habitats, stock and community structure, and spatial and temporal complexity of fish stocks has received little attention in the ocean trawl fishery.

Response

The draft strategy contains a number of responses that address the issues for the retained species. The extent to which the risks overall have been reduced will depend on the effectiveness of the combined management controls in the draft strategy and their effective implementation. The major programs in the draft strategy to address these risks can be divided into the following:

Management:

- Implementation of refuge area closures and other refuge areas - these will create refuges for adult populations and spawning/pupping areas from the direct effects of fishing and for depleted stocks of some species to rebuild.
- Fishing effort – there is a stated intent to reduce the number of endorsements, although the draft strategy does not specify the level or the mechanism that would be used to achieve it. The proposal is to establish a ten year effort target for restructuring.
- Recovery programs for overfished species – the draft strategy includes recovery actions for one overfished species and provides for the development of recovery programs for any other species later identified as being overfished.
- Changes to gear selectivity – changes in the short term to mesh size and cod end diameter to select species at more appropriate sizes (apart from on specified school whiting grounds), and further changes in all areas based on the results of a proposed research program.

Research:

- Observer program – will collect biological information on shark species and commercial discards of other retained species, and record data the quantity and composition of bycatch species; determine exploitation status of these species.

Monitoring:

- Monitoring landings – age/length, sex composition and quantity of landings of primary, key secondary and secondary species.

Predicted outcome

These management responses will result in a minor reduction in risk for sharks and most species at moderately high risk. A few species at moderately high risk will have a major to moderate reduction in risk. Some of the management controls in the proposed strategy only reduce risk by a minor degree. For many of the management controls details on the specific mechanisms to be used are to be developed during the implementation of the strategy. A lot rests, therefore, on the expectation that the details of the implementation arrangements including research and monitoring will be adequate to fulfil the goals and objectives stated in the strategy and thereby reduce risk.

Fish not retained by the fishery – 'bycatch'

Initial risk

The risk assessed is the probability of bycatch species becoming ecologically unsustainable within the next 20 years if the current operation of the fishery were to continue unchanged. The same methodology for determining risk levels for the retained species was used for this component of the environment.

Based on observer studies done in the 1990s it is estimated that over 60% of non-commercial bycatch species (ie. species that have no commercial value) are at high or moderately high risk. This is primarily due to their very low survival after trawling and handling on deck and no or few known refuges from fishing. There is no information about species of commercial importance that are discarded (ie. due to being undersized) but their risk level would be the same as the adults of these species – moderate to high.

Issues Arising

Six issues arise from the risk assessment on bycatch. Bycatch consists of a large number of species, not all of which will be encountered or caught by every trawl. Therefore, the best approach to managing this type of bycatch for the ocean trawl fishery is to minimise bycatch as a whole. The wide range and lack of information about these species means that reducing bycatch on a species specific basis will largely be ineffective except for some commercial bycatch species.

There is some historical information on the bycatch of commercially important species, however, there is insufficient quantified information on a number of key bycatch variables (eg. non-commercial bycatch and post bycatch reduction device introduction). Information needed for better management includes the spatial and temporal variability in the abundance and diversity of bycatch species, the survival of species after they have been discarded and the factors that contribute to their survival. In addition, the effectiveness of the current compulsory bycatch reduction devices used in the fishery needs to be assessed in terms of how well they reduce all bycatch, but with a particular emphasis on non-commercial species.

Changes to gear selectivity should be monitored to determine whether it results in either major differences in composition of species and/or changes in the quantities of bycatch either positively or negatively.

Currently bycatch reduction devices are only compulsory in prawn trawling. Such devices are unsuitable for fish trawlers because their design would necessarily exclude many of the key species that fishers target. Consequently, different methods of reducing bycatch in fish trawling are needed. A better understanding of the variability in the composition and quantity of bycatch caught in fish trawls will enable specific methods to be developed to reduce unwanted catch.

There is currently no quantified information on potential effects of discards from the ocean trawl fishery providing a source of food for marine scavengers such as sea birds, sharks and marine mammals. Such information is needed to determine whether additional management measures are necessary.

Response

Six types of management controls are proposed in the draft strategy to reduce risk to bycatch species. Of these, time and area closures and improved bycatch reduction devices will provide the greatest reduction in overall risk to bycatch. Gear selectivity will be effective for a portion of bycatch species. Because so little is known about bycatch species and discarding patterns, the observer program will play a key role in reducing risk for these species.

The major programs in the draft strategy to address the risk to all bycatch species can be divided into the following:

Management:

- Additional and improved bycatch reduction devices – those bycatch reduction devices found to be more effective at reducing bycatch without significant loss of primary and key secondary species will be promoted to fishers as the best options to use or implemented on a mandatory basis
- Closures of all reef areas
- Closures at river entrances during high flow – closures near the mouths of rivers during periods of floods will reduce catches of small fish that have moved from those estuaries
- Improve gear selectivity – this will reduce the capture of undersized commercial species and some non-commercial species. It will be especially effective for fish trawl gear as they cannot use conventional bycatch reduction devices like prawn trawlers
- Recovery programs – development of recovery programs for species determined as overfished (eg. silver trevally, redfish and gemfish) will potentially address the capture of undersize individuals

Research:

- Observer program – to assess the effectiveness of the range of bycatch reduction methods implemented in the draft strategy and quantify discard patterns of many non-commercial species and hence determine if the objectives of the management have been achieved

Monitoring:

- Monitor catches – monitoring the size and age composition of both commercial and non-commercial species will provide information that will assist in identifying areas and times of high bycatch and facilitate improvements in the management regime

Predicted outcome

These management responses will result in a minor to moderate reduction in the risk to bycatch species. The fishery closures and improved bycatch reduction devices will provide the greatest reduction in overall risk. Changes to gear selectivity will be effective for a portion of the catch.

Threatened and Protected Species and Communities

Initial risk

The risk assessed is the probability that any aspect of the fishery would impede the conservation and recovery of a threatened species. The assessment determined that all threatened and protected fish species were at low or moderately low risk. The risk of the fishery impeding the conservation and recovery of threatened marine mammals and reptiles was low to moderately low, for threatened seabirds moderately low and low for the endangered little penguin population at Manly. These low risks are primarily due to the apparently low rate of interaction between the fishery and these species and communities.

Issues Arising

On-going monitoring of the interaction between the fishery and threatened species is required to ensure that the level of impact on these species does not increase in the future. Such monitoring should quantify the species, type of interaction (eg. direct capture, boat strike, etc) and outcome (ie. level of injury, if any, endured by the organism).

The dependence of threatened species on the discards of the fishery should be investigated. More information is needed in order to quantify the importance of trawl discards in the diets of threatened species. Any future changes to fishing practices, such as closures, could adversely affect threatened species if they have become dependent on the discards of the fishery as a source of food.

The strategy will need a mechanism to respond to future listings of species under the threatened species legislation. Such a mechanism will be necessary to ensure any species regularly caught by the fishery is protected in a timely manner.

Response

The measures proposed to mitigate risk to threatened and protected species are focussed on obtaining better information on interactions between fishers and these species in the fishery. The major programs in the draft strategy to address the risk to threatened and protected species can be divided into the following:

Management:

- Mandatory reporting of fishers' interactions with threatened species – changes to monthly reporting forms to promote the recording of interactions between fishers and threatened species will assist in improving the information base and identifying potential problem areas
- Implement actions required in accordance with recovery plans for threatened species or threat abatement plans – adherence to the provisions in such plans will promote the recovery of these species
- Promote fishing techniques that avoid interaction with protected fish and threatened species – these practical measures could lead directly to reduced catches of threatened species and increased survival of certain threatened species caught by trawlers.

Research:

- Observer program – independent reporting and quantification of the frequency, type and potential outcome of fishers' interactions with threatened species

Monitoring:

- Record interactions between fishers and turtles – to quantify to what extent interaction with marine turtles occur in the fishery and the need for specific mitigation measures.

Predicted outcome

In general, risks to threatened species from trawling under the present management arrangements are low to moderately low and there is no change to these risks under the draft strategy. Given the low level of risk the measures contained in the draft strategy are considered adequate provided that the information obtained is fed back into other management responses (such as for closed areas) and used to reduce impacts. It should be noted that fisher self-reporting of threatened species interaction carries with it an element of potential bias against mentioning them, and will require verification from the observer program.

Marine Habitats

Initial risk

The risk assessed for marine habitats is the likelihood that marine habitats will be degraded by the current activities of the fishery such that populations and/or stock levels of species associated with these habitats will become ecologically unsustainable within the next 20 years.

Three habitat types were assessed as being at a high level of risk – hard-ground low vertical reef; sessile animals and plants living on low level reef; and sessile animals and plants living in soft ground (sand, mud and gravel). These habitats are readily accessible to trawling and suffer permanent (low level reef) or long term damage due to the slow growth of many of the sessile animals making up these habitats. Soft ground habitat, such as sand, mud and gravel were at moderately high risk as the intensity and frequency of trawling on these habitats is unknown. Hard ground reef greater than 2 metres high and its associated biota were assessed at intermediate risk from trawling due to the greater difficulty trawlers have in accessing this type of habitat.

Issues Arising

There were four major issues arising from the risk assessment of marine habitats. Of primary concern were fishing practices that cause irreversible damage. The trawl fishery has expanded its operations onto hard-ground low reef habitats by using modified trawl gear that are equipped with large bobbins/rollers as indicated by the reef fish species being recorded on the fishers returns. This expansion is likely to be causing major impacts on these habitats. If this degradation continues it is likely that productivity will decrease and the sustainability of some species may be threatened.

Adequate refuge areas from trawl fishing are needed to conserve habitats. In particular there is currently limited protection for soft-sediment habitat, low reef and habitat forming animals and plants that live in these habitats from the impacts of fishing. There is a need to protect representative areas of these habitats if risks are to be mitigated.

Trawl fisheries on the continental slope and shelf are managed by several State and Federal government agencies that have different management regimes. Therefore, the effectiveness of management initiatives of one jurisdiction could be undermined by the lack of consistency of another. Consequently, widespread habitat degradation can continue to occur unless a common approach to management is adopted.

Four major information gaps were identified. These are i) identification of fishing grounds and mapping the distribution of fishing effort, ii) identification and mapping the distribution of broad habitat types, iii) assessment of the magnitude of fishery impacts on habitats, iv) lack of biological and ecological knowledge for habitats made of living animals. It is essential that these information gaps be addressed in the draft strategy.

Response

There were five management responses that relate to mitigating the risk to marine habitats. These can be divided into the following:

Management:

- Establishment of refuge areas – as a precautionary measure a series of closures to will be implemented to protect a range of habitats until more information about the different types and spatial extent of habitats is gathered, including closing all waters beyond the 1,100 metre depth contour
- Closure of all reefs – the closure of all reefs (ie. all hard rock) is a firm step to reducing the risk on these habitats and will have flow on effects to fish productivity and ecological sustainability
- Modification of trawl gear – the closure of reefs will make the use of bobbin gear redundant in the fishery. Furthermore, the restriction on the ground chains (number and gauge) will lessen potential impacts on soft ground habitat

Research:

- Map habitat types – initial work of identifying habitats on trawl grounds will be conducted in conjunction with mapping trawl grounds
- Promotion of research on habitat issues – part of the research plan of the draft strategy is to promote research into this area but no details are given

Monitoring:

- None proposed given the difficulty and high cost of such work.

Predicted outcome

Overall, the draft strategy will have a minor to moderate influence in reducing the risk to marine habitats. A significant reduction in risk levels for some habitats will be achieved by closing all reefs and waters deeper than 1100m to trawling but more detail on other habitats is required for a full assessment.

Species assemblages, species diversity and ecological processes

Initial risk

The risk assessed for species assemblages, species diversity and ecological processes is the likelihood that these components will be degraded or impaired by the current activities of the fishery such that they will become ecologically unsustainable within the next 20 years. Two species assemblages were identified as being at potential risk – macroalgal assemblages and bottom dwelling mobile invertebrates. Both of these assemblages are closely associated with the habitats that support the species harvested by the fishery. Therefore, any impact by the fishery on these habitats will also impact these assemblages.

Species diversity is the variety of organisms between and within marine species. Given the poor knowledge of the spatial and temporal patterns of species diversity for major groups of animals and plants in marine waters, risk relating to species diversity can only be determined at the largest scale of ecosystem components. The risks to species diversity are closely linked to the risks to habitats and ecological processes.

An ecological process, broadly defined, is any process that affects the distribution and abundance of living organisms. These processes include interactions such as competition, predation, parasitism and physiological effects of temperature, light, nutrient availability on individual organisms. Ecologists are generally concerned with the cumulative effects of such interactions at the population or species assemblage level. Fisheries management takes into account the effects of fishing on parts of the system other than the harvested species, and acknowledges that effects on these other parts of the system may also have consequences for target species. Of the nine major ecological processes considered, five were considered at high risk from activities of the fishery and two were at intermediate risk.

Issues Arising

The major issues arising from the risk assessment of these components of the environment focus on the lack of information about how they operate in the ocean environment. In all these areas there is an inadequate knowledge base on which to determine effective management action. A better understanding of the interactions between ecological processes and commercial and non-commercial species is urgently needed, although the complexity, difficulty and high cost of obtaining such information must be acknowledged. The long term ecological sustainability of the exploitable fish assemblages of the fishery is likely to be jeopardised without more detailed knowledge of the ecological processes they depend on.

Because habitats are critical for maintaining species assemblages, sustainable ecological processes and biodiversity, habitat loss and fragmentation are the greatest threats to these components becoming unsustainable. Substantial efforts must be made in a number of areas to conserve and, where appropriate, restore lost habitats due to the activities of the fishery. Until the spatial and temporal extent of trawl grounds, species assemblages, interactions between trawling and ecological processes and the level of intensity of trawling on these grounds are known, refuges will be needed to protect species biodiversity, species assemblages and ecological processes. The draft strategy should be sufficiently precautionary to ensure the proposed management regime will enable the best possible chance of the various components of the ecosystem to recover in the face of an unexpected outcome.

Response

Six management responses contribute to the conservation of marine habitats, and protection of species assemblages, diversity and ecological processes. These can be divided into the following:

Management:

- Establish refuge areas and protect marine habitats – there is a commitment to develop strategies to establish refuge areas and to manage the fishery consistently with other management programs that seek to protect marine habitats, such as marine parks
- Close all reefs and depths exceeding 1100m – this will provide substantial protection to important habitats that are essential for the sustainability of ecological processes and diversity
- Modification of trawl gear – the restriction on ground chains (number and gauge) will lessen impacts on habitats and species diversity and restrictions on bobbin gear will also minimise the ability for fishers to access a variety of habitats

Research:

- Map habitats – there is a strong commitment to mapping habitat types within and near the trawl grounds of the fishery
- Map trawl grounds and frequency of trawling on these grounds – as part of mapping habitats the draft strategy proposes to map all trawl grounds and determine the intensity of trawling on each ground

Monitoring:

- None proposed given the complexity, difficulty and high cost of such work

Predicted outcome

The risk to species assemblages and species diversity will be reduced to some extent provided the commitment to conserve the diversity of marine habitats is fulfilled. Until details of the proposed closures are known, the level of risk reduction for these components will be uncertain. It is also difficult to quantify to what extent the risk to ecological processes is reduced for two reasons. First, there is little actual information on the impact of the current activity to ecological processes, making it difficult to quantify the extent to which impacts would be reduced under the draft strategy. Second, the draft strategy requires the development of the detailed arrangements for implementing several key responses (e.g. the closures). Whilst the detailed arrangements will need to be adequate to fulfil the goals and objectives stated in the strategy, making assessment of the outcome is difficult until those details are known. Overall, the management responses regarding establishing refuge areas and research on the impacts of the fishery on ecological processes should be given a high priority. Furthermore, monitoring the effectiveness of closures in enhancing ecological sustainability for components of the environment assessed would be required to determine the effectiveness of these management responses.

Economic

Initial risk

The ocean trawl is the most valuable commercial fishery in NSW. In the 1997/98-2001/02 period, the prawn trawl and fish trawl components of the fishery had annual average revenues of $24.65m and $4m respectively.

Out of 330 (311 prawn trawl and 99 fish trawl) businesses holding endorsements to fish in the fishery, 158 did not report any catch in 2001/02. The fishery comprises predominantly one person businesses forming teams, with partnerships between fishers, and a limited amount of corporate involvement. Businesses in the fishery are highly variable in their levels of capital investment, ranging from $240,000 to $300,000 per business, and differ according to the diversity of business activities and assets. The total capital investment in the 252 active ocean trawl fishing businesses is estimated at approximately $73 million.

An economic survey of businesses in 1999/2000 indicated that an economic surplus existed for 41% of ocean trawl fishing businesses. The remaining 59% of ocean trawl fishing businesses were operating below long-term viability levels. There is substantial overcapacity in the fishery, reducing the economic performance and not generating sufficient economic rent. Currently the ocean trawl fishing businesses are not required to meet full management costs.

The fishery is currently facing a number of risks, including:

- excess active fishing effort;
- potential activation of latent effort;
- ineffective control of total effort levels;
- lack of economic incentives to fishers to reduce fishing effort;
- increasing operational, management and the costs of restructuring; and
- lack of access security for long-term business certainty.

Response

The FMS aims to address these issues by proposing a number of management responses, and these have been assessed as follows:

- the move to category 1 shares provides more security of access for fishers than the current *restricted fishery* regime or the former proposal to implement category 2 shares, and increases the capacity of fishers to trade shares in access rights;
- A further reduction in active fishing capacity is needed due to excess active fishing effort.
- the intent to limit latent effort is stated, but the level of structural adjustment or the means to achieve it remain to be determined. Limiting the activation of latent fishing capacity can occur through a range of adjustment tools, such as the minimum shareholdings limits, higher requirements for new entrants, surrenders, and buybacks – each tool would have different implications for fishers if implemented;
- The draft strategy proposes the establishment of ten-year target for fishing effort. As current active fishing effort is above the profit maximising level, the active effort needs to be set in the fishery;
- the total management charges for an average fishing business are estimated to increase from current $2,035 to $4,620 per annum, assuming an increase in management charges due to the new programs in the FMS and adjustment initiatives reducing business numbers in the management cost levy base.
- vessel capacity restrictions, such as horsepower and other unitisation rules, would remain in place to avoid substitution to uncontrolled inputs. Area and time closures are necessary for maintaining sustainable fish and prawns stocks;
- the draft strategy intends to evaluate whether a limit on the number of days/nights fished is appropriate. This would have a positive impact on controlling total effort in the fishery. Ideally the days and nights allocated to each business would be tradable to realise economic efficiency. Equity would need to be a key consideration when considering an allocation of days/nights, for example, having regard to share holdings and past restrictions on vessel capacity;
- the potential economic benefits of rebuilding any overfished species may be significant, but these benefits will largely depend on the rate of recovery and they must be weighed against the costs of recovery programs;
- the draft strategy specifies a performance measure to monitor the commercial viability of commercial fisheries at the fishery level and to move from a gross return to a net return indicator. Developing performance measures for monitoring viability at the individual fishing business level is not recommended as it may be problematic from a confidentiality perspective;
- full incorporation of effective and efficient management requires a framework for improving the delivery of fishery management services.

Predicted outcome

In summary, the draft strategy reflects the current move to category 1 share management which will provide a secure, long term property right for fishers. It signals the intent to limit latent effort, however the way that this will be achieved must be addressed if viable fisheries are to be achieved. Fishing businesses remaining in the fishery in the long term will likely incur costs in reducing fishing capacity depending on the adjustment tools used, the extent of restructuring and the pace of adjustment. Limitation of total effort could be an issue as fishers faced with increased management charges have an incentive to increase their effort, although this should be offset if returns to fishers improve as a result of restructuring.

A regime with a more specific limited number of days/nights per fisher may be preferred to support a structural adjustment plan and to augment category 1 share management. Other available management strategies that provide fishers with more incentives, in addition to moving towards category 1 share management, warrant further investigation. For example, implementing more advanced input and output control management systems should be evaluated during the next 5 years, taking account of the outcomes of adjustments in fishing effort and improvements in gear.

Fishing capacity and fishing effort levels must be addressed if a viable fishery is to be achieved in the long term. It is important that the strategy provide for a high level of industry involvement in decision making with regard to structural adjustment and that decisions to improve long term viability are implemented.

Social Impacts

Initial risk

A social profile of ocean trawl fishers revealed fishers to be an aged, highly resident population, with substantial fishing experience and strong family involvement with fishing. Approximately 60% of prawn trawl and 30% of fish trawl fishers were insistent about their identity as fishers and were unable, or unwilling, to consider re-training.

Between 803 and 1,314 persons (full-time and part-time) were employed in the fishery in 2001/02. About 40% of ocean trawl fishers had estimated dependents of 370 - spouses, children, stepchildren, parents, grandparents and others.

Approximately 73-74% of ocean trawl fishers who responded to survey have 100% income from fishing. Part-time fishing involvement is limited. Fishers contribute from 68–92% to the average household income.

The review of current operational arrangements shows that people who depend on the ocean trawl fishery are facing a number of risks. The major risks are: loss of jobs; decreasing incomes; lack of alternative employment opportunities; insufficient involvement of fishers in management; conflicts; insecurity and uncertainty; and inadequate information to monitor social aspects of the fishery.

Response

The draft strategy proposes a number of management responses to address the key social issues in the fishery. The potential social impacts of implementing the draft strategy are:

- the category 1 share scheme provides increased security and therefore more certainty and security for fishers. It will also increase the incentives for fishers to add value to their shares as a form of investment or superannuation;
- fishing will be seen more as a commercial activity than a lifestyle, which may have negative impact on some fishers as their main objective is not maximising economic returns from the fishery;
- the major social impact involves the potential displacement of fishers and employees, due to removal of overcapacity in the fishery. Fishing lifestyle, old age, lack of skills to start alternative businesses, and lack of alternative employment opportunities are major impediments for fishers who may wish to leave the fishery. On the over hand, structural adjustment would provide the basis for a viable commercial fishery, with more secure

opportunities for investment, jobs and value adding, and would enable elderly fishers to retire with a payment from the sale of shares;

- there may be some reduction in conflicts, as allocation of access rights and compliance issues are comparatively well addressed in the draft strategy, reflecting an improvement on previous arrangements; and monitoring of social aspects in the fishery is likely to be improved, if an increased emphasis on socio-economic research programs in implemented.

Predicted outcome

In summary, the move to the category 1 share scheme provides significantly greater security and certainty for fishers, their families and local communities. However, effort reduction leads to displacement of a number of fishers, although the impact of this will depend on the scale and pace of many changes. Fishers with ownership in a licence will be able to sell their shares, if they wish to leave the fishery or reduce their fishing operations. However, crew members will be displaced with a resultant loss of income.

Outgoing fishers may face difficulties in finding alternative employment or business opportunities, though some fishers are latent in the ocean trawl fishery as they fish elsewhere and others may take the opportunity to retire. The nature of the fishery will change. Fishers who remain in the fishery will see fishing more as a commercial activity than a lifestyle, being able to develop long-term business plans and increase their economic returns if firm decisions are made to improve the economic health of the fishery. These changes will have flow-on effects in local and regional communities where there is a substantial commercial fishing fleet.

Indigenous issues

Initial risk

The review of existing information and responses to surveys from Aboriginal communities made it apparent that ocean fishing is part of their cultural identity. Most often, the fishing described is inshore fishing, based on beaches or rock platforms, although there is no doubt that some people also historically fished the ocean from canoes and continued this tradition as ocean fishing from small boats in contemporary times. This fishing is for subsistence and socio-cultural purposes. People fish to feed their families, but also to meet obligations for looking after other people in their community, either as part of daily routines, or for special events such as funerals. Aboriginal Elders still pass on stories and information about places and species of traditional importance to their children and grandchildren.

The views expressed by local Aboriginal community representatives during this assessment process and other recent research on Indigenous fishing indicated a strong community perception that Aboriginal fishers consider themselves as custodians of valuable natural resources, who participate in fishing activities both for subsistence reasons and to continue to transfer cultural values and ecological knowledge. They also expressed strong interests in rights to access ocean resources, in the sustainability of ocean fisheries, and interests in the well being of particular species. Broadly, totemic marine species were thought to be at moderate risk due to the current operation of the fishery, but it was also recognised that the relationship between those species and the fishery was poorly understood.

The existence of commercial ocean fisheries, such as the Ocean Trawl Fishery, does not in itself detract from Aboriginal access to traditional fisheries. Community members believe, however, that the low representation of Aboriginal people in the commercial sector, the regulation of the commercial fishery and the imposition of strict bag limits for non-commercial fishers disadvantages them and conflicts with traditional fishing customs.

Only one Aboriginal person is currently known to hold a commercial licence in the Ocean Trawl Fishery and there appears to be little direct engagement between Aboriginal people and the commercial Ocean Trawl sector. During consultation, Aboriginal people have expressed strong views that the wealth generated from use of marine resources (including, but not restricted to the Ocean Trawl Fishery) does not accrue fairly and that Aboriginal people have been disadvantaged in their participation in the commercial sector. It was also apparent that Aboriginal people do not participate because they do not have the capital to invest in commercial vessels and equipment.

The physical evidence of past ocean fishing practices is (poorly) preserved in midden sites on headlands and behind ocean beaches along the NSW coast. There are also places of contemporary value, where social activities associated with fishing have occurred within memory and continue to occur. There is minimal risk that the operation of the Ocean Trawl Fishery will impact on these archaeological sites or other sites of cultural value.

In addition to addressing some concerns about participation in commercial fisheries, the draft strategy is viewed as an opportunity to raise awareness about Aboriginal fishing practices, to improve communication and to support in implementing many of the actions within the Indigenous Fisheries Strategy.

Response

The draft strategy proposes to address Indigenous issues as they relate to the ocean trawl fishery by:

- including a section early in the document that describes the role of the Indigenous Fisheries Strategy and the aspirations and some of the constraints relating to Indigenous people becoming more involved in commercial fishing.
- managing the fishery in a manner that is consistent with the Indigenous Fisheries Strategy and Implementation Plan.
- modifying the activity of ocean trawl fishing, where relevant, in response to new information about areas or objects of cultural significance.
- continuing to provide a dedicated position on the Ocean Trawl Management Advisory Committee for an Indigenous person.

Predicted outcome

The initial risks due to the current fishery were generally low for most aspects of Aboriginal culture, and so there was limited need for changes under the draft strategy. In particular, there was a low risk to: the physical evidence of past Aboriginal land use; locations that are associated with stories about the landscape or with personal and community totemic associations with the natural world; and distribution of Aboriginal foods and medicines in the marine landscape. Under the draft strategy, these risks will not be increased and in some cases will decrease further due to involvement of Aboriginal people in the Management Advisory Committee, and as better information about species of concern to communities along the whole coast become better documented and Indigenous participation in fishery management is enhanced.

The assessment reported moderate risk to marine totem species and to Aboriginal socio-economic participation in the commercial fishing sector. There is limited detailed documentation about Indigenous totem species in the NSW marine environment and until such information is available, there is little that can be changed through the ocean trawl strategy. The draft strategy may facilitate enhanced opportunities for economic participation and skill development, in association with the actions that are priorities in the Indigenous Fisheries Strategy and are further explored in the Indigenous commercial fishing opportunities action plan. Adoption of key recommendations of the

Indigenous Fisheries Working Group will help to open up opportunities and reduce the risk that commercial fishing strategies present to Indigenous rights.

European heritage sites

The assessment of the existing activity found that there was a very low potential for the fishery to interact with, or impact on, heritage items of known historical significance, primarily shipwrecks. Continuation of the fishery as proposed under the draft strategy will not increase the risk of impacts on these items.

Justification for the draft strategy

The EIS highlights the importance of the ocean trawl fishery in terms of employment, supply of seafood to the community and economic benefits. The fishery directly employs between 800 and 1300 people, and produces over 4,000 tonnes of seafood annually, valued at about $36 million at first point of sale. The economic and employment flow-on effects to local and regional communities are significant, and across the fishery the multiplier values range from 1.5-2.0 (i.e. every dollar spent directly in the fishery is worth $1.5-$2 in the community).

The nature of trawl fishing, and the large number of species captured by the fishery, demand that selectivity and bycatch issues are appropriately addressed, and the draft strategy proposes means to investigate these issues and develop effective responses. The draft strategy also provides for a significant improvement in the information base for the fishery, and the development of assessments of the status of the stocks of the important species. Another major issue for trawl fisheries is that of habitat protection, and the draft strategy commits to the mapping of trawl grounds and the closure of sensitive habitat areas. Ongoing assessment of the impacts of significant management reforms is also proposed under the draft strategy.

The draft strategy contains a range of immediate and short term actions, and establishes a range of programs that will require ongoing consultation with key stakeholders and the conclusion of implementation details. A significant level of work will be required to undertake the tasks which the EIS has found as being crucial to the long term sustainable management of the ocean trawl fishery. In order to ensure that the fishery operates in an ecologically sustainable manner into the future and that the environmental risks are meaningfully reduced, it will be important to ensure that the strategies and plans subsequently developed under the fishery management strategy are implemented so as to fulfil the stated goals and objectives. With this major qualification, the EIS concluded that the range of measures are consistent with the principles of ecologically sustainable development.

Table A1. The environmental impact statement summary table showing the risks associated with the current activity, the programs proposed in the draft strategy to mitigate those risks, and an assessment of the predicted effectiveness of the draft strategy.

*It is important to note that many components are related and as such the listed programs address more components than is possible to list in table format.

Component	Sub-Component	Current Risk Level#	Number of entities	Potential risk reduction by draft FMS	Issues arising from Risk Assessment	*Programs in draft FMS to mitigate risk
Ecological	Primary, key secondary & secondary species[A] (includes discards of undersized commercial species)	H	5	Minor	- Elasmobranchs at highest risk - Action needed on moderately high risk species - Lack of stock assessments - Inappropriate gear selectivity - Poor understanding of discarding - Limited knowledge of the effectiveness of BRD (bycatch) - Inconsistent management regimes - Poor data quality - Information gaps	*Management:* implement closures & refuge areas, recovery programs for overfished species; change gear *Research:* observer study to collect information on elasmobranchs, primary & key secondary species *Monitoring:* age/length, sex composition, quantity of landings, exploitation status
		MH	9	Moderate - Major for few species Minor most species		
		I	12	Minor		
		ML	1	Unchanged		
		L	13	Unchanged		
	Section in EIS	B2.3(b)(ii) Table B2.18		E1.2(a) Table E1.3	B2.3(c)	D3(b) Table E1.3
	Bycatch[A] (non-commercial species)	H	43	Minor - Moderate	- No quantification of non-commercial species bycatch - Limited knowledge of the effectiveness of BRD - Evalutation of changed gear selectivity to changes in weight & composition of bycatch - Limited bycatch reduction methods for fish trawls - Information gaps about food provisioning to scavengers & survival of discards	*Management:* additional BRD requirements, closures at river entrances particularly during high flow, identify areas & times of high bycatch, improve BRDs, improve gear selectivity, prawn counts, recovery programs, code of conduct *Research:* observer program *Monitoring:* monitor catches
		MH	93	Minor - Moderate		
		I	7	Unchanged		
	Section in EIS	B2.4(c) Table		E1.3(a) Table E1.12	B2.4(d)	D3(b) Table E1.12

Table A1. Continued

Component	Sub-Component	Current Risk Level#	Number of entities	Potential risk reduction by draft FMS	Issues arising from Risk Assessment	*Programs in draft FMS to mitigate risk
Ecological	Threatened species, populations & communities[A]			No Change	Applying to all species groups: - need for on-going monitoring of interactions between fishery and threatened species - need to investigate dependence of threatened species on discards - need for a mechanism to incorporate future listings into management	*Management:* mandatory reporting of fishers' interactions with threatened species, implement actions required in any recovery plans for threatened species *Research* : observer program *Monitoring:* interactions between fishers & turtles, intensity of interaction with threatened species
		Birds:				
		ML	26			
		Mammals:				
		ML	4			
		L	3			
		Reptiles:				
		ML	0			
		L	4			
		Fish:				
		ML	2			
		L	5			
		Populations:				
		ML	1			
		L	0			
	Section in EIS	B2.5(a)		E1.4(a)(b)	B2.5(c)	D3(b)
	Marine habitats[1]	*Geological* :		Minor to Moderate	- Need to eliminate fishing practices that destroy habitat - Need for adequate refuge areas to conserve habitats - Non-complimentary management regimes between jurisdications - Major information gaps	*Management:* refuges areas, close all reefs, modify gear, cross jurisdiction consultation, close depths >1100m *Research* : map habitats, promote research on habitat associations, prohibit bobbins Monitoring: none proposed
		H	1			
		MH	1			
		I	1			
		L	0			
		Biological:				
		H	2			
		MH				
		I	1			
		L	1			
	Section in EIS	B2.7(c)(iii)		E1.6(a)(b)	B2.7(d)	D3(b) Table E1.19

Table A1. Continued

Component	Sub-Component	Current Risk Level#	Number of entities	Potential risk reduction by draft FMS	Issues arising from Risk Assessment	*Programs in draft FMS to mitigate risk
Ecological	Ecological processes[2]	H	1	Minor to Moderate	- Establish refuge areas - Lack of knowledge impacts on ecosystem & ecological processes & associated management	*Management:* refuge areas, close depths >1100m, closures to protect marine habitats, close all reefs, prohibit bobbins *Research*: map habitats *Monitoring:* none proposed
		MH	1			
		I	5			
		L	2			
	Species assemblages	H	✓		- Conserve marine habitats - Establish refuge areas	
	Species diversity	H	✓		- Establish refuge areas	
	Section in EIS	B2.6(a)(iii), (b),(c)(ii)		E1.5(a)(b)	B2.6(d)	D3(b)
Biophysical	Water quality	L	✓	No Change	None	Not necessary
	Noise/light	L	✓		None	Not necessary
	Air quality & greenhouse gases	L	✓		None	Not necessary
	Section in EIS	B3(c)(d)		E2	B3(d)	
Economic	Fishery viability	H	✓	Major for Property Rights Negligible for effort level	- Excess fishing effort - Potential activation of latent fishing effort - Insufficient controls on fishing effort - Lack of economic incentives to fishers to reduce fishing effort - Increasing operating, management and restructuring costs - Lack of access security for long-term business certainty	*Management*: limiting endorsement numbers, strategies to maximise economic return, school whiting specifications, process to establish maximum level of fishing effort, cross-fishery & cross-jurisdicational consultation *Research:* feasibility of performance measure for viability *Monitoring*: monitor landings between sectors
	Section in EIS	B4.6		E3.1(b)	B4.1-6	D3(b)

Table A1. Continued

Component	Sub-Component	Current Risk Level#	Number of entities	Potential risk reduction by draft FMS	Issues arising from Risk Assessment	*Programs in draft FMS to mitigate risk
Social	Social capital	I	✓	Minor	- Excess fishing effort - Loss of fishing lifestyle - Lack of alternative employment opportunities - Conflict - Uncertainty - Lack of secure property rights - Inadequate information on social aspects of the fishery	*Management:* manage multiple use trawl grounds, depth limitation for prawn trawlers, implement category 1 share management provision, *Research & Monitoring* : Surveys to collect social & economic information
	Section in EIS	B5.1(d)		E4.1	B5.1(a-d)	D3(b)
	Health & safety	L	✓	No Change	None	Not necessary
	Section in EIS	B5.2(c)		E4.2	B5.2(a-b)	
	Indigenous	L	✓	No Change	- Continued access to fishery resource	Management: Manage consistently with Indigenous Fishing Strategy
	Section in EIS	B5.3(f)		E4.1	B5.3(a-e)	D3(b)
	European heritage	L	✓	No Change	None	Not necessary
	Section in EIS	B5.4(b)		E4.1	B5.4(a)	

H - high, MH - moderately high, I - intermediate, L - low

✓ - level of risk for single entities

A - numbers in entities column refer to the number of species with that level of risk

- Risk level due to current activity of the fishery

1 - numbers refer to number of habitat types

2 - numbers refer to number of ecological processors

How the environmental impact statement was developed

This EIS was developed using a modified framework of the generic risk management process (AS/NZS 4360) acknowledged by Standards Australia and Standards New Zealand. AS/NZS 4360 uses a seven-step process for risk management, but this EIS has added an eighth step in that following the treatment of risk (i.e. the draft strategy), it has re-evaluated the level of risk that would eventuate if the management strategy was to be implemented.

As well as satisfying the environmental assessment requirements of the NSW Environmental Plan*ning and Assessment Act 1979*, the EIS will also be submitted to the Commonwealth Government to meet the assessment requirements for the *Environment Protection and Biodiversity Conservation Act 1999.*

Development of the draft strategy

The draft strategy for Ocean Trawl was compiled with significant input from the Ocean Prawn and Ocean Fish Trawl Management Advisory Committee. The Management Advisory Committee includes elected representatives from the two fisheries and appointed representatives from the recreational fishing sector, the NSW Nature Conservation Council and NSW Department of Primary Industries. Input on the proposed management arrangements was also sought from all fishers endorsed in the ocean trawl fishery through a specifically designed overview paper, and the Ministerial Advisory Council’s on Commercial Fishing (which includes representatives from other NSW commercial fisheries) and Recreational Fishing.

The draft strategy for ocean trawl fishery contains the proposed rules for management of the fishery, but it is much more than a collection of rules. The draft strategy contains the objectives for the fishery, a detailed description of the way the fishery operates, and describes the management framework for at least the next five years. It also outlines a program for monitoring the environmental, social and economic performance of the fishery, establishes trigger points for the review of the strategy, and requires regular reporting on performance in order to ensure that the strategy meets its objectives.

Development of the environmental impact assessment

It is important to understand that the environmental impact assessment and the strategy have been developed concurrently, in a series of steps. The draft strategy assessed here is in fact the second draft of the strategy. The process has been designed to give early feedback to the MAC and allow a response to the predicted environmental impacts of the management proposals. Each draft of the strategy is then modified to ensure that the proposed management framework appropriately addresses the environmental impacts identified during the assessment process.

One difference between assessing the impacts of an existing fishing industry and assessing, for example, a new building development is that the activity being assessed already exists. Consequently, changes to fishing practices and levels of harvest will have direct social and economic impacts on already-established fishing and related industries.. It is important that when the impacts of proposed changes are assessed time is allowed, where appropriate, for industry to adjust to any required changes.

The assessment of fishery impacts is also much more difficult than is the case with many other natural resources because, in comparison to our knowledge of terrestrial resources, much less is known about aquatic ecosystems. The environmental assessment acknowledges such uncertainty and, where there is little information upon which to draw definitive conclusions, the precautionary principle is applied. The precautionary principle, a key component of the principles of ecologically sustainable development, states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent that environmental degradation.

Consulting the Community

You are invited to comment on the Environmental Impact Statement on the Ocean Trawl Share Management Fishery and the Southern Ocean Fish Trawl Fishery in NSW, which is on public exhibition until 10 September 2004. The full EIS can be viewed at offices of the NSW Department of Primary Industries, the head office and regional offices of the Department of Infrastructure, Planning and Natural Resources, NSW Government Information Service, local councils and the Sydney office of Environment Centre (NSW) during normal business hours. A paper or CD copy can be purchased for $25 (includes GST) by contacting the Department of Primary Industries on 1300 550 474. It is also available on the NSW Department of Primary Industries website at www.fisheries.nsw.gov.au.

For more information, visit: www.fisheries.nsw.gov.au

Would you like to comment?

Write to:	Environmental Impact Statement Submission
	Ocean Trawl Fishery
	PO Box 21
	CRONULLA NSW 2230
Fax:	(02) 9527 8576 (marked attention “Ocean Trawl EIS Submission”)
Email:	oceantrawl.eis@fisheries.nsw.gov.au

If you wish your submission to remain confidential, it should be so marked.

Comments must be received by 10 September 2004.

CHAPTER B REVIEW OF THE EXISTING OPERATION OF THE FISHERY

1. General Information

1.1 Introduction

The ocean trawl fishery off NSW has two components, fish trawling and prawn trawling, which have different management histories. Prior to 1990, all trawling in ocean waters more than 3 nautical miles from the coast was under Commonwealth jurisdiction, while trawling in coastal waters out to 3 nautical miles was under NSW jurisdiction. In December 1990 an Offshore Constitutional Settlement (OCS) agreement gave NSW jurisdiction over trawling in depths less than 4000 m (approximately 80 nautical miles from the coast) for waters between Barrenjoey Point (near Sydney) and the Queensland border. The Commonwealth retained jurisdiction for trawling outside 3 nautical miles south of Barrenjoey Point, and NSW retained jurisdiction for trawling in all waters within 3 nautical miles of the NSW coastline.

There is considerable overlap between ocean prawn trawling and ocean fish trawling in terms of the species caught and the operators who participate in each fishery. A common type of fishing gear (the demersal trawl net) is used throughout the fishery, and while most trawling for prawns occurs off the north coast and most trawling for fish occurs off the central and southern coasts, there is also considerable geographical overlap. For these reasons, and to prevent unnecessary duplication, it was decided to prepare a single fishery management strategy for all trawling in NSW ocean waters.

a) Trawling for fish

Trawling for fish in ocean waters off NSW commenced just after the First World War, when the New South Wales government commissioned three steam trawlers to develop a commercial fishery on grounds discovered by the research vessel *Endeavour*. The fishery developed rapidly following the sale of the vessels to commercial interests in 1923, and the fleet expanded to a maximum of 17 vessels in 1929, when more than 6,500 t of fish were landed. Fish trawling was carried out on continental shelf grounds between Newcastle and Gabo Is, and concentrated on stocks of tiger flathead, with annual landings exceeding 4,000 t throughout the 1930’s. Smaller diesel powered vessels (which used Danish seine nets) entered the fishery in the late 1930’s, and by the mid 1940’s about 60 Danish seiners operated from NSW coastal ports. During this period the flathead stock showed signs of being over fished (Fairbridge, 1952; Houston, 1955), and secondary species, such as jackass morwong and redfish, began to be landed in increasing quantities.

Minimum cod-end mesh size regulations were introduced for fish trawl nets used in the fishery in the 1950’s, to allow small flathead to escape from the nets and so improve the status of the tiger flathead stock. However, the stock was slow to recover, and in the 1960’s the last of the steam trawlers left the fishery. Modern diesel powered trawlers then entered the fishery, and fishing was extended to deeper waters along the edge of the continental shelf, where the main species targeted were gemfish, redfish, mirror dory, ling, ocean perch and several species of sharks. Again there was a rapid development of the fishery, and by 1980 about 130 trawlers were operating from ports between Crowdy Head and Eden, with only 6 vessels still using the Danish seine method (Graham *et al.*, 1982). Annual landings of all species by the NSW fishery at this time were about 12,000t, with gemfish, redfish, jackass morwong and tiger flathead comprising about 85% of total landings (Rowling, 1979 and 1981).

Since the early 1990's there has been a significant decline in both the number of fish trawlers operating and annual landings of the fishery off NSW. This can be attributed to the collapse of the eastern gemfish stock, and the impact of fishing on a number of other secondary species (chiefly redfish and silver trevally). The introduction in 1992 of quota-based management for the Commonwealth segment of the fishery also significantly affected the operations of fish trawlers in the area south of Sydney. To complement the Commonwealth quota management scheme, NSW progressively introduced "trip limits" for many species that were taken in both jurisdictions, thereby limiting the quantity of each species that could be landed from a fishing trip in NSW waters.

As at February 2003, a total of 99 fishing businesses held endorsements to operate in the Ocean Fish Trawl Fishery. Of these, 47 were endorsed to operate in the southern sector of the fishery, south of Barrenjoey Point. With the exception of one small inshore trawler (and two vessels which were recently inactive in both the NSW fishery and the South East Trawl Fishery), all of the vessels endorsed for the NSW southern sector also held permits to operate in the Commonwealth South East Trawl Fishery outside 3 nautical miles from the coast. A total of 62 fishing businesses were endorsed to trawl for fish in the northern sector of the fishery between Barrenjoey Point and Smoky Cape, out to 80 nautical miles from the coast. Of these, 60 also held endorsements enabling them to trawl in at least one of the sectors of the Ocean Prawn Trawl fishery. Total landings reported by fish trawl operators from NSW managed waters in 2000/01 were 1,171 t, valued at about $4 million at first point of sale.

b) Trawling for prawns

Trawling for prawns in ocean waters off NSW commenced in the summer of 1947/48 when commercial quantities of prawns were discovered in the waters of Stockton Bight, off Newcastle. Initial catches comprised mostly school prawns, with small numbers of eastern king prawns, however the fishery soon extended to grounds further offshore, where the main catch comprised eastern king prawns. The fishery also quickly expanded to encompass other grounds off Evans Head, the Richmond and Clarence Rivers, and later off the Macleay River. By the late 1950's about 75 vessels were engaged in the Ocean Prawn Trawl Fishery, and annual landings of prawns from ocean waters had increased to about 900 t (Anon., 1960). The fishery also landed some commercial fish species for market, but most of the incidental catch of invertebrate species (e.g. octopus, cuttlefish, squid, bugs) was discarded at sea as there was little demand in the market for these species.

The Ocean Prawn Trawl Fishery continued to expand throughout the 1960's and 1970's, and with changes in consumer acceptance during this period many of the secondary species became significant in landings. A deepwater fishery for royal red prawns developed off the central coast of NSW in the 1970's following exploratory work undertaken by the NSW Fisheries research vessel *Kapala*. By the mid 1980's more than 300 prawn trawlers operated in NSW ocean waters, with annual catches of about 800 t of king prawns, 350 t of school prawns and 300 t of royal red prawns.

Developments in trawl gear during the late 1970s saw the majority of prawn trawl vessels convert to 'triple gear' (see description in Section 4 following), and the 'ground gear' of prawn trawl nets was modified by the inclusion of longer droppers, to lessen catches of incidental species. An initial Management Plan for prawn trawling was introduced in 1985, which restricted entry of new vessels to the fishery, and included regulations based on hull size and engine power that aimed to control increases in fishing effort. In 1990, further management controls were introduced, restricting the size of net that each vessel could tow. These controls reduced by about 40% the total amount of net that could be used in the offshore sector of the fishery (outside 3 nautical miles).

Seasonal area closures were first introduced in the fishery in September 1982 to protect juvenile king prawns that had recently migrated to sea from their estuarine nursery grounds in the Brunswick, Richmond, Clarence, Evans and Macleay Rivers. At the request of industry, these closures were later extended to offer better protection to juvenile prawns. Additional 'juvenile king prawn' closures were implemented off Port Stephens and Wallis Lake in 2000, and Crowdy Head in 2004.

A significant development of a species caught incidentally in the Ocean Prawn Trawl Fishery occurred in the late 1970s when an export market developed for ‘school’ whiting. Two species, red spot whiting and stout whiting, which had previously been mostly discarded by prawn trawlers, were retained in increasing amounts, and in some areas targeted fishing for whiting developed. Annual landings of school whiting increased to around 800-1000 t in the late 1980s, then declined to around 500 t in the early 1990s. Landings then increased again and recently peaked at 1500 t in 1998/99, before declining by about 40% following the implementation of ‘bycatch reduction devices’ in prawn trawl nets used in the fishery.

As at February 2003, a total of 312 fishing businesses held endorsements to operate in one or more sectors of the Ocean Prawn Trawl Fishery in NSW. Of these, 267 fishing businesses were endorsed to trawl for prawns in the inshore sector of the fishery, where the main species taken are school prawns, school whiting, and eastern king prawns. A total of 238 businesses were endorsed to trawl in the offshore sector, catching mainly eastern king prawns and school whiting, and 63 fishing businesses were endorsed for the deepwater sector, targeting royal red prawns. The total reported landings of all species by the Ocean Prawn Trawl Fishery in 2000/01 were 3,411 t, valued at about $32 million at first point of sale.

1.2 The Ocean Trawl Fishery

a) Extent of the fishery

Trawling is conducted on suitable grounds in ocean waters off the entire length of the NSW coast. Trawling cannot be successfully conducted on areas of rocky reef, or where there are obstacles (such as shipwrecks or undersea cables) that could snag the net or attached gear.

Trawling for eastern king prawns is concentrated mainly off the north coast of NSW, with the majority of fishing occurring north of Newcastle, in depths from 20 to 200m. Trawling for school prawns occurs mainly in shallow waters adjacent to the north coast estuaries, although some fishing also occurs seasonally on southern grounds. Trawling for royal red prawns and associated species occurs in depths of 400 - 600 m, mainly off the central and lower north coasts, between 29°S and 35°S. The trawl fishery for eastern king prawns is believed to be based on a single species stock, and extends from eastern Bass Strait into waters off Queensland, as far north as the Swains Reef (22°S). The fishery for school prawns occurs in local stock areas in NSW and southern Queensland, while the fishery for royal red prawns off eastern Australia is almost entirely confined to waters off NSW.

Trawling for fish species occurs on continental shelf and slope grounds between Smoky Cape (approx. 31°S) and the Victorian border. Depending on the season and the species mix being targeted, trawling for fish can occur in water depths from 10m to around 1000m. Trawling for fish also occurs in waters off Victoria, Tasmania and South Australia.

Trawling targeted at school whiting occurs year round on sandy bottoms in depths of 20 to 80m, mainly north of Sydney. Targeted fishing for whiting occurs mainly in those areas located close to processing plants or the Sydney Fish Markets. A small number of trawlers target school whiting on a regular basis, but additional trawlers may target whiting during periods when prawns are less available. Trawl fisheries for school whiting also occur off southern Queensland (where stout whiting are targeted) and Victoria (where red spot whiting is the main target species).

b) Species taken by the ocean trawl fishery

The non-selective nature of demersal trawl gear, and the wide range of latitude, depth and bottom types over which trawling occurs, results in a large number of fish and invertebrate species being captured. More than 300 species of fish and about 80 species of mobile invertebrates were recorded in fish and prawn trawl catches during observer studies and research trawls conducted in NSW waters during the 1990s (Liggins, 1996; Graham *et al.*, 1996). At least 120 species of fish and 30 species of invertebrates are marketed from trawl catches off NSW.

Table B1.1 contains a list of species that constituted 99% of the landed weight reported by ocean trawlers during 2000/01 (prawn trawlers and fish trawlers combined). The list contains 44 species (or ‘species groups’ such as ‘squid’), comprising 33 finfish, 6 crustacean and 5 mollusc species (or species groups). Table B1.2 lists species that constituted the remaining 1% of the landed weight reported by ocean trawl fishers during 2000/01. The list contains 90 species (or ‘species groups’) comprising 75 finfish, 14 crustacean and 1 mollusc species (or species groups).

Table B1.1 List of species that constituted 99% of the landed weight of ocean trawlers in 2000/01.

Common name	Scientific name	Taxonomic Family / Class name
Boarfish	Various	PENTACEROTIDAE
Bream, Black and Yellowfin	*Acanthopagrus* spp	SPARIDAE
Bug, Balmain	*Ibacus* spp	SCYLLARIDAE
Calamari, Southern	*Sepioteuthis australis*	LOLIGINIDAE
Crab, Blue Swimmer	*Portunus pelagicus*	PORTUNIDAE
Cuttlefish	*Sepia* spp	SEPIIDAE
Dory, John	*Zeus faber*	ZEIDAE
Dory, Mirror	*Zenopsis nebulosus*	ZEIDAE
Flathead, Tiger	*Neoplatycephalus richardsoni*	PLATYCEPHALIDAE
Flathead, Sand	*Platycephalus* spp	PLATYCEPHALIDAE
Flathead, Dusky	*Platycephalus fuscus*	PLATYCEPHALIDAE
Flounder	Various	PLEURONECTIDAE / PARALICHTHYIDAE
Gurnard, Red	*Chelidonichthys kumu*	TRIGLIDAE
Latchet	*Pterygotrigla polyommata*	TRIGLIDAE
Leatherjacket, mixed species	Various	MONACANTHIDAE
Moonfish (Pink Tilefish)	*Branchiostegus wardi*	MALACANTHIDAE
Morwong, Rubberlip	*Nemadactylus douglasii*	CHEILODACTYLIDAE
Mullet, Red	Various	MULLIDAE
Octopus, mixed species	*Octopus* spp	OCTOPODIDAE
Perch, Ocean	*Helicolenus percoides and H.barathri*	SCORPAENIDAE
Prawn, Eastern King	*Penaeus plebejus*	PENAEIDAE
Prawn, School	*Metapenaeus macleayi*	PENAEIDAE
Prawn, Royal Red	*Haliporoides sibogae*	SOLENOCERIDAE
Prawn, Unspecified	Various	Various
Redfish	*Centroberyx affinis*	BERYCIDAE
Shark, Unspecified	Various	Various
Shark, Angel	*Squatina australis, Squatina* 'species A'	SQUATINIDAE
Shark, Fiddler / Shovelnose	*Aptychotrema rostrata* and *Trygonorrhina sp. A*	RHINOBATIDAE
Shark, Dogfish Endeavour	*Centrophorus* spp	CENTROPHORIDAE
Shark, Dogfish Greeneye	*Squalus* spp	SQUALIDAE
Shark, Gummy	*Mustelus antarticus*	TRIAKIDAE
Shark, Saw	*Pristiophorus* spp	PRISTIOPHORIDAE
Shark, Whaler species	*Carcharhinus* spp	CARCHARHINIDAE
Shark, Wobbegong (Carpet)	*Orectolobus ornatus* and *O. maculatus*	ORECTOLOBIDAE
Shells	Various	Class: GASTROPODA
Silver biddy	*Gerres subfasciatus*	GERREIDAE
Sole, mixed	Various	SOLEIDAE / CYNOGLOSSIDAE
Squid unspecified	Various	LOLIGINIDAE & OMMASTREPHIDAE
Stingray	*Myliobatus australis*	MYLIOBATIDIDAE
Tarwhine	*Rhabdosargus sarba*	SPARIDAE
Trevally, Silver	*Pseudocaranx dentex*	CARANGIDAE
Yellowtail	*Trachurus novaezelandiae*	CARANGIDAE
Trumpeter	*Latris lineata* and *Latridopsis forsteri*	LATRIDIDAE
Whiting, School	*Sillago flindersi and Sillago robusta*	SILLAGINIDAE

Table B1.2 List of species that constituted 1% of the landed weight of ocean trawlers in 2000/01.

Common name	Scientific name	Taxonomic Family / Class name
Australian salmon	*Arripis trutta*	ARRIPIDAE
Barracouta	*Thyrsites atun*	GEMPYLIDAE
Bass groper	*Polyprion americanus*	POLYPRIONIDAE
Blue-eye	*Hyperoglyphe antarctica*	CENTROLOPHIDAE
Blue Grenadier	*Macruronus novaezelandiae*	MACRURONIDAE
Bonito	*Sarda australis*	SCOMBRIDAE
Bug, Deepwater	*Ibacus alticrenatus*	SCYLLARIDAE
Bullseye, Red	*Cookeolus japonicus*	PRIACANTHIDAE
Catfish, Forktailed	*Arius graeffei*	ARIIDAE
Catfish, unspecified	Various	PLOTOSIDAE
Cobia	*Rachycentron canadum*	RACHYCENTRIDAE
Cod, Bar	*Epinephelus ergastularius*	SERRANIDAE
Cod, Maori	*Epinephelus undulatostriatus*	SERRANIDAE
Cod, Red Rock	*Scorpaena cardinalis*	SCORPAENIDAE
Cod, Unspecified	Various	Various
Crab, Coral	Various	PORTUNIDAE
Crab, Mud	*Scylla serrata*	PORTUNIDAE
Crab, Redspot / Threespot	*Portunus sanguinolentus*	PORTUNIDAE
Crab, Spanner	*Ranina ranina*	RANINIDAE
Crab, Unspecified	Various	Various
Dolphinfish	*Coryphaena hippurus*	CORYPHAENIDAE
Dory, Silver	*Cyttus australis*	ZEIDAE
Dory, unspecified	Various	ZEIDAE
Drummer	Various	GIRELLIDAE
Eel, Conger	*Conger* spp	CONGRIDAE
Eel, Pike	*Muraenesox bagio*	MURAENESOCIDAE
Eel, Unspecified	Various	Various
Flathead, Marbled	*Platycephalus marmoratus*	PLATYCEPHALIDAE
Flathead, Ghost	*Ratabulus diversidens*	PLATYCEPHALIDAE
Flutemouth	*Fistularia petimba*	FISTULARIIDAE
Garfish, Unspecified	*Hyporhamphus* spp	HEMIRAMPHIDAE
Gemfish	*Rexea solandri*	GEMPYLIDAE
Hairtail	*Trichiurus lepturus*	TRICHIURIDAE
Hapuku	*Polyprion oxygeneios*	POLYPRIONIDAE
Kingfish, Yellowtail	*Seriola lalandi*	CARANGIDAE
Ling	*Genypterus blacodes*	OPIHIDIIDAE
Lobster, Slipper	Various	SCYLLARIDAE
Lobster, Unspecified	Various	PALINURIDAE
Longtom	Various	BELONIDAE
Luderick	*Girella tricuspidata*	GIRELLIDAE
Mackerel, Blue	*Scomber australasicus*	SCOMBRIDAE
Mackerel, Jack	*Trachurus declivis*	CARANGIDAE
Mackerel, Unspecified	*Scomberomorus* spp	SCOMBRIDAE
Mantis Shrimp	Various	Order STOMATOPODA

Table B1.2 (cont).

Common name	Scientific name	Taxonomic Family / Class name
Morwong, Jackass	*Nemadactylus macropterus*	CHEILODACTYLIDAE
Morwong, Red	*Cheilodactylus fuscus*	CHEILODACTYLIDAE
Mullet, Sea	*Mugil cephalus*	MUGILIDAE
Mullet, Unspecified	Various	MUGILIDAE
Mulloway	*Argyrosomus japonicus*	SCIAENIDAE
Old Maid	*Selenotoca multifasciatus*	SCATOPHAGIDAE
Oilfish	*Ruvettus pretiosus*	GEMPYLIDAE
Orange Roughy	*Hoplostethus atlanticus*	TRACHICHTHYIDAE
Parrotfish	Various	LABRIDAE
Perch, Moses	*Lutjanus russelli*	LUTJANIDAE
Perch, Orange	*Lepidoperca pulchella*	SERRANIDAE
Perch, Pearl	*Glaucosoma scapulare*	GLAUCOSOMIDAE
Perch, Unspecified	Various	Various
Pigfish	*Bodianus vulpinus*	LABRIDAE
Pike	Various	DINOLESTIDAE and SPHYRAENIDAE
Pilchard	*Sardinops neopilchardus*	CLUPEIDAE
Prawn, Carid	*Aristaeomorpha* spp *and Heterocarpus* spp	ARISTEIDAE and PANDALIDAE
Prawn, Endeavour	*Metapenaeus endeavouri*	PENAEIDAE
Prawn, Racek	*Parapenaeus australiensis*	PENAEIDAE
Prawn, Scarlet	*Plesiopenaeus edwardsianus*	ARISTEIDAE
Prawn, Tiger	*Penaeus esculentus*	PENAEIDAE
Rainbow Runner	*Elegatis bipinnulata*	CARANGIDAE
Ribbonfish	*Lepidopus caudatus*	TRICHIURIDAE
Rudderfish	*Centrolophus niger*	CENTROLOPHIDAE
Samson Fish	*Seriola hippos*	CARANGIDAE
Scallop	*Pecten fumatus*	PECTINIDAE
Sergeant Baker	*Aulopus purpurissatus*	AULOPODIDAE
Shark, Dogfish Unspecified	Various	SQUALIDAE
Shark, Ghost and Elephant	Various	CALLORHINCHIDAE and CHIMAERIDAE
Shark, Hammerhead	*Sphyrna* spp	SPHYRNIDAE
Shark, Roughskin	*Deania* spp	DALATIIDAE
Shark, tiger	*Galeocerdo cuvier*	CARCHARHINIDAE
Snapper	*Pagrus auratus*	SPARIDAE
Stargazer	Various	URANOSCOPIDAE
Surgeonfish	Various	ACANTHURIDAE
Sweep	*Scorpis lineolatus*	SCORPIDIDAE
Sweetlip, Unspecified	Various	Various
Swordfish, Broadbill	*Xiphias gladius*	XIPHIIDAE
Tailor	*Pomatomus saltatrix*	POMATOMIDAE
Teraglin	*Atractoscion aequidens*	SCIAENIDAE
Trevally, bigeye	*Caranx sexfasciatus*	CARANGIDAE
Trevally, Black	*Siganus nebulosus*	SIGANIDAE
Tuna, Mackerel	*Euthynnus affinis*	SCOMBRIDAE
Warehou, Blue and Silver/Spotted	*Seriolella punctata and Seriolella brama*	CENTROLOPHIDAE
Whiting, Sand	*Sillago ciliata*	SILLAGINIDAE
Whiting, Trumpeter	*Sillago maculata*	SILLAGINIDAE

c) Bycatch species (discards)

Demersal otter trawling is a relatively unselective fishing method, capturing most of the mobile species in the path of the net, and retaining those which are of a size that cannot escape through the meshes of the net. Trawl nets have been shown to have varying efficiencies for capturing the large range of species likely to be encountered, and the selectivity of a trawl net for an individual species also depends on the behaviour exhibited by that species in the path of the net. Several studies (Liggins, 1996; Kennelly *et al.*, 1998) have investigated the incidental catch of commercial trawling with both fish trawl and prawn trawl nets in ocean waters off NSW. The results of these and other studies have been used to suggest fishing gears which could reduce the amount of unwanted bycatch from trawls conducted in NSW waters (Broadhurst and Kennelly, 1995 and 1997; Knuckey, *et al* in prep.).

Observations aboard fish trawlers in the northern sector of the NSW fishery (Newcastle to Forster) in 1993–1995 showed that the major part (83% by weight) of the discarded portion of the catch comprised small non-commercial species. However, about 17% of discards (by weight) comprised small individuals of commercial species, chiefly redfish, tiger flathead and snapper (Liggins, 1996).

Incidental catches which were discarded from ocean prawn trawl catches during 1990-92 comprised mostly small commercial and non-commercial species of finfish and invertebrates (Kennelly *et al.*, 1998). A “bycatch to prawn” ratio of 10.4 to 1 (by weight) was reported in this study. Following the introduction of Bycatch Reduction Devices (BRDs) for prawn trawl nets used in the fishery, in recent years the quantity of incidental catches taken by prawn trawlers has declined. However, the onboard observer studies conducted in 1993-1995 have not been repeated and quantitative data on recent bycatch levels are not available.

Sessile invertebrate species (including sponges, bryozoans and sea pens) frequently comprise a significant component of trawl catches on grounds that have not been trawled for some time, and the greatest impacts of trawling often occur soon after trawling has commenced on these grounds (Watling and Norse, 1998). However the impacts of trawling on such species have not been studied off NSW and remain unquantified.

d) Bait species

Trawl fisheries do not use bait during fishing operations and therefore have no consequent effect on bait resources. However, there is an impact of the ocean trawl fishery on some bait fish species resulting from the direct capture of these species in trawl nets.

1.3 Existing Operational Areas

a) Normal areas of operation

The NSW ocean trawl fishery extends from the Queensland border in the north to the Victorian border in the south (Figure B1.1). North of Barrenjoey Point (Sydney) the boundaries of the fishery extend from the coastal baseline out to the 4000 m depth contour (approximately 80 nautical miles to sea). South of Barrenjoey Point the seaward boundary of the fishery is 3 nautical miles from the coastal baseline (trawling outside this boundary is managed by the Commonwealth).

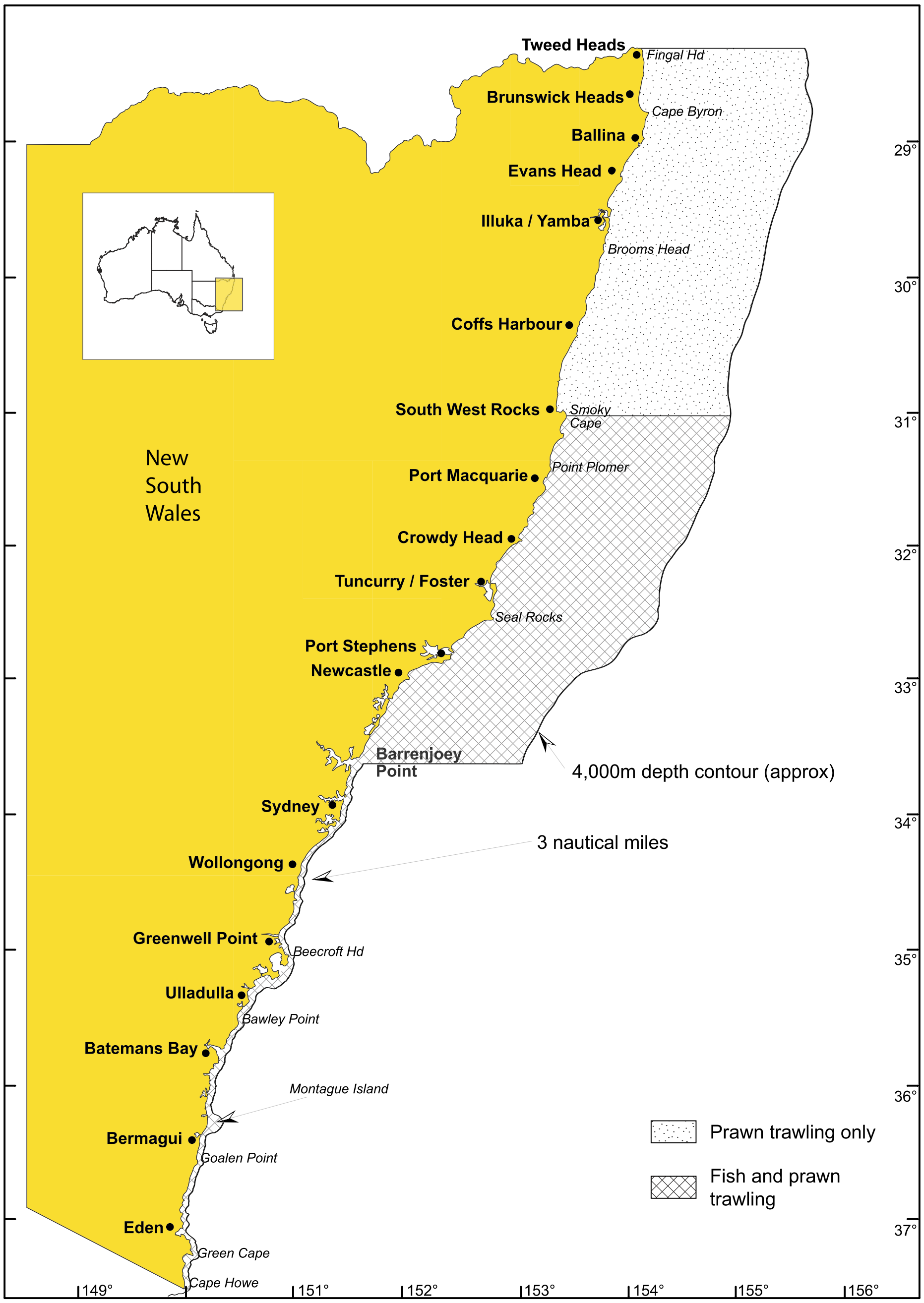


Figure B1.1 Area of operation in the ocean trawl fishery including identification of major ports.

1.4 Methods of Harvesting

a) Gear used in the fishery

During the 1960s and early 1970s, most ‘trawling’ for fish was by Danish seining (also termed Scottish seining or fly dragging). Recently, all trawling in ocean waters off NSW has been by the demersal ‘otter trawling’ method.

Otter trawling employs a combination of towing warps, otter boards (or ‘doors’), sweeps and bridles, and the trawl net. The boards, sweeps and net are dragged along the seabed using wire warps that are wound on and off the trawler’s winch. The shearing action of the boards through the water laterally spreads the net(s). A typical trawl net is like a flattened funnel culminating in a ‘cod end’ of stronger netting where the catch accumulates. In fish trawling gear, long sweeps (typically 180 to 275 m of combination wire/rope) and bridles (generally. 50 m of wire and/or chain) connect the boards to the wing-ends of the net (Figure B1.2). The sweeps and lower bridles contact the seabed during trawling and act to herd fish inwards into the path of the net. As prawns do not ‘herd’, prawn trawling gear has short bridles (maximum of 5 m, and sometimes also called sweeps) with the wing-ends of the net(s) being attached almost directly to the boards (Figure B1.3).

Various designs of net are used to target different fish and prawn species, however the general characteristics of each type of net are similar. Regulations prescribe a minimum mesh size for trawl nets (which is the internal length of individual meshes of the net, measured under tension with an approved net measuring device), and in some cases the dimensions of the overall net and any attachments to the net are also regulated.

The nets currently prescribed for trawling in ocean waters off NSW are as follows (also see Figures B1.2, B1.3 and B1.4):

- **Otter Trawl Net (Prawns)** – has a mesh size of not less than 40 mm and not more than 60 mm, except for the cod-end (the rear end of the net where the catch accumulates as the net is being trawled) which must have a mesh size of not less than 40 mm and not more than 50 mm. The total length of the headline of the net(s) is not to exceed 33 m, unless a different maximum length is specified in the boat licence of the vessel from which the net is being fished. The length of each sweep is not to exceed 5 m, or the distance from the trawl gallows to the stern of the boat (whichever is the greater).
- **Otter Trawl Net (Fish)** – has a mesh size of not less than 90 mm throughout. The length of the headline of the net and the length of sweep is not specified. In waters south of a line drawn due east from Seal Rocks, ‘bobbins’ up to 100 mm in diameter may be used on the ground rope of fish trawl nets. In waters north of the Seal Rocks line, the use of bobbins is banned. (Bobbins are round or cylindrical rollers on the ground rope of a trawl net, which allow the net to ride up and over small variations in bottom topography, which might snag a conventional ground rope. This type of gear is used on harder bottoms comprising low relief rocky slabs or small protruding rocks. It will not allow the net to be successfully worked over rocky reefs with large protruding rocks or boulders, or in areas with high relief e.g. the sides of undersea canyons or pinnacles.)
- **Danish Seine Net (Fish)** – has a mesh size of not less than 83 mm throughout. The length of the headline of the net is not specified. Danish seine nets do not utilise otter boards or sweeps, but have a long length of rope attached to each end of the net by means of short

bridles. The gear is set in a large triangular shape on the bottom, and the ropes are slowly retrieved, closing the gear and herding the fish into the path of the net.

Provided the nets comply with the above regulations, different designs of trawl net may be used to target different species of fish, or on different bottom types. During the past decade changes have occurred in the design of fish trawl nets, with increased cod end hanging ratios, and the use of double-twined material for cod ends. Ocean prawn trawlers in NSW now use 'triple gear' almost universally. As the name suggests, triple gear involves the use of three separate nets which fish side by side. The two outer nets are held open by the otter boards outside each net, while 'sleds' are used between the centre net and each side net to maintain the configuration of the gear. Trawlers targeting royal red prawns from southern ports usually tow a large single prawn net.

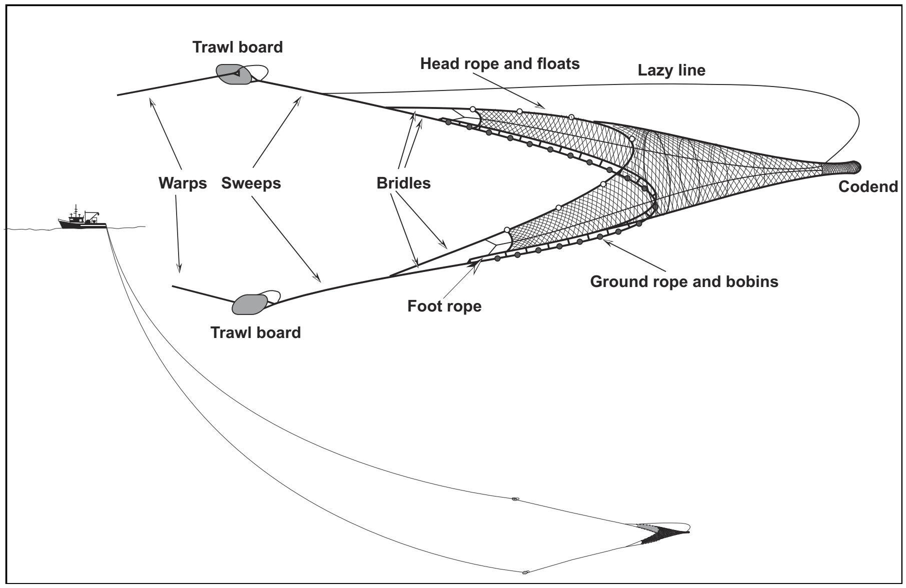


Figure B1.2 Schematic diagram (not to scale) of ocean fish trawl gear.

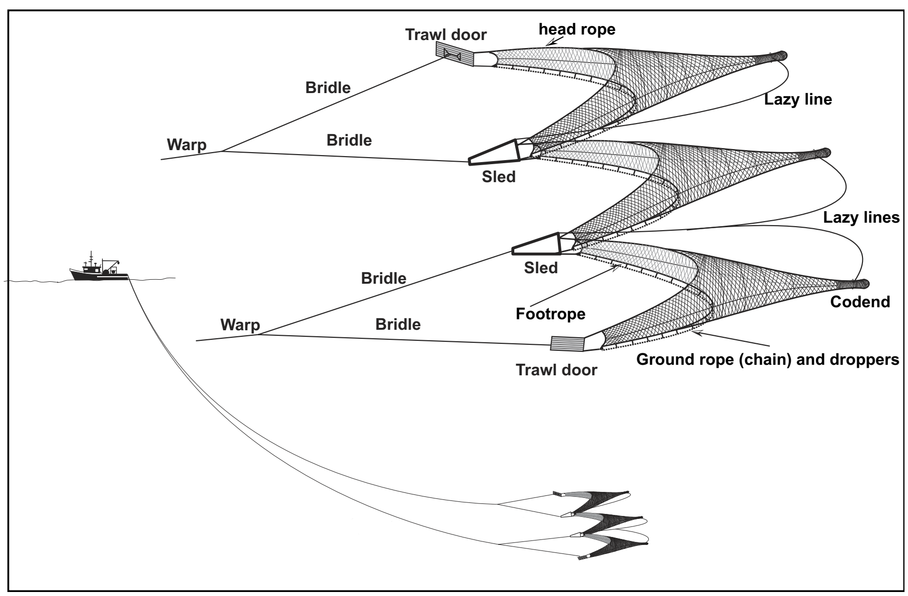


Figure B1.3 Schematic diagram (not to scale) of ocean prawn trawl triple gear.

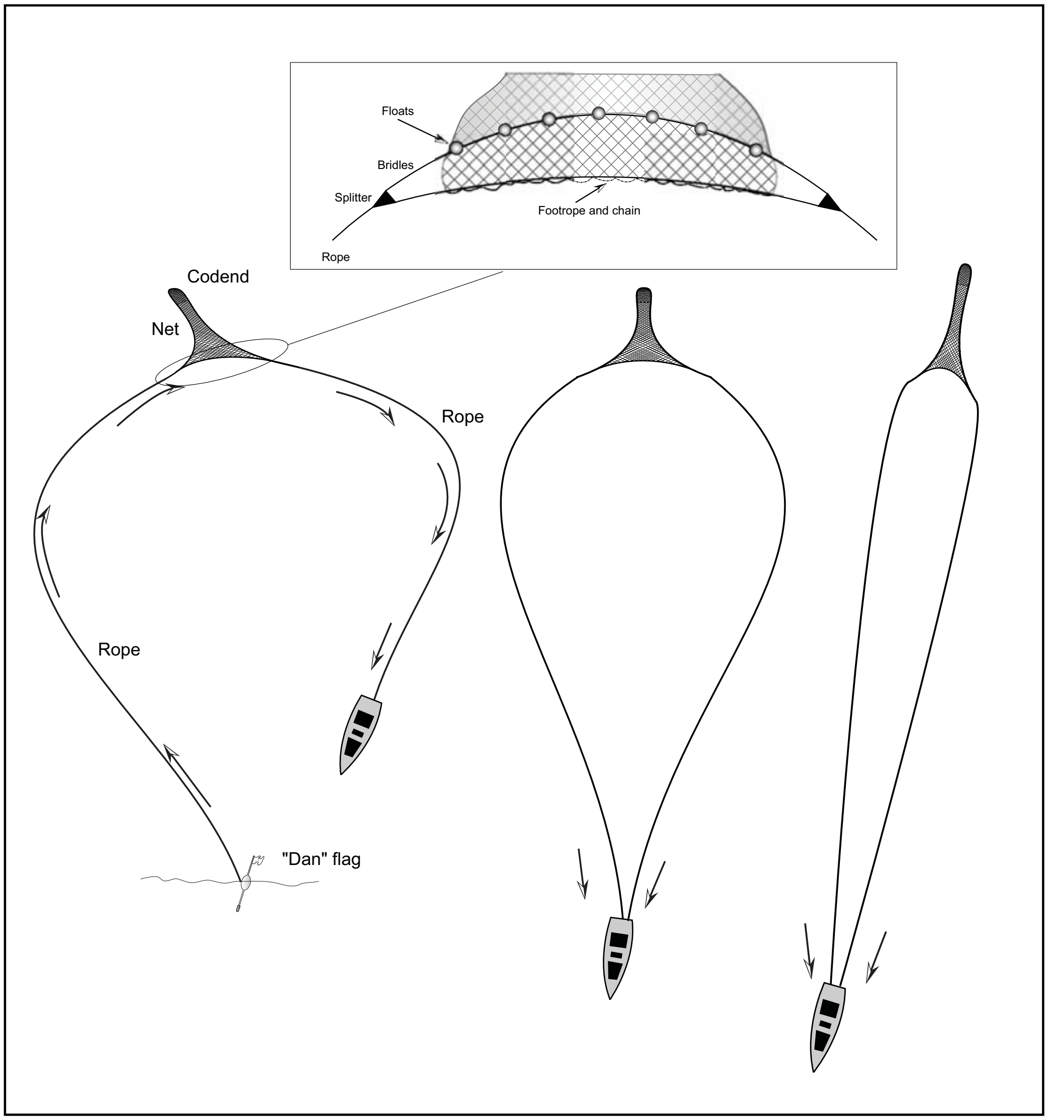


Figure B1.4 Schematic diagram (not to scale) of Danish seine gear.

b) Bycatch reduction devices

All prawn trawl nets must be fitted with a bycatch reduction device that has been approved for use in the fishery. Bycatch reduction devices reduce the incidental capture of finfish in prawn trawl nets. There are currently eight bycatch reduction devices approved for use in the fishery (see table B1.3). The effectiveness of these devices is improved as better information and technology becomes available. A description of the bycatch reduction devices is given in Appendix B1.1.

Turtle exclusion devices are not mandatory in NSW ocean trawl nets. Based on previous observer studies and advice from industry, interaction with turtles is believed to be low, but there are few quantitative data.

Table B1.3 Bycatch Reduction Devices approved for use in ocean prawn trawl nets.

Bycatch Reduction Devices
Square mesh panel
Nordmore grid
Blubber chute
Composite square mesh panel
Diamond
V-cut
Fish eye
Big eye

c) Types of boats used

Vessels used in the fishery range from 9 to 27 m in length (subject to current management rules), with displacement hulls constructed from timber or steel. Vessels are powered by single or twin diesel main engines of 60 to 400 kilowatts (80 to 540 horsepower). In the offshore prawn trawl sector of the fishery, replacement vessels are restricted to a maximum of 20 m in length and propulsive power of 300 kilowatts (400 horsepower). Smaller auxiliary diesel engines provide electric power and drive hydraulic pumps that operate the trawl winches. Modern electronic navigation and fish-finding equipment is now found almost universally on ocean trawl boats in NSW, and some vessels which operate under other jurisdictions also carry satellite-based vessel monitoring systems. Most boats in the fishery use ice to chill their catches, however some boats are also equipped with refrigerated holds, and some prawn trawlers are also equipped with dry freezers for storing product.

d) Operation of fishing gear in the fishery

The trawl gear is deployed over the stern of the vessel while the vessel steams ahead along the chosen course. Once the otter boards are submerged, they begin to shear away from each side of the vessel, opening the mouth of the trawl net. Sufficient warp is unwound from the winch to ensure the boards and attached net contact the sea floor in the appropriate configuration. Brakes are then applied to the winches and the vessel tows the trawl gear along the chosen course at a speed of 2-4 knots, until the skipper decides it is time to winch the trawl net back to the boat. The catch accumulates in the cod end of the net(s) and after the gear is winched back to the boat, the cod end (or cod ends if triple gear is being used) is lifted aboard the vessel and the catch is emptied onto the deck or sorting tray by opening the tie at the rear of the cod end. Marketable product is manually sorted from the catch and placed in fish boxes for storing, while non-commercial species are returned to the water. The introduction in recent years of bycatch reduction devices in the prawn trawl sector of the fishery has considerably reduced catches of non-commercial species and also the time and effort required to sort the catch.

Fishing is dependent on suitable weather and oceanographic conditions. Strong winds and heavy seas generally preclude trawling in ocean waters. Most vessels fish between 50 and 200 days per year. Strong ocean currents can also influence both fishing practices and the species composition of the catch (how well the trawl gear works can depend significantly on the direction and speed of the prevailing currents, and the ability of the vessel to tow the net in the chosen direction). Trawling for fish may occur during day or night, however most trawling for prawns occurs at night (except immediately after flooding when prawns can be caught in turbid waters during daylight hours).

e) Maintenance of fishing gear

Trawl gear, and the deck machinery to operate it, require significant maintenance. It is not uncommon for trawl nets to suffer damage in the form of torn meshes or broken lashings, particularly when working ‘rough’ grounds. “Pin-ups” (either natural rock outcrops, or man-made in the form of shipwrecks or lost shipping containers) can cause major damage or loss of a whole trawl net, although the frequency of complete gear loss is rare (such areas are usually avoided). Vessels usually carry spare nets and netting materials, and moderate amounts of damage are repaired at sea prior to shooting the net away for the next shot. Vessels require annual slipping to repair and repaint hulls, whilst engine oil is replaced at intervals of 250 hours of operation.

f) Post-harvest handling of product

Fish trawlers generally land catches on the vessel’s deck, where the catch is sorted and fish to be retained are boxed, iced and stored below deck. Sorting is done manually, generally with the aid of fish spikes, and non-retained species are either manually lifted over the side of the vessel or washed from the deck with a deck hose. Fishing trips off NSW are generally for less than 24 hours, with the vessel returning to port in the afternoon where the catch is unloaded, weighed and consigned to market.

Ocean prawn trawlers generally land catches onto raised sorting trays, and again the catch is manually sorted. Non-retained species are discarded overboard during sorting, frequently by means of a shute from the sorting tray. Prawns are often cooked (by immersion in boiling seawater) aboard the vessel whilst fishing or returning to port. Recently, however, there has been an increase in the landing of live prawns for the export market, and uncooked ice-slurried prawns for sale on local markets.

A number of regulations currently apply to the post-harvest handling of trawl product:

- shark finning and dumping of carcasses at sea was banned in 2001 to prevent the wasteful practice of discarding the finned carcasses of sharks
- discarding of cooked prawns was banned in January 2003 to prevent the sorting (riddling) and discarding of small cooked prawns from trawl catches
- at-sea processing or mutilation of fish which are subject to a minimum legal length is prohibited
- all trawlers must carry ice to chill the catch, unless refrigeration is available.

1.5 Catch Information

a) Catch levels and value

Total landings reported from ocean waters by fish trawl operators in 2000/01 amounted to 1,171 t, with a value at first point of sale of about $4 million. The main species landed by this sector of the fishery were school whiting (264 t valued at $0.7m), tiger flathead (152 t valued at $0.5m) and silver trevally (112 t valued at $0.3m). Catches of a further 16 species (or species groups) exceeded 10 t in 2000/01.

Total landings reported from ocean waters by fishers using prawn trawls in 2000/01 amounted to 3,411 t, with a value at first point of sale of about $32 million. The main species landed by this sector of the fishery were eastern king prawns (953 t valued at $20m), school whiting (689 t valued at $1.7m), octopus (425 t valued at $2.6m), school prawns (326 t valued at $2.3m), royal red prawns (211 t valued at $0.8m) and cuttlefish (113 t valued at $0.3m). Catches of a further 11 species (or species groups) exceeded 10 t in 2000/01.

b) Definition of regions and reporting zones

There is no 'regional' structure for ocean trawling in NSW, however the fishery is divided into different sectors, with access being determined by specific endorsement (descriptions of the areas covered by each endorsement are below):

1. Ocean Prawn Trawl – Inshore (from the coast to 3 nautical miles to sea)
2. Ocean Prawn Trawl – Offshore (between 3 and approx. 80 nautical miles to sea, for all ocean waters north of Barrenjoey Point, near Sydney)
3. Ocean Prawn Trawl – Deepwater (same as for 'offshore' above, but for taking 'deepwater' prawns of the families Solenoceridae and Aristaeidae)
4. Ocean Fish Trawl – North (north of Barrenjoey Point, to approx. 80 nautical miles to sea)
5. Ocean Fish Trawl – South (south of Barrenjoey Point, to 3 nautical miles from the coast).

Reporting of landed catches occurs through the monthly Fisherman's Returns system whereby fishers report their landings by species and relevant effort details to NSW Fisheries at the end of each month. Landings by species and fishing effort are generally reported by fishing method for an 'ocean zone' (each ocean zone comprises 1° of latitude along the NSW coast), however some data are reported for 'mixed' zones.

c) Catch by sector

Landed catches reported by fishers in 2000/01 were summarised for each of the three main divisions in the fishery (inshore and offshore prawn trawl; deepwater prawn trawl; and fish trawl).

Table B1.4 Species reported taken with ocean fish trawl nets in 2000/01.

SPECIES	Weight (Kg)	% of Catch	SPECIES	Weight (Kg)	% of Catch
Whiting, School	265583	23.99	Hairtail	492	0.04
Flathead, Tiger	150928	13.63	Teraglin	487	0.04
Trevally, Silver	112475	10.16	Eel, Unspecified	397	0.04
Shark, Fiddler	75914	6.86	Dory, Silver	389	0.04
Flathead, Sand	64475	5.82	Australian salmon	376	0.03
Calamari, Southern	62358	5.63	Flathead, Marbled	368	0.03
Cuttlefish	47843	4.32	Prawn, Royal Red	326	0.03
Latchet / Gurnard	36645	3.31	Gemfish	318	0.03
Dory, John	25846	2.33	Orange Roughy	288	0.03
Shark, Angel	23294	2.10	Stargazer	240	0.02
Redfish	19458	1.76	Flathead, Unspecified	239	0.02
Leatherjacket, mixed spp	16911	1.53	Perch, Pearl	213	0.02
Octopus	16689	1.51	Perch, Orange	194	0.02
Stingray	14428	1.30	Cod, Bar	150	0.01
Yellowtail	14318	1.29	Pike	138	0.01
Shark, Saw	13826	1.25	Catfish, Unspecified	111	0.01
Squid	13066	1.18	Bug, Deepwater	111	0.01
Perch, Ocean	12298	1.11	Shark, tiger	110	0.01
Flounder, mixed spp	12168	1.10	Kingfish, Yellowtail	87	0.01
Shark, Unspecified	8635	0.78	Whiting, Trumpeter	66	0.01
Morwong, Rubberlip	8508	0.77	Perch, Unspecified	65	0.01
Tarwhine	8310	0.75	Old Maid	58	0.01
Dory, Mirror	8241	0.74	Bronze Whaler	53	< 0.01
Shark, Gummy	7672	0.69	Flutemouth	51	< 0.01
Bream, Black and	6895	0.62	Mullet, Unspecified	51	< 0.01
Flathead, Dusky	4447	0.40	Crab, Unspecified	51	< 0.01
Shark, Dogfish Endeavour	3885	0.35	Pilchard	50	< 0.01
Shark, Dogfish Greeneye	3686	0.33	Mackerel, Unspecified	35	< 0.01
Mullet, Red	3425	0.31	Sergeant Baker	33	< 0.01
Ling	3270	0.30	Cobia	29	< 0.01
Shark, Carpet	2853	0.26	Prawn, Scarlet	29	< 0.01
Silver biddy	2691	0.24	Cod, Red Rock	27	< 0.01
Trumpeter	2618	0.24	Cod, Unspecified	22	< 0.01
Crab, Blue Swimmer	2540	0.23	Hapuku	21	< 0.01
Bug, Balmain	2518	0.23	Swordfish, Broadbill	21	< 0.01
Shells	2406	0.22	Sweep	19	< 0.01
Sole, mixed	1836	0.17	Rudderfish	16	< 0.01
Snapper	1772	0.16	Dory, Unspecified	15	< 0.01
Boarfish	1719	0.16	Trevally, bigeye	14	< 0.01
Moonfish	1470	0.13	Eel, Pike	12	< 0.01
Shark, Roughskin	1407	0.13	Samson Fish	12	< 0.01
Morwong, Jackass	1395	0.13	Blue-eye	12	< 0.01
Warehou, mixed spp	1307	0.12	Shrimp, Mantis	11	< 0.01
Prawn, Eastern King	1293	0.12	Prawn, Unspecified Ocean	9	< 0.01
Mulloway	1195	0.11	Eel, Conger	8	< 0.01
Shark, School	1119	0.10	Bass groper	7	< 0.01
Tailor	1033	0.09	Grenadier, Blue	6	< 0.01
Whiting, Sand	798	0.07	Bullseye, Red	6	< 0.01
Ribbonfish	664	0.06	Bonito	6	< 0.01
Shark, Ghost	663	0.06	Crab, Three spotted	5	< 0.01
Mackerel, Jack	628	0.06	Pigfish	4	< 0.01
Barracouta	621	0.06	Crab, Mud	2	< 0.01
Mackerel, Blue	612	0.06	Dolphinfish	1	< 0.01
Shark, Hammerhead	523	0.05	Morwong, Red	1	< 0.01

Table B1.5 Species reported taken with ocean prawn trawl nets in 2000/01.

SPECIES	Weight (Kg)	% of Catch	SPECIES	Weight (Kg)	% of Catch
Prawn, Eastern King	953374	32.70	Cod, Bar	364	0.01
Whiting, School	689472	23.65	Bream, Black and Yellowfin	331	0.01
Octopus	424836	14.57	Morwong, Rubberlip	309	0.01
Prawn, School	325910	11.18	Mulloway	292	0.01
Cuttlefish	112501	3.86	Eel, Unspecified	276	0.01
Flathead, Sand	54253	1.86	Kingfish, Yellowtail	274	0.01
Squid	52258	1.79	Cobia	252	0.01
Crab, Blue Swimmer	44623	1.53	Spanner crab	234	0.01
Shark, Fiddler /Shovelnose	33389	1.15	Mullet, Sea	225	0.01
Bug, Balmain	28392	0.97	Tailor	206	0.01
Prawn, Unspecified Ocean	24129	0.83	Teraglin	205	0.01
Fish, Unspecified Ocean	24069	0.83	Trevally, Silver	203	0.01
Mullet, Red	19349	0.66	Shark, tiger	183	0.01
Flounder, mixed	17538	0.60	Cod, Red Rock	177	0.01
Shark, Unspecified	11272	0.39	Shark, Hammerhead	152	0.01
Calamari, Southern	10777	0.37	Crab, Mud	129	< 0.01
Sole, mixed	9701	0.33	Crab, Coral	107	< 0.01
Shark, Angel	5969	0.20	Bullseye, Red	107	< 0.01
Dory, John	5227	0.18	Perch, Pearl	98	< 0.01
Shark, Gummy	4987	0.17	Hairtail	77	< 0.01
Yellowtail	4785	0.16	Surgeonfish	72	< 0.01
Shark, Black Tip	4668	0.16	Catfish, Unspecified	72	< 0.01
Shells	4437	0.15	Longtom	71	< 0.01
Flathead, Dusky	4189	0.14	Eel, Pike	68	< 0.01
Leatherjacket, mixed	4019	0.14	Pike	67	< 0.01
Moonfish	3713	0.13	Trumpeter	65	< 0.01
Shark, Carpet	3275	0.11	Sole, Lemon	60	< 0.01
Boarfish	3164	0.11	Prawn, Carid	59	< 0.01
Latchet / Gurnard	1983	0.07	Eel, Conger	56	< 0.01
Redfish	1856	0.06	Parrotfish	54	< 0.01
Flathead, Unspecified	1758	0.06	Pigfish	43	< 0.01
Prawn, Tiger	1736	0.06	Ling	42	< 0.01
Flathead, Tiger	1628	0.06	Rainbow Runner	40	< 0.01
Cod, Unspecified	1436	0.05	Shark, Dogfish Unspecified	30	< 0.01
Crab, Three spotted	1502	0.05	Dolphinfish	30	< 0.01
Crab, Unspecified	1210	0.04	Whiting, Trumpeter	22	< 0.01
Shark, Saw	1186	0.04	Flutemouth	15	< 0.01
Flathead, Marbled	1182	0.04	Catfish, Forktailed	14	< 0.01
Shark, Dogfish Greeneye	1122	0.04	Samson Fish	14	< 0.01
Morwong, Unspecified	1043	0.04	Bonito	13	< 0.01
Snapper	909	0.03	Tuna, Mackerel	11	< 0.01
Bronze Whaler	903	0.03	Garfish, Unspecified	10	< 0.01
Bug, Deepwater	901	0.03	Trevally, Black	6	< 0.01
Tarwhine	815	0.03	Oilfish	4	< 0.01
Perch, Ocean	695	0.02	Rudderfish	4	< 0.01
Shark, School	677	0.02	Cod, Maori	3	< 0.01
Prawn, Racek	571	0.02	Lobster, Unspecified	3	< 0.01
Stingray	514	0.02	Australian salmon	2	< 0.01
Flathead, Ghost	471	0.02	Drummer	2	< 0.01
Whiting, Sand	441	0.02	Lobster, Slipper	2	< 0.01
Mackerel, Blue	431	0.01	Sweetlip, Unspecified	1	< 0.01
Shark, Ghost	423	0.01	Luderick	1	< 0.01
Scallop	419	0.01	Morwong, Red	1	< 0.01
Silver biddy	403	0.01	Perch, Moses	1	< 0.01

Table B1.6 Species reported taken with ocean prawn trawl nets in the deepwater sector of the fishery in 2000/01.

SPECIES	Weight (Kg)	% of Total Catch
Prawn, Royal Red	209853	91.83
Perch, Ocean	5986	2.62
Shark, Dogfish Greeneye	2633	1.15
Squid	1784	0.78
Dory, Mirror	1672	0.73
Bug, Deepwater	1632	0.71
Ling	1256	0.55
Shark, Dogfish Endeavour	648	0.28
Prawn, Unspecified Ocean	533	0.23
Fish, Unspecified Ocean	479	0.21
Cuttlefish	462	0.20
Prawn, Scarlet	365	0.16
Stargazer	308	0.13
Crab, Unspecified	266	0.12
Ribbonfish	150	0.07
Shark, Unspecified	143	0.06
Gemfish	138	0.06
Octopus	40	0.02
Shark, Saw	38	0.02
Shark, Roughskin	34	0.01
Oilfish	33	0.01
Shark, Angel	32	0.01
Hapuku	22	0.01
Shark, Ghost	7	< 0.01
Cod, Red Rock	1	< 0.01

For each species reported, the catch in kg and the proportion of the total catch (as a percentage for each species) are shown in Tables B1.4, B1.5 and B1.6. In each case, the importance of a small number of species in the catch is apparent - for fish trawl nets the top seven species comprise 70% of the landed catch, while for prawn trawl nets used in the inshore and offshore sectors, 86% of landings is made up of the top five species. For ocean prawn trawl nets used in the deepwater fishery the main target species, royal red prawns, comprised 92% of landings, and the number of 'by-product' species was much less than for the other sectors. [Note that the identification of some species is difficult and reported catches might include other species, e.g. most shark reported as “school” shark is known to be other species of whaler sharks. Also note that the data are as reported by fishers and have not been formally validated, and reported weights have not been corrected for 'processing' prior to landing, e.g. many shark species are landed as 'trunks', headed and gutted.]

1.6 Existing Management Strategy

a) History and status of commercial fisheries management in NSW

Controls on commercial fishing in NSW date back to 1865 when the first fisheries legislation was introduced. Since that time, several Acts have been introduced to improve the ability to manage the impacts of fishing. The *Fisheries & Oyster Farms Act 1935* provided a good set of management tools, such as licensing rules, gear controls and fishing closures, and was in force for some 60 years.

With the advent of new technology and ongoing increases in effective fishing capacity, more contemporary management regulations were needed. The *Fisheries Management Act 1994* replaced the *Fisheries & Oyster Farms Act 1935* and provided a more comprehensive set of instruments to manage fisheries. Table B1.7 below provides a summary of relevant developments in fisheries management in NSW.

The *Fisheries Management Act 1994* provides several broad frameworks for managing commercial fisheries including category 1 and category 2 share management fisheries and restricted fisheries. Each framework provides a different level of access right along with different levels of cost and responsibility for industry. Table B1.8 provides a comparison between the three management frameworks. The Ocean Fish Trawl and Ocean Prawn Trawl Fisheries have been declared as category 2 share management fisheries. With the exception of the southern fish trawl sector, the ocean trawl fishery is moving towards a category 1 share management fishery framework.

b) Controls on fishing activity

The Ocean Prawn Trawl Fishery currently operates under the set of management measures contained in a "management plan" introduced in 1990, and subsequently amended in September 1994. No formal management plan currently exists for fish trawling in ocean waters off NSW, however numerous management controls are in operation for the fishery.

There are two broad types of fishery management controls, known as input controls and output controls. Input controls limit the fishing capacity of the gear used or the amount of effort commercial fishers can apply to their fishing activities, indirectly controlling the amount of fish caught. The effectiveness of input controls needs to be regularly reviewed due to improvements in fishing technology. Input controls can include restrictions on the number of licences, the size and engine capacity of boats, the design and dimensions of trawl nets, and the locations and times which may be worked. Output controls, on the other hand, seek to directly control the amount of fish that can be taken by the fishery, and are generally applied in the form of an annual total allowable catch (TAC), which might be allocated among fishers according to some pre-determined formula. Output controls are well suited for single species, high value fisheries using single gear types (Goulstone, 1996), but can be more problematic to apply in multi-gear, mixed-species fisheries.

Table B1.7 Chronology of relevant fisheries management events in NSW.

Year	Management event
Mid 1800s	Commercial fishing commenced in NSW estuaries
1865	*Fisheries Act 1865* commenced in response to concerns of overfishing, declaring seasonal and area fishing closures
1881	*Fisheries Act 1881* commenced, allowing for the regulation of fishing gear, including controls over mesh sizes in nets, and the licensing of fishers and fishing boats
1895	Report of the *Royal Commission* into the marine and other fisheries of NSW
1919	Trawling for fish commenced in NSW ocean waters (steam trawlers)
1935	*Fisheries and Oyster Farms Act 1935* introduced
1947	Trawling for prawns commenced in NSW ocean waters
1980	Access to abalone fishery limited
1982	Area closures introduced to protect juvenile eastern king prawns
1983	s117 Endorsements issued to ocean prawn trawler (industry request)
1984	Freeze on the issue of new fishing boat licences introduced
1985	Boat replacement policy- restricts boat length/HP for ocean prawn trawlers
1986	Access to estuary and offshore prawn trawling limited
1987	Freeze on the issue of new commercial fishing licences introduced
1990	Signing of Offshore Constitutional Settlement with the Commonwealth and warnings issued by Government against new investment and/or new diversification in commercial fishing activities
1990	Net length restrictions introduced for offshore ocean prawn trawlers
1992	Introduction of Total Allowable Catch quotas in the Commonwealth SEF
1993	Access to the lobster fishery limited
1993	"Trip Limits" specified for NSW Fish Trawl Fishery for some SEF species
1994	Licensing Policy introduced, commencing the process of catch validation
1995	Commencement of the *Fisheries Management Act 1994* which provided for the establishment of ‘share management fisheries’ and ‘restricted fisheries’.
1995	Closure to fish trawling in waters north of Smoky Cape
1996	1994 Licensing Policy revised and re-issued
1997	*Marine Parks Act 1997* established the NSW Marine Parks Authority
1997	Restricted fisheries introduced for major marine commercial fisheries: ocean prawn trawl, ocean fish trawl, ocean trap & line, ocean hauling, estuary prawn trawl, estuary general (NB. the abalone and lobster fisheries were declared share management fisheries)
1997	Introduction of Bycatch Reduction Devices for ocean prawn trawl nets
2000	Amendment to the *Fisheries Management Act 1994* provides an alternate management framework called category 2 share management fisheries
2000	Further closures to protect juvenile king prawns in ocean waters
2001	Declaration of Recreational Fishing Areas in 30 NSW estuaries
2001	Implementation of Indigenous Fisheries Strategy
2004	Ocean trawl fishery moves to category 1 share management fishery framework

Trawling in ocean waters off NSW is currently managed using a diverse range of input controls. The following section sets out in broad terms the controls that apply to activities in the fishery.

Table B1.8 Comparison of the restricted fishery and share management fishery frameworks.

* exceptions apply in some fisheries where validated catch history is not required to hold the endorsement

	Restricted fishery	**Category 1 share management fishery**	**Category 2 share management fishery**
Right issued	Validated catch history which gives rise to an "entitlement"*	Shares	Shares
Term of shares	Annual	10 years automatic renewal	15 years discretionary renewal
Access	Endorsement	Endorsement	Endorsement
Transferability	Subject to transferability rules	Subject to management plan	Subject to management plan
Statutory compensation payable?	No	Yes, if shares are cancelled	Yes, if shares are cancelled
Statutory management plan required?	No	Yes, 5 year plan	Yes, 5 year plan
Appeal mechanism	Statutory review panel	Statutory review panel	Statutory review panel
Community contribution payable?	No	Yes	Small rental payment

i) Licences required in the fishery

A commercial fishing licence is required by an individual before he/she can take fish for sale or be in possession of commercial fishing gear in or adjacent to waters. The licence only authorises activities that are covered by the endorsements, issued in respect of each sector of the fishery and specified on the licence.

Generally speaking, commercial fishing licences are currently available to persons who held a licence immediately prior to the commencement of the *Fisheries Management Act 1994*, owners of recognised fishing operations (RFO), in the case of an offshore prawn trawler the skipper of the vessel, or the nominated fisher of an RFO (see section 6(b)(ix) of this chapter for further details on the nomination policy). An RFO is a fishing business with a minimum level of validated catch history or particular fishing entitlements. The RFO policy was introduced via the Licensing Policy issued by NSW Fisheries in June 1994.

The common objectives of the 1994 Licensing Policy and its replacement in 1996 were to:

- provide transitional arrangements which did not pre-empt future management whilst longer term management arrangements were being introduced
- provide a mechanism which allowed existing fishers with catch history to identify and subsequently dispose of their fishing business/es
- allow new entrants into the industry in a manner which ensured that active fishing effort only is being replaced
- provide a mechanism for the consolidation of smaller fishing businesses.

The RFO policy has been effective at restructuring and consolidating fishing businesses at the lower end of the income range and has been contributing to the objective of promoting a viable commercial fishing industry (Murphy, 1999).

ii) Limited entry

The ability to trawl for fish or prawns in ocean waters off NSW was historically available to all NSW licensed commercial fishers with a suitable vessel. Access to trawling for eastern king prawns outside 3 nautical miles was restricted in July 1985 to vessels with a demonstrated history of participation or financial commitment to the fishery. Restrictions on hull size, engine power and the amount of trawl net that could be towed by each vessel were also introduced at this time. On 1 March 1997, both the prawn trawl and fish trawl fisheries were declared as restricted fisheries under section 111 of the *Fisheries Management Act 1994*. Under the restricted fishery scheme, access to the inshore prawn trawl, deepwater prawn trawl, and fish trawl sectors of the fisheries became restricted for the first time. Fishers were required to hold an endorsement on their commercial fishing licence that authorised them to use the relevant fishing method in a defined sector of the trawl fisheries.

Entry to the Ocean Prawn and Fish Trawl Restricted Fisheries was dependent on the business having a demonstrated history of participation in the fishery, determined mainly on the basis of catch history of relevant trawl species during a criteria period. Ownership of nets and net registrations, and in some cases appropriately endorsed boat licences, were also important in distinguishing eligibility for classes of endorsements. An extensive statutory appeals process followed the initial allocation of endorsements based on these criteria.

Following changes to the *Fisheries Management Act 1994* in December 2000 the ocean prawn and fish trawl fisheries, along with most other major commercial fisheries, were selected to become category 2 share management fisheries.

More recently the ocean trawl fishery along with all other category 2 share management fisheries is moving towards becoming a category 1 share management fishery. Under this framework, access to the fishery would be limited to the holders of shares (subject to any minimum share holding requirements specified in the management plan). The fishery continues to operate in accord with the restricted fishery regulations until a share management plan for the fishery has been made by regulation.

iii) Fishing endorsements

In determining the number of ocean trawl fishers, it is important to understand the difference between endorsements and entitlements in the fisheries and how they relate to commercial fishing licences. In summary, entitlements in a fishery are associated with fishing businesses, and give the business the right to operate in the fishery. Endorsements are attached to a commercial fisher's licence, and allow fishers the right to use specific gear or to take nominated species. Further information on endorsements and entitlements is presented in other parts of this chapter including sections 6b(i) and 6b(ix).

Some fishing businesses are owned or held by more than one individual (as in the case of companies or partnerships) and, therefore, an entitlement associated with a business may provide for more than one fisher’s licence to be endorsed to use a certain method or to take certain species. In the ocean trawl fisheries, it is the capacity of the boat that influences the level of fishing effort and generally there is only one trawler associated with each fishing business with ocean trawl entitlements.

There are five types of endorsements in the ocean trawl fisheries. Table B1.9 outlines the numbers of fishing businesses holding each of the five classes of endorsement, as at February 2003.

Table B1.9 Endorsements available for trawling in NSW ocean waters, and the number of fishing businesses with each endorsement type as at February 2003.

Endorsement type	Number of fishing businesses
Ocean Prawn Trawl (Inshore)	267
Ocean Prawn Trawl (Offshore)	238
Ocean Prawn Trawl (Deepwater)	63
Ocean Fish Trawl (North)	62
Ocean Fish Trawl (South)	47

Note: Individual Fishing Businesses may hold multiple endorsements.

iv) Controls on fishing gear and boats

In addition to limiting the number of boats in the fishery, the fishing capacity of individual trawlers is restricted. Boats endorsed to operate in the offshore sector of the Ocean Prawn Trawl Fishery have been subject to controls on hull size and engine power since November 1985, and the amount of trawl net that may be used has been restricted since 1990. This resulted in an estimated 40% reduction in total net length available in the fishery.

Detailed restrictions relating to the dimensions and type of fishing gear are set out in the *Fisheries Management (General) Regulation 2002* and the Ocean Trawl Vessel Capacity Restrictions and Transferability Rules V1.1 (see Appendix B1.2). Despite the various input controls (e.g. restricted access and boat capacity restrictions) the fishing power of individual trawlers may have increased over the years due to improvements in technology, such as the introduction of colour echo sounders and satellite position fixing equipment. These aids can allow fishers to more efficiently target fish and prawn stocks. A summary of the controls currently in place follows:

Fishing boat licensing

In addition to each fisher having to be licensed, every fishing boat used for trawling in NSW ocean waters must also be licensed. There has been a limit on the total number of boat licences used in NSW commercial fishing since 1984. To prevent increases in size (and therefore fishing capacity) of vessels in the fishery, strict boat replacement policies apply, and conditions may also be applied to fishing boat licences. During the 1990s boats authorised to access the offshore sector of the Ocean Prawn Trawl Fishery were issued with P1, P2, P3 or P4 boat licence conditions, depending on the boat's level of historical participation in the Ocean Prawn Trawl Fishery. These conditions identify whether the boat may be upgraded, the waters in which the boat may operate, and whether the entitlement to operate in the offshore prawn trawl fishery is 'transferable' (see sections 6b(v) and 6b(viii)). In summary, these conditions had the following effect:

P1 – the boat may be upgraded and the offshore prawn trawl entitlement is 'transferable';

P2 – the boat cannot be upgraded, but the offshore prawn trawl entitlement is 'transferable';

P3 – the boat cannot be upgraded, and the offshore prawn trawl entitlement is not 'transferable';

P4 – the boat is restricted to operating in offshore waters north of Cape Byron, cannot be upgraded, and the offshore prawn trawl entitlement is 'transferable' subject to the parallel transfer of the Queensland fishing entitlement allocated to the boat.

Boats endorsed to access the offshore sector of the prawn trawl fishery are also subject to vessel capacity restrictions that limit increases in hull capacity, engine power and net length. The process is known as 'unitisation' because the allowable hull capacity, engine power and net length for each boat is expressed in terms of 'units'.

All other ocean trawlers (i.e. those not endorsed for offshore prawn trawling) are currently subject to boat length restrictions. These boats have recently been 'unitised' and will become subject to the same vessel capacity restrictions as the boats endorsed for offshore prawn trawling upon implementation of the management plan for this fishery. The boat capacity and net length restrictions are further explained below.

Hull size

In the offshore prawn trawl sector the hull capacity of a replacement boat must not exceed the hull capacity of the replaced boat. Hull capacity is defined in terms of 'hull units', which are calculated using the following formula;

Hull units = length x depth x beam x 0.6 / 2.83.

A maximum length of 20 m also applies. For consistency, the dimensions of a boat must be specified in a survey and are determined using the Uniform Shipping Laws Code method for measuring boats. Hull units cannot be amalgamated for the purpose of increasing hull capacity.

Boats used in other sectors of the ocean trawl fishery are subject to length restrictions. Boats may be replaced by another boat that is up to 10% or 1 m greater in length, whichever is lesser. The 10% tolerance continues to relate to the original boat length to avoid a progressive increase in boat length over time.

Engine controls

In the offshore prawn trawl sector a fisher must request approval from the Director of Fisheries before replacing the engine in a trawler. The power rating of a replacement engine, or the engine in a replacement boat, must not exceed the power rating of the engine that is replaced. A 10% tolerance applies in some instances. For consistency, the continuous brake kilowatt power rating published by the manufacturer is used when assessing applications for engine replacement (for a given engine, the number of engine units is equal to the manufacturer's published power rating in Kw). In other sectors of the ocean trawl fishery engine power restrictions do not currently apply.

Nets

Trawl nets do not need to be registered and a detailed description of the net types is provided in section 4a. To limit fishing effort on prawn stocks the headrope length of prawn trawl nets is restricted to 33 m, unless otherwise specified on the boat's licence. Limiting the headrope length restricts the size of the net that can be used, limiting the area of sea floor that can be swept during each trawl shot. Boats endorsed for the offshore prawn trawl sector have the allowable headrope length recorded on the boat's licence. Headrope lengths in this sector of the fishery range from 33 m to a maximum of 60 m. Following the transfer or amalgamation of a boat licence, or upon replacing a boat or its engine the maximum allowable headrope length for the boat is reduced to 55 m. The headrope length of fish trawl nets is not restricted.

Net units in the offshore prawn trawl sector are based on the 'Total Units' of the boat, using the following method:

Total Units = Engine Units + Hull Units

For each ‘total unit’ up to 100, allocate 0.275 net units,

then add 0.183 net units for each total unit between 101 and 200,

and 0.092 net units for each total unit over 200.

1 net unit equates to 1 m of headrope length allowed for the trawl net.

Sweeps are used to herd fish into the path of a trawl net. Sweeps (or bridles) on prawn trawl nets are restricted to a maximum of 5 m, or the distance between the trawl gallows and the stern of the boat, whichever is the greater. The length of sweeps on fish trawl and Danish seine nets is not regulated.

v) Restructure programs

A study completed during November 1998 (McIlgorm, 1998) concluded that fishing effort in the Ocean Prawn Trawl Fishery could increase significantly if the businesses inactive in the fishery and the businesses operating at low levels of effort were to increase their level of participation. The study noted that poor economic returns and alternative fishing activities kept many businesses from increasing effort in the Ocean Prawn Trawl Fishery. There are also significant levels of latent fishing capacity in the ocean fish trawl sector of the fishery.

Programs are currently in place to remove some of the latent fishing capacity from the fishery. They include:

- Offshore prawn trawl P3 endorsement transfer restrictions – 12 of the 238 fishing businesses endorsed for offshore prawn trawling are allocated a P3 offshore prawn trawling entitlement. The offshore prawn trawl endorsements for these 16 businesses are ‘not-transferable’ and will be removed from the industry upon transfer. All other offshore prawn trawl endorsements are fully transferable (also see section 6 b(viii)).
- Ocean trawl endorsement transfer criteria – Inshore prawn trawl, deepwater prawn trawl, and northern and southern fish trawl endorsements are subject to ‘transfer criteria’. These endorsements are removed from the industry upon transfer of the fishing business if the business does not have a sufficient level of historic participation in the commercial fishing industry (also see section 6 b(viii)).
- Offshore prawn trawl ‘unit’ amalgamation policy – in the offshore sector of the Ocean Prawn Trawl Fishery boat licences with a P1 authorisation may be amalgamated to increase engine power and net headrope length. Restructuring occurs because upon amalgamation one of the boat licences is removed from the industry. In some instances, particularly if an amalgamated licence has not been active in the industry, latent effort is reactivated as a result of an amalgamation. Upon amalgamation of two or more boat licences, 50% of the ‘engine units’ allocated to the secondary licence(s) are forfeited. The remaining 50% of the engine units are added to the boat’s licence and the net units for the boat are re-calculated and increased, up to a maximum of 55 net units.

vi) National licence splitting policy

The Commonwealth and State Governments have a long-standing nationally agreed policy in place on "licence splitting". The policy seeks to prevent entitlements held by one person or entity, and issued by more than one jurisdiction, from being split and transferred separately. In NSW the transfer of a fishing business is not approved unless all entitlements issued to the business by other jurisdictions are also transferred to the same person or surrendered, unless the separate transfers have been approved by all agencies involved.

Where fishing effort has been historically ‘shared’ across a number of entitlements held by a person, the National licence splitting policy seeks to prevent any increase in effort in each of the respective fisheries that might occur following the splitting of the entitlements.

vii) Transfer of licensed fishing boats

Boats used in the ocean trawl fishery are classed as “boat history” vessels, which cannot be transferred separately to the fishing business. Any transfer of a fishing boat licence must first be approved by the Director-General of Fisheries.

viii) Transfer of fishing business entitlements

Commercial fishing licences and endorsements to participate in a fishery are not freely transferable. Currently, commercial fishing licences and endorsements only become available to a new entrant if they acquire a fishing business with the required level of validated catch history or particular fishing entitlements.

In addition to acquiring a RFO in order to be issued a fisher licence, Table B1.10 outlines the criteria that apply to transfers of fishing business entitlements relevant to trawling in ocean waters off NSW. A restrictive transfer policy is necessary to prevent endorsements that were granted under a low entry criteria from being issued to new owners of fishing businesses and utilised at much higher levels of fishing effort.

Under the current Licensing Policy, fishing businesses must be sold as an entire package (i.e. the catch history, boat history vessels and/or endorsements associated with boats cannot be split). Proposals regarded as licence splitting, or contrary to the intention of the Licensing Policy are not approved.

ix) Nomination policy

Part of the introduction of the restricted fishery regime was the creation of rules to allow the endorsements of a fishing business to be nominated to a person. This was necessary due to fishing businesses being held in company or partnership names, and because fishing licences can only be issued to natural persons. Only one person can be nominated to hold endorsements in respect of a fishing business.

Table B1.10 Summary of transfer criteria for entitlements in the ocean trawl fisheries.

Entitlement	Transfer criteria
Inshore prawn trawl Deepwater prawn trawl Northern fish trawl Southern fish trawl	The fishing business must have a minimum of $30 000 worth of catch in any two years between 1986 and 1990 and in one year between 1991 and 1993.
Offshore prawn trawl	
P1	Transferable
P2	Transferable
P3	Not transferable
P4	Transferable

x) Zoning

The five endorsements relevant to trawling in NSW ocean waters establish the methods that may be used, the area in which fishing may be conducted under that endorsement, and in some cases the species that may be taken. The following summarises these conditions for each endorsement type:

1. Ocean Prawn Trawl (Inshore) – waters between the coastal baseline and 3 nautical miles to sea, from the Queensland border in the north to the Victorian border in the south, including the waters of Jervis Bay and Coffs Harbour.

2. Ocean Prawn Trawl (Offshore) – waters between 3 nautical miles and the 4000m depth contour (approximately 80 nautical miles to sea), from the Queensland border in the north to a line drawn due east from Barrenjoey Point (Sydney) in the south. Offshore prawn trawlers with a P4 boat licence condition are restricted to waters north of a line drawn due east of Cape Byron, Byron Bay.

3. Ocean Prawn Trawl (Deepwater) - waters between 3 nautical miles and the 4000m depth contour (approximately 80 nautical miles to sea) from the Queensland border in the north to a line drawn due east from Barrenjoey Point (Sydney) in the south. For taking deepwater prawns of the families Solenoceridae and Aristaeidae.

4. Ocean Fish Trawl (North) – waters between the coastal baseline and the 4000m depth contour (approximately 80 nautical miles to sea), from a line drawn due east of Smoky Cape (South West Rocks) in the north to a line drawn due east of Barrenjoey Point (Sydney) in the south.

5. Ocean Fish Trawl (South) – waters between the coastal baseline and 3 nautical miles to sea, from a line drawn due east of Barrenjoey Point (Sydney) in the north to the Victorian border in the south.

xi) Time and area closures

The *Fisheries Management Act 1994* provides for the use of fishing closures in the Ocean Fish and Prawn Trawl Fisheries to, among other things:

- protect and conserve areas of key habitat
- manage the amount of fishing effort in an area
- to manage conflicts between stakeholders over the use of the resource and to ensure it is equitably shared
- minimise bycatch and the impacts of the fishery on threatened and protected species.

Fishing closures are required to be published in the NSW Government Gazette, however, if the Minister for Fisheries considers that a fishing closure is required urgently, the Minister may introduce the closure and advise the public through media outlets and by displaying prominent signs in areas adjacent to the waters affected. In the case of an urgent closure, the Minister is to publish the closure in the Government Gazette as soon as practicable. Fishing closures can be established on a seasonal, time, area, operator or gear specific basis. Fishing closures in place in NSW which limit fishing in the Ocean Prawn Trawl Fishery are listed in Table B1.11.

Table B1.11 Ocean Prawn Trawl Fishery Closures as at March 2004.

Name of closure	Location of closure	Period	Purpose
Tweed Heads	Specified ocean waters off Tweed River	Sunset 30 September to Sunrise 1 March	Protect juvenile prawns
Brunswick Heads	Specified ocean waters off Brunswick River	Sunset 30 September to Sunrise 1 March	Protect juvenile prawns
Ballina	Specified ocean waters off Richmond River	12 months each year	Protect juvenile prawns and fish and habitat
Evans Head	Specified ocean waters off Evans River	12 months each year	Protect juvenile prawns and fish and habitat
Evans Head	Specified ocean waters off and to the south of Evans Head	12 months each year	Protect juvenile prawns and fish and habitat
Angourie Point	Specified ocean waters off Clarence River	12 months each year (until 1 March 2003)	Protect juvenile prawns and fish and habitat
South West Rocks	Specified ocean waters off Macleay River	Sunset 1 November to sunrise 1 March	Protect juvenile prawns and snapper
Forster	Specified ocean waters between Seal Rocks and Forster	Sunset 30 September to Sunrise 1 March	Protect juvenile prawns
Crowdy Head	Specified ocean waters off Crowdy Head	12 months each year	Protect juvenile prawns
Port Stephens	Specified ocean waters between Port Stephens and Seal Rocks	Sunset 30 September to Sunrise 1 March	Protect juvenile prawns
Newcastle	Specified ocean waters off Newcastle	Sunset 30 September to Sunrise 1 March	Protect juvenile prawns
Port Kembla	Specified ocean waters between Red Pt and Windang Island	Five years from 13th August 1999	Protect juvenile fish

The only closures currently specified for fish trawling in NSW ocean waters are the closure to fish trawling in all waters north of Smoky Cape (approx. 31°S latitude) and the 'Port Kembla' closure listed in Table B1.11. All forms of trawling are excluded from areas declared as 'sanctuary' and 'habitat protection' zones in Marine Parks, and grey nurse shark critical habitat protection areas.

xii) Permits

Section 37 of the *Fisheries Management Act 1994* allows for permits to be issued for research or other authorised purposes. These permits provide a legal framework for activities that fall outside normal operating rules set out in the Act or its Regulation. Each permit sets out a number of conditions, which vary depending on the purpose of the permit. These conditions ensure that permits are used only for the purpose intended by his/her issuing and are often used to limit the extent of the permitted activity. The permits that may be issued in relation to trawling in ocean waters are outlined in Table B1.12.

Permits issued under section 37 of the *Fisheries Management Act 1994* are only valid insofar as they do not conflict with approved determinations of native title made under the Commonwealth *Native Title Act 1993*. Permits are valid for the period specified on the permit, and may be suspended or cancelled at any time by the Minister for Fisheries. Permits are not transferable.

In January 2003 the *Fisheries Management (General) Regulation 2002* was amended to make it an offence to breach a condition of a permit issued under section 37 of the *FM Act 1994*. A maximum penalty of $11,000 was established, with a penalty notice of $200.

Table B1.12 Description of permits issued to operators in the ocean trawl fisheries.

Permit type	Description
Research	Permits are issued to research scientists (including NSW Fisheries staff, universities and other research organisations) and commercial fishers assisting in undertaking research programs. The permits generally authorise the retention of prohibited size fish, fish in excess of the possession or bag limits or use of gear not prescribed in the Regulation
Development of new fishing gear	This permit provides a legal framework for the possible development of more selective or passive fishing methods. Permits are often required to trial types of fishing gear with dimensions or configurations not prescribed in the Regulation. Permits may be issued to facilitate industry in developing alternate fishing practices in line with the goals of the Act and existing policy

xiii) Code of conduct

Fish trawl operators who are also endorsed in the Commonwealth managed South East Trawl Fishery abide by an "Industry Code of Conduct for Responsible Fishing in the South East Trawl Fishery". Copies of this code of conduct are available from the South East Trawl Fishing Industry Association (email: trawline@tassie.net.au). No formal code of conduct currently exists for the other sectors of the ocean trawl fishery in NSW.

xiv) Size limits

Size limits apply to a number of important species taken by trawling in NSW waters. Size limits are designed to allow a sufficient proportion of the population to survive to maturity and thereby provide sufficient recruitment to sustain the population in the long term.

The size limits for fish are prescribed in the Regulation and apply to both commercial and recreational fishers. Size limits that apply to species taken by trawling in NSW ocean waters are listed in Table B1.13.

Table B1.13 Minimum legal sizes of species that may be taken by trawling in ocean waters.

Species	Minimum Legal Length (cm)
Bream, Black and Yellowfin	25
Flathead, Dusky	36
Flathead, Sand and Tiger	33
Kingfish, Yellowtail	60
Luderick	25
Morwong. Jackass and Rubberlip	28
Morwong, Red	25
Mullet, Sea	30
Mulloway	45
Shark, School	91
Snapper	30
Tailor	30
Tarwhine	20
Teraglin	38
Whiting, Sand	27

xv) Threatened and/or protected fish

One of the ways that the FM Act (Part 7A) aims to conserve biological diversity is by listing threatened species, populations and ecological communities and their habitats. Table B1.14 lists those species, populations and communities, some species of which are also referred to as protected species under the FM Act. Protected species generally encompass most of those listed as threatened, but is designed to protect fish from all forms of fishing (section 19) or from commercial fishing (section 20). Protected species that are not also threatened species are listed in Table B1.15.

A range of threatened species, other than fish, are protected by other legislation including the NSW *Threatened Species Conservation Act 1995*, the NSW *National Parks and Wildlife Act 1974*, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Those other animals, and the fish from Tables B1.14 and B1.15 that could be encountered by the fishery, will be discussed in detail in the risk assessment in section B2.

Table B1.14. Threatened species, populations and ecological communities. An * denotes species that could be encountered by the ocean trawl fishery; and P19 and P20 denotes species protected under sections 19 or 20 of the FM Act, respectively.

COMMON NAME	SCIENTIFIC NAME
Endangered species	
Eastern freshwater cod P19	*Maccullochella ikei*
Green sawfish*	*Pristis zijsron*
Grey nurse shark * P19	*Carcharius taurus*
Murray hardyhead	*Craterocephalus fluviatilis*
Oxleyan pygmy perch	*Nannoperca oxleyana*
River snail	*Notopala sublineata*
Trout cod P19	*Maccullochella macquariensis*
Endangered populations	
Western population of olive perchlet	*Ambassis agassizii*
Western population of purple spotted gudgeon	*Mogurnda adspersa*
Endangered ecological communities	
Aquatic ecological community in the natural drainage system of the lower Murray River catchment	
Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River	
Species presumed extinct	
Bennetts seaweed	*Vanvoorstia bennettiana*
Vulnerable species	
Adams emerald dragonfly	*Archaeophya adamsi*
Black rock cod * P19	*Epinephelus daemelii*
Buchanans fairy shrimp	*Branchinella buchananensis*
Great white shark * P19	*Carcharodon carcharias*
Macquarie perch P19	*Macquaria australasica*
Silver perch P20	*Bidyanus bidyanus*
Southern pygmy perch	*Nannoperca australis*

Table B1.15. Protected species of fish (other than those that are also threatened species). *denotes species that could be encountered by the fishery.

PROTECTED FROM FISHING (section 19)	
Common name	**Scientific name**
Australian grayling	*Prototroctes maraena*
Ballina angelfish *	*Chaetodontoplus ballinae*
Eastern blue devil fish *	*Paraplesiops bleekeri*
Elegant wrasse *	*Anampses eleganus*
Estuary cod *	*Epinephelus coioides*
Giant Queensland groper *	*Epinephelus lanceolatus*
Herbst nurse shark *	*Odontaspis ferox*
Weedy sea dragon *	*Phyllopteryx taeniolatus*
PROTECTED FROM COMMERCIAL FISHING (section 20)	
Atlantic salmon	*Salmo salar*
Australian bass *	*Macquaria novemaculeata*
Black marlin *	*Makaira indica*
Blue groper *	*Achoerodus viridis*
Blue marlin *	*Makaira nigricans*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Eel-tailed catfish	*Tandanus tandanus*
Estuary perch *	*Macquaria colonorum*
Freshwater crayfish	*Euastacus & Cherax* spp. (except *C. destructor*)
Rainbow trout	*Oncorhynchus mykiss*
Striped marlin *	*Tetrapturus audax*

xvi) Catch limits or quotas

Trip limits apply to some species that are managed by way of Total Allowable Catch Quotas in the Commonwealth South East Fishery. These trip limits were introduced in the mid 1990s to discourage the mis-reporting of SEF catches in NSW waters (and thereby avoiding having the catches decremented against the vessel's available quota for that species). The trip limits currently applying to species taken by trawl fishers in NSW ocean waters are listed in Table B1.16.

Table B1.16 Trip limits applying to species taken in the ocean trawl fisheries in NSW.

Species	Period	Method	Waters	Trip limit
Gemfish (*Rexea solandri*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters other than those waters listed below	No more than 50 kg whole weight, or where the vessel is not a commercial fishing vessel 10 whole fish, in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters south of Barrenjoey Headland, and west of a line drawn 3 nautical miles from the coastal baseline	0 kg
Orange roughy (*Hoplostethus atlanticus*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters including those waters subject to an OCS agreement between the State and the Commonwealth	0 kg
Pink ling (*Genypterus blacodes*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters west of a line drawn 3 nautical miles east of the coastal baseline	0 kg
Mirror dory (*Zenopsis nebulosis*)				
Blue-eye trevalla (*Hyperoglyphe antarctica*)				
Blue grenadier (*Macruronus novaezelandiae*)				
Tiger flathead (*Neoplatycephalus richardsoni*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters south of Barrenjoey Headland including waters 3 nautical miles east of the coastal baselines	No more than 200 kg whole weight of all flathead species combined in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
Blue warehou (*Seriolella brama*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 100 kg whole weight in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
Spotted warehou (*Seriolella punctata*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 50 kg whole weight in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)

Table B1.16 (cont)

Species	Period	Method	Waters	Trip limit
Jackass morwong (*Nemadactylus macropterus*)	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters north of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 50 kg whole weight in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters south of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 350 kg whole weight in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
Ocean perch (*Helicolenus percoides*)	From 1 January to 31 March of each year, all dates inclusive	By all methods	All NSW ocean waters north of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 500 kg whole weight in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 April to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters north of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 1000 kg whole weight of each fish species in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 January to 31 December of each year, all dates inclusive	By all methods	All NSW ocean waters south of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the	No more than 300 kg whole weight of each fish species in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer
Redfish (*Centroberyx affinis*)	From 1 January to 30 June and 1 November to 31 December of each year, all dates inclusive	Otter trawl net (fish)	All NSW ocean waters north of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 250 kg whole weight of each fish species in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 July to 31 October each year, all dates inclusive	Otter trawl net (fish)	All NSW ocean waters north of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 1000 kg whole weight of each fish species in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)
	From 1 January to 31 December of each year, all dates inclusive	Otter trawl net (fish)	All NSW ocean waters south of Barrenjoey Headland including those waters subject to an OCS agreement between the State and the Commonwealth	No more than 100 kg whole weight of each fish species in possession on board the fishing vessel once each day or from the time of departure to the time of return to port (when longer than a day)

xvii) Seafood safety programs

Food safety programs that relate to the ocean trawl fisheries are administered by SafeFood Production NSW under the *Food Act 1989*. Food safety programs for all commercial fisheries are currently being prepared by SafeFood Production NSW.

xviii) Provisions for unlicensed crew

Unlicensed crew may be employed to work on board ocean trawlers. To be eligible to employ crew the boat owner must apply and pay an application fee for a block licence. The block licence applies for a period of 12 months and may be attached to either the skipper's fishing licence or the boat's licence. Alternatively a person may apply and pay an application fee to become a registered crew member. A registered crew member may work on a vessel or with a skipper that does not have a block licence.

xix) Special arrangements for skippers

The introduction of the restricted fishery required the creation of rules to allow skippers to continue operating in the industry as employees. To acquire this type of skipper endorsement the person must have skippered another person's boat in the fishery immediately before it became a restricted fishery (i.e. during 1996).

Because only one person may be nominated to hold the endorsements in respect of a fishing business, new rules were introduced so that part owners of a fishing business could continue to work in the industry. To acquire this type of skipper endorsement the person must have owned a business in partnership and held an unrestricted commercial fishing licence in 1996.

There is a third provision that allows for 'conditional' skipper endorsements to be issued in respect of the offshore sector of the Ocean Prawn Trawl Fishery. To acquire conditional skipper endorsements the person must be employed to skipper an offshore prawn trawler (P1, P2 and P4 only) and the owner must agree to surrender any entitlements to the estuary general and ocean haul fisheries while the skipper is employed.

xx) Training licences

Training licences are not relevant in the ocean trawl fishery. To gain experience in the operation of an ocean trawler a person may work as crew on a vessel under the block licence or registered crew provisions outlined above. The operation of an ocean trawler requires significant formal training which must be undertaken through approved courses, such as those offered at the Australian Maritime College.

c) Administration

i) Renewal of licences and permits

At present commercial fishing licences and fishing boat licences must be renewed annually. Fishers are sent renewal application forms approximately one month before the expiry date on the licence. If a commercial fishing licence is not renewed within 60 days of the expiry date on the licence, the renewal application is generally taken to be an application for a new licence. Additional fees apply to late renewal applications (see below).

Abeyance period for fishing boat licences

Fishing boat licences can be held in abeyance for a period of up to two years from the date of expiry of the licence. Owners may also provide written advice that a boat licence is to be placed in abeyance. Fishing boat licence fees and the ocean trawl unit levy are not payable during the period of abeyance, but the full amount due is payable if the licence is reinstated within the two years specified.

ii) Fees

A number of fees are payable in the ocean prawn and fish trawl fisheries. An outline of the cost recovery policy and a summary of the fees follows. (Note: fees change periodically in response to the CPI and other factors.)

Cost recovery policy

NSW Fisheries recoups costs that are attributable to industry through a cost recovery policy. The cost recovery policy applies to existing services traditionally provided by NSW Fisheries in administering and regulating commercial fishing.

In November 2000, the Government announced a new cost recovery policy for category 2 share management fisheries. By November 2005 the Government will develop and implement a cost recovery framework. The framework will be subject to extensive industry consultation. During this period, the total amount of money collected by NSW Fisheries for its existing management services will not increase without the support of the relevant management advisory committee. After November 2005, recovery of the costs that have been identified as attributable to the industry will be progressively introduced over a further three-year period. A cost recovery framework is currently being developed that will apply to new category 1 share management fisheries.

Commercial fishing licences

The following fees are payable on application for issue or renewal of a licence:

New licence application	
Fee	$443
Contribution to management costs	$221
FRDC research levy	$122
Unlicensed crew application	
Fee per crew member	$56
Licence renewal received within 30 days of expiry	
Fee	$221
Contribution to management costs	$221
FRDC research levy	$122
Unlicensed crew (class C and D only)	$56
Licence renewal received more than 30 days after expiry	
Fee	$332
Contribution to management costs	$221
FRDC research levy	$122

Fishing boat licences

The following fees are payable on application for renewal of a fishing boat licence:

Renewal application lodged within 30 days after licence expiry:

Boats not greater than 3 metres in length...................$44

Boats in excess of 3 metres in length according to the scale hereunder:

Boats over 3 metres but not over 4 metres.................$67

Boats over 4 metres but not over 5 metres.................$90

Boats over 5 metres but not over 6 metres...............$113

Boats over 6 metres but not over 7 metres...............$136

Boats over 7 metres but not over 8 metres..............$159

Boats over 8 metres but not over 9 metres..............$182

etc… for each additional metre, or part thereof, add an additional $23

Renewal application received over 30 days after licence expiry:

Boats not greater than 3 metres in length $155

Boats in excess of 3 metres in length according to the scale hereunder:

Boats over 3 metres but not over 4 metres..............$178

Boats over 4 metres but not over 5 metres..............$201

Boats over 5 metres but not over 6 metres..............$224

Boats over 6 metres but not over 7 metres..............$247

Boats over 7 metres but not over 8 metres..............$270

Boats over 8 metres but not over 9 metres..............$298

etc… for each additional metre or part thereof, add an additional $23

The fee to replace an existing licensed boat with a new boat is approximately $111, plus the cost of the new boat licence fee, which depends on the length of the boat.

Net registration

Trawl nets used in NSW ocean waters do not currently require registration.

Share management fishery rental charge

The *Fisheries Management Act 1994* provides that a rental charge of $107 applies to shareholders in a category 2 share management fishery (irrespective of the number or type of shares held). This charge has applied from the date of commencement of category 2 share management fisheries on 23 March 2001, and is adjusted annually according to the Consumer Price Index. This rental charge continues for new category 1 share management fisheries.

Environmental impact assessment charges

Arrangements have been made under Part 5 of the *Environmental Planning and Assessment Act 1979* for recovery of part of the costs associated with the preparation of the Environmental Impact Statement (EIS). Fishers have the option of paying these charges and the share management fishery rental charge in one or in four instalments over the course of each year.

Research levy

An annual fee of $122 is collected upon commercial fishing licence renewal and paid directly to the Fisheries Research and Development Corporation (FRDC) to support funding of fisheries related research programs around Australia. Commercial MACs have the opportunity to comment on priorities for research funded by FRDC. The FRDC currently supports three research projects relating to the ocean trawl fishery in NSW.

Endorsement application fees

There are no endorsement application fees for commercial fishers in the Ocean Prawn Trawl and Ocean Fish Trawl Fisheries.

Ocean trawl unit levy

A levy applies to all ocean trawlers to cover the costs associated with implementing and administering the ‘unit’ scheme (i.e. vessel capacity restrictions). The unit levy for each vessel is calculated by multiplying the 'total units' for the vessel by $1.61. The total units are calculated by adding the engine and hull units of the vessel (see Section 6b(iv)).

Other transaction fees

Several other fees payable in the fishery to cover the costs of individual licensing transactions, however these only apply to the persons utilising these services. An example of this type of fee is the $268 fee payable for the transfer of a fishing boat licence.

iii) Appeals mechanisms

Fishers may lodge an appeal to the Administrative Decisions Tribunal (ADT) against a decision to refuse to issue or renew, suspend, cancel or place conditions on a commercial fishing licence (or an endorsement on that licence) or a fishing boat licence.

The main role of the ADT is to review administrative decisions of NSW government agencies. To lodge an appeal with the ADT, a request must first be made to NSW Fisheries for an internal review of the decision, then a written application should be lodged with the ADT no more than 28 days after the internal review was finalised.

The ADT can make various orders concerning an appeal application including:

- upholding the original decision
- reversing the decision completely or in part
- substituting a new decision for the original decision
- ordering the agency to reconsider the decision in light of the ruling.

For further information, refer to the *Administrative Decisions Tribunal Act 1997* or the following website: http://www.lawlink.nsw.gov.au

d) Research

Much of the research into the ocean trawl fisheries in NSW has historically been undertaken in collaboration with the agencies responsible for management of trawling in adjoining jurisdictions (Queensland DPI in the case of the Ocean Prawn Trawl Fishery, and the Australian Fisheries Management Authority in the case of the Ocean Fish Trawl Fishery and the deepwater fishery for royal red prawns). This situation acknowledges the significant overlap of the resources exploited across the jurisdictions (i.e. the 'shared stocks').

Commercial trawling for fish off NSW actually commenced on the basis of the results from research trawling in the early 1900s. However, only minimal research was conducted on the developing fishery, and it was not until the tiger flathead stock was severely overfished during the late 1940s that significant research efforts were made to determine the cause of the overfishing and suggest remedial action (Fairbridge, 1952). Even then, the research was confined almost entirely to the study of tiger flathead, just one species out of the many that were important in trawl landings. Routine market monitoring of the size composition of some of the main fish species commenced about this time, but few resources were allocated to analysis of the results, or towards conducting complementary biological studies on the other important trawl species. Results from the analysis of information collected during this period were not published until the late 1970s (Blackburn 1978 and 1979).

Research into fish trawl species remained at a relatively low level, until exploratory fishing on continental slope grounds by the Fisheries Research Vessel *Kapala* prompted the development of the 'deepwater' fishery in the 1970s. A joint research program studying the biology and stock assessment of the important trawl species commenced in the mid 1970s, with funding from the NSW and Commonwealth governments (Rowling, 1979). This ‘temporary’ research program persisted until the 1990s, and provided the source of much of the biological and fishery knowledge that is relied on for current management of the Ocean Fish Trawl Fishery off NSW. Significant assessments for eastern gemfish and redfish resulted from this research, while useful biological and fishery data were collected and analysed for jackass morwong, tiger flathead, ocean perch, mirror dory, school whiting and royal red prawns. A repeat after 20 years of the original mid-slope survey conducted by FRV *Kapala* in the 1970s (Andrew *et al.*, 1997) documented significant changes in the abundance and size composition of trawl fish resources. Recent research on the biology and fishery for silver trevally (Rowling and Raines, 2000) concluded that the silver trevally stock could be considered to be 'growth overfished'. In a collaborative research project with AFMA and other south-eastern Australian research agencies, the selectivity of fish trawl gear was described for a number of important species, and recommendations made to reduce the level of discarding by SEF trawlers operating off southern NSW (Knuckey *et al*, in prep.).

Research into ocean prawn resources commenced in the 1950s, when NSW State Fisheries scientist Dr. A Racek reported the results of survey work and biological investigations into the main prawn species (Racek, 1959). Studies during the 1960s and 1970s identified the significant influence of rainfall and river discharge on prawn catch rates (Ruello, 1971 and 1973; Glaister 1978), and first suggested the extensive northward migration of eastern king prawns after they entered ocean waters from their estuarine nursery habitats (Ruello, 1975). The FRV *Kapala* was instrumental in identifying fishing grounds for royal red prawns and associated species, and this fishery developed rapidly in the late 1970s and early 1980s (Graham and Gorman, 1985). The majority of research during the late 1980s and early 1990s was conducted on the valuable eastern king prawn resource. The characteristics and fishing power of the prawn trawl fleet were quantified (Glaister and McDonall, 1983). When combined with the results of studies on the biology and migration patterns of eastern king prawns (Glaister *et al.*, 1987; Montgomery, 1990; Montgomery *et al.*, 1995), this work culminated in the development of detailed yield models for the ocean king prawn fishery (Glaister *et al.*, 1990; Gordon *et al.*, 1995).

In the early 1990s, comprehensive observer studies were conducted aboard both prawn and fish trawlers to document incidental and discarded catches by trawlers operating off NSW (Kennelly, 1993; Liggins, 1996). Observations aboard fish trawlers which also work in the Commonwealth SEF have continued to the present day (see Knuckey *et al.*, 2001 for a recent report), however only sporadic observations have been made aboard fish and prawn trawlers working under NSW jurisdiction (e.g. see the results of observer work undertaken in the oceanic closure off the Richmond River reported by Miller, 2000).

A number of research projects relevant to the ocean trawl fishery are currently underway, including studies on the growth and mortality of school prawns, the selectivity of prawn and fish trawl nets, and the effectiveness of Marine Parks in conserving biodiversity. Details of these research projects can be found at: www.fisheries.nsw.gov.au/sci/projects.

While considerable research has been undertaken into both the fish trawl and prawn trawl components of the fishery, current levels of knowledge are not sufficient to ensure the sustainable management of the ocean trawl fishery. Few of the primary and key secondary species have an adequate assessment of their stock status, and the collection of monitoring data and development of stock assessments is a high priority for most of these species.

e) Landed catch data

Records of commercial catch have been collected in NSW for over 50 years. The forms used by fishers to record catches have changed several times over the years (Pease and Grinberg, 1995), and most recently in July 1997. The information collected on commercial landings assists in the ongoing monitoring and assessment of the status of fish stocks (see Kennelly and McVea, 2001).

Fishers in the ocean trawl fisheries are required to submit a Statutory Catch Return on a monthly basis detailing their catch and fishing effort. The information includes total landed catch for each species, the effort expended (for each method) to take the catch (i.e. days fished), and the area/s fished. The current forms also request an estimate of the total trawl time and the total number of shots (trawls) made in each month, split by method and area or port of landing. This information is entered onto a database by NSW Fisheries, and can be analysed for fishing activity, catch levels and effort levels.

The accuracy of data supplied by fishers on monthly catch returns cannot be directly verified, however a number of quality control procedures are in place to maximise data quality and reliability of the information provided, including random checking of reported catches against records from Fishermen's Co-operatives or Fish Receivers. However, information on the location of catches is supplied at a very broad scale - grouped into 1° latitude bands, each of which covers approximately 60 nautical miles of coastline.

f) Compliance

Fisheries Field Services aim to provide protection and ensure long term sustainability in the ocean trawl fishery through an effective and cost efficient advisory and enforcement program, consistent with the management arrangements for the fishery. Fisheries Field Services strategies include:

- maximising voluntary compliance
- providing effective deterrence
- providing effective support services.

The compliance objectives are:

- to advise and educate the commercial and marketing sectors on the management rules for the fishery and promote and encourage sustainable fishing practices
- to maximise compliance with management rules by all sectors including the detection of black-marketing
- to apprehend and prosecute fishers involved in illegal fishing activities.

Fisheries officers have broad powers, which include the authority to board and search vessels and enter and search premises. Officers also have powers to seize various items connected with fisheries offences including fishing equipment, boats and motor vehicles. NSW Fisheries has approximately 90 fisheries officers responsible for coordinating and implementing compliance strategies in NSW. Approximately 65 of these fisheries officers are located in coastal areas of NSW, including ports from which ocean trawl vessels operate. The general duties of these fisheries officers include conducting patrols, inspecting commercial fishers and fishing gear, and recording rates of compliance. Some officers also perform sea-going compliance aboard patrol vessels based in Coffs Harbour, Sydney and Eden.

NSW Fisheries manages compliance service delivery for each significant fishing or target program through a district compliance planning process administered within the Fisheries Services Division. Each district fisheries office is responsible for compliance service delivery within a geographical area, and develops a district plan based on the particular priorities associated with that area. The district plan for each location sets out the percentage of available time officers from that office will spend on particular compliance duties, which in coastal areas includes compliance in the Ocean Prawn Trawl and Fish Trawl fisheries. Other target service areas, including the recreational fishery, related commercial fisheries and the patrolling of fishing closures whilst carrying out routine duties, provide indirect compliance benefits for the trawl fishery.

The *Fisheries Management Act 1994* and the *Fisheries Management (General) Regulation 2002* provide a number of offences relating to fishing activities that encompass the methods used, and species taken by trawling in ocean waters. These offences and the maximum penalties are summarised in Table B1.17. The table is not a comprehensive list of offences under the Act or its regulations, but highlights the offences that are most relevant in the ocean trawl fisheries.

The Regulation lists a number of forfeiture offences for the seizure of boats and motor vehicles. A court may order the forfeiture of these items if it is satisfied that they were used to commit a forfeiture offence.

Forfeiture offences can include the following examples:

- Offences under the Fisheries Management Act 1994:
  - Section 8 Waters closed to fishing
  - Section 24 Lawful use of nets or traps
  - Section 25 Possession of illegal fishing gear
  - Section 247 Obstructing / impersonating a fisheries officer
- Offences under the Fisheries Management (General) Regulation 2002:
  - Clause 111 Use of explosive substances
  - Clause 113 Use of electrical devices
- An offence against the Fisheries Management (Aquatic Reserves) Regulations 1995

Table B1.17 Current offences under the *Fisheries Management Act 1994* relevant to the ocean trawl fishery.

Please note that these offences and penalties are the current offences and penalties under the FM Act and its Regulation (as at March 2003), and apply to both commercial and recreational fishers

Section	Short title	Maximum penalty
14(1)	Take fish contrary to fishing closure	$22,000 and/or 6 months imprisonment
14(2)	Possess fish taken contrary to fishing closure	$11,000 and/or 3 months imprisonment
16(1)	Possess prohibited size fish	$11,000 and/or 3 months imprisonment
16(2)	Sell prohibited size fish	$11,000 and/or 3 months imprisonment
19(2)	Take protected fish	$11,000 and/or 3 months imprisonment
19(3)	Possess protected fish	$11,000 and/or 3 months imprisonment
20(2)	Take commercially protected fish for sale	$11,000 and/or 3 months imprisonment
20(3)	Sell commercially protected fish	$11,000 and/or 3 months imprisonment
24(1)	Unlawful use of net or trap	$22,000 and/or 6 months imprisonment
25(1)	Possess fishing gear in / on / adjacent to closed waters when use of that gear or taking of fish is prohibited	$22,000 and/or 6 months imprisonment
35(1)	Possess fish illegally taken	$11,000 and/or 3 months imprisonment
102(1)	Take fish for sale when unlicensed	$11,000
104(7)	Contravene condition of a commercial fishing licence	$11,000
107(1)	Use unlicensed boat to take fish / land fish for sale	$11,000
108(7)	Contravene condition of boat licence	$11,000
110(9)	Carry unregistered crew	$5,500
121	Fail to make catch record	$22,000
122	Fail to send catch record to Director	$1,100
133	Contravene conditions of Section 37 permit	$11,000
247(1)	Resist or obstruct a fisheries officer	$22,000 and/or 6 months imprisonment
248(4)	Fail to assist in boarding and search of boat	$5,500
249(3)	Fail to comply with requirement to remove gear from water	$5,500
256(4)	Fail to comply with requirement to produce records or answer questions	$5,500
257(4)	Fail to comply with requirement to produce authority	$2,750

g) Consultation

There is a range of consultative bodies established in NSW to assist and advise the Minister for Fisheries and NSW Fisheries on management issues. Committees are established to provide advice on specific fisheries as well as on matters which cut across different fisheries or fishing sectors. Committees and Councils with responsibilities relevant to ocean trawl fisheries are as detailed below:

i) Management advisory committees

Share management and restricted fisheries in NSW each have a management advisory committee that provides advice to the Minister for Fisheries on:

- the preparation of any management plan or regulations for the fishery
- monitoring whether the objectives of the management plan or those regulations are being attained
- reviews in connection with any new management plan or regulation
- any other matter relating to the fishery.

Following the declaration of the fishery as a restricted fishery, elections were held to determine industry membership on the Ocean Prawn Trawl and Ocean Fish Trawl Management Advisory Committees (MACs). Each MAC comprises industry members and members representing the recreational fishing sector, Indigenous and conservation interests and NSW Fisheries. The MACs provide advice to NSW Fisheries and the Minister on the development of a management plan for their respective fishery, and on changes to Regulations and policy affecting the fishery.

Table B1.18 details the current membership of the MACs. The industry members of the MAC comprise representatives that are elected by endorsement holders in the fishery. The members hold office for a term of three years, however, the terms of office are staggered and the terms of half of the industry members expire every 18 months.

The non-industry members on the MAC are appointed by the Minister for Fisheries and also hold terms of office for up to three years. To ensure that all issues discussed by the committee are fairly represented, each MAC is chaired by a person who is not engaged in the administration of the *Fisheries Management Act* and is not engaged in commercial fishing.

Although the MACs receive advice from NSW Fisheries observers on research, compliance and administrative issues relating to the fishery, only members of the MAC have voting rights on the decisions of the MAC.

Table B1.18 Composition of the Ocean Prawn Trawl and Ocean Fish Trawl Management Advisory Committees

Ocean Prawn Trawl	Ocean Fish Trawl
Region 1 Upper north coast	Northern region (three positions)
Region 2 Clarence	Southern region (one position)
Region 3 North coast	Recreational fishing
Region 4 Central	Indigenous fishing
Region 5 to 7 Sydney and south coast	Conservation
Recreational Fishing	NSW Fisheries
Indigenous fishing	
Conservation	
NSW Fisheries	

ii) Ministerial advisory councils

Four Ministerial advisory councils are currently established under the FM Act. The Councils provide advice on matters referred to them by the Minister for Fisheries, or on any other matters the Councils consider relevant. They report directly to the Minister for Fisheries.

The Ministerial advisory councils currently established are:

- Advisory Council on Commercial Fishing (ACCF)
- Advisory Council on Recreational Fishing (ACoRF)
- Advisory Council on Aquaculture (ACoA)

The Ocean Prawn Trawl and Ocean Fish Trawl Fisheries and each of the other major share management fisheries have representatives on the ACCF. These representatives are nominated by each of the respective management advisory committees and appointed by the Minister for Fisheries. .

The name and composition of Ministerial advisory councils are determined by regulations under the FM Act, and may be altered from time to time.

iii) Indigenous Fisheries Strategy Working Group

The Indigenous Fisheries Strategy Working Group (IFSWG) was established in 2002 upon the commencement of the Indigenous Fisheries Strategy (IFS). Membership of the IFSWG includes representatives from Indigenous agencies and community groups as well as Indigenous persons involved in the commercial fishing industry. The groups involved include the NSW Aboriginal Land Council, the Aboriginal and Torres Strait Islander Commission and the NSW Department of Aboriginal Affairs.

The IFSWG's role is to assist in the implementation of the IFS and provide sound recommendations for the ongoing fisheries issues that affect Indigenous people in NSW. The IFSWG is actively engaged in and contributes to the development of the fishery management strategies being prepared under the FM Act, in conjunction with other key stakeholders. The IFSWG predominantly meets on a quarterly basis, however, sub-committees are formed and meet on an 'as needs' basis for the purpose of providing specialist Indigenous input into the fishery management strategies.

1.7. Interaction with Other Fisheries and the Environment

a) Interaction with other fisheries

The ocean fisheries of NSW are complex due to their relatively long history, the diversity of species occurring in NSW coastal waters, and the overlap both between fisheries and with other jurisdictions. Many species taken by trawling are also significant in other commercial, recreational and Indigenous fisheries, and fisheries under the jurisdiction of the Commonwealth or other states.

i) Species interactions

Ocean waters off NSW contain a large number of fish and invertebrate species, due to the overlap of sub-tropical and temperate ecosystems, and the relatively narrow continental shelf. As demersal trawl nets are not a highly selective method of fishing, they catch a large number of species, many of which are significant in other commercial or recreational fisheries. Of the primary and key secondary species taken by trawling in NSW ocean waters, most are also significant in the catch taken by one or more commercial or recreational fisheries, either in NSW or in adjoining jurisdictions.

ii) Other NSW commercial fisheries

Apart from interaction by way of the species taken, trawling in ocean waters overlaps with the other ocean fisheries in regard to the areas fished. Significantly, there have been interactions between trawl fishers and trap fishers in the Ocean Trap and Line Fishery, and the Lobster fishery, mainly involving conflict between the two types of fishing gear being fished on the same grounds. A significant number of fishing businesses are endorsed to operate in both the ocean trawl and ocean trap and line fisheries, although the nominated fishing vessel can only operate in one fishery at any given time. Many businesses endorsed for trawling in ocean waters also hold endorsements in other NSW commercial fisheries, such as the Estuary General, Estuary Prawn Trawl or Ocean Hauling fisheries.

iii) Commercial fisheries in adjacent jurisdictions

Significant interactions occur between the NSW ocean trawl fishery and the Queensland East Coast Trawl Fishery in the case of prawn trawl fishers, and between the NSW ocean trawl fishery and the Commonwealth South East Trawl Fishery in the case of fish trawl and deepwater prawn trawl fishers. Many fishing businesses are endorsed to operate in these adjoining jurisdictions, and there have been significant problems with ensuring complementary management arrangements for the adjoining fisheries. Management of the Commonwealth SETF is based on setting an annual Total Allowable Catch for each of 16 important species, which is allocated to each operator as an Individual Transferable Quota. Management of prawn trawling in the Queensland fishery is by way of controls on the dimensions of trawl nets and allocation of the number of nights allowed to be fished each year.

Offshore Constitutional Settlement

Offshore Constitutional Settlements (OCS) involve an exchange in power between the States and the Commonwealth over marine and seabed resources. These settlements aim to provide a framework for more ecologically rational management of fish populations and simplification of administration and licensing for fishers.

An OCS was reached between NSW and the Commonwealth in 1990 that defines jurisdiction over specific fisheries by area, species and gear type.

Resolution of the OCS meant that many fishers who previously held both NSW and Commonwealth licences needed only to renew their State licence each year, resulting in large licence fee savings. Under OCS agreements, fishing boats that were previously licensed to fish outside 3 nautical miles under Commonwealth jurisdiction were automatically issued an authority on their State boat licence (called an ‘OG1’ for general offshore fishing and an ‘OP1’ for prawn trawling) to continue to work in offshore waters.

While the OCS provided a better management framework, many species taken by the trawl fishery are also taken in Commonwealth fisheries. Trip limits have been introduced in NSW on some species to complement the Commonwealth's quota management scheme.

Since the signing of the initial OCS agreement, negotiations have continued between the Commonwealth and NSW in an attempt to further simplify the agreement and meet fishers' requirements and expectations. These negotiations are continuing, and issues under consideration include southern bluefin tuna, fishing in waters surrounding Lord Howe Island, a proposal to return jurisdiction for some fish trawl grounds off the south coast of NSW to the Australian Fisheries Management Authority, and a proposal to manage school and gummy sharks under a single (Commonwealth) jurisdiction.

iv) Recreational fishery

The level of interaction between ocean trawl fishers and recreational fishers off NSW could be described as relatively low. Ocean trawlers generally fish further offshore than most recreational fishers, however on some occasions when trawlers are targeting inshore species (e.g. school prawns, sand flathead, southern calamari or school whiting) there is potential for considerable interaction between the groups. There is also a perception amongst recreational fishers that trawlers operating in an area capture a high percentage of fish present, making recreational fishing less successful. During the past 10 - 15 years, increased ownership of recreational boats capable of fishing offshore has led to an increase in the potential for conflict with ocean trawl fishers.

v) Indigenous fishery

As most Indigenous fishing occurs in estuarine and near shore ocean waters, the level of interaction between the ocean trawl fishery and Indigenous fisheries could also be said to be low. However a number of species taken by the ocean trawl fishery have also been found to be targeted by Indigenous fishers, including eastern king prawns, school prawns, blue swimmer crabs, octopus, squid, leatherjackets, silver trevally, sand flathead, flounder and shovel-nose sharks (Schnierer and Faulkner, 2002).

b) Stakeholders

Apart from commercial fishers, a number of community members could be described as stakeholders in the ocean trawl fishery, as ocean waters are used for a diverse range of commercial and recreational activities.

i) Commercial fishers

The primary stakeholders in the ocean trawl fishery are those fishing businesses endorsed to operate in the fishery. The commercial fishers involved in these businesses clearly have the greatest direct stakeholding in the management strategy, as it will effect the sustainability of their operations in the fishery. A well managed, sustainable fishery will provide ongoing financial benefits to commercial trawl fishers, their families and the community.

There is a diverse level of participation in the fishery by the endorsed businesses, ranging from fishers who work full-time in the ocean trawl fishery, to fishers who participate in a range of commercial fisheries, to fishers who appear to undertake very little or no trawling activity.

ii) Recreational fishers

Recreational fishing in ocean waters has increased significantly over the past 2 decades, and some of the species targeted by recreational fishers are significant in ocean trawl catches (e.g. sand flathead, southern calamari, rubberlip morwong). Apart from direct overlaps of target species, recreational fishers also have an interest in the preservation of ocean habitats, especially reefs and surrounding hard-bottom habitats, where significant amounts of recreational fishing occurs, and which have been shown to be vulnerable to the effects of trawling.

iii) Indigenous people

It is important for NSW Fisheries to work with Indigenous people to take collaborative approach to fisheries management. While there is provision for Indigenous representation on the ocean trawl MACs, to date no Indigenous representative has been nominated.

NSW Fisheries has recently released an Indigenous Fisheries Strategy that will lead to the development of a range of initiatives and programs to facilitate Indigenous fishing in NSW. The aim of the Indigenous Fisheries Strategy is to focus on:

- Indigenous people's interests in fisheries, including customary marine tenure and traditional fishing practices
- the extent of Indigenous people's involvement in management of fisheries and the marine environment
- impediments to Indigenous people's participation in commercial fisheries and mariculture operations
- the impact of commercial fishing on fishing for traditional purposes
- cultural awareness and improved relations between Indigenous peoples and other stakeholder groups.

The exact number of Aboriginal people directly involved in the ocean trawl fishery is not presently known. In 1997, NSW Fisheries conducted a small survey on Aboriginal coastal fishing. The survey showed that Indigenous people fished regularly and that they often fished to feed large or extended families. When certain circumstances exist, the Minister for Fisheries may issue a permit under the *Fisheries Management Act 1994* that authorises Indigenous people to meet specific cultural obligations with respect to traditional fishing.

iv) Conservationists

Conservation groups and individuals have a significant stakeholding in the resources harvested by the ocean trawl fisheries through their interest in ensuring the conservation and protection of natural resources and ecological systems.

The Nature Conservation Council of NSW (NCC) is the peak umbrella organisation for around 130 conservation and environment groups in NSW.

The goals of the NCC are to conserve the environment of NSW. Specifically, the Council aims to conserve and protect:

- the diversity of living plants and animals in NSW, especially rare and threatened species
- unique ecosystems in NSW, from the western arid lands to the eastern coastline
- the environmental quality of NSW land, air, waterways, and adjacent sea - and of the urban environment.

The conservationist interest in trawling in ocean waters may involve concerns over threatened species, bycatch and the impact of the gear used on habitat, or simply knowing that the fishery is being managed in a manner that will ensure the conservation of marine resources for future generations. Conservationists place a significant value on non-consumptive uses of the resource.

As stakeholders in the ocean trawl fisheries, conservationists are represented on the MACs. The conservation representative on each management advisory committee has full voting power and equal participation to the commercial fishing, recreational and Indigenous representatives.

v) The community

The fisheries resources of NSW are owned by the community at large. The Minister for Fisheries is responsible for the legislation under which fisheries are managed and the development and implementation of government policy in relation to fisheries.

The community includes people with interests in one or more of the stakeholder groups discussed above. Other groups in the community who have a significant stakeholding in the fishery, include divers and tourism operators that come in contact with trawling operations and the fish eating public. A considerable issue relating to all community stakeholders is promoting harmony and resource sharing.

Yearsley *et al.* (1999) notes that Australians are beginning to understand the health benefits of eating seafood and the fact that it is generally widely available and quick and easy to prepare. It is also estimated that 60% of the seafood consumed in Australia is imported from overseas, leaving 40% to be supplied from domestic fisheries. It is therefore important to provide for the demand generated by the broader community to access seafood products harvested in a sustainable manner by the commercial fishing industry.

vi) Fisher based organisations

There are a number of fishermen's co-operatives in NSW that provide services for fishers in the ocean trawl fishery. The major co-operatives are located at Brunswick-Byron, Ballina, Clarence River, Evans Head, Coffs Harbour, Macleay River, Hastings River, Wallis Lake, Crowdy Head, Newcastle / Nelson Bay, Wollongong, Ulladulla, Bermagui and Twofold Bay. In addition, a number of trawl fishers operate from ports which do not have a fishermen's co-operative, notably Sydney, Greenwell Point and Bateman's Bay.

The co-operative system is not only important for fishers in terms of a way of distributing catch to market, and supply of fuel, ice, fishing gear and equipment, but also provides a link for communication within industry, and between industry and other organisations including NSW Fisheries. A number of other fisher based organisations exist in NSW including the Northern Professional Fishermen's Association, Metropolitan Fishermen's Association, NSW Seafood Industry Council, and Oceanwatch. Many NSW fish trawl operators with Commonwealth SEF endorsements belong to the South East Trawl Fishing Industry Association (SETFIA).

vii) Markets and fish receivers

The *Fisheries Management Act 1994* places restrictions on the sale of fish. Fish taken by a commercial fisher when using a commercial fishing boat or commercial fishing gear are deemed by the Act to have been taken for sale.

Prior to 1999, commercial fishers were required to sell their catch through a recognised market, being either the Sydney Fish Market or a Fisherman's Co-operative trading society. In areas not serviced by a recognised market the fisher could sell the catch to a Certificate of Exemption (COE) holder, or direct to the public if the fisher held a ‘consent’ under the Act. Consents were issued to fishers who were able to show they resided beyond a certain distance from a recognised wholesale market, or that the market did not cater for their product (e.g. for the sale of bait to local suppliers). The Sydney Fish Market has historically been the major market place for fish caught in NSW, although there has traditionally been a more diverse market for prawns, many of which have been sold into local markets. Fishers in southern NSW also consigned significant quantities of fish to the Melbourne Fish Market.

Under the regulated marketing system prior to 1999, there were 22 Fishermen’s Co-operatives, 45 COE holders and 154 consent holders. In November 1999, the marketing of fish in NSW was deregulated and a system of “fish receivers” was implemented. Co-operatives and COE holders were granted Registered Fish Receiver (RFR) certificates and consent holders were granted Restricted Registered Fish Receiver (RRFR) certificates. Under the new arrangements any person, commercial fisher, business or company could apply for a Fish Receiver certificate. All Fish Receivers must supply summaries of all fish received to NSW Fisheries on a monthly basis.

A small proportion of the catch from the ocean trawl fishery is exported, either whole (e.g. live prawns) or after processing (e.g. frozen fish fillets). Accurate figures on the level of exports taken in this fishery are not currently available, however, prices achieved for exported product are generally greater than those achieved on domestic markets.

c) Ecosystem and habitat management

This section provides a brief overview of NSW coastal ecosystem factors which may be relevant to the ocean trawl fishery. A comprehensive review of the habitat types important for the long-term sustainability of the ocean trawl fishery is included in Chapter E of this EIS.

i) NSW coastal ecosystem

The coastal zone of NSW extends over a range of almost ten degrees of latitude (about 1,000 km). Approximately 30% of the coastline consists of rocky foreshores and headlands, many of which extend as subsurface reefs offshore, and there are over 700 sandy ocean beaches, which often adjoin extensive areas of sandy substrate in ocean waters. More than 40 offshore islands occur close to the NSW coast. The NSW coastal zone and the near-shore ocean environment are strongly influenced by the mixing of the warm south-flowing East Australian Current and cooler Tasman Sea waters (Godfrey *et al.*, 1980). The seasonal north-south migration of the boundary between these two water bodies, and the diversity of habitats found in the relatively narrow continental shelf area, gives rise to a rich fauna and flora. The ten degree range in latitude also results in a high degree of biogeographical complexity, which has implications for both the study and management of the fishery. Boyd *et al.* (draft) classified the NSW continental shelf seabed into a variety of geomorphological units, based on an analysis of geometry and slope, and described the sediment characteristics of each unit. These authors described the continental margin in this area as relatively "narrow, deep and sediment deficient" compared with other 'passive' continental margins in other oceans. The biogenic habitats and species assemblages associated with these geomorphological units are yet to be described.

ii) Habitat management

The importance of maintaining healthy fish habitat in ensuring the long term sustainability of fish stocks is understood and well recognised (see also Chapter B, Section 2.7).

Proper management of land-based catchment uses is essential to the long term survival of fish habitat and fish stocks, including those which are important to the ocean trawl fisheries. The *Fisheries Management Act 1994* provides for the protection of fish habitats. These provisions can be found in Part 7 of the Act, and the primary habitat related provisions of this part are:

Habitat protection plans - allow for the preparation and gazettal of management plans for the protection of specific aquatic habitats. NSW Fisheries has gazetted two plans under this provision. The first of these plans summarises various protective measures in the Act, but also protects 'snags' such as fallen trees and logs. The second plan deals specifically with the protection of seagrasses. A further plan for the Hawkesbury Nepean River system has recently been completed.

Aquatic reserves - allow for the creation and management of aquatic reserves.

Dredging and reclamation – allows for the control and regulation of dredging and reclamation activities which may be harmful to fish and fish habitats. It establishes requirements to obtain a permit from, or consult with NSW Fisheries.

Protection of mangroves and certain other marine vegetation – allows for the regulation of damage to, or removal of, certain marine vegetation. At this stage, mangroves, seagrasses and macroalgae (seaweed) are the only forms of marine vegetation protected in this way. A permit is required to remove or damage marine vegetation.

Noxious fish and noxious marine vegetation – allows for the declaration of undesirable fish and marine vegetation as noxious. Once declared noxious these fish or vegetation may be liable to be seized and destroyed.

Release or importation of fish – allows for the control of the release, import, sale or possession of fish not originating from NSW waters. The purpose of this provision is to prevent the spread of disease and the introduction of undesirable species. A permit is required to import fish into, or release fish in, NSW waters.

Miscellaneous (including fish passage) – provides for the free passage of fish past barriers such as dams and weirs. This facilitates the installation of fishways, and/or implementation of appropriate operational procedures for weirs.

Other legislation is in place, such as the *Environmental Planning and Assessment Act 1979*, to ensure that all environmental impacts are taken into account during the approval of new developments or alterations of existing developments. Development applications which have the potential to harm fish or fish habitat are referred to NSW Fisheries for comment or recommendations.

In 1999 NSW Fisheries published an updated version of *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation*. This document aims to improve the conservation and management of aquatic habitats in NSW and is targeted at local and State government authorities, proponents of developments and their advisers, and individuals and organisations concerned with planning and management of aquatic resources, such organisations include those concerned with conservation.

There is a range of other whole-of-government programs underway to manage the environmental problems across catchments and to enable the consideration of flow-on effects from activities undertaken in an area. These include:

- Coastal Council of NSW
- total catchment management, involving catchment management authorities

- water reform
- improving community access to natural resource information
- acid sulphate soils management.

iii) Marine protected areas

NSW is committed under international, national and state agreements to conserve marine biodiversity and manage the ecologically sustainable use of fish and marine vegetation. A key component of these strategies is to establish a system of marine protected areas that adequately represent the biodiversity found in the oceans and estuaries of Australia.

Marine protected areas can preserve many different types of marine environments, and the animals and plants that live in them. No-take areas within marine protected areas provide a refuge from fishing and should allow fish to breed and grow. They provide unspoilt natural sites for people to visit, and offer areas for education and research.

The NSW system comprises three distinct types of marine protected areas and these are discussed below. It is important to note that some marine protected areas allow for a range of activities to occur. The activities permitted depend on the particular area and may include the collection of bait, harvest of lobsters or abalone by hand and recreational angling.

Marine parks

Marine parks are areas of coastal, estuarine or oceanic waters and adjoining lands permanently set aside to protect the organisms including plant life, fish species, birds and other animals that live in that environment. Marine parks are managed to effectively conserve biodiversity and associated natural and cultural resources, while still allowing for the sustainable use and enjoyment of these areas by the community. The community has a vital role in the management of marine parks. Community input is provided at two levels – at the State-wide level through the Marine Parks Advisory Council, and at the local level through advisory committees established for each park.

Marine parks are the largest type of marine reserve in NSW, and incorporate a range of levels of protection, including ‘sanctuary’ zones where most ‘extractive’ activities such as commercial and recreational fishing are excluded. The four marine parks that have already been declared are at Cape Byron, Solitary Islands (north from Coffs Harbour), Jervis Bay, and Lord Howe Island. The three coastal parks contain areas that were previously trawled, and which are or will be protected from trawling.

Aquatic reserves

Aquatic reserves are administered by NSW Fisheries and play an important role in conserving biodiversity and protecting significant marine areas. Thirteen aquatic reserves have been declared in NSW, with the type of protection varying between the reserves. In some areas, diving and observing are the only activities permitted whilst in others, activities such as recreational angling are allowed.

Of the thirteen aquatic reserves already declared, only one (Cook Island off Tweed Heads) is in ocean waters. This declaration had minimal or no impact on trawling activities in this area.

Intertidal Protected Areas

Intertidal Protected Areas (IPA) were created at 14 areas around Sydney in July 1993. They extend from mean high water to 10 m seaward, beyond mean low water, and all are on rocky coastlines where trawling does not occur.

Marine or estuarine extensions of National Parks or Nature Reserves

There are currently 35 National Parks or nature reserves dedicated or reserved under the *National Parks and Wildlife Act 1974* that contain marine protected areas. These areas are administered by the NSW National Parks and Wildlife Service. As for IPAs, these occur in areas where trawling does not occur.

d) Hazard issues

A number of hazards potentially effect operations in the ocean trawl fishery, and care and attention to detail are required in all aspects of operation of an ocean-going trawler. One of the most obvious hazards which must be faced is that of bad or rapidly deteriorating weather and sea conditions. Ocean trawlers frequently operate long distances from port, and individual trawl shots can be several hours in duration. Trawl fishers rely heavily on the accuracy of weather forecasts, and must be aware of the potential for rapidly deteriorating weather to quickly turn 'marginal' operating conditions into more dangerous situations.

Trawlers use a lot of heavy deck machinery to work the trawl gear, and the operation of this machinery aboard a constantly pitching platform gives rise to numerous hazards. Retrieval of fouled trawl gear (fouled on the bottom or on other obstacles such as sunken ships or lost shipping containers or machinery) can also be a source of hazard in the day-to-day operations of trawl fishers. Heavier than normal catches sometimes occur, and this can stress the lifting gear to its full capacity when landing the catch aboard the boat. Mechanical failure is an ever-present hazard aboard ocean trawlers.

Many NSW ports used by ocean trawlers are characterised by a river-bar entrance. Bars can be extremely dangerous to cross in some tide and weather conditions, and a number of boats have been lost whilst crossing river bars in NSW. Other hazards that can be encountered during fishing operations include contact with dangerous sea creatures (e.g. numbfish, stonefish, large stingrays and sharks) and marine viruses that can cause severe infections of small wounds (which are common place aboard fishing trawlers). Another hazard which confronts trawl fishers is the potential for close contact with large ships while at sea, especially during night-time trawling operations.

2. Ecological Issues

The aim of this section of the EIS is to describe the potential environmental impacts arising from the current manner in which the ocean trawl fisheries operate. Ocean fish and ocean prawn are the two ocean trawl fisheries being examined, and hereafter will be collectively known as the Ocean Trawl Fishery (OTF). A risk analysis, considering all components of the ecosystem and large-scale ecological processes, will be used to identify those aspects of the existing operation of the fishery (described in Chapter B1) that could impact the environment. Those aspects of the current fishery that are assessed as having a high likelihood of compromising the ecological sustainability of the environment and/or the fishery will be identified and may be modified or changed through the FMS, whereas aspects assessed as posing little or negligible risk will receive little, if any, modification in the FMS (Chapter D).

The recommendations arising from this risk analysis should be incorporated into the proposed management strategy for the fishery (Chapter D) to improve the ecological performance of the fishery. In Chapter E the proposed management strategy will be assessed to determine whether its management measures can effectively reduce the risk to the environment to ensure that the fishery operates in an ecologically sustainable manner.

2.1 An Outline of the Risk Analysis Process Used to Examine the Operation of the Ocean Trawl Fishery

a) Introduction to the Risk Analysis Process

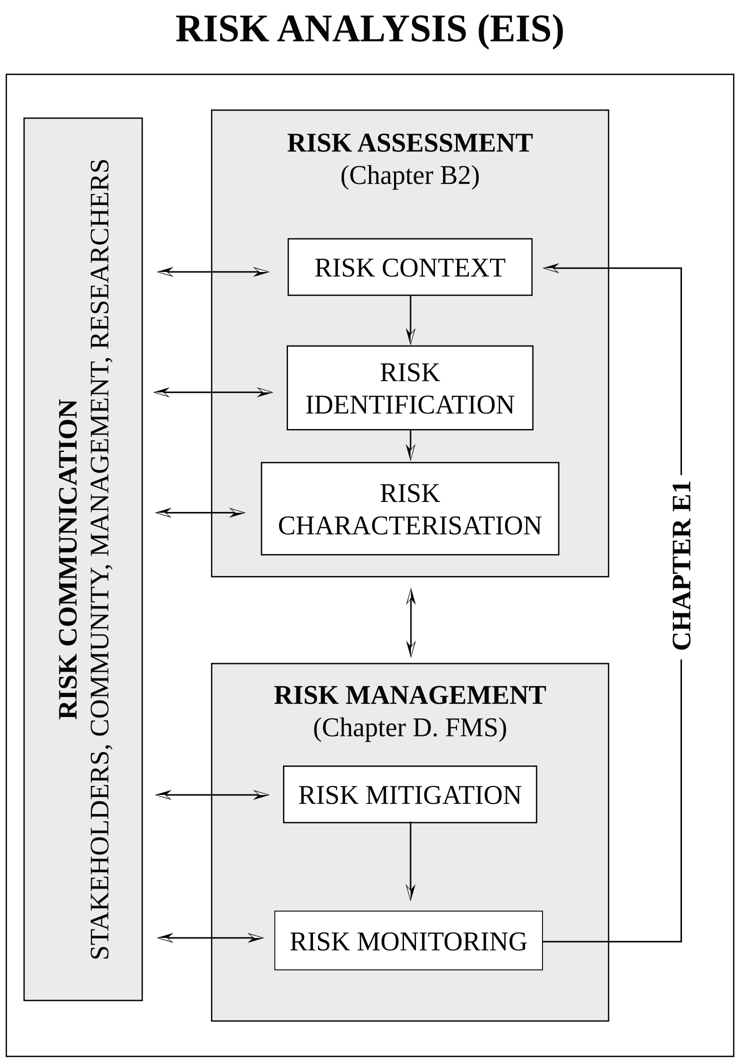
A broad range of risk analysis, risk assessment and risk management information and literature was reviewed. This information and literature covered generic risk analysis principles (Standards Australia/Standards New Zealand, 1999), generic environmental risk analysis principles (Standards Australia/Standards New Zealand, 2000), a risk analysis and reporting framework for ecologically sustainable development in fisheries (Fletcher *et al*., 2002), a comprehensive review of risk assessment terminology for the fields of chemistry and toxicology (Duffus, 2001), the risk analysis terminology provided by the Food and Agriculture Organisation of the United Nations (FAO) in their online glossary of fisheries terms and definitions (http://www.fao.org/fi/glossary), and relevant publications in the aquatic sciences dealing with quantitative and qualitative risk analyses and assessments (Francis, 1992; Francis and Shotton, 1997; Lane and Stephenson, 1998).

The practical application of the risk analysis process for assessing and managing risks in the OTF was made difficult because of the: (a) different risk analysis methods and frameworks that are used among and within different fields of research and management; (b) inconsistent usage of risk analysis terminology throughout the literature (Hayes, 1997); (c) complex relationships that exist between assemblages of species, habitats and ecological processes in the marine environment (Dayton *et al*., 1995; Hall, 1999; Jennings *et al.*, 2001a,b, Polunin and Pinnegar, 2002); and (d) lack of detailed biological and ecological data for many species and habitats. These difficult issues were resolved by modifying the ASNZ Standards (2000) risk analysis framework that modified and integrated the general concepts and principles that had been used previously across the different areas of risk analysis. A description of this risk analysis framework and the definitions of the terms used are provided below.

b) Risk Analysis Framework and Terminology

Risk analysis is an iterative process that has three main steps: risk assessment, risk management and risk communication (see Figure B2.1). The risk analysis process is intended to provide insights about sources of risk and their potential impacts, which then enables managers to take mitigative action against undesirable outcomes.

Figure B2.1 Framework of the risk analysis used for the OTF.



Risk is the probability or likelihood of an undesirable event happening. This broad definition of risk reflects common usage in fisheries science (Francis and Shotton, 1997; FAO, http://www.fao.org/fi/glossary). This definition requires that an *a priori* definition of consequence be given for the undesirable event that is being analysed. In this way, the definition of risk combines the consequence and likelihood of an undesirable event happening.

Consequence is the outcome of an event expressed either quantitatively or qualitatively. In qualitative risk analysis an *a priori* definition of the consequence of an event can be used to provide the context or scope of the risk analysis.

Likelihood is a qualitative description or estimate of probability. This means that likelihood is a qualitative measure or estimate of risk.

Risk assessment is the first main step in the risk analysis process. Risk assessment contains three parts: risk context, risk identification, and risk characterisation (see Figure B2.1).

Risk context must be the first part of any risk analysis. The scope or context of the risk analysis can be defined clearly by specifying three main elements: (1) the risk that is to be analysed (eg. in a qualitative risk analysis the risk should be defined explicitly by: (a) describing the undesirable event that is to be avoided; and (b) stating the consequence of the undesirable event); (2) the relevant temporal extent of the risk analysis (eg. this may be the life of a management plan); and (3) the spatial extent of the risk analysis (eg. this could include the entire known distribution of a target species or be restricted to a single jurisdiction).

Risk identification is the second part of risk assessment. The aim of risk identification is to generate a comprehensive list of sources of risk. This can be done using a variety of methods that include: literature reviews, examination of historical records, expert panels, brainstorming, and consultation meetings to discover stakeholder opinions and perceptions. The results of this risk identification step are often presented as lists, tables or as component trees (see Fletcher *et al*., 2002).

Risk characterisation is the third part of risk assessment. The aim of risk characterisation is to estimate the probability or likelihood that the various sources of risk (identified in the previous step) will indirectly or directly cause the undesirable event that has been defined. Risk characterisation is an iterative process that involves: (a) the integration of qualitative and/or quantitative information, including the associated uncertainties, about the sources of risk; (b) the separation of the sources of risk into categories according to their estimated probability or likelihood of causing the previously specified undesirable event; (c) the acceptance of negligible risks with a justification supporting the conclusion reached (these negligible risks are now eliminated from the subsequent risk analysis); and (d) the rejection of the remaining sources of risk that have been estimated to be above the threshold of negligible risk, followed by an iterative re-analysis of relevant factors at a finer scale of resolution within each major source of risk.

In a qualitative risk analysis it is acceptable to use categories such as low, intermediate and high to describe risk. There is no restriction to the number of categories that can be used but it is implied that each category has an equal weighting of risk (eg. the use of five categories –low, low – intermediate, intermediate, intermediate to high and high – implies each category accounts for one fifth of the total risk). The re-analysis of major risk sources then involves a detailed investigation of all lower level factors that may influence the probability or likelihood of that source of risk causing the undesired event. This approach is useful when risk characterisation is done iteratively by stepping down through a series of hierarchical levels. For example, risk characterisation can be done initially at the broad ecosystem level to examine large-scale ecological processes and biodiversity issues, and then at a finer resolution for individual taxa (or other ecological component) impacted by the fishery.

Risk management is the second step in the risk analysis process. Risk management contains two main components: (a) risk mitigation; and (b) risk monitoring (see Figure B2.1)

Risk mitigation is the first part of risk management. The aim of risk mitigation is to minimise the risk of the undesirable event that has been defined in the risk context. This is done by evaluation and implementation of regulatory and/or non-regulatory (eg. code of conduct) management responses. The draft FMS document provides a detailed overview of the proposed management initiatives that have been designed to mitigate the risk of the undesirable event that was specified in the risk context section of the risk analysis. It is assumed that management initiatives outlined in the draft FMS will be effective for mitigating risk. Consequently, the risk analysis done on the proposed FMS for the OTF should be regarded as a “best outcome” because the effectiveness of the management initiatives are unproven.

Risk monitoring is the second part of risk management. The aim of risk monitoring is to collect information to determine whether the management initiatives that were implemented previously were effective in minimising the risk of the undesirable event. Quite simply, risk monitoring is useful for: (a) validating management actions when they have been effective; and (b) highlighting areas that need further management response when previous initiatives have been shown to be ineffective. Risk monitoring should be regarded as a practical appraisal of management initiatives and an opportunity to modify management plans in a timely manner.

Risk communication is an important step in the risk analysis process because it provides the basis for information flow among stakeholders, fisheries managers, scientists and consultative committees. Risk communication should occur continuously during the risk analysis process in order to achieve a better outcome (see Figure B2.1).

c) Issues in Applying the Risk Assessment Framework

i) The marine ecosystem, ecological processes and ecosystem components

The **marine ecosystem** encompasses all ecological, physical and other processes that affect or are influenced by finfish, shellfish and the operation of all commercial and recreational fisheries. The relevant processes that may affect the ecology of finfish, shellfish and the environment in which they live include hydrological, geomorphological and biological factors, such as oceanographic circulation patterns, climate change, food-webs, interactions among species, interactions of species with habitats, spawning migrations and behaviour, dispersal and recruitment, and natural variability in population abundance (Underwood and Chapman, 1995; Underwood, 2000; Brodziak and Link, 2002; Heino and Godo, 2002). Great emphasis has been recently directed towards assessing the impacts of fisheries on the whole ecosystem (Dayton *et al*., 1995; Trites *et al*., 1999; Murawski, 2000; Reynolds *et al*., 2002;). However, the assessment of fishery-related impacts is difficult because relationships between assemblages of species, habitats and ecological processes in the marine environment are inter-related and very complex (Hall, 1999; Trites, 2002). Figure B2.2 provides a simplistic model of the complex web of links between ecological processes, habitats and the marine biota. This simple model shows the importance of ecological processes within a marine ecosystem and it is evident from this model that the sustained viability of habitats and biota are dependent on the long-term integrity of these ecological processes.

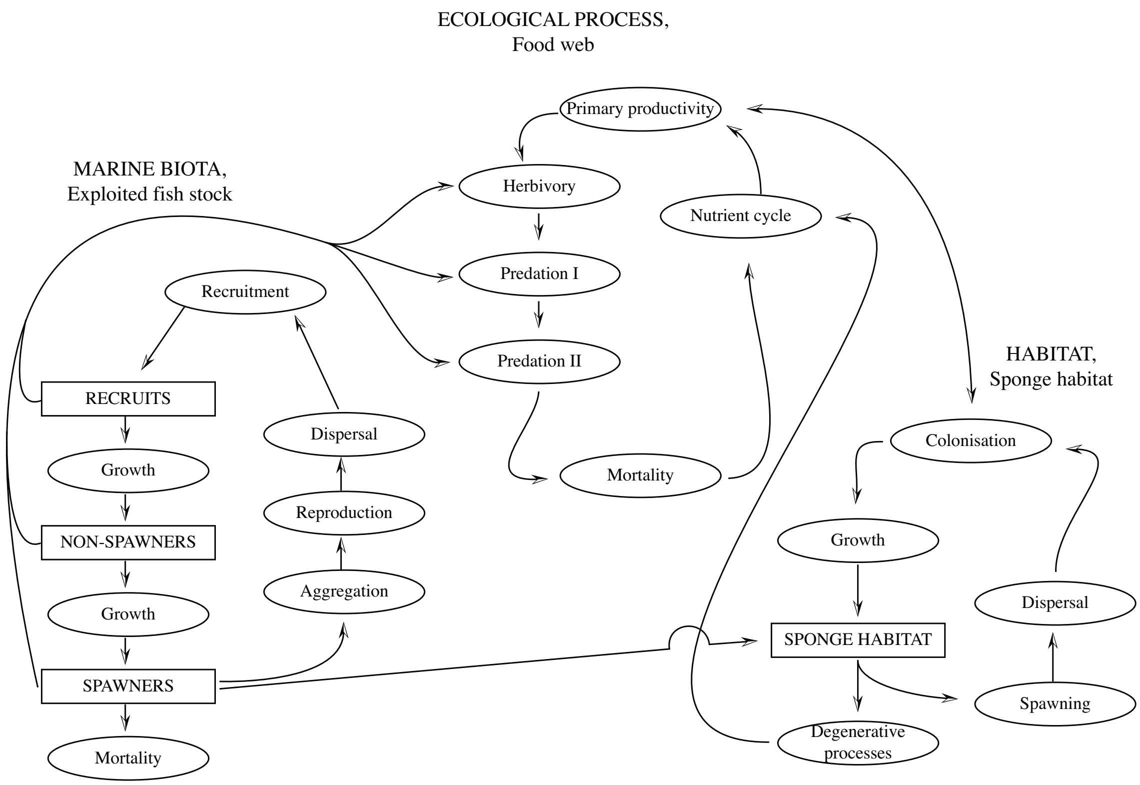


Figure B2.2. Example of the complex web of links between ecological processes within a marine ecosystem.

Note: Mortality is assumed to occur at all stages but is only indicated at some points to simplify the example.

A fishery can impact a marine ecosystem directly or indirectly in three main areas – marine biota (including fauna and flora), habitats (including biophysical habitats and physical habitats) and ecological processes (including trophic cascades, primary productivity, spawning and recruitment processes). Each of these main areas can be divided into smaller ecosystem components. These **ecosystem components** are the different aspects of the environment relevant to the fishery being examined by the risk analysis. They include retained species, non-retained species including bycatch species, bait sources, protected and threatened species, species diversity, ecological processes and relationships, habitats and biophysical properties of the environment. Systematically dividing the ecosystem into smaller manageable components ensures that all relevant sources of risk are examined (Fletcher *et al*., 2002).

ii) Qualitative versus quantitative ecological risk analysis

Ecological risk analysis of potential impacts on aquatic environments and their associated flora and fauna are limited by the quality and quantity of information that is available for use in the risk analysis process. Recent audits of the state of the Australian marine environment have concluded that our knowledge of the marine environment remains limited (Zann, 1995; Australian State of the Environment Committee, 2001). There is also a paucity of quantitative data for most of the important species harvested in the oceanic commercial fisheries in NSW (NSW Fisheries, 2001a). For example, stock-recruitment relationships have not been described for most of the retained species in these oceanic fisheries (NSW Fisheries, 2001a) and many aspects of the basic biology and ecology for some of these species remain poorly understood (NSW Fisheries, 2001b,c). The lack of knowledge in these areas is due to the time and resource consuming nature of the work required for the analysis of the relevant data of each species.

Ideally, a quantitative model of the fishery should be used as an aid in the ecological risk analysis process (Francis, 1992) but this is only possible in "data-rich" fisheries (i.e. those high value fisheries that can support the economic cost of long-term, intensive monitoring programs) (e.g. Hutchings, 1999; Hilborn *et al.*, 2001). Ecological risk assessment models for many "data-rich" northern hemisphere fisheries make use of information which describes stock-recruitment relationships and estimates of fishing mortality and spawning biomass (Linder *et al*., 1987; Hilborn *et al*., 1993; Rosenberg and Restrepo, 1994). These quantitative models are used to assess the potential impacts of different harvest levels and changes to management regimes (e.g. Hall *et al*., 1988). However, it should be noted that the use of stock assessments based on sophisticated quantitative modeling techniques alone does not guarantee a sustainable fishery. The catastrophic stock collapse of the "data-rich" northern cod fishery in Canada (Hutchings and Myers, 1994; Myers and Cadigan, 1995;) was not prevented despite the vast amounts of resources devoted to quantitative stock assessments in this fishery (Walters and Maguire, 1996; Myers *et al*., 1997).

The oceanic commercial fisheries in NSW are "data-poor" when compared to the larger more valuable fisheries of the northern hemisphere. This lack of quantitative information means that the ecological risk analysis for the commercial oceanic fisheries in NSW must incorporate a qualitative approach. The paucity of biological information for many species, particularly secondary and minor species, that are taken in the multi-species OTF makes it difficult to analyse the risk of fishing-related impacts. Two potential solutions exist for overcoming these knowledge gaps and completing a risk analysis for the fishery. The first solution is to apply the precautionary principle whenever biological information for a species is unknown. The application of this "precautionary-at-all-times" approach would mean that all species for which biological knowledge gaps exist would be assessed as having a higher level of risk. The outcome of a "precautionary-at-all-times" approach in a multi-species fishery would lead to most secondary and minor species in the fishery being assessed as having a high level of risk. This could result in limited management resources being allocated disproportionately to mitigating these high risk levels for these secondary and minor species which might be more appropriately directed to the urgent primary and key secondary species at high risk. A second solution is to consider the available biological information at a coarser taxonomic resolution (generic or family level). This "best available knowledge" approach is particularly useful when examining general biological traits or characteristics such as reproductive modes and strategies in fishes. In this way, biological inferences can be made for most species for which biological knowledge gaps exist by using the best available information. To ensure species are placed within a realistic range of risk levels species with known levels of risk at the upper and lower ends of the range of risk can be used. These species, known as "benchmark species", function as a point of reference. Other species can then be given a level of risk based on what was known about their biology or family biology in comparison with the risk level of a benchmark species. The outcome of this approach enables a better ranking of most secondary and minor species according to their broad levels of risk.

iii) Accounting for scientific uncertainty in risk assessment

The term "scientific uncertainty" includes two components: (a) ecological uncertainty, and (b) statistical uncertainty. Ecological uncertainty refers to the levels of natural variability that are inherent in ecological processes and in the intrinsic biological characteristics expressed by populations of species and/or assemblages. Thus, ecological uncertainty cannot be regulated to mitigate for any effects related to fishing or environmental impacts. At best, it should be possible to obtain a measure of the magnitude of ecological uncertainty, either from existing information or by planning some sort of monitoring program. Once the magnitude of ecological uncertainty has been estimated it can be incorporated into the risk assessment process by categorising the likelihood of a species as being either risk-averse or risk-prone.

Statistical uncertainty refers to the likelihood of making an erroneous conclusion or interpretation based on a statistical analysis of data or an examination of information. In formal hypothesis testing these statistical errors are known as Type I (i.e. concluding that an action has a deleterious effect when in fact it doesn't) and Type II errors (i.e. concluding that an action has no deleterious effect when in fact it does) (Cohen, 1988; Underwood and Chapman, 2003a) and the inverse relationship between these error types is known as statistical power (Cohen, 1988; Fairweather, 1991; Peterman and M'Gonigle, 1992; Underwood, 1997a). In all probability-based statistical tests there is a trade-off between the probability of making Type I and Type II errors. Whenever a scientist/statistician attempts to minimise the probability of making a Type I error it is always the case that there is an increased probability of making a Type II error (Cohen, 1988; Peterman and M'Gonigle, 1992; Underwood, 1997a). The corollary of this argument is that whenever a scientist/statistician attempts to minimise the probability of making a Type II error it is always the case that there is an increased probability of making a Type I error.

Several authors have argued that the potential consequences of making Type II errors can be more costly than Type I errors for environmental management (Fairweather, 1991; Peterman and M'Gonigle, 1992; Mapstone, 1995; Underwood, 1997a; Underwood and Chapman, 2003a). For example, the potential consequences arising from a Type I error do not impact on the resource but cause the management agency to respond in the short term by committing resources (people, time, money) to further monitoring until the false alarm is identified (Table B2.1). In contrast, the potential consequences arising from a Type II error could be ecologically, socially and economically catastrophic and irreversible (eg. stock collapses, changes in trophic structures). Thus, Type II errors have the potential to adversely impact the resource base and also the management agency, which will be compelled to respond in the long term by committing resources (people, time, money) to monitor any recovery (note -–there is no guarantee that recovery will ever occur!).

The likelihood of making Type I and Type II errors in any quantitative study can be described in terms of probability which can be calculated when the sample size, effect size, and significance criterion (Type I error rate) are known or have been specified (see Cohen, 1988; Mapstone, 1985). In comparison, a qualitative assessment of information does not permit a calculation of probability for making Type I and Type II errors. However, the concept of statistical uncertainty is equally valid in qualitative risk assessment because it is still possible to make wrong conclusions based on a qualitative assessment of available information. In qualitative approaches to risk assessment it may be helpful to think of "statistical uncertainty" in terms of "decision uncertainty" when deciding if assigned risk levels are sufficiently precautionary.

Therefore, given the consequences of making type I and II errors it is important to ensure that the risk levels assigned are sufficiently precautionary. Applying the precautionary principle to "decision uncertainty" in qualitative risk assessment enables the greatest potential for a component to be managed in such a way as to minimise the effects of undetectable adverse impacts (i.e. decision errors analogous to Type II errors in quantitative assessments). However, it is possible that decision errors (analogous to either Type I and Type II errors in quantitative assessments) could still occur.

Table B2.1. The possible implications of making interpretation/decision errors (analogous to Type I and Type II errors) in a qualitative risk assessment.

These implications assume that the management regime remains constant.

Interpretation/Decision Errors		**Implications of Interpretation/Decision Errors**		
Error type	**Interpretation/ Decision**	**Reality**	**For management agency**	**For fisheries resource**
Conclude: **an effect** has occurred when **it doesn't** (analogous to Type I)	Increase in stock/population size	No change in stock/population size	No problem, but possible that stock maybe underutilised	No problem
	Decrease in stock/population size	No change in stock/population size	Short-term problem. Unnecessary monitoring wastes limited agency resources	No problem.
Conclude: **no effect** has occurred when **it does** (analogous to Type II)	No change in stock/population size	Increase in stock/population size.	No problem	No problem
	No change in stock/population size	Decrease in stock/population size	Long-term problem. Cost of recovery programs and legal liability.	Long-term problem. Potential for stock collapses and irreversible changes to ecological processes.

2.2 Risk Analysis of the Current Operation of the Ocean Trawl Fishery – Broad Ecosystem

In this section the risk analysis framework described in Section 2.1 is applied to the OTF. This is done in a series of iterative steps which include: (a) defining the context for the risk analysis; (b) identifying and assessing the sources of risk at the broad scale level of the whole ecosystem; (c) providing justification for eliminating sources of negligible risk from subsequent analyses; (d) re-analysing all remaining sources of risk at a finer scale by examining individual ecosystem components (e.g. primary and secondary species, bycatch, habitats) and their constituent elements (e.g. individual taxa and habitat types). Part (d) is addressed in Sections 2.3 to 2.6 of the document.

a) Context for the Risk Analysis

The guidelines for the Environmental Impact Assessment of the OTF issued by the Department of Infrastructure, Planning and Natural Resources (formerly Planning NSW) in February 2003 state that the environmental assessment should test the sustainability of authorised fishing activities. This means that the risks being assessed can be defined as: (a) the likelihood that the current activities of the ocean trawl fishery will lead to the widespread degradation of major ecological processes, biodiversity and habitats; and (b) the likelihood that the current activities of the OTF will lead to ecologically unsustainable impacts on populations and communities of primary and key secondary species, bycatch species, and protected and threatened species. These broad definitions of risk are used to define the parameters of the risk analysis and to explicitly describe the consequence that is being adopted at each step of the risk assessment. That is, the consequences for which we wish to mitigate risk are: (a) widespread degradation of major ecological processes, biodiversity and habitats; and (b) ecologically unsustainable levels of populations and communities of primary and key secondary species, bycatch species and protected and threatened species.

b) Broad Scale Analysis

Risk identification

To identify areas of risk the OTF was divided into its individual activities (e.g. harvesting levels for retained species, discarding of non-retained species, physical impact of trawling etc; see Table B2.2). The link between these activities and the broad components of the ecosystem was examined and levels of risk assigned (Table B2.3). It's important to note that the activities of the fishery can affect the environment both directly and indirectly and the risks of all of these effects need to be considered in the analysis.

Table B2.2 Description of activities of the OTF that interact with the environment.

Activity	Description
Trawling	Deployment, towing and retrieval of trawl net by the fishing boat
Harvesting	Capture and retaining of fish for sale
Discarding	Returning unwanted catch to sea
Contact without capture	Contact of trawl net with components of the environment whilst being towed but which do not capture any part of the environment
Loss of fishing gear	Partial or complete loss from the boat of nets, warps and otter boards
Travel to/from grounds	Steaming of boat from port to fishing grounds & return
Disturbance due to presence in the area	Stationary boat on the water whilst on-board activities take place
Boat maintenance & emissions	Tasks that involve fuel, oil or other engine & hull related activites that could be accidently spilled or leaked into the sea or air
Marketing	Sale of fish to a registered fish reciever

Risk characterisation

Table B2.3 summarises the level of risk the various activities of the OTF pose on each ecological component of the fishery (economic and social are addressed in Sections B4 & 5). It also indicates whether the activities potentially exert a direct or indirect effect, or both, on the component. A direct effect occurs when the activity itself can cause some change (not necessarily permanent) to the component (e.g. harvesting has a direct effect on fish kept for sale). An indirect effect occurs when the activity causes some change to the component via its effect on something else (e.g. trawling damages habitat that some primary species rely on and so affects their ecology). The highest levels of risk all occur in the three major activities of the fishery – trawling, harvesting and discarding. These activities were examined in more detail for each ecological component (see Sections B2.3-2.6). The areas of the environment with no or negligible risk are justified below and will not be considered further in the finer scale risk analysis. The remaining components of the ecosystem which have a risk level that is greater than negligible were examined to determine the extent and types of risks posed by the OTF.

There were a number of activities of the fishery which posed no or negligible risk to the ecological sustainability of some components of the environment. Justification of the risk levels for these components is given below.

Table B2.3 Levels of risk posed on each component of the environment by the activities of the OTF at a broad scale.

	Activities of the Ocean Trawl Fishery							
Component	Trawling (physical damage)	Harvesting (what's kept)	Discarding (what's returned to sea)	Contact but not capture	Loss of fishing gear	Travel to/from grounds	Disturbance due to presence in the area	Boat maintenance & emissions
Primary & key secondary species	H↯	H↙	H↙	M↙	L↙		-	-
Secondary & minor byproduct species	H↯	H↙	H↙	M↙	L↙		-	-
Bycatch species	H↯		H↙	M↙	L↙		-	-
Bait sources	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Threatened & protected species:								
Reptiles -	M↙↯				L↙	L↙	L↙	
Mammals & birds -				L↙	L↙	M↙	M↙	
Fish -	H↯		H↙	M↙	L↙	L↙	L↙	-
Species assemblages & diversity, ecological processes	H↯	H↯↙	H↯↙	L↙	-	-	-	L↙
Marine habitats	H↙			M↙	L↙	-	-	L↙

H = high risk, M = moderate risk, L = low risk, - = negligible risk, blank = not applicable, ↙ = direct, ↯ = indirect effect.

Components with no or negligible risk from the activities of the OTF

Bait is not used in the OTF and therefore none of the activities of the fishery pose a risk to bait species (apart from direct capture as part of bycatch) and are not considered further in the EIS.

The physical act of trawling has direct and indirect impacts on all components of the ecosystem. These components will be will be covered in more detail at the finer scale risk analysis below.

Levels of harvesting for retained species poses no risk to bycatch species (i.e. non-retained) and threatened and protected species because by definition these species are not kept for sale. Similarly, marine habitats are not at risk from harvesting because habitat is not landed for sale. Damage to habitats is primarily done through the activity of trawling.

Discarding poses no risk to marine habitats because any material brought up in the net has already been impacted by the trawling activity itself. Furthermore, because discarding is primarily done while the vessel is moving there is no accumulation of discard material at anyone place on the bottom, thus avoiding concentrated massive decomposition events changing the bottom's habitat quality.

Contact but not capture poses a risk to all components of the ecosystem because of the unknown effects of the interaction between fishing gear and the survival of species and habitats. This will be dealt with in more detail at the finer scale risk analysis.

Loss of fishing gear is negligible for species assemblages, ecological processes and species diversity. This is due to the apparently low incidence of lost gear in OTF and the small overlap between lost gear and the large range of spatial and temporal scales of ecological processes and diversity.

Travel to and from fishing grounds poses no risk to primary and key secondary species and bycatch species as there is no overlap between this activity and these species. There is negligible risk to ecological processes and aquatic habitats from travel to and from fishing grounds as any interference from the boat would only be for a short period of time.

Disturbance due to the presence of a fishing vessel in the area is a negligible risk to primary and key secondary species, ecological processes and marine habitats. There is infrequent overlap between this activity and these components. The magnitude of any effects from this activity would be small compared to other activities, such as trawling and harvesting.

Boat maintenance and emissions are a negligible risk to primary and key secondary species, bycatch species and threatened and protected species. There is little overlap between these components and activities and consequently any effects will be small in comparison to the effects of other activities of the fishery.

2.3 Risk Analysis of Primary and Key Secondary Species

The species covered in this section includes finfish and shellfish species that were reported as retained in the OTF in year 2000/2001. Primary, key secondary and secondary species are those species that the fishery captures in large quantities on a consistent basis and comprise 99% of the reported landed catch in 2000/01. These species groups are defined in Section B1.2b). The remaining species are those that are part of the remaining 1% portion of the landed catch known as “other species”. This section will also include commercial species that are discarded either because they are undersized or are unmarketable in some periods.

a) General Fishery Information on Species

i) Primary, key secondary and secondary species

In 2000/01 43 species comprised 99% of the reported landings of the Ocean Trawl fishery (Table B2.4). This consisted of 33 species groups of finfish, 5 species groups of crustaceans and 5 species groups of molluscs. General descriptions of the biology and ecology of these species are given in Appendix D7. The top ten finfish species contributed to 87% of the total landings of finfish in 2000/2001. The three main prawn species contributed 95% of the total landings of crustaceans and four mollusc groups (comprising octopus, squids, shells and cuttlefish) contributed almost the total of mollusc landings.

Table B2.4. List of primary, key secondary and secondary species landed in the ocean prawn and fish trawl fishery during 2000/01. Species listed in order of importance. Weight in tonnes.

Species in 99% Landings	Species Type	OPT	FT	TOTAL OTF
Fish				
Whiting, School	P	689.74	264.67	954.41
Flathead, Tiger	P	2.21	151.54	153.76
Flathead, Sand	P	54.88	64.93	119.81
Trevally, Silver	P	0.20	112.47	112.68
Shark, Fiddler	P	33.39	75.60	108.99
Latchet / Gurnard	K2	1.98	36.74	38.72
Dory, John	K2	5.28	25.85	31.13
Shark, Angel	K2	6.00	23.29	29.29
Flounder (all species)	K2	17.55	11.03	28.58
Mullet, Red	K2	19.35	3.38	22.73
Redfish	K2	1.86	19.38	21.23
Leatherjacket (mixed spp)	K2	4.02	16.91	20.93
Shark, Unspecified	K2	11.41	8.63	20.05
Perch, Ocean	K2	6.68	12.30	18.98
Shark, Saw	K2	1.22	13.83	15.05
Sole, mixed	K2	9.70	1.84	11.54
Morwong, Rubberlip	K2	1.35	8.51	9.86
Dory, Mirror	K2	1.67	8.05	9.72
Moonfish (Pink tilefish)	K2	3.71	1.47	5.18
Boarfish	K2	3.16	1.72	4.88
Yellowtail	S	4.78	14.32	19.10
Stingray	S	0.51	14.43	14.94
Shark, Gummy	S	5.21	7.67	12.87
Tarwhine	S	0.82	8.31	9.13
Flathead, Dusky	S	4.19	4.45	8.64
Shark (whalers)	S	6.25	1.17	7.42
Bream, Black and Yellowfin	S	0.33	6.89	7.23
Shark, Dogfish Greeneye	S	3.76	3.16	6.91
Shark, Carpet	S	3.28	2.85	6.13
Shark, Dogfish Endeavour	S	0.65	3.41	4.06
Silver biddy	S	0.40	2.69	3.09
Trumpeter	S	0.06	2.62	2.68
Sub Total		905.62	934.08	1839.70

Species in 99% Landings	Species Type	OPT	FT	TOTAL OTF
Crustaceans				
Prawn, Eastern King	P	953.37	0.02	953.39
Prawn, School	P	325.91	0.00	325.91
Prawn, Royal Red	P	209.85	0.83	210.68
Crab, Blue Swimmer	K2	44.63	2.54	47.16
Bug, Balmain	P	28.45	2.42	30.88
Prawn, Unspecified Ocean	S	24.66	0.01	24.67
Sub Total		1586.88	5.81	1592.69
Molluscs				
Octopus	P	424.88	16.23	441.10
Cuttlefish	P	112.96	47.59	160.55
Calamari, Southern	P	10.78	62.36	73.14
Squid	K2	54.04	12.85	66.90
Shells	S	4.44	2.41	6.84
Sub Total		607.10	141.44	748.54
Total - 43 species		3099.60	1081.33	4180.94

OPT – Ocean prawn trawl; FT – Ocean fish trawl; OTF – Ocean trawl fishery, P – primary, K2 – key secondary, S – secondary.

Catch Trends

Six of the top 12 finfish species have shown declines in landings over the last 10 to 20 years (see figures in Appendix D7, and Table B2.5). Prior to 1997/98 whiting landings were increasing but have declined in the last three years, reportedly due to the introduction of bycatch reduction devices in prawn trawl nets. A number of species have shown marked declines and then stabilised at a lower level. Sand flathead declined in the late 1980s to 120 tonnes which is approximately half of its former peak and has fluctuated, sometimes by 40 – 60 tonnes, below this level. It is believed that this decline was due to a change in reporting (K. Rowling, NSW Fisheries, pers. comm., 2003). Silver trevally has declined steadily since the mid 1980s to approximately 10% of its former peak and is considered growth overfished (Rowling and Raines, 2000). Similarly John Dory shows a general decline since the mid 1990s, however, this species is primarily caught as byproduct in NSW waters and declines may reflect fishing effort or environmental factors rather than actual abundances. Fluctuation in catches over 20 years can't be explained by changes in fishing effort alone. Redfish has seen the greatest decline in landings. Since the mid 1980s landings have declined to 25% of its former peak in fish trawls. This species is fished heavily in the South East Trawl fishery which has also seen major declines and fluctuation in landings and is considered growth overfished (Rowling, 2001). Landings of leatherjackets were highly variable but have improved in the late 1990s.

The remaining finfish species in the top 12 either show highly variable catch trends (e.g. flounder species) or are relatively stable (e.g. tiger flathead). It is concerning that a large proportion of the primary and key secondary finfish species have shown declines or have started to decline in the OTF in the last decade (Table B2.5, figures in Appendix D7).

The three main prawn species have had variable catch levels. Eastern king prawns fluctuated between 500-800 tonnes from 1985 to 1998 and since then have increased to approximately 1000 tonnes in 2000/01. Catch rate of eastern king prawns has increased since 1996/97 but the stock as a whole is considered growth overfished (NSW Fisheries, 2002). Landings of school prawns show a sharp decline from a peak in 1988/89 to about 100 tonnes and has fluctuated at this level. There was an increase in landings in 2000/01 to 400 tonnes (figures Appendix D7). Catch rates have declined since 1990. The stock of school prawns as a whole is considered to be growth overfished taking into account significant catches of small prawns in estuaries (Montgomery, 1999). Royal red prawn landings increased to 400-500 tonnes in 1989-1992 and had large fluctuations up until 1996/97. Since then there has been a large decline in landings to less than 200 tonnes where they currently appear to have stabilised (this decline may be due to market factors, see Appendix D7). Although catch rates have fluctuated overall they remain steady for royal red prawns.

Of the remaining primary, key secondary and secondary shellfish species in 99% of the landed catch Balmain bugs, cuttlefish and squids have shown declines in landings since 1996/97, 1995/96 and 1993/94 respectively (Table B2.5). Landings of blue swimmer crabs have increased since 1998/99 to a peak of 35 tonnes in 2000/01 and octopus have been relatively stable since increasing to 300 tonnes in 1991/92. Southern calamari have had steady landings since 1990/91 (Table B2.5).

Table B2.5 Summary of catch trends for 12 finfish species and major shellfish species in the OTF.

Species (99% of catch)	Species Type	NSW Commercial Fishery Catch Trends for OTF
Fish		
Whiting, School	P	800-1000t stable; general increase in catches over last 14 years but declining in last 3 years due BRD introduction in prawn trawl
Flathead, Tiger	P	80-100t stable since late 1980s
Flathead, Sand	P	100-140t recently stable; declined in late 1980s to approximately half of its peak, then has remained stable at 120-150t since.
Trevally, Silver	P	100t declining; steady decline since mid 1980s to approximately 10% of its peak in mid 1980s to < 50t in 2000/2001
Shark, Fiddler	P	100-120t stable; consistent level of landings since 1994/95
Latchet / Gurnard	K2	Relatively stable but high annual variability in fish
Dory, John	K2	Caught primarily as bycatch, therefore catch depends on fishing effort for other species; general decline in catches since mid 1990s by approximately one third
Shark, Angel	K2	stable for approximately 9 years since late 1980s, declining since 1999
Flounder (all species)	K2	substantial increase in catches from late 1980s to mid 1990s then stable, but large annual variability
Mullet, Red	K2	Large peak in catches in late 1990s then declining by approximately 50% in 2000/01
Redfish	K2	declining since mid 1980s by approximately 50% of peak in mid 1980s
Leatherjacket (mixed spp)	K2	large annual variability, declining in fish trawl since late 1990s, recent increase
Crustaceans		
Prawn, Eastern King	P	Steady with fluctuation between 500t-800t from 85-97/98; increase since 96/97 to c. 1000t in 00/01
Prawn, School	P	Peaked in 88/89, sharp decline next 2yr, then fluctuate at 25% of peak of about 100t, increase in 00/01 to 400t
Prawn, Royal Red	P	From 85/86 to 88/89 steady at 200t, increase in 89/92 to 400-500t, large fluctuations c. 300-500t until 96/97, large decline to < 200t & fluctuated at this level since
Crab, Blue Swimmer	K2	Peaked in 91/92 30t then fell to steady at 15-20t, increase from 98/99 to 35t in 2000/01
Bug, Balmain	P	increase from 89/90, peaked in 96/97 at c.150-160t, declined since to c.50t since
Molluscs		
Octopus	P	steady increase from 84/85 to 91/92 c.400-600t; relatively stable since c. 600t
Cuttlefish	P	increased in most years since from 84/85 to 94/95 & fallen most years since
Calamari, Southern	P	Steady since 90/91 c.20-70t
Squid	K2	Large fluctuations of c.100-200t from 84/85 to 92/93; decline to c.90t since but fluctuating
Shells	S	Peaked in 84/85, sharp decline to 12% of peak in 86/87; large fluctuations since between 2-8t

Source: NSW Fisheries Status Report, 2000/01; P – primary, K2 – key secondary, S - secondary

Fishing Pressure

All the primary, key secondary and secondary species are also fished by other NSW fishing sectors. Figure B2.3 shows the proportion of total annual catch for finfish species by weight in the OTF and other commercial fishing sectors in NSW in 2000/2001. Clearly, for most species the OTF takes the largest proportion of the total catch, often close to 100%. The OTF therefore exerts the largest fishing pressure on these species of the commercial fisheries in NSW. Table B2.6 shows the approximate annual catches in all relevant fishing sectors including all Commonwealth South East Fisheries and the NSW recreational fishery. Victorian and Queensland commercial fisheries also target some of the same species as the OTF in NSW and the proportion of the landings taken by these fishing sectors has not been included in this table. Therefore, for some species the proportion attributed to the OTF will be an overestimate. OTF takes greater than 50% of the total catch for 12 species, including fiddler sharks, school whiting and eastern king prawn (Table B2.6). OTF exerted proportionally low pressure on redfish of only 2% of the total catch, but this species is heavily fished by the South East trawl fishery, which has also shown declines in catches and is regarded as growth overfished (Rowling, 2001).

Of the shellfish species, the OTF takes the greatest proportion of reported landings in NSW for eastern king prawns, royal red prawns, Balmain bug, octopus, squid, cuttlefish and southern calamari (Figure B2.4). The Queensland fishery takes the largest proportion of the landed catch of eastern king prawns on the east coast, in the order of 1500-2000t annually. Blue swimmer crabs and school prawns are taken in larger proportions by the estuary general and estuary prawn trawl fisheries. It is important to note that the estuarine fisheries land school prawns at a smaller size than ocean prawn trawlers and therefore will be having a different impact on this species than the OTF which catches primarily adult school prawns. In addition, recreational fishers land large quantities of blue swimmer crabs (Henry and Lyle, 2003). Quantities of other shellfish species taken by the recreational sector could not be determined with any accuracy because identification of species was uncertain in the National Recreational Survey (Table B2.6).

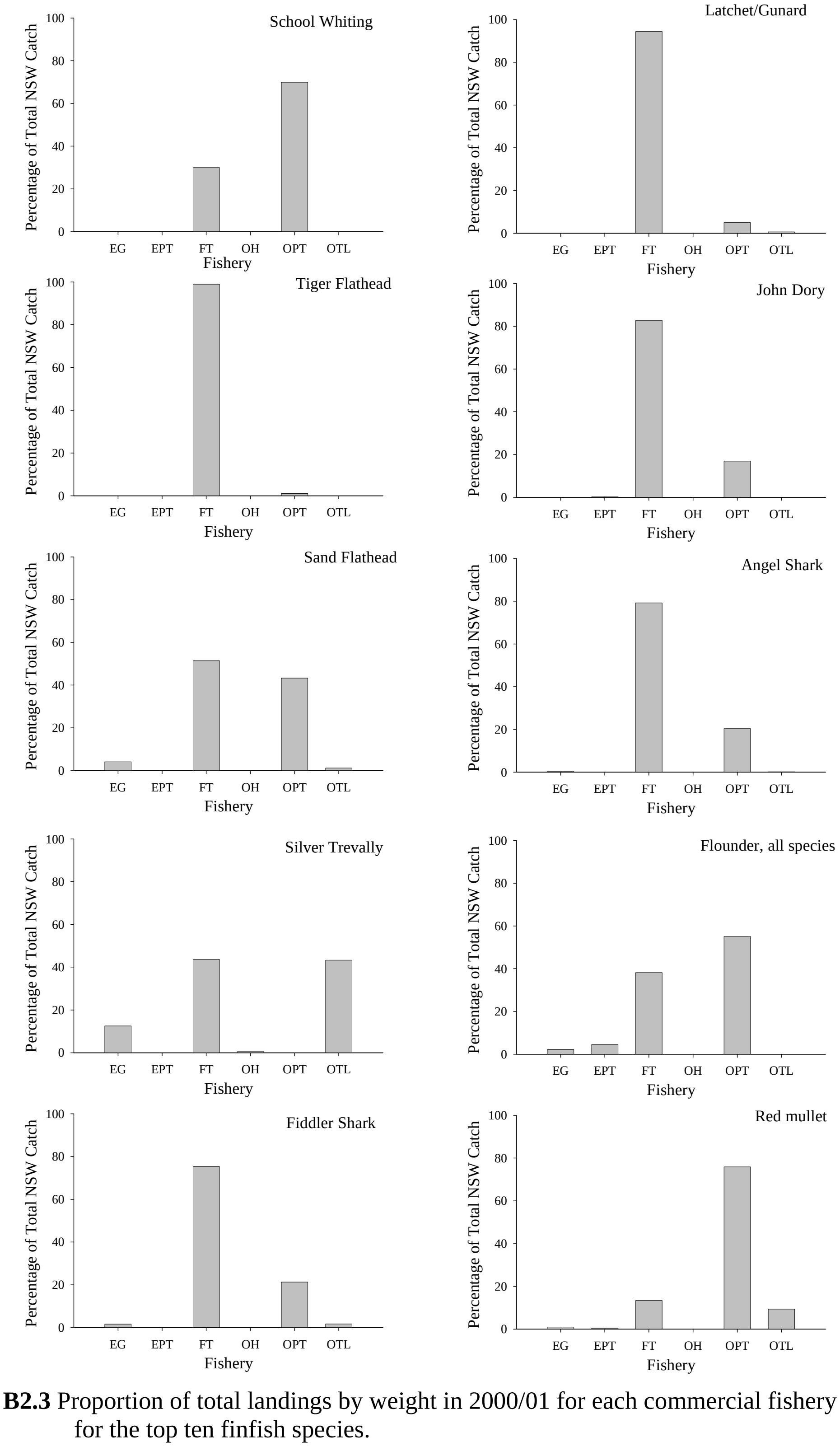


Figure B2.3 Proportion of total landings by weight in 2000/01 for each commercial fishery in NSW for the top ten finfish species.

EG – estuary general, EPT – estuary prawn trawl, FT – fish trawl, OH – ocean hauling, OPT – ocean prawn trawl, OTL – ocean trap and line.

Table B2.6 Reported landings of finfish and shellfish species taken in 99% of the OTF landings for all fishing sectors within NSW waters (except SEF data) and the proportion of total landings taken by the OTF. * all species of flathead included. See text for explanation.

Species in 99% of Landings	Species Type (OTF) - P, K2, S	NSW Recreational Harvest (2000) tonnes	All SEF Landings tonnes (trawl only)	All SEF Landings tonnes (non-trawl only)	All other NSW Commercial sectors	Total OTF tonnes	Total Commercial tonnes	Total all Landings	Proport'n OTF of total percentage
Whiting, School	P	89.83♰	496.50	0.00	0.46	936.77	1433.74	1433.74	65
Flathead all*		509.75	2630.60	0.50	165.95	282.20	3079.24	3588.99	8
Trevally, Silver	P	63.84	121.00	1.39	145.22	112.68	380.29	444.13	25
Shark, Fiddler	P	•			3.18	108.99	112.17	112.17	97
Latchet / Gurnard	K2	7.22	373.30	0.90	0.32	38.72	413.24	420.46	9
Dory, John	K2	•	143.00	0.03	0.10	31.13	174.25	174.25	18
Shark, Angel	K2		36.70		0.13	29.29	66.12	66.12	44
Flounder (all species)	K2	2.66	1.54		2.13	28.58	32.24	34.91	82
Mullet, Red	K2	1.64	3.60		2.72	22.73	29.05	30.68	74
Redfish	K2	22.97	773.50	1.89	8.13	21.23	804.75	827.72	3
Leatherjacket (mixed spp)	K2	89.44	69.10	0.02	104.77	20.93	194.82	284.26	7
Yellowtail	S	19.44✞			425.25	19.10	444.35	463.79	4
Perch, Ocean	K2	•	352.10	8.29	7.25	18.98	386.62	386.62	5
Shark, Saw	K2		49.50	0.09	0.03	15.05	64.67	64.67	23
Stingray	S				4.59	14.94	19.53	19.53	77
Shark, Gummy	S	•	1.82	0.87	19.99	12.87	35.55	35.55	36
Sole, mixed	K2	•			0.34	10.38	10.72	10.72	97
Dory, Mirror	K2		239.07	0.16	0.00	9.91	249.14	249.14	4
Tarwhine	S	11.40	0.18		61.90	9.13	71.21	82.61	11
Morwong, Rubberlip	K2	88.10			71.39	8.82	80.21	168.31	5
Shark, Dogfish Greeneye	S		23.50	0.07	1.31	7.44	32.32	32.32	23
Bream, Black and Yellowfin	S	359.22	2.48		280.25	7.23	289.96	649.18	1
Shark, Carpet	S	•			51.56	6.13	57.69	57.69	11
Moonfish (Pink tilefish)	K2				0.05	5.18	5.23	5.23	99
Boarfish	K2		4.76	11.50	0.01	4.88	21.15	21.15	23
Shark, Black Tip	S				38.06	4.67	42.73	42.73	11
Ling	S		1465.30	231.00	4.56	4.57	1705.43	1705.43	0
Shark, Dogfish Endeavour	S		12.30	0.09	3.69	4.41	20.50	20.50	22
Silver biddy	S				129.11	3.09	132.21	132.21	2
Trumpeter	S	0.03			8.20	2.68	10.88	10.91	25
Crustaceans									
Prawn, Eastern King	P	•			43.42	953.39	996.82	996.82	96
Prawn, School	P				705.02	325.91	1030.93	1030.93	32
Prawn, Royal Red	P		283.00	0.00	0.02	210.68	493.70	493.70	43
Crab, Blue Swimmer	K2	4.86✞			104.98	47.16	152.14	157.00	30
Bug, Balmain	P		83.00		0.00	30.88	113.88	113.88	27
Molluscs									
Octopus	P	•	62.30	0.25	12.39	441.10	516.05	516.05	85
Cuttlefish	P	0.23	99.90	0.01	4.02	160.55	264.49	264.72	61
Calamari, Southern	P	•			6.72	73.14	79.87	79.87	92
Squid	K2	6.30	829.30	0.18	30.26	66.90	926.64	932.94	7
Shells	S		3.30	0.11	0.11	6.84	10.37	10.37	66

✞ - likely to be an underestimate, data not accurate; ● - significant recreational catch; ♰ – probably includes >1 species
NSW Recreational Harvest based on National Recreational Survey (2000)

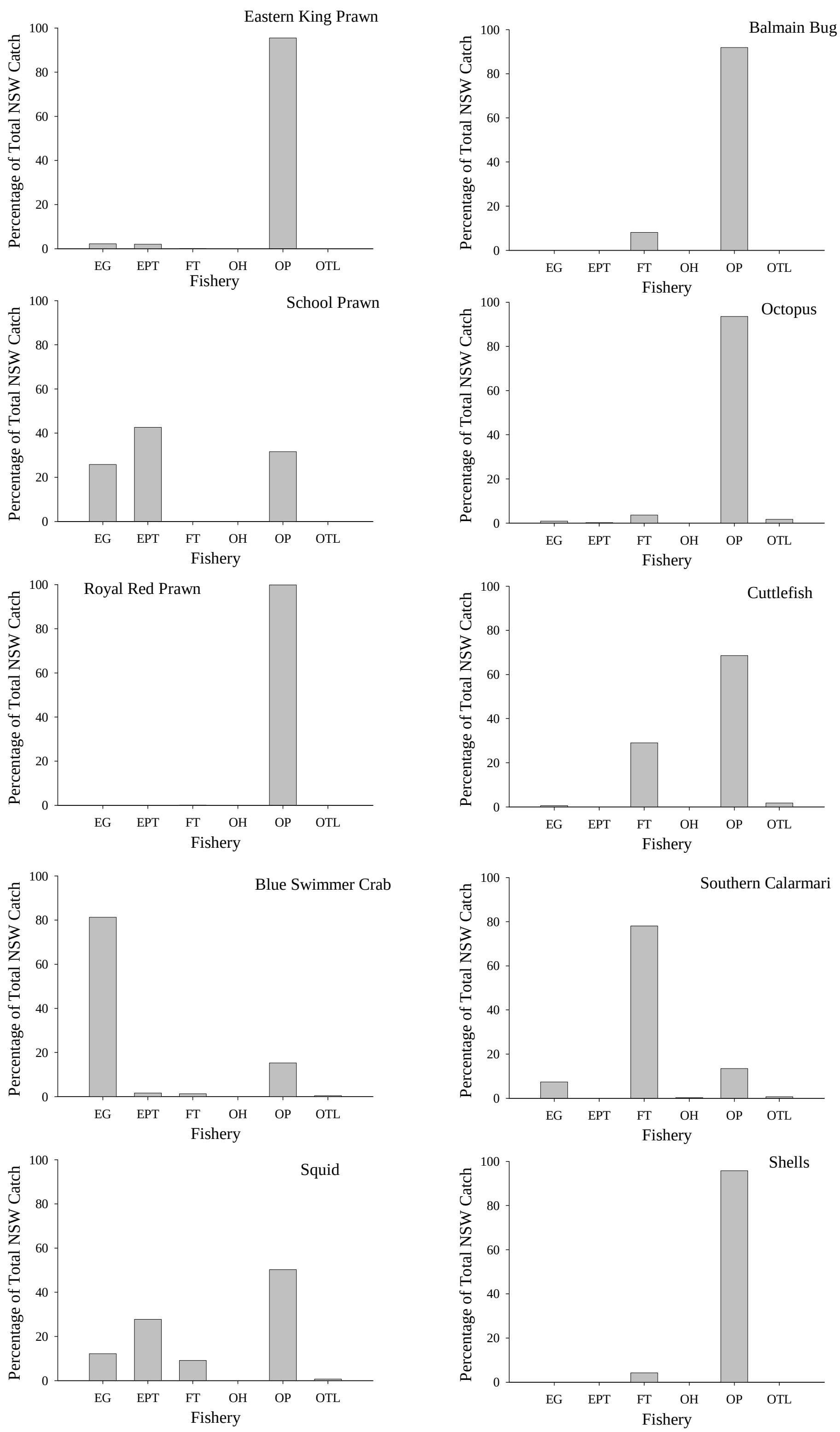


Figure B2.4 Proportion of total landings by weight in 2000/01 for each commercial fishery in NSW for ten shellfish species.

EG – estuary general, EPT – estuary prawn trawl, FT – fish trawl, OH – ocean hauling, OPT – ocean prawn trawl, OTL – ocean trap and line.

Discard of commercial species

Discards of commercial species occur in NSW OTF when they are too small, have low economic value or have a legal size limit (Kennelly, 1995; Cook, 2001). Discarding can be a serious problem in trawl fisheries as many finfish species do not survive (Dayton *et al*., 1995; Hill and Wassenberg, 2000) thereby increasing actual fishing mortality, potentially by a substantial amount. Levels of discarding are difficult to quantify and the most reliable way is through observer surveys on commercial vessels (Liggins, 1996; Kennelly *et al*., 1998). Liggins (1996) has done the only observer surveys on the NSW ocean fish trawl fishery. His study showed that there was a high degree of spatial and temporal variability in the composition and size of bycatch for fish trawlers. Importantly, he also found that the proportion of discarded catch, by weight, was about the same as the retained catch (Figure B2.5). Individual levels of discards (by weight) estimated by Liggins (1996) for some of the primary and key secondary species in the OTF and SEF are summarised in Table B2.7. Inshore ocean perch had the largest proportion of discarding, followed by rubberlip mowong and redfish. The species with the largest quantity of fish discarded was redfish (1187 tonnes). It should be noted that the South East trawl fishery (which is managed by the Commonwealth) is the major harvester of redfish in NSW (Table B2.6) and discards a greater volume of fish than the reported catch of the OTF due to the inappropriate selectivity of the trawl gear being used in that fishery.

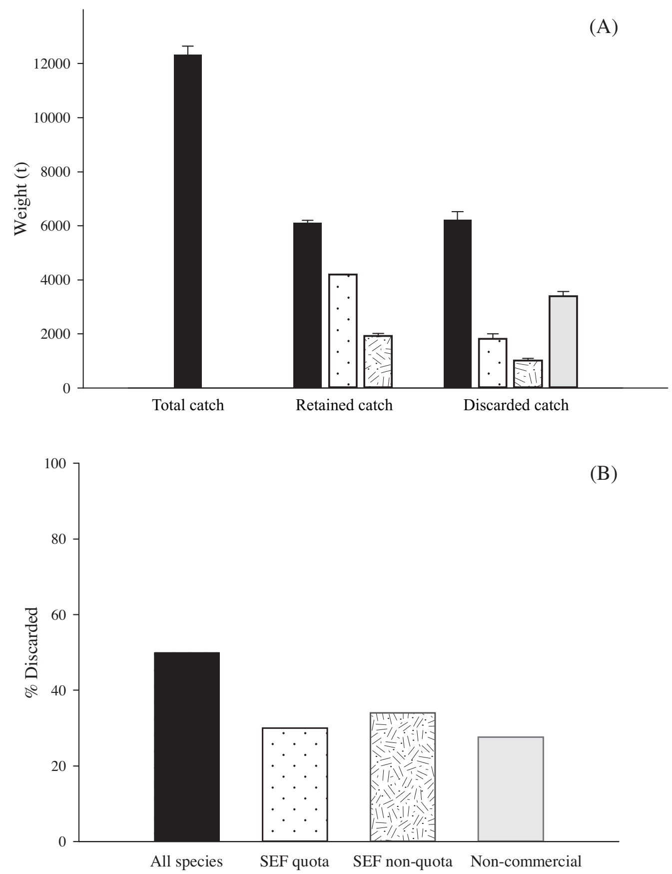


Figure B2.5. (A) Mean weight of landed catch (±SE) in tonnes of ocean fish trawlers from 4 ports in NSW. (B) Percentage of catch discarded. SEF – South East Fishery (Commonwealth Fishery). Source: Liggins, 1996

Table B2.7 Estimated annual discard weights (t) ± SE for some of the primary, key secondary and secondary commercial species for fish trawls from four ports in NSW.

Note: includes catches in both OTF and SEF

Species of fish in OTF	Species Type	Total catch	Retained	Discarded	% Discard
Perch, Ocean (inshore)	K2	145 (17)	22 (3)	123 (16)	85
Morwong, Rubberlip	K2	48 (4)	18 (1)	30 (4)	63
Redfish	K2	2303 (174)	1116 (5)	1187 (173)	52
Dory, Mirror	K2	177 (28)	99 (0)	78 (28)	44
Perch, Ocean (offshore)	K2	176 (17)	105 (11)	71 (11)	40
Flathead, Tiger	P	671 (12)	582 (4)	89 (11)	13
Shark, Gummy	S	25 (2)	24 (2)	1 (1)	4
Dory, John	K2	143 (3)	138 (3)	5 (1)	3
Trevally, Silver	P	388 (19)	386 (19)	2 (1)	1
Shark, Angel	K2	93 (7)	93 (7)	0	0

Source: Liggins, 1996

For the ocean prawn trawl sector Kennelly *et al*. (1998) found that, for the ports examined, discarded bycatch was several times larger than the retained catch of prawns (Figure B2.6). It was estimated that for the period 1990 to 1992 in catching 1578 tonnes of prawns 16435 tonnes of bycatch was landed, with a bycatch to prawn ratio of 10.4:1. It was further estimated that 2953 tonnes of the bycatch was retained and 13459 tonnes discarded (74.7% of the total catch). The proportion of discarded catch consisting of commercial species was 13.9% with the bulk being non-commercial species (60.8%) (Figure B2.6).

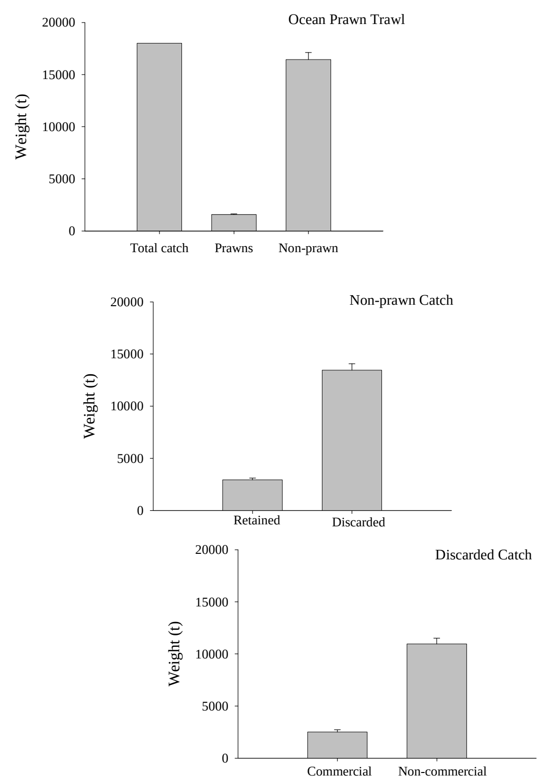


Figure B2.6. Mean weight of catch (tonnes), showing quantities of its components of prawns, non-prawn and discarded catch, for ocean prawn trawlers from selected ports on NSW coast. *Source*: Kennelly *et al*., 1998

The levels of discarding reported by Kennelly *et al.* (1998) and Liggins (1996) should only be taken as an indication of the possible current discard levels and not actual current levels. Bycatch reduction devices (BRD) were introduced for prawn trawl nets in July 1999, after Kennelly *et al*.'s (1998) study was done. In addition, their study did not include species specific information on all commercial discard species caught during the study and Liggins (1996) did not record individual weights of discarded species. More recent information is required on bycatch composition and quantity in the OTF to assess the severity or otherwise of discarding of commercial species in this fishery.

ii) Other retained species

The Ocean Trawl fishery landed 90 species in 2000/2001 comprising 1% of landings (Table B2.8). The 1% portion of the landed catch consisted of 75 species groups of finfish, 14 species groups of crustaceans and 1 species group of mollusc. These species and the secondary species in the 99% portion of the catch are referred to as byproduct species because they are not specifically targeted by the fishery, but are retained when captured because of their commercial value.

Table B2.8. List of other retained species caught in the Ocean Trawl fishery during 2000/01 that made up 1% of the catch. Species listed in order of magnitude by weight in tonnes.

1% of catch	OPT	OFT	Total
Fish			
Snapper	0.9	1.8	2.7
Flathead, Marbled	1.8	0.4	2.1
Ling	< 0.1	1.8	1.8
Mulloway	0.3	1.2	1.5
Cod, Unspecified	1.4	< 0.1	1.5
Shark, Roughskin	< 0.1	1.4	1.4
Morwong, Jackass	< 0.1	1.4	1.4
Warehou (all species)	< 0.1	1.3	1.3
Tailor	0.2	1.0	1.2
Whiting, Sand	0.4	0.8	1.2
Shark, Ghost	0.4	0.7	1.1
Mackerel, Blue	0.4	0.6	1.0
Ribbonfish	0.2	0.6	0.7
Teraglin	0.2	0.5	0.7
Shark, Hammerhead	0.2	0.5	0.7
Eel, Unspecified	0.3	0.4	0.7
Mackerel, Jack	< 0.1	0.6	0.6
Barracouta	< 0.1	0.6	0.6
Hairtail	0.1	0.5	0.6
Stargazer	0.3	0.2	0.5
Cod, Bar	0.4	0.1	0.5
Flathead, Ghost	0.5	0.0	0.5
Gemfish	0.1	0.3	0.4
Perch, Orange	< 0.1	0.4	0.4
Dory, Silver	< 0.1	0.4	0.4
Australian salmon	< 0.1	0.4	0.4
Kingfish, Yellowtail	0.3	0.1	0.4
Shark, tiger	0.2	0.1	0.3
Cobia	0.3	0.0	0.3
Orange Roughy	< 0.1	0.3	0.3
Mullet, Sea	0.2	< 0.1	0.2
Pike	0.1	0.1	0.2
Cod, Red Rock	0.2	0.0	0.2
Catfish, Unspecified	0.1	0.1	0.2
Perch, Pearl	0.1	< 0.1	0.1
Bullseye, Red	0.1	< 0.1	0.1
Whiting, Trumpeter	< 0.1	0.1	0.1
Eel, Pike	0.1	< 0.1	0.1
Surgeonfish	0.1	< 0.1	0.1
Longtom	0.1	< 0.1	0.1
Flutemouth	< 0.1	0.1	0.1
Perch, Unspecified	< 0.1	0.1	0.1
Eel, Conger	0.1	< 0.1	0.1
Old Maid	< 0.1	0.1	0.1
Parrotfish	0.1	< 0.1	0.1
Mullet, Unspecified	< 0.1	0.1	0.1
Pilchard	< 0.1	0.1	0.1

1% of catch (ctd)	OPT	OFT	Total
Fish			
Pigfish	0.04	< 0.01	0.05
Hapuku	0.02	0.02	0.04
Rainbow Runner	0.04	< 0.01	0.04
Oilfish	0.04	< 0.01	0.04
Mackerel, Unspec.	< 0.01	0.03	0.03
Sergeant Baker	< 0.01	0.03	0.03
Dolphinfish	0.03	< 0.01	0.03
Shark, Dogfish Unspecified	0.03	< 0.01	0.03
Samson Fish	0.01	0.01	0.03
Swordfish, Broadbill	< 0.01	0.02	0.02
Rudderfish	< 0.01	0.02	0.02
Bonito	0.01	0.01	0.02
Sweep	< 0.01	0.02	0.02
Dory, Unspecified	< 0.01	0.01	0.01
Catfish, Forktailed	0.01	< 0.01	0.01
Trevally, bigeye	< 0.01	0.01	0.01
Blue-eye	< 0.01	0.01	0.01
Tuna, Mackerel	0.01	< 0.01	0.01
Garfish, Unspecified	0.01	< 0.01	0.01
Bass groper	< 0.01	0.01	0.01
Grenadier, Blue	< 0.01	0.01	0.01
Trevally, Black	0.01	< 0.01	0.01
Cod, Maori	< 0.01	< 0.01	< 0.01
Drummer	< 0.01	< 0.01	< 0.01
Morwong, Red	< 0.01	< 0.01	< 0.01
Luderick	< 0.01	< 0.01	< 0.01
Sweetlip, Unspecified	< 0.01	< 0.01	< 0.01
Perch, Moses	< 0.01	< 0.01	< 0.01
Sub Total	10.16	19.24	29.40
Crustaceans			
Bug, Deepwater	2.53	0.02	2.55
Prawn, Tiger	1.74	0.09	1.82
Crab, Unspecified	1.48	0.05	1.53
Crab, Three spotted	1.50	0.01	1.51
Prawn, Racek	0.57	< 0.01	0.57
Prawn, Scarlet	0.37	0.03	0.39
Spanner crab	0.23	< 0.01	0.23
Crab, Mud	0.13	< 0.01	0.13
Prawn, Endeavour	0.01	< 0.01	0.01
Crab, Coral	0.11	< 0.01	0.11
Prawn, Carid	0.06	< 0.01	0.06
Shrimp, Mantis	0.01	0.01	0.02
Lobster, Unspecified	< 0.01	< 0.01	< 0.01
Lobster, Slipper	< 0.01	< 0.01	< 0.01
Sub Total	8.73	0.20	8.93
Molluscs			
Scallop	0.42	< 0.01	0.42
1% Total - 90 species	19.31	19.44	38.75

Catch Trends

Catch trends of species in the 1% portion of the catch reflect both changes in fishing effort and changes to species identification and reporting. Consequently, catches of most of the byproduct species were highly variable.

Harvest Pressure

Harvest pressure on the other 1% portion of the catch is by definition very low. Table B2.9 shows which of these is a major species (i.e. in top 80-90% of their catches) in other NSW commercial and recreational fisheries. Only 13 finfish species and one crustacean species are major species in other NSW fisheries. The majority of the species are not part of the major catches of the other fisheries (except recreational), indicating that overall they are not subject to large fishing pressure from commercial fishing. It should be noted that the recreational fishing sector takes a wide range of species that would include these other species, sometimes in large amounts (Henry and Lyle, 2003).

Table B2.9 Summary of species taken in 1% portion of the OTF catch (2000/01) that are major species taken in other NSW fisheries.

Species in 1% of OTF	EPT	OH	EG	OTL	Rec
Snapper				✓	✓
Morwong, Jackass				✓	✓
Tailor		✓		✓	✓
Whiting, Sand			✓		✓
Mackerel, Blue		✓			✓
Teraglin				✓	✓
Australian salmon		✓			✓
Kingfish, Yellowtail				✓	✓
Mullet, Sea		✓	✓		
Bullseye, Red				✓	✓
Whiting, Trumpeter	✓				✓
Bonito				✓	✓
Luderick		✓	✓		✓
Crab, Mud			✓		✓

Fisheries: EPT – estuary prawn trawl, OH – ocean hauling, EG – estuary general, OTL – ocean trap and line, Rec – recreational.

Discard of other commercial species

There is little information for NSW OTF about the level of discarding of species in the 1% portion of the landings. Table B2.10 summarises discard levels for some species of in the 1% portion of the OTF catches recorded by Liggins (1996) which are only indicative of the possible discard rates in the OTF. Species of greatest concern is gemfish, with a discard level of 72% (mean weight 146 tonnes). Recent assessments of gemfish have concluded that stocks have been very significantly reduced by prolonged recruitment failure and fishing pressure in the SEF. The stock is now determined to be well below the level considered necessary for a viable population (Rowling and Makin, 2001). Therefore, any additional pressure placed on this species from discarding in the OTF could be having a significant impact. Some of the other species may only be landed sporadically depending on market trends and fisher's individual practices, so discarding might be substantial at certain times.

Table B2.10 Summary of annual discard levels of some species in the other OTF commercial group. Based on Liggins (1996) and is indicative only.

Note: includes catches in both OTF and SEF

Species	Discarded	% Discarded
Jack mackeral	156 (25)	80
Gemfish	146 (71)	72
Silver dory	42 (4)	56
Snapper	5 (1)	51
Barracouta	202 (47)	44
Mulloway	2 (1)	39
Tailor	3 (1)	38
Blue Warehou	45 (14)	15
Jackass mowong	10 (2)	4
Blue Grenadier	4 (1)	4

iii) Quality of data used in the assessment

Data used for species in the OTF were extracted from NSW Fisheries catch database. This database holds information on the monthly catch returns of all fishers in the OTF and specifies the species or species group reported, quantity and method used over a month by each licensed fisher for each zone and sector of the fishery that their catch was landed in (see Section B1.2) for further explanation). There have been several significant changes to the way in which fishers have had to report their catch since 1990/91 and 1997, which have affected the quality of the data used in this assessment.

Prior to 1990/91 a number of species were not separately listed on the return form and were only recorded when fishers wrote them in as “new species” listed in 1990/91. Before 1997 catch was reported by method. Landings have been split into different fisheries on the basis of the main method recorded on the forms. Furthermore, the number of days fished by method was not required on the catch return form. Consequently, effort data by method prior to 1997 is not reliable. Since 1997 landings were reported on a per fishery basis.

Prior to 1997 fishers who fished in both the South East Trawl Fishery (SETF) fishery and OTF recorded their landings as a total on the NSW catch returns. Therefore the landings taken in the SETF could not separated from the OTF in the database. Consequently, landings from the OTF for some species could be over-estimated prior to 1997. From 1997 onwards landings taken by the SEFT are reported separately, however, there are still some inclusions of SET fishery landings in the OTF for zones 7-10 due to Commonwealth quota management.

Many species of finfish are processed, eg. gutted, before being weighed and hence whole weights of finfish are not always recorded. Prior to 1997 the process method was not included in the catch returns. Since 1997 a correction factor for three common processes (as used by AFMA for one species) was included in the database so that total weights of landed catch could be calculated. Because the data used in this assessment to determine catch trends was over a period that straddled these changes the data post 1997 were not corrected for process method. Hence weights are not for whole finfish. Therefore, the landings may represent an underestimate of the total catch.

Finally, fishers will report mixed boxes of species of finfish under the category “ocean fish mixed – unspecified”. These contain a variety of species that are either unidentified or are too few to fill a separate fish box (these may also contain fished caught in the SEFT). The cumulative quantity of these boxes over all fishers in the OTF could be quite large and therefore be a source of unknown fishing mortality on some species. The magnitude and extent to which the "ocean fish mixed" category is used in the OTF has not been analysed.

One further short-coming of the current monthly catch returns is the reporting of effort. The number of days fished is meant to be reported for each zone, sector and method fished. However, effort is often reported in groups of zones, e.g. Zones 7-8, and for prawn trawl across sectors, e.g. inshore and offshore and methods, e.g. royal red and ocean prawn trawl. Consequently, the reported landed catch of species cannot be accurately matched to the number of days fished to catch them. Therefore, catch per unit effort can only be accurately calculated when a single method is used in a month. Because fish trawl uses only one method the total number of days per month can be applied to the total catch per month. However, prawn trawl is has three sectors – deepwater prawn trawl, inshore and offshore prawn trawl. Catch rates can be calculated if the effort per sector is clearly reported. Catch rates, in conjunction with other variables, provide important information in determining stock assessments of primary and key secondary species.

Fishery independent surveys by NSW Fisheries' research vessel "*Kapala*" were done during the 1970s, 1980s and 1990s (Graham and Wood, 1997; Graham *et al*., 1993a,b; 1995, 1996, 1997). These surveys were not done for the purpose of validating fishery dependent data. There were some difficulties in using the "*Kapala*" data for determining trends in catch composition of commercial trawlers as they did not fish in the same manner as commercial trawlers, such as shorter tow times. Differences in methodology can lead to discrepancies in effort data and catch per unit effort calculations (Fox and Starr, 1996). However, the "*Kapala*" data provide the only fishery independent data trends in trawl fish stocks in oceanic waters in NSW.

The quality of the data used for the assessment of the fishery clearly has major limitations. The reporting changes pre- and post- 1997 result in complicating the precision of the data making it very difficult to unravel. Whilst these difficulties with the database are recognised it is also acknowledged that the current catch database is the only long-term data of reported landed catch for the OTF available. In accordance with the precautionary principle (Myers and Mertz, 1998) limitations in the data can't be used as a reason to avoid assessment of the fishery. Consequently, the database information was used in conjunction with "expert judgement" and advice from industry to provide an overview view of the trends in reported landings but only tentative conclusions were drawn from these trends.

b) Risk Assessment of Primary, key secondary and secondary species

Context

The primary goal in managing primary, key secondary and secondary species is to ensure their ecological sustainability. Therefore, the risk being assessed is the probability of the stocks of the primary, key secondary and secondary species becoming unsustainable within the next 20 years if the current operation of the OTF fishery continues. The period of 20 years was chosen as it is about the average turnover time of a generation of fish assemblages for NSW oceanic waters (Kailola, *et al*., 1993).

Potential impacts of OTF on primary key secondary and secondary species

The main direct impact on primary, key secondary and other retained species is the potential for biological overfishing that substantially decreases exploitable mature biomass and spawning biomass of stocks. Indirect impacts occur through habitat damage and disruption of ecological processes. This section will focus on the direct impacts on exploitable mature biomass and spawning biomass from the activities of the OTF and indirect impacts will be assessed under other components of the ecosystem (see Table B2.11).

Table B2.11 Summary of main areas of risk for the primary and key secondary species in the OTF. Highlighted row indicates aspect that is assessed under Section 2.3 of the EIS.

	Activities of the Ocean Trawl Fishery				
Aspects needed to maintain ecologically sustainable populations	Harvested catch	Discarded catch	Contact but not captured	Gear loss	Boat maintenance & emissions
Food availability and feeding sites	I	I	L	L	
Species interactions	H	H	L	L	
Sustainable levels of exploitable mature biomass and spawning biomass	H	H	I	L	
Spawning sites & spawning aggregations	I	I	L	L	
Dispersal of propagules/larvae					L
Recruitment	H	H	L	L	
Growth	H	H	L	L	
Distribution & movement	I	I	L	L	

H – high risk, I – intermediate risk, L – low risk.

Overfishing occurs when a high proportion of one or all age classes in a fishery are caught so as to reduce yields and drive biomass and spawning potential below safe levels (FAO glossary, website, 2002). Broadly there are two types of overfishing - growth and recruitment. Growth overfishing occurs when too many small fish are being harvested, usually because of excessive effort and/or inappropriate gear selectivity and the fish are not given the time to grow to the size at which the maximum yield-per-recruit would be obtained for the stock (FAO glossary, website, 2002). Recruitment overfishing occurs when the rate of fishing is such that annual recruitment to the exploitable stock has become significantly reduced, producing a greatly reduced spawning stock, a decreasing proportion of older fish in the catch and generally very low recruitment year after year (FAO glossary, website, 2002).

Indirect impacts on primary and key secondary species are destruction of habitats, disruption to species interactions (Jennings and Kaiser, 1998) through depletion of predator and prey species, depletion of juvenile commercial species (via bycatch and discarding) and reduction in spawning success due to capture of gravid females and disruption to spawning sites through disturbance (see Table B2.11). These indirect impacts and their effects will be examined in detail in sections 2.6 – 2.7.

Effects of overfishing

Growth Overfishing

The primary effect of growth overfishing is a decrease in optimal yield from the fishery. Too many small fish from the stock are being caught and hence larger numbers of fish need to be landed for a given catch weight than if the optimum size were fished. Slower growing fish species are more likely to suffer substantial decreases in their mature biomass over a short period of time if this type of overfishing continued. In growth overfishing larger slower growing fish of the fishery are reduced through fishing pressure and smaller fish are being caught so that very few are allowed to grow to a mature size. Lower mature biomass means less weight of fish is available for the same number of fishers, increasing fishing pressure. As fishers increase the number of their trawls to catch fewer and fewer fish the rate of non-retained species will also increase. Non-retained finfish species caught as bycatch usually do not survive trawling and handling (Kaiser and de Groot, 2000).

Another effect of growth overfishing is that lower yielding catches may result in fishers switching to target more profitable species (Orenzanz *et al*., 1998). Depending upon the extent and magnitude of growth overfishing and the species, switching targets could occur for a short period while the stock replenishes or indefinitely if biomass rebuilding is uncertain. Switching target species could produce cascading effects on other fish species possibly resulting in sequential depletion of fish stocks (Orensanz *et al.*, 1998). Clearly targeting other species at a higher rate than usual increases their fishing mortality and could be subjected to overfishing in some form themselves. To what extent target switching occurs in the OTF is unknown. Growth overfishing will not necessarily on its own result in stock collapses. However, left unchecked it can lead to recruitment overfishing which is more serious.

Recruitment Overfishing

The primary effect of recruitment overfishing is collapse of the fish stock (in fact a stock can be considered to have collapsed when it is recruitment overfished, K. Rowling, NSW Fisheries, pers. comm.). Recruitment becomes so low that it cannot replenish the exploitable stock and eventually result in insufficient landings. There have been several well documented large stock collapses of fish around the world that have been caused by over exploitation. These include northern cod off Newfoundland and Labrador (Hutchings and Myers, 1994), anchoveta of Peru (Patterson *et al*., 1992) and haddock in Georges Bank (Spence and Collie, 1997). In Australia, eastern gemfish has already suffered a protracted recruitment collapse (Rowling, 1999). Clearly, a collapse of a primary species is bad for both fishers and the well-being of the ecosystem.

Effects on the Ecosystem from Overfishing

In the past decade there has been increasing attention given to the effects of fishing on whole ecosystems (e.g. Pauly and Christensen, 1995, Fogarty and Murawski, 1998; Hall, 1999; Murawski, 2000) beyond just the effects on the fish stocks. For example, overfishing for higher trophic level fish stocks, such as sharks, which results in fishers switching to other species can mean a decline in the average trophic level of landings (Pauly *et al*., 1998). This could significantly disrupt food webs and have cascading implications for the stability of fish stocks and the wider ecosystem. These effects of overfishing on the ecosystem will be discussed more thoroughly in other sections of the EIS (see Section B2.6(c)), suffice to say that there are important wider implications of overfishing other than on the target finfish and shellfish stocks.

i) Risk Characterisation

Risk on primary and key secondary species from harvesting

The impact of the activity of harvesting on the spawning and mature biomass of primary and key secondary species of the OTF was examined using a qualitative risk matrix. The matrix and outcomes of the risk analysis are described below. Other activities of the fishery that potentially impact the biomass of primary and key secondary species have less information available and so the matrix could not be used to assess these activities. An alternative method consisting of inference drawn from scientific literature was used, as described in sections B2.3b(ii).

Development of risk matrix

Information on the biology and ecology of each species and factors on the operation of the OTF (e.g. catch trends) were collated from scientific literature and fishery status reports. This information was then used to rank species along two axis of a risk matrix (Figure B2.7) that described the overriding factors that would determine a species' risk of becoming unsustainable. The y-axis indicated the level of fishery impact exerted by the OTF and the x-axis indicated the level of resilience of a species. The fishery impact profile represents the overall disturbance that is exerted on these species. The various factors that make up the operation of the fishery were used to determine the level of fishery impact being exerted on a species. Resilience has a formal definition in scientific publications (e.g. Underwood, 1989) which is a measure of the response a population or assemblage of species has to a disturbance of a known magnitude. For the OTF we were unable to determine the magnitude of the disturbance on commercial species due to substantial knowledge gaps (e.g. discard rates). Therefore resilience could only be described qualitatively for this assessment and was a theoretical description based on the biology of the species.

The two axes formed a five by five matrix (25 squares) which was divided into five levels of risk (Figure B2.7). In a qualitative matrix it can not be determined how the fishery impact profile interacted with resilience so each level of risk was allocated an equal number of squares (5 each). The arrangement of the five risk levels on the matrix was determined by recognising that only the fishery impact profile can be changed by management action. The resilience axis can't change by management intervention because resilience is part of the biology of a species. Therefore, the risk levels were arranged in the matrix so that if there was a change in the fishery impact profile risk will either increase or decrease. The arrangement and description of the five risk levels is given below.

The top right hand corner and the bottom left hand corner of the matrix represent the highest and lowest levels, respectively. High levels of risk correspond to species with lower resilience and largest level of fishery impact, whilst low levels of risk correspond to species with higher resilience and smallest level of fishery impact. Management measures should give first priority to species with highest levels of risk, which require direct and immediate action to decrease the level of the fishery impact exerted on them to reduce their risk of becoming ecologically unsustainable. The top left hand corner and the bottom right hand corner represent moderately high and moderately low levels of risk respectively. Moderately high levels of risk corresponded to species that have larger levels of the fishery impact profile but higher resilience. The focus of management action for species at this level should be to decrease their fishery impact but because their resilience is higher than those species at highest risk they would be second in priority. Moderately low levels of risk correspond to species that have smaller levels of fishery impact but lower resilience. The lower resilience of these species means that potentially any increase in the fishery impact profile could put these species at a higher level of risk. Therefore, management measures should be focused as a minimum on ensuring the fishery impact profile does not increase on these species. Intermediate levels of risk correspond to species with an intermediate level of fishery impact and resilience levels from high to low. Management measures for these species should focus on reducing their fishery impact profile starting with those species with lowest levels of resilience.

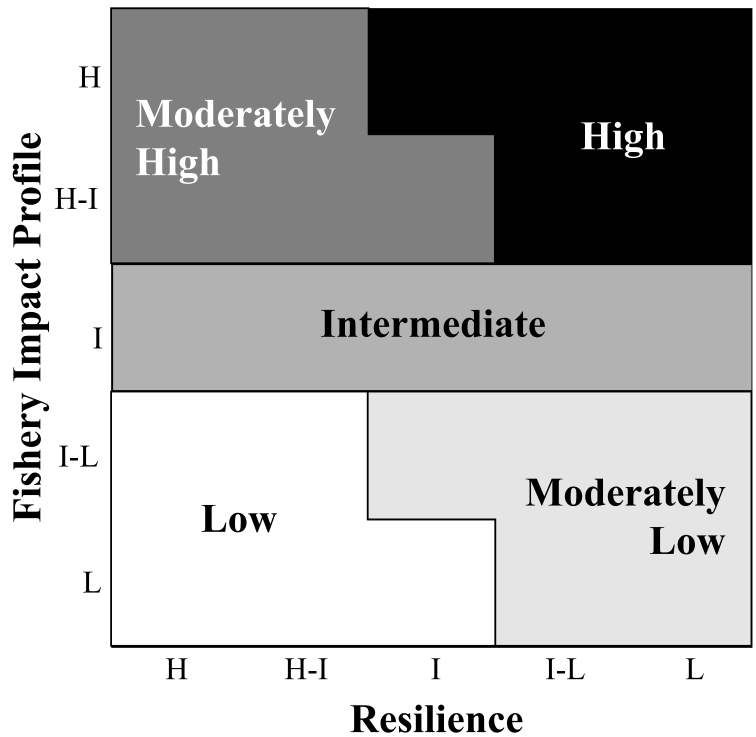


Figure B2.7 Risk matrix used to determine levels and grade of risk for primary key secondary and secondary species in OTF by combining resilience and fishery impact profile for each species.

H – High, H-I – High to intermediate, I – intermediate, I-L – intermediate to low, L – low.

Resilience - Biological Characteristics

Eight biological characteristics were chosen (Table B2.12) out of a possible nine to describe qualitatively the resilience of each species. Fecundity and life history strategy (Table B2.12) were double weighted as these were seen as the major determinants of how well a species could respond to increased mortality due to fishery impacts. The relevant information for each primary, key secondary and secondary species in the OTF (comprising 99% of the catch) for each characteristic was collected from scientific literature, both journal publications and books. Where information for a particular character was not available for a species either information about the family was used instead or it was marked as “unknown” (for details see Appendix B2.1).

A set of decision rules (or criteria) were determined for each character that distinguished between risk prone and risk averse character traits in a species (Appendix B2.2). Those species with a majority of risk prone characters were least resilient and those with few risk prone characters were most resilient. The overall resilience level for each species was determined by a summation of the number of risk prone characters and allocated to high, intermediate or low resilience according to their number of risk prone characters (Table B2.13). To ensure that species did not end up clumped under intermediate or at either end of the resilience scale, two species were chosen to act as “benchmarks” for the extreme higher and lower ends of resilience (i.e. a species that acts as a reference point for each end of the resilience scale) – tiger flathead and endeavour dogfish respectively. Endeavour dogfish are elasmobranchs that have relatively low fecundity and a vulnerable life history strategy, i.e. they mature late, are slow growers, bear few young and have relatively long gestation times. In addition, they are currently nominated to be listed as a vulnerable species under the EPBC Act 1999. These characteristics place endeavour dogfish at the extreme lower end of the resilience scale. Tiger flathead are highly fecund producing between 1-3 million eggs during a spawning period. Their eggs and larvae are pelagic which maximises opportunities for large dispersal of offspring and makes abundances very variable and they mature at 2-3 and 3-4 years of age for females and males respectively. This enables them to start reproducing relatively early, making their life history strategy very productive. Therefore, tiger flathead was placed at the higher end of the resilience scale. Based on these two benchmarks all other species fell either in between or equal to these species.

Table B2.12 List of biological characteristics used to determine the level of resilience of primary and key secondary species in the OTF. * indicate factors that are highly correlated.

Category	Character	Reasons for use	Weighting
Life history	Fecundity	Indication of a species' productivity in producing recruits	Double
	Life history strategy	Indication of a species' ability to maintain viable population sizes or to rebuild populations after depletion	
Distribution & abundance	Geographic distribution	How widely a species is distrbuted gives an indication of the potential for refuges from fishing	Single
	Habitat specificity	Indicates how vulnerable a species is if it only associates with particular types of habitats that are more accessible to trawling	
	Stock or population size	Indicates the strength of the biomass available to produce offspring [this character was not used because of lack of information]	
Other	*Growth rate	Indicates how quickly it reaches adult size and therefore its ability to escape the more vulnerable stages of development [correlated with age at maturity]	Single
	Longevity	Indicates turnover of populations and productivity of a species	
	*Age at maturity	Indicates how old a species is before it can reproduce	
	Diet specificity	Indicates how restricted a species' diet is which may make accessibility to food affecting growth rate	

Table B2.13. Decision rules for assigning levels of resilience to biological characters for primary, key secondary and secondary species.

Resilience Level	No. risk prone characters
High	Nil prone
High - Intermediate	1 prone
Intermediate	2 prone
Intermediate - Low	3 prone
Low	4 prone

Sixteen species had a high biological resilience (Table B2.14). This was primarily due to their life history strategies of pelagic eggs and larvae, high fecundity, fast growth and early maturity. Six species of finfish and two species of shellfish showed a high to intermediate level of resilience. The remaining finfish species were all elasmobranchs and were spread over the lower end of the resilience scale. Their life history strategies have very low fecundity, slow growth rates and late maturity. Gummy sharks had intermediate resilience because their distribution and abundance categories were risk averse unlike the other elasmobranchs. Carpet sharks also showed intermediate resilience, because of the large number of knowledge gaps in our understanding of their biology. Their level of resilience should be treated with caution. Seven shellfish species showed intermediate resilience levels because their life history strategies of egg brooding and habitat specificity were considered more risk prone than the other shellfish species.

Table B2.14 Summary of resilience levels of primary, key secondary and secondary species in 99% of the reported landings of OTF.

Species in 99% of Landings	Resilience
Fish	
Whiting, School	H
Flathead, Tiger	H
Flathead, Sand	H
Latchet / Gurnard	H
Flounder (all species)	H
Mullet, Red	H
Leatherjacket (mixed spp)	H
Yellowtail	H
Sole, mixed	H
Morwong, Rubberlip	H
Tarwhine	H
Flathead, Dusky	H
Bream, Black and Yellowfin	H
Moonfish (pink tilefish)	H
Boarfish	H
Silver biddy	H
Trevally, Silver	H-I
Dory, John	H-I
Redfish	H-I
Perch, Ocean	H-I
Dory, Mirror	H-I
Trumpeter	H-I

Species in 99% of Landings	Resilience
Fish cont'd	
Shark, Gummy	I
Shark, Carpet	I
Shark, Fiddler	I-L
Shark, Angel	I-L
Shark, Saw	I-L
Stingray	I-L
Shark (whalers)	I-L
Shark, Dogfish Greeneye	I-L
Shark, Dogfish Endeavour	I-L
Crustaceans	
Prawn, Eastern King	H-I
Prawn, School	H-I
Prawn, Royal Red	I
Crab, Blue Swimmer	I
Bug, Balmain	I
Molluscs	
Octopus	I
Cuttlefish	I
Calamari, Southern	I
Squid - broad &bottle	I

H – high, I-H – intermediate to high, I – intermediate, L-I – low to intermediate, L – low.

Fishery Impact Profile – operations of the fishery

A set of factors that describe the activities of the fishery were developed that collectively indicated the fishery impact profile on a species. Generally, these factors are ones that can be changed by management intervention. Unlike biological characteristics, which remain largely unchanged by management intervention, fishery factors represent those things management can alter to reduce the risk to primary, key secondary and secondary species becoming ecologically unsustainable.

Eleven factors of the operation of the OTF were chosen out of a possible 12 (Table B2.15), as not all factors had sufficient information to be used in the assessment (e.g. discard rates). The factors were grouped into categories of similar types and prioritised according to their level of importance in contributing to the fishery impact on a species (Appendix B2.3). Catch trends, gear selectivity and the targeting of aggregations were given double weighting as they were thought to reflect the largest contribution of the operation of the fishery on the fishery impact profile. A set of decision rules was determined to distinguish between risk prone and risk averse factors (Appendix B2.4). The overall fishery impact profile for each species was determined by a summation of the number of risk prone factors and allocated to high, intermediate and low according to the number of these factors (Table B2.16). To ensure that species did not end up clumped under intermediate or at either end of the fishery impact profile scale two species were chosen to act as “benchmarks” for the extremes of higher and lower impact – silver trevally and trumpeter respectively. As for the biological characters, these species had factors that clearly put them at either the high or low ends of the scale. All other species therefore had to fall either in between or equal to these benchmarks. Trumpeter is caught in low abundance by the OTF compared to other species and its catch level trends have not been declining for the past 5 years. It had less than four risk prone (seven risk averse) fishery factors putting it at the lowest end of the fishery impact profile scale. By contrast, silver trevally had eight risk prone factors, including declining catch level trends, overfished exploitation status and the fact that aggregations are targeted by OTF. These factors put it at the highest level of the fishery impact profile scale.

Table B2.15 List of fishery factors used to determine the fishery impact profile of primary, key secondary and secondary species in the OTF.

Category	Factor	Weighting	Explanation
How much is caught	Catch level & trends	Double	Indicates consistency in catches, changes in trends over a specified period could suggest a possible decline in stocks
	Catch per unit effort (CPUE) trends	Single	Used as an index of abundance, changes in catch rate indicate changes in abundance; only used when data is available
	Discard rate/% discarded		Indicates level of commercial fish species landed but not caught; essentially another form of mortality on the population or stock; Not used because no data available
	Stock assessment adequacy		Indicates whether the information on which the stock assessment was based was sufficient
	Exploitation status		Indicates whether there is evidence of growth or recruitment overfishing based on either NSW Fisheries 2000/01 status report or SE trawl fishery 2001 status report.
How is it fished	OTF fishery targets aggregations	Double	Indicates how vulnerable a species is to being caught by OTF
	Gear selectivity		Indicates whether the trawl gear is catching the smallest fish at an age that allows the majority of the population to spawn at least once
	Bycatch reduction device used for species (prawn trawl only)	Single	Indicates whether the BRD is effective in reducing undersize fish of a species
How many fishers catch it	Proportion OTF of total %	Single	Indicates the level of fishing being exerted by the OTF in comparision to all other relevant fishing sectors
What is caught	Species identification problem	Single	Indicates whether species of the same genus can be easily identified; if not then the stock status, biology and resilence of different species cannot be determined and therefore managed well
	Marketability		Surrogate for the economic value of a species and therefore it is a priority in targetting areas where a species occurs
Where is it fished	Refuge availability	Single	Indicates whether a species has available places to escape fishing mortality

Note 1. Discard factor was not included because there is no recent information for NSW OTF. It is shown in the table for the purpose of highlighting its importance.

Note 2. Weighting indicates the contribution of the operation of the fishery on the fishery impact profile.

Table B2.16 Decision rules for assigning fishery impact profile levels to primary and key secondary species in the OTF.

Fishery impact profile level	Number of risk prone factors
L	< 4
L - I	4 & 0 PP
I	5 or =4 + 2PP
I-H	6
H	> 6

H – high, I-H – intermediate to high, I – intermediate, L-I – low to intermediate, L – low; PP – double prone

Thirteen species in 99% of the landed catch had an intermediate-high or high fishery impact profile (Table B2.17). This includes five species of sharks, two finfish species that are growth overfished – silver trevally and redfish - and two crustaceans - eastern king and school prawns. These fishery impact profile levels are mainly due to the decline in catch trends for these species over the last 5-10 years. Most of the teleost species under intermediate and high levels of risk have some form of aggregating behaviour, school prawns, which are targeted by fishers. The large proportion of the total reported catch (44%) with a high fishery impact profile is of concern.

Table B2.17 Summary of fishery impact profile levels on primary, key secondary and secondary species in the OTF for 99% of landed catch in 2000/01.

Species	Impact Profile Level	Species	Impact Profile Level	Species	Impact Profile Level
Trevally, Silver	H	Whiting, School	I	Tarwhine	L
Shark, Fiddler	H	Flathead, Sand	I	Shark, Black Tip	L
Redfish	H	Dory, John	I	Ling	L
Perch, Ocean	H	Stingray	I	Silver biddy	L
Shark, Dogfish Endeavour	H	Shark, Gummy	I	Trumpeter	L
Latchet / Gurnard	I-H	Shark, Carpet	I		
Shark, Angel	I-H	Boarfish	I		
Leatherjacket (mixed spp)	I-H	Bream, Black and Yellowfin	H		
Shark, Saw	I-H	Flathead, Tiger	L-I		
Morwong, Rubberlip	I-H	Flounder (all species)	L-I		
Shark, Dogfish Greeneye	I-H	Mullet, Red	L-I		
Moonfish,	I-H	Yellowtail	L-I		
		Sole, mixed	L-I		
		Dory, Mirror	L-I		
		Flathead, Dusky	L-I		

H – high, H-I – high to intermediate, I – intermediate, L-I – low to intermediate, L – low.

Risk Levels

Using the risk matrix in Figure B2.7 by applying the qualitative fishery impact profile levels and resilience ratings determined above, the level of risk to the sustainability of the biomass was assigned to each species (Table B2.18). Five species of finfish were at the highest level of risk, all of whom were elasmobranchs – fiddler, angel and saw sharks and greeneye and Endeavour dogfishes. These species are at highest risk due to their low resilience and factors such as low refuge availability, poor selectivity of fishing gear and inadequate stock assessments.

Seven species of finfish and two species of shellfish had moderately high levels of risk. Silver trevally and redfish have relatively high resilient biological characteristics but are growth overfished (Rowling and Raines, 2000) indicated by declining catch trends and small sizes of landed fish, have aggregations that are targeted by fishers, and low availability of refuges from fishing mortality. The remaining finfish species in this category of risk all have inadequate stock assessments, declining catch trends and poor gear selectivity. The total stocks of eastern king and school prawns are growth overfished (Montgomery, 1999).

Eight species of finfish and four species of shellfish are at intermediate risk of becoming unsustainable primarily because of their declining catch trends. Species of greatest concern in this category are the three elasmobranchs, gummy and carpet sharks and stingrays, because of their low resilience.

The remaining species with low risk levels have fewer risk prone fishery and biological factors and do not show declining catch trends based on the information currently available.

Table B2.18 Summary of risk levels for primary, key secondary and secondary species landed in 99% of the reported catch (2000/01) for the OTF.

Species in 99% Landings	Risk	Species	Risk
Fish		**Fish cont'd**	
Shark, Fiddler	High	Trumpeter	Low
Shark, Angel	High	Flathead, Tiger	Low
Shark, Saw	High	Flounder (all species)	Low
Shark, Dogfish Greeneye	High	Mullet, Red	Low
Shark, Dogfish Endeavour	High	Yellowtail	Low
Trevally, Silver	Moderately High	Sole, mixed	Low
Latchet / Gurnard	Moderately High	Dory, Mirror	Low
Redfish	Moderately High	Tarwhine	Low
Leatherjacket (mixed spp)	Moderately High	Flathead, Dusky	Low
Perch, Ocean	Moderately High	Silver biddy	Low
Morwong, Rubberlip	Moderately High	**Crustaceans**	
Moonfish	Moderately High	Prawn, Eastern King	Moderately High
Dory, John	Intermediate	Prawn, School	Moderately High
Shark, Gummy	Intermediate	Prawn, Royal Red	Intermediate
Shark, Carpet	Intermediate	Bug, Balmain	Intermediate
Bream, Black and Yellowfin	Intermediate	Crab, Blue Swimmer	Low
Boarfish	Intermediate	**Molluscs**	
Whiting, School	Intermediate	Cuttlefish	Intermediate
Flathead, Sand	Intermediate	Squid	Intermediate
Stingray	Intermediate	Octopus	Low
Shark (whalers)	Moderately Low	Calamari, Southern	Low

ii) Risk on primary, key secondary species and secondary species from discarding, contact but not capture and gear loss

Discarding

As noted earlier there is little information on the current rates of discarding of undersized commercial species in the OTF. Until quantitative data is gathered it is not possible to properly assess the impact of discarding on the biomass of the primary, key secondary and secondary species. However, some preliminary observations can be made based on the current management regime and previous studies.

Pascoe (1997) suggests two reasons why fishers might discard commercial species. First, fish that are of lower quality or grade are discarded in favour of higher quality individuals that will bring greater economic benefit. Second, limited storage capacity on-board fishing vessels may motivate fishers to only keep high value species and discard lower value species. These two reasons are known as highgrading, i.e. the value of the catch is maximised by only landing higher valued fish. A third reason for discarding commercial species comes from the management input control of minimum legal sizes. Fishers discard individuals of commercial species that are under the legal size limit. There are 15 commercial species (see Table B1.14) of the OTF that have a minimum legal size limit.

There is no information to what extent, if any, highgrade discarding occurs nor the extent of minimum legal size limit discards in the OTF. Furthermore, bycatch reduction devices, made compulsory for ocean prawn trawlers in July 1999, may not be effective at reducing bycatch of commercial species, particularly in floodwaters (Ashby, 1999 – NSW Fisheries internal report).

Based on the limited information available (see Section B2.3 (a)) for the OTF it appears that bycatch is a large problem in the fishery which is consistent with other trawl fisheries around the world (e.g. Andrew and Pepperell, 1992; Murawski, 1996; Stratoudakis *et al*., 1998; Hall *et al.*, 2000; Carbonell *et al*., 2003). Furthermore, other studies have shown that survival of discarded individuals is very low (Wassenberg and Hill, 1990a,b) for a variety of commercial species. However, before a realistic assessment can be made on the effects of discard mortality on biomasses of primary and key secondary species three pieces of information are required (Kennelly *et al.*, 1998). First, an estimate of the species-specific post trawl mortality is essential. Second, information is needed on important population parameters of the species such as natural mortality and growth rates. Third, knowledge is needed of the relative proportion of available biomass represented by the discarded catch.

There is an absence of recent detailed information on the variability, magnitude and fate of commercial discards in the OTF. Therefore, as a precaution a high level of risk is assigned to all primary, key secondary and secondary species of becoming unsustainable as a result of the current discarding practices.

Contact but not capture

Contact without capture can occur when a fish comes within the influence of any part of the fishing gear that causes it to be herded, alarmed, scared or pass through the mesh without being retained in the net (Chopin and Arimoto, 1995). All these encounters can induce a level of stress on a fish and possibly affect its survival. Direct effects on fish escaping include physical damage and stress and indirectly by a reduced capacity to flee predators (Chopin e*t al*., 1996; Ryer, 2002) and resist disease. Escaping fish may also have their growth and reproductive capacities reduced. The ability of a fish to escape from the influence of fishing gear will depend on the selectivity of the gear and the size and species of the fish (Chopin and Arimoto, 1995). A review of studies on fisheries in the North Atlantic showed a wide variation in the mortality of escaped fish (Chopin and Arimoto, 1995). For example, there was 65% mortality of escaped Atlantic halibut 48 hours after contact with trawling (Neilson *et al*., 1989) but 0-50% mortality of flounder and cod after trawling (DeAlteries and Reifsteck, 1993). There have been very few studies done on the fate of fish that have escaped from the influence of fishing gear used by the OTF. Broadhurst *et al*. (1997a) found in experiments with juvenile sand whiting there was minimal scale loss from being forced through square mesh panels and negligible mortalities. A similar result was found in juvenile school prawns in experiments that simulated multiple capture and release (Broadhurst *et al*., 2002).

Although these latter two studies show minimal impact from contact without capture for these species there have been no studies done under normal trawling operations of the OTF on the fate of fish who encounter but escape fishing gear (Ryer, 2002). Given the lack of information on how fish condition is affected by the various encounters with fishing gear without being caught and the magnitude of these effects this activity, like that of discarding, becomes another potenial source of mortality to primary and key secondary species (Chopin *et al*., 1996). In comparison to other sources of mortality, such as harvesting, contact without capture may only contribute a minor proportion of the overall fishing induced mortality. However, a precautionary level of risk to the sustainability of the biomass of all primary, key secondary and secondary species in OTF is intermediate.

Gear Loss

When trawl fishing gear is lost at sea either in part or whole it has little ability to continue “fishing” because the heavy netting collapses and is very visible so fish can avoid it. Fishers in the OTF report that the incidence of lost fishing gear is minimal due to the expertise of the fishers operating the gear and the expense of replacing lost nets and associated equipment. In addition, fishers usually make an effort to retrieve any lost gear. However, in a study recording fishing debris on NSW beaches there was a noted dominance of prawn trawl debris on the state’s northern beaches and fish trawl debris on the southern beaches which was correlated to the distribution and intensity of trawling along the NSW coast (Hertford, 1997). The study did not distinguish commercial fishing debris from state and Commonwealth fishing operations.

Trawl netting behaves differently from passive fishing gear such as gill or drift nets. When not being pulled by a vessel the net collapses and can no longer fish. In addition, the heavy twine makes the net or parts thereof highly visible and therefore easily detectable by fish and other fauna (K. Graham, pers. comm., NSW Fisheries, 2004). Even if some species could get caught in the collapsed net it will depend on the size and configuration of the gear, vicinity in which it was lost, ocean currents and habitat it encounters as well as the type and size of species. Given the high cost of replacing lost gear, it is assumed that fishers are diligent in ensuring loss of fishing gear is kept to a minimum. Therefore the level of risk to the sustainability of the biomass of primary, key secondary and secondary species due to gear loss is considered low.

c) Issues arising from the risk analysis on primary, key secondary and secondary species

Direct action on species at highest risk - elasmobranchs

All the species with the highest level of risk were elasmobranchs. This group of species is recognised both nationally (Graham *et al*., 2001; AFFA, 2003a) and internationally (Cavanagh *et al*., 2003; IUCN, 2002) as being at risk from commercial fishing. Elasmobranchs are particularly vulnerable to trawling because their slow growth rate, long life span and life history strategy is not conducive to rapid recovery after populations have been depleted (Walker, 1998). Specific and immediate action should be implemented to reduce the high risk on these species. Their large size and body shape means they will not respond to changes in gear selectivity as for some species of teleosts. Consequently, management strategies will need to entail such things as providing adequate refuges from fishing mortality and protecting pupping and nursery areas. The draft National Plan of Action for the Conservation and Management of Sharks (AFFA, 2003) identifies 18 issues that need to be addressed in the management of sharks in Australia. Of these eight are of direct relevance to the NSW OTF (Table B2.?). They include the need for validated data sets compatible with other jurisdictions, improvement of shark identification, assessment of harvesting and handling practices of sharks and better understanding of the effects of shark fishing on ecosystem structure. These issues should be considered in the draft FMS.

Table B2.19. Summary of relevant issues from the Draft National Plan of Action for the Conservation and Management of Shark Species.

Note: Number in brackets refers to the issue number listed in the plan

No.	Summary of Issue
[1]	Need to improve identification of shark species by all resource users
[2]	Need for secure, accessible and validated sets that record all catch and are consistent over time with compatiable resolution between jurisdictions
[6]	Need for reliable assessments for bycatch and byproduct shark species
[7]	Need for an assessment of the adequacy of management for all shark species
[10]	Need for an assessment of shark handling practicies
[12]	Need for risk assessments for all shark species from all impacts
[13]	Where necessary develop strategies for the recovery of shark species and populations
[14]	Need to reduce or, where necessary, eliminate shark bycatch

Direct action on species at moderately high risk

Two species of finfish and two species of shellfish were at moderately high risk and are considered to be growth overfished – redfish, silver trevally, eastern king prawns and school prawns. Redfish and silver trevally are being caught at too small a size and changes to gear selectivity to allow a proportion of their populations to grow to larger sizes before being captured is required. Such changes should also increase the yield to fishers of these species.

Estuary prawn trawl and estuary general fisheries target eastern king and school prawns primarily as juveniles inside estuaries whilst OT fishers target them as adults. Evidence suggests that these prawns are currently being first caught at a size below their optimal size therefore reducing the probability that a sufficient proportion of the population has spawned at least once before being caught (Montgomery, 1999; NSW Fisheries, 2002). The two most important aspects to be addressed in reducing the risk to these prawn species are gear selectivity and protection of the spawning and nursery areas of the stocks.

Serious consideration needs to be given to what direct action could be taken for the remainder of the finfish and shellfish species in the moderately high level of risk. Latchet/gurnards, leatherjackets and moonfish all have species identification problems. It is difficult to determine the exploitation status of fish where species cannot be distinguished, resulting in basic population dynamic information being unknown. In the absence of species identification, management strategies would need to be more precautionary on these species groups than perhaps is needed which could result in species being under-exploited. Therefore, it is important to pursue strategies to better identify the species being taken and report catches at a species level.

Lack of stock assessments for primary and key secondary species

Many of the species that make up a large proportion of the landings of the OTF have either inadequate or no stock assessments. Therefore, there is no quantitative data on which to base more precise management measures. This is a serious problem and a major obstacle to reducing the risk for primary and key secondary species. Recently within NSW Fisheries there has been a classification of stock assessment into five different types ranging from no information to status inferred via ecosystem indicators, or some other indirect measure, to a fully modelled assessment based on detailed data for a number of key parameters (Scandol, 2003a, see Appendix B2.5). Together with the results of the risk assessment these classes of stock assessment provide NSW Fisheries with valid options in prioritising species and the level of information needed to determine more accurate status of the stocks of the fishery. This should form an important part of the proposed FMS.

Inappropriate gear selectivity

Trawl nets are considered to be relatively unselective in terms of the range of species they capture (Hall, 1999). However, there are a number of components of trawl gear that contribute to catching fish at certain sizes. The components of the size selectivity of fishing gear include mesh size, cod-end diameter and extension length (Reeves *et al*., 1992). Gear selectivity can contribute to growth overfishing of retained species by catching fish at too small a size (Godo and Sunnana, 1992). In addition, smaller fish above the legal size that are landed could be below the optimumal size for maximum yield. There are a number of species in the OTF where size at first capture is below their size at maturity (e.g. silver trevally and tiger flathead). Changes to gear selectivity in a multi-species fishery like the OTF are a compromise and not all species will benefit from such changes, (for example elasmobranchs, see discussion above). However, better selectivity of fish trawl gear, in particular for most teleost finfish and prawns, should improve both the yield to fishers and reduce the catch of smaller size classes. Priority should be given to species that are currently growth overfished (e.g. silver trevally) or fully fished. Coupled with improved gear selectivity should be research into the fate of fish that come in contact with the fishing gear but are not caught. There is little point in changing gear selectivity if fish that escape die or whose growth or reproductive capacity is impaired (Chopin and Arimoto, 1995). Information on the fate of escaped fish from trawl nets will assist in addressing any risk associated with contact without capture.

Poor understanding of discarding commercial bycatch

Quantification and identification of commercial bycatch has received insufficient attention in the OTF. There have been no observer studies done on the fishery since the early 1990's. There is no information on the quantity, composition, frequency and temporal and spatial variability of discarding of unmarketable commercial species. This is a source of unaccounted mortality, which means the stock status of some of the primary and key secondary species will be inadequate. This in turn leads to poor management of the stocks. Therefore, it is essential that the level and composition of discarding of unmarketable commercial species in the OTF be investigated. Furthermore, the motives for discarding of commercial species should also be analysed to determine whether the management strategy itself contributes to excessive discarding, such as legal size limits.

Limited knowledge of the effectiveness of bycatch reduction devices

There are two aspects to the effectiveness of bycatch reduction devices (BRD) relevant to the sustainability of primary, key secondary and secondary species. First, is whether the BRD actually reduces unwanted catch of commercial species and second, is whether those that escape the BRD survive long enough to contribute to the biomass of the stocks.

There has been little work done assessing the effectiveness at reducing unwanted catch in the OTF. There has been no monitoring of ocean prawn trawlers since the compulsory introduction of BRD in July 1999. This is despite the fact there is a good baseline of "before" data (Kennelly *et al*., 1998) which is necessary (Underwood, 1992) to detect whether the BRD have significantly reduced bycatch. Internal studies done by NSW Fisheries (Ashby, 1999; Broadhurst, 2001) suggest that the BRD fitted to ocean prawn trawlers are ineffective under some conditions. Research is required to determine whether the range of BRD actually used by fishers whilst trawling do reduce the bycatch of unmarketable commercial species. Effectiveness of BRD for this fishery have only been conducted under experimental conditions rather than actual trawl conditions (e.g. Broadhurst *et al*., 1997a,b).

The survival of species that escape from BRD has received little attention in this fishery (Broadhurst *et al*. 1997a, 2002). Investigation in the survival of species after passing through BRD under trawl conditions is necessary to determine the magnitude of unaccounted fishing-induce mortality in stock assessments of primary and key secondary species. Study of the fate of escapees from BRD should include the composition, size range, condition, quantity and proportion of each species escaping compared to that caught and the level of behavioural impairment. As a first step experimental laboratory studies should be considered in providing some insights as to scope the extent of the problem as has been done elsewhere (Ryer, 2002). This information will help to assess whether poor survival contributes to the risk of ecological unsustainability of primary and key secondary species and would assist in addressing risk due to contact without capture.

Inconsistent management regimes between state and Commonwealth jurisdictions for some primary and key secondary species

There are a number of primary and key secondary species caught in the OTF that are also taken in large quantities in the South East Trawl Fishery, Queensland and Victoria. For example, redfish are heavily fished by the South East Fishery, which discards up to 48% of its catch (AFFA, 2003b; BRS, 2003). Clearly, this practice has flow-on effects for the OTF. Furthermore, there are inconsistent management regimes across the Commonwealth and State jurisdictions, with quota management in the South East Trawl Fishery and effort control management in NSW Fisheries. Differing management regimes increases the risk of species with common stocks (the majority of the primary, key secondary and secondary species in the OTF are part of the same stocks fished by the South East Trawl Fishery) becoming ecologically unsustainable because the controls do not complement each other. Therefore, there needs to be better cooperation and consistency of approach between the Commonwealth and the State in the management of these common stocks. A similar issue exists between State jurisdictions especially with Queensland as it lands a large proportion of eastern king prawns from a common stock as that targeted by NSW fishers.

Poor data quality of primary key secondary and secondary species

As noted in Section B2.3(b) the NSW Fisheries catch database has a number of problems which limits its usefulness in providing reliable information on which to base appropriate management regimes. This is a serious obstacle to reducing the risk of primary and key secondary species in the OTF. Improving the way information is recorded on the catch returns, changing from monthly to daily reporting, coupled with validation of reported landings by independent observers either on vessels and/or at local fish cooperatives would address a number of the issues already highlighted and greatly increase the reliability of the database. Furthermore, appropriately designed fishery-independent surveys would also assist in improving the reliability of stock assessments (e.g. Ault *et al*., 1999; Korsbrekke *et al*., 2001). These measures would in turn allow more effective management strategies to be developed.

Knowledge gaps and their consequences

There are a number of substantial knowledge gaps that hinder the OTF from being managed and fished in an ecologically sustainable manner. Evans and Grainger (2002) describe four main groups of information used in managing a fishery – fishery operations, biological/ecological, economic and sociocultural. With respect to the risk assessment of primary and key secondary species of the OTF knowledge gaps exist in at least the first two groups. In the area of fishery operations specific knowledge is needed on the location of trawl grounds for the each sector of the fishery. All fishers have a number of grounds where they operate on a regular basis. The frequency the grounds are fished and by how many fishers is also required. This information, combined with improved catch and effort returns, would provide an estimate of the spatial and temporal magnitude and variability of fishing pressure being exerted on the key species of the fishery. The location and area of fishing grounds will also provide potential information about fish habitats which would help improve our knowledge of fish ecology. There are many other gaps about the fishery's operation but these highlight the main ones that could be filled relatively easily by a FMS.

In the area of biological and ecological information there is little to no knowledge on the ecology and basic biology of many of the primary and key secondary species (see Appendix B2.1). Research on the interactions among fish species and non-target species, interactions of fish with the environment and habitats, stock and community structure, and spatial and temporal complexity of fish stocks has received little attention in the OTF. The number of gaps in our basic knowledge of the primary and key secondary species is very large and the resources available to fill these gaps is limited. Therefore, it is very important that research is directed toward areas that will provide maximise our understanding of the biology and ecology of the primary and key secondary species.

The consequences of not filling these and other knowledge gaps needs to be understood. Knowledge gaps lead to uncertainty in the appropriateness and/or effectiveness of management strategies instigated to reduce the risk of ecological unsustainability of fished stocks (e.g. Charles, 1998, 2001; Pitcher *et al*., 1998). The more uncertainty there is in a fishery the more precautionary management measures are needed to mitigate possible long-term damage to fish stocks and the ecosystem (FAO, 2003). The more precautionary management measures must be the more likely there will be increased restrictions on fishers, limiting their revenue, at least in the short term. More importantly, longer term effects will be felt if knowledge gaps are not filled. Furthermore, even with precautionary measures the level of uncertainty involved means that fishery managers and scientist cannot guarantee that these measures will completely prevent overexploitation of primary and key secondary species.

Only when the right kind of information is obtained, analysed and interpreted correctly will the risk of overexploitation be reduced. This will assist in establishing an ecologically and economically sustainable management strategy for the OTF (Evans and Grainger, 2002). By filling the crucial knowledge gaps in the areas of fishery operations and the biology and ecology of primary key secondary and secondary species the degree of precaution required should be reduced and management measures can be more specific. Investment in filling the knowledge gaps in the fishery by all stakeholders and government is urgently required. Knowledge gaps should not simply be acknowledged but also acted upon. To do so will require the cooperation of everyone involved in the fishery from industry to government. Limited resources will mean that careful consideration must be given to what areas of research will maximise our understanding of the primary and key secondary species and the fishery.

2.4 Risk Analysis of Non-commercial Bycatch Species

The species covered in this section includes non-commercial finfish and shellfish species (hereafter referred to as non-commercial bycatch) that are not retained in the OTF, excluding threatened and protected species. Also excluded are commercial species that are discarded either because they are undersized or are unmarketable in some periods; these were examined in the previous section. Threatened and protected species will be analysed in Section B2.5.

a) Non-commercial Species of Bycatch in the OTF

During the 1970s, 1980s and 1990s, NSW Fisheries RV *Kapala* completed several trawling surveys and other trawling activities across all areas of the OTF. These surveys were conducted with commercial trawling gear with little or no modification, and catch compositions were representative of commercial trawling. Comprehensive species lists were compiled for several hundred trawls on OTF grounds and published in *Kapala* Cruise Reports Nos 114-117 (Graham *et al*, 1993a,b, 1995, 1996, 1997; Graham and Wood, 1997). Using these lists and the Kapala Species Distribution database a list of non-commercial bycatch species in the OTF was generated. The percentage-frequency of occurrence of each non-commercial fish and invertebrate (molluscs and crustaceans) species across all trawls within each main sector was calculated and ranked accordingly. This produced a list of over 300 species. For the purpose of assessing the impact of the OTF on non-commercial bycatch only the top 50 species (finfish and invertebrates) from each sector was used (Tables B2.21-22). In addition, species caught by *Kapala* that were also observed during observer studies in the OTF by Liggins (1996) and Kennelly *et al*. (1998) were also noted in Tables B2.21-22. A complete list from the *Kapala* surveys is given in Appendix B2.7. These lists should be used as an indicator of the range of possible species that could be taken as bycatch in the OTF and not a definitive list of species that is actually taken and discarded by OT fishers.

For the purposes of listing non-commercial bycatch, three main sectors of the OTF were defined as follows:

1. Ocean prawn trawl (OPT) shelf: includes OPT inshore and offshore sectors and operates mainly between Newcastle and Tweed Heads in 10-100 m depth for school and/or king prawns; prawn trawl gear ~ 40 mm mesh.
2. Ocean fish trawl (OFT) shelf: includes fish trawlers endorsed for OFT north (operating mainly from Sydney, Newcastle and Port Stephens in 10-200 m), and OFT south (SEF trawlers from southern ports that fish occasionally in NSW waters inside 3 n. miles). Fish trawls are required to be fitted with ~ 90 mm mesh codends.
3. OPT deepwater/OFT upper slope: includes prawn trawlers (and some fish trawlers) operating mainly from Sydney (some vessels occasionally from Newcastle, Port Stephens, Coffs Harbour and Clarence R) in 200-650 m for fish, deepwater bugs and royal red prawns; fish-trawl and prawn-trawl gear with 90 or 42 mm mesh codends respectively.

The largest number of species were caught in the OPT Shelf sector between Newcastle and Tweed Heads consisting of 185 finfish and 85 invertebrates species. The least number were caught between Sydney and Tuncurry in the OFT sector consisting of 73 finfish and 7 invertebrate species (Table B2.20). An overall indication of the range of non-commercial bycatch that could be caught by the OTF was obtained from the top 50 species (finfish and invertebrates) caught in each sector and combined (Table B2.20). Of the 150 species listed, 25 species were elasmobranchs, 100 were teleosts and 25 were invertebrate species. Eighty six of the finfish species occurred in only one sector and one species (*Apogonops anomalus*) occurred in all four sectors (Table B2.20). The majority of invertebrate species occurred in only one sector, the OPT shelf and one species (from a hermit crab family) occurred in all four sectors (Table B2.20).

Table B2.20 Summary of the number of species caught during *Kapala* surveys in four sectors of the OTF.

Note:. Invert – invertebrates; Spp. - species

Sector	Finfish	Invert.	Total
OPT Shelf	185	85	270
OFT Shelf	73	7	80
OFT South	69	16	85
OPT Deep	148	30	178

# Sectors	# Finfish Spp.	# Invert. Spp.
1	86	24
2	30	0
3	7	1
4	1	1

Table B2.21 Summary of finfish species found in the top 50 species in frequency of occurrence from each sector caught during *Kapala* surveys.

Numbers are percentage occurrence in trawls; R - rank, Obs – observer study; OPT - ocean prawn trawl, OFT – ocean fish. Trawl.

		OPT		OFT Shelf		OFT South		Deepwater		
Family	**Species**	**%**	**R**	**%**	**R**	**%**	**R**	**%**	**R**	**Obs**
HEXANCHIDAE	*Heptranchias perlo*							41.3	14	✓
HETERODONTIDAE	*Heterodontus portusjacksoni*	22.6	35	20.1	27	64.1	9			✓
	Heterodontus galeatus					5.5	48			✓
UROLOPHIDAE	*Urolophus bucculentus*			86.5	2	24.2	27			✓
	Urolophus sufflavus			78.6	5	12.5	40			
	Urolophus viridis			91.3	1	17.2	31			
	Urolophus paucimaculatus			5.4	46	81.3	3			✓
	Urolophus cruciatus					46.1	14			✓
	Urolophus sp.A	25.1	29			71.9	6			
	Trygonoptera testaceus	37.2	16			38.3	20			
	Trygonoptera sp.B					16.4	32			✓
PARASCYLLIIDAE	*Parascyllium collare*			17.7	28	26.6	25			
SCYLIORHINIDAE	*Asymbolus rubiginosus*			29.6	20					
	Cephaloscyllium sp.A							23	40	✓
	Asymbolus analis					57.0	10			✓
	Cephaloscyllium laticeps					43.8	15			✓
SCYLIORINIDAE	*Galeus boardmani*							30.4	28	✓
SQUALIDAE	*Etmopterus lucifer*							24.7	36	✓
HYPNIDAE	*Hypnos monopterygium*	41.9	12							
NARCINIDAE	*Narcine tasmaniensis*			26.8	24			21.9	44	✓
RAJIDAE	*Raja australis*			73.8	7	24.2	27			✓
	Pavoraja nitida							22	43	✓
	Raja gudgeri							22.1	42	✓
	Raja sp.B							35.7	20	✓
	Raja sp.C							25.1	35	
CONGRIDAE	*Gnathophis longicaudus*	48.3	10							
	Gnathophis grahami	34.4	18							
	Bassanago bulbiceps							20	49	
AULOPIDAE	*Aulopus curtirostris*			40.4	14					✓
SYNODONTIDAE	*Trachinocephalus myops*	18.2	44			14.8	35			✓
HARPADONTIDAE	*Saurida filamentosa*	17.6	49	5.6	45					
	Saurida undosquamis	18.7	42							
PARAULOPIDAE	*Paraulopus nigripinnis*			64.1	9			69.7	3	
CHLOROPHTHALMIDAE	*Chlorophthalmus sp.2*							32.1	23	
GONORYNCHIDAE	*Gonorynchus greyi*	33.8	19	6.0	43	47.7	13			
BATRACHOIDIDAE	*Batrachomeus dubius*	17.88	46							
LOPHIIDAE	*Lophiomus setigerus*			7.0	41					
	Lophiodes mutilus							24.6	37	✓
ANTENNARIIDAE	*Antennarius striatus*	36.3	17							
CHAUNACIDAE	*Chaunax endeavouri*							23.1	38	
	Chaunax penicillatus							37.7	17	
OGCOCEPHALIDAE	*Halieutia brevicauda*			32.8	19					✓
MORIDAE	*Pseudophycis breviuscula*	33.8	19	11.4	37					
	Trypterophycis gilchristi							28.9	32	
	Euclichthys sp.A							20.5	47	
MACROURIDAE	*Caelorinchus parvifasciatus*							44.1	9	✓
	Caelorinchus mirus							29.3	31	✓
	Caelorinchus maurofasciatus							42.5	10	✓
	Lucigadus nigromaculata							35.6	21	
	Malacocephalus laevis							32.1	23	
	Lepidorhynchus denticulatus							60.8	4	✓
	Hymenocephalus longibarbis							29.4	30	
	Ventrifossa nigrodorsalis							18.9	50	

Table B2.21 cont'd.

		OPT		OFT Shelf		OFT South		Deepwater		
Family	**Species**	**%**	**R**	**%**	**R**	**%**	**R**	**%**	**R**	**Obs**
TRACHICHTHYIDAE	*Optivus sp. cf. elongatus*					19.5	29			
	Aulotrachichthys novaezelandiae			14.6	33					
	Optivus cf elongatus	33.8	19							
	Hoplostethus intermedius							40.3	15	✓
ZENIONTIDAE	*Zenion japonicum*							33.6	22	
GRAMMICOLEPIDIDAE	*Xenolepidichthys dalgleishi*							23.1	38	
CAPROIDAE	*Antigonia rubicunda*			15.2	32					
VELIFERIDAE	*Velifer multiradiatus*					5.5	48			✓
FISTULARIIDAE	*Fistularia petimba*	18.7	42	29.4	21	40.6	18			
CENTRISCIDAE	*Macroramphosus scolopax*			83.7	3	40.6	18			
	Macroramphosus gracilis			36.8	15					
	Centriscops humerosus							41.4	13	
SYNGNATHIDAE	*Solegnathus spinsissimus*			14.0	34	7.8	44			✓
SCORPAENIDAE	*Centropogon australis*	22.9	33			10.2	42			✓
	Maxillicosta whitleyi	59.5	8			79.7	4			
	Neosebastes incisipinnis			35.5	17	14.1	36			✓
	Neosebastes scorpaenoides					35.9	21			✓
TRIGLIDAE	*Lepidotrigla argus*	76.8	3	8.0	40	64.8	8			✓
	Lepidotrigla grandis			28.5	22					
	Lepidotrigla modesta			70.4	8					✓
	Lepidotrigla mulhalli			83.6	4	65.6	7			✓
	Lepidotrigla papilio	21.5	38			53.9	11			
	Lepidotrigla sp.			10.1	38					
	Lepidotrigla vanessa					50.8	12			
PERISTEDIIDAE	*Peristedion liorhynchus*							25.2	34	
PLATYCEPHALIDAE	*Platycephalus longispinis*	85.2	1			91.4	1			✓
	Suggrundus jugosus	29.1	24							
HOPLICHTHYIDAE	*Hoplichthys ogilbyi*			16.8	29					
	Hoplichthys haswelli							78.1	1	✓
SERRANIDAE	*Lepidoperca brochata*			13.6	35					✓
	Lepidoperca pulchella			16.8	29					
TERAPONTIDAE	*Pelates quadrilineatus*	21.8	36							
PRIACANTHIDAE	*Priacanthus macracanthus*	39.7	13							
DINOLESTIDAE	*Dinolestes lewini*					13.3	39			
APOGONIDAE	*Apogon nigripinnis*	21.8	36							
EPIGONIDAE	*Epigonus denticulatus*							31	27	
ACROPOMATIDAE	*Apogonops anomalus*	19.3	41	47.5	13	8.6	43	51.3	7	
	Synagrops japonicus			10.1	38			52.4	6	
LEIOGNATHIDAE	*Equulites mortoniensis*	23.2	32							
SCORPIDIDAE	*Atypichthys strigatus*					14.1	36			
CHAETODONTIDAE	*Chelmonops howensis*			5.9	44					
PENTACEROTIDAE	*Zanclistius elevatus*			33.8	18	7.8	44			
	Pentaceros decacanthus							32	25	
PINGUIPEDIDAE	*Parapercis allporti*			59.8	12					
	Parapercis nebulosa	17.6	49							
URANOSCOPIDAE	*Uranoscopus sp.1*			6.7	42					
CALLIONYMIDAE	*Callionymus calcaratus*	57.5	9			29.7	22			
	Synchiropus calauropomus	26.5	27			26.6	25			
	Callionymus moretonensis			26.9	23					
	Callionymus japonicus	17.88	46							
TRICHIURIDAE	*Benthodesmus elongatus*							20.4	48	
NOMEIDAE	*Cubiceps squamiceps*							26.2	33	
BOTHIDAE	*Lophonectes gallus*	83.5	2	24.8	25	16.4	32			
	Chascanopsetta lugubris							29.9	29	
	Engyprosopon grandisquama	20.9	40							

Table B2.21 cont'd.

Family	Species	OPT %	OPT R	OFT Shelf %	OFT Shelf R	OFT South %	OFT South R	Deepwater %	Deepwater R	Obs
PLEURONECTIDAE	*Azygopus pinnifasciatus*							36.8	19	
SOLEIDAE	*Zebrias scalaris*	64.5	7			15.6	34			
	Synclidopus macleayanus	47.8	11							
MONACANTHIDAE	*Thamnaconus degeni*					10.9	41			
OSTRACIIDAE	*Anoplocapros inermis*	65.6	6	23.6	26	86.7	2			
	Trioris reipublicae	67.6	5			42.2	16			
	Kentrocapros flavofasciatus			4.7	50					
TETRAODONTIDAE	*Arothron firmamentum*					18.0	30			
	Lagocephalus cheesemani	28.5	25	4.8	48	4.7	50			
	Sphoeroides pachygaster			59.9	11			20.9	45	
	Lagocephalus sp.			5.4	46					
	Reicheltia halsteadi	25.1	29							
	Torquigener altipinnis	26.5	27							
DIODONTIDAE	*Allomycterus pilatus*			73.9	6	73.4	5			
	Dicotylichthys punctulatus	18.2	44			4.7	50			
	Diodon nicthemerus					42.2	16			

Table B2.22 Summary of invertebrate species found in the top 50 species from each sector caught during *Kapala* surveys

Family	Species	OPT %	OPT R	OFT Shelf %	OFT Shelf R	OFT South %	OFT South R	Deepwater %	Deepwater R	Obs
MAJIDAE	*Leptomithrax tuberculatus*	25.1	29							✓
	Leptomithrax waitei			60.5	10					✓
PAGURIDAE	*Pagurus investigatoris*							58.3	5	
PANDALIDAE	*Plesionika martia*							41.7	11	
PENAEIDAE	*Trachypenaeus curvirostris*	70.7	4							
PINNIDAE	*Atrina tasmanica*					6.3	46			
PORTUNIDAE	*Ovalipes molleri*							22.9	41	
	Portunus argentatus	21.2	39							
	Portunus rubromarginatus	28.5	25							
	Charybdis bimaculata	39.7	13							
	Charybdis granulosus	17.9	46							
	Charybdis miles	31.3	23							
	Charybdis natator	17.3	51							
RANELLIDAE	*Fusitriton retiolus*							37.5	18	
DIOGENIDAE	*Dardanus arrosor*	22.9	33	36.3	16	28.1	24	39.6	16	
	Trizopagrus strigimanus			16.1	31	28.9	23	20.8	46	
HOMOLIDAE	*Latreillopsis petterdi*							41.7	11	
BUCCINIDAE	*Penion maxima*			4.8	48					
ENOPLOTEUTHIDAE	*Enoploteuthis galaxias*							31.3	26	
SEPIIDAE	*Sepia cultrata*							77.1	2	
SEPIOLIDAE	*Rossia australis*							50.0	8	
SEPIOLOIDIDAE	*Sepioloidea lineolata*	38.5	15							
SQUILLIDAE	*Belosquilla laevis*	31.8	22							
	Kempina mikado			12.1	36					
VOLUTIDAE	*Amoria undulata*					6.3	46			
	Ericusa sowerbyi					14.1	36			

b) Trends in Discarding Non-commercial Species in the OTF

Two studies on the NSW coast examined the discarding of species in the ocean prawn and ocean fish trawl fishery. Kennelly *et al*. (1998) recorded the weight of bycatch caught by ocean prawn trawlers on the NSW coast before the introduction of bycatch reduction devices (BRD). Their study only identified the most numerous species discarded in the catches and therefore is not a comprehensive list of what was discarded. Liggins (1996) identified all bycatch species caught by ocean fish trawlers along the NSW coast but did not record individual weights of catch of these species. Liggins (1996) study primarily drew data from vessels in the Commonwealth South East Trawl fishery operating from Eden but also included some NSW vessels operating further north in the fish trawl sector of the OTF. However, most fish trawlers south of Barrenjoey Point have dual endorsements to fish in Commonwealth and state waters. Liggins (1996) study is the only observer data we have of fish trawl discarding patterns in NSW and will be indicative only of the fish trawl sector rather than precise information. Both Kennelly *et al*. (1998) and Liggins (1996) studies used observers on actual commercial fishing vessels to obtain their data and therefore provide a generally realistic picture of what fishers catch during their trawling operations.

A list of all non-commercial bycatch species recorded from observer surveys on commercial fishing vessels was compiled from the studies of Kennelly *et al.* (1998) and Liggins (1996). A total of 156 species were caught, containing 37 species of elasmobranchs, 109 species of teleosts, 10 species of crustaceans and 1 species group of molluscs. The composition of bycatch species of commercial species taken by fish trawlers varied substantially between years and at large and small spatial scales (Liggins, 1996). Although no quantitative data on non-commercial species was recorded, their spatial and temporal variability is likely to be similar given comparable environmental conditions. Fifty percent of the total catch (over all years and ports) was discarded by fish trawlers and 54 % of the discarded catch consisted of non-commercial species (Figure B2.8). The quantity of non-commercial bycatch discarded from fish trawls varied little between or within years but was approximately four times larger at Eden than either of the two northern ports (over all years). The large quantities of bycatch discarded in Eden was a reflection of the generally larger catches of fish overall for this port (Liggins, 1996).

The non-commercial component of the discarded catches of ocean prawn trawlers was approximately three times larger than the commercial discards (over all ports and years) (Kennelly *et al*., 1998) (Figure B2.9). Of the four ports studied the Clarence River had the largest quantity of non-commercial discarded catch but this was a reflection of the greater number of days prawn trawlers spent fishing from this port compared to the other ports over the two year period. For both fish and prawn trawling the proportion of non-commercial discards or bycatch was at least equal to or greater than the commercial discarded catch (Figures B2.8-9).

Table B2.23 List of non-commercial bycatch species from observers surveys in ocean prawn and ocean fish trawls in the OTF.

Family	Species
ANTENNARIIDAE	*Antennarius striatus*
AULOPIDAE	*Aulopus curtirostris*
BATRACHOIDIDAE	*Batrachomoeus dubius*
BOTHIDAE	*Chascanopsetta lugubris*
	Lophonectes gallus
PLEURONECTIDAE	*Azygopus pinnifasciatus*
CALLIONYMIDAE	*Callionymus calcaratus*
	Callionymus moretonensis
	Foetorepus calauropomus
CAPROIDAE	*Antigonia rhomboidea*
CHAETODONTIDAE	*Chelmonops howensis*
CHAUNACIDAE	*Chaunax endeavouri*
CHEILODACTYLIDAE	*Cheilodactylus vestitus*
PARAULOPIDAE	*Paraulopus nigripinnis*
CLINIDAE	*Cristiceps aurantiacus*
CONGRIDAE	*Gnathophis spp.*
CYNOGLOSSIDAE	*Paraplagusia unicolor*
DACTYLOPTERIDAE	*Dactylopter orientalis*
DASYATIDIDAE	*Dasyatis brevicaudata*
	Dasyatis fluviorum
	Dasyatis kuhlii
	Dasyatis thetidis
DIODONTIDAE	*Allomycterus pilatus*
	Dicotylichthys punctulatus
	Diodon nicthemerus
EMMELICHTHYIDAE	*Emmelichthys nitidis*
ENOPLOSIDAE	*Enoplosus armatus*
HETERODONTIDAE	*Heterodontus galeatus*
	Heterodontus portusjacksoni

Family	Species
HEXANCHIDAE	*Heptranchias perlo*
HOPLICHTHYIDAE	*Hoplichthys haswelli*
HYPNIDAE	*Hypnos monopterygium*
LOPHIIDAE	*Lophioides mutilus*
	Lophioides naresi
CENTRISCIDAE	*Centriscops humerosus*
	Macroramphosus scolopax
	Notopogon xenosoma
MACROURIDAE	*Caelorinchus innotabilis*
	Caelorinchus maurofasciatus
	Caelorinchus mirus
	Caelorinchus parvifasciatus
	Lepidorhynchus denticulatus
	Lucigadus nigromaculata
MONACANTHIDAE	*Acanthaluteres vittiger*
MONOCENTRIDIDAE	*Cleidopus gloriamarisu*
NARCINIDAE	*Narcine tasmaniensis*
OGCOCEPHALIDAE	*Halieutaea brevicauda*
OSTRACIIDAE	*Anoplocarpros inermis*
	Aracana aurita
	Kentrocapros flavofasciatus
	Lactoria cornuta
	Lactoria diaphana
	Lactoria fornasini
	Tetrasomus republicae
OXYNOTIDAE	*Oxynotus bruniensis*
PARASCYLLIIDAE	*Parascyllium collare*
PATAECIDAE	*Pataecus fronto*
PEMPHERIDAE	*Pempheris affinis*
	Pempheris compressus
	Pempheris multiradiatus
PENTACEROTIDAE	*Pentaceros decacanthus*
	Zanclistius elevatus
	Zanclistius elevatus

Table B2.23 cont'd

Family	Species
ACROPOMATIDAE	*Apogonops anomalus*
	Synagrops japonicus
PINGUIPEDIDAE	*Parapercis allporti*
PLATYCEPHALIDAE	*Platycephalus longispinis*
	Ratabulus diversidens
	Suggrundus jugosus
PRIACANTHIDAE	*Cookeolus japonicus*
	Pricanthus macracanthus
RAJIDAE	*Pavoraja nitida*
	Raja australis
	Raja gudgeri
	Raja polyommata
	Raja whitleyi
	Raja sp. 1
	Raja sp.B
SCORPAENIDAE	*Centropogon australis*
	Gymnapistes marmoratus
	Neosebastes scorpaenoides
	Neosebastes thetidis
	Notesthes robusta
SCORPIDIDAE	*Atypichthys strigatus*
	Microcanthus strigatus
SCYLIORHINIDAE	*Apisturus sp.G*
	Asymbolus analis
	Cephaloscyllium laticeps
	Cephaloscyllium sp.A
	Galeus boardmani
DALATIIDAE	*Etmopterus lucifer*
SERRANIDAE	*Anthias pulchellus*
	Caesioperca lepidoptera
	Lepidoperca brochata
SOLEIDAE	*Aesopia microcephala*
	Pardachirus hedleyi
	Synclidopus macleayanus

Family	Species
SPHYRAENIDAE	*Sphyraena africana*
STEGOSTOMATIDAE	*Stegostoma fasciatum*
SYNGNATHIDAE	*Solegnathus spinosissimus*
SYNODONTIDAE	*Trachinocephalus myops*
	Saurida spp.
TERAPONIDAE	*Pelates quadrilineatus*
TETRAODONTIDAE	*Arothron firmamentum*
	Contusus richei
	Lagocephalus cheesemani
	Lagocephalus inermis
	Omegophora armilla
	Reicheltia halsteadi
	Sphoeroides pachygaster
	Tetractenos hamiltoni
	Torquigener altipinnis
	Torquigener hicksi
	Torquigener pleurogramma
TORPEDINIDAE	*Torpedo macneilli*
TRACHICHTHYIDAE	*Hoplostethus intermedius*
	Optivus sp.
	Paratrachichthys sp. 1
TRICHIURIDAE	*Benthodesmus elongatus*
TRIGLIDAE	*Lepidotrigla argus*
	Lepidotrigla modesta
	Lepidotrigla mulhalli
	Lepidotrigla papilio
PERISTEIDAE	*Peristedion picturatum/liorhynchus*
UROLOPHIDAE	*Trygonoptera testacea*
	Trygonoptera sp. B
	Urolophus bucculentus
	Urolophus cruciatus
	Urolophus paucimaculatus
VELIFERIDAE	*Velifer multiradiatus*
ZEDIDAE	*Cyttus novaezelandiae*

Invertebrates

Family	Species
CALAPPIDAE	*Calappa philargius*
	Matuta planipes
LATRIELLIDAE	*Latriellopsis petterdi*
LOLOGINIDAE	*Sepioloidea lineolata*
PORTUNIDAE	*Charybdis bimaculata*
	Charybdis miles
	Charybdis natator
	Ovalipes molleri
MAJIDAE	*Leptomithrax tuberculatus*
	Leptomithrax waitei
RANINIDAE	*Lyreidus tridentatus*

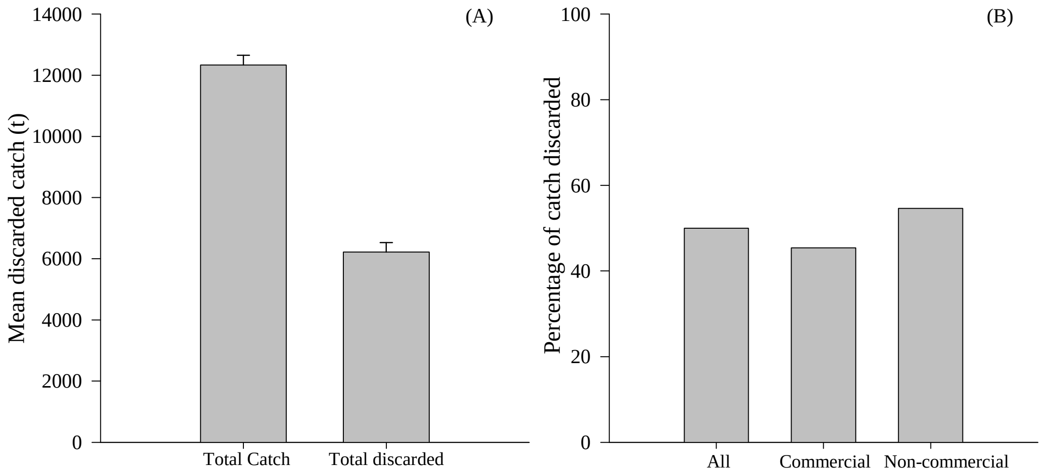


Figure B2.8 Summary of catch taken by ocean fish trawlers over all years and ports. (A) Total catch and total discarded. (B) Percentage of discarded catch consisting of commercial and non-commercial species.

Note: In (B) "All" is the percentage of the total catch that was discarded; "Commercial" and "Non-commercial" is the percentage of the discarded catch consisting of commercial and non-commercial species respectively. Source: Liggins (1996).

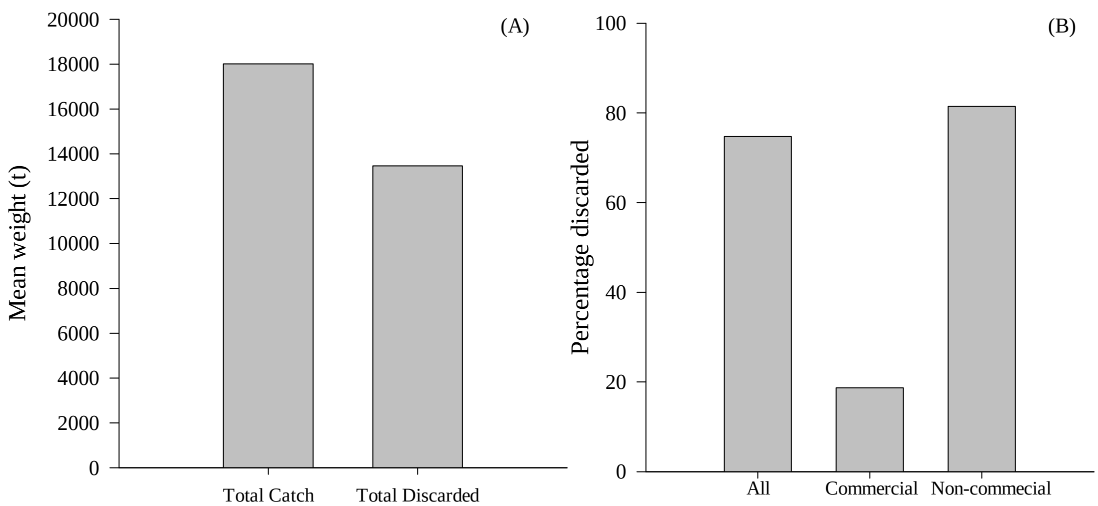


Figure B2.9 Summary of catch taken by ocean prawn trawlers over all years and four ports. (A) Total catch and total discarded catch. (B) Percentage of discarded catch consisting of commercial and non-commercial species.

Note: In (B) "All" is the percentage of the total catch that was discarded; "Commercial" and "Non-commercial" is the percentage of the discarded catch consisting of commercial and non-commercial species respectively. Source: Liggins (1996). Source: Kennelly *et al*. (1998).

Mitigation methods to reduce unwanted bycatch were introduced into the prawn trawl fishery in July 1999 by means of compulsory bycatch reduction devices (BRD). There are a number of different types available for fishers to use (see discussion in Section B2.3 and B1.2) but there have been no follow-up studies on how effective these different BRD perform under commercial trawling conditions. Therefore, it is not known what BRD are commonly used by fishers nor whether they have been effective in reducing non-commercial bycatch apart from designated scientific studies (e.g.

Broadhurst and Kennelly, 1997, Broadhurst *et al*., 2002). There are currently no observer studies being conducted on either ocean prawn or fish trawlers to further quantify non-commercial bycatch.

c) Food Provided from Bycatch (commercial and non-commercial)

Discarded catch from trawlers potentially provides food for a wide range of predators and scavengers including sea birds, marine mammals, sharks, predatory fish, crabs, snails, peracarid crustaceans, seastars and a variety of worms. There have been no direct studies on the extent discarding from the OTF provides food for other organisms. However, there have been a number of studies done on the fate of discards from prawn trawling in northern Australia (Harris and Poiner, 1990; Wassenberg and Hill, 1990b; Hill and Wassenberg, 1990b, 2000). These studies have shown that whether discards float or sink determines what organisms will feed on them. The proportion of finfish that floated ranged from 35 to 50%, cephlapods 33-53% and echinoderms 2% (Hill and Wassenberg, 1990, 2000). Floating discards were eaten at the surface by sharks, dolphins and seabirds. Around coral reefs seabirds were the most common scavengers (Hill and Wassenberg, 2000). Most seabirds (e.g. crested terns, brown boobies and lesser frigates) were size selective in their scavenging and generally took discards that were < 10-12cm long. The extent to which these species of seabirds depends on discards as a food source was estimated to be relatively small and only one species, crested terns, was thought to make up a substantial proportion of its diet (40%) from trawler discards (Hill and Wassenberg, 2000).

Overall, up to 80% of discards from prawn trawlers in northern Australia sank,. Approximately 50% of finfish and all rays sank (Harris and Poiner, 1990; Hill and Wassenberg, 1990, 2000). Of the molluscs 66-74% sank including most cephalopods sank (Hill and Wassenberg, 1990, 2000) and octopus (Harris and Poiner, 1990). All discarded crustaceans sank but the majority of these were alive although damaged (Harris and Poiner, 1990; Hill and Wassenberg, 1990, 2000). Hill and Wassenberg (1990) estimated that, depending on the species and depth of water, most sinking discards did so rapidly spending only 5-10 minutes in the water column. Sharks and predatory fish were the main mid-water scavengers on these discards (Hill and Wassenberg, 1990, 2000). The majority of sinking discards ended up on the bottom and were eaten by benthic scavengers including fish, echinoderms, and crabs (Hill and Wassenberg, 2000).

Whilst the above studies showed that a variety of marine animals, such as sea birds and sharks, feed on discards from trawlers in northern Australia they did not suggest that discards were a primary source of food for these animals, except possibly crested terns. Although there have been many studies in the northern hemisphere on the reliance of seabirds and other organisms on discards (Oro, 1996; Mertinez-Abrain *et al*., 2002) there have been very few in Australian waters. Blaber *et al*. (1995) found that during the trawling season in the northern Great Barrier Reef, 70% of the diet the tropical turn (*Sterna bergii*) comprised benthic fauna made available at the sea surface by discarding from trawler vessels compared to only 5% of the diet during the non-trawl season. This and two other species were active opportunistic feeders around trawlers but there was little evidence that discards had a direct affect on the breeding success or nesting frequency of these birds. This is in contrast to studies done in the northern hemisphere where there have been direct links made between breeding success of some seabird species or changes in their foraging habits and availability of discards (Reheher and Montevecchi, 1997, Stenhouse and Montevecchi, 1999).

d) Risk Assessment of Non-commercial Bycatch Species

The risk analysis was done on the 156 species from observed data only of studies by Kennelly *et al.* (1998) and Liggins (1996) as an indication of the risk to non-commercial bycatch species. Tables

B2.21-22 are not a complete list of all observed bycatch species of the OTF because only the most abundant species in the bycatch of Kennelly *et al.'s* (1998) study were identified.

Context

The goal of managing non-commercial bycatch is to ensure that these species are ecologically sustainable. Therefore, the risk being assessed is the probability of non-commercial bycatch species becoming unsustainable under the current operation of the OTF if it continues unchanged for the next 20 years.

Potential impacts of trawling on non-commercial bycatch species

The impacts on non-commercial bycatch species are the same as that for primary and key secondary species (see Section B2.3(b)). The sources of risk for these species are summarised in Table B2.24. The primary direct impact is biological overfishing that decreases spawning biomass of these species. Indirect impacts can also occur through habitat damage and disruption of ecological processes which will be covered in later sections. For discussion on the different types of overfishing and its effects see Section B2.3(b).

Table B2.24 Summary of main areas of risk for bycatch species in the OTF. Highlighted row indicates aspect that is assessed under Section 2.4(c) of the EIS.

	Activities of the Ocean Trawl Fishery							
Aspects needed to be sustainable	Trawling (physical damage)	Harvest (what is kept)	Discarding (what is put back)	Contact but not capture	Gear loss	Travel to/from grounds	Presence of vessel	Boat maintenance & emissions
Food availability and feeding sites	M		H	H				
Species interactions			H	L	L			
Sustainable levels of spawning biomass & mature biomass			H	M	L			
Spawning sites & spawning aggregations	H			L	L			
Dispersal of propagules/larvae								L
Recruitment	L							L
Growth			H	L				
Distribution/movement	H		H	L	L	L		

i) Risk on bycatch species from discarding

Very little is known of the biology of the non-commercial species discarded in the OTF and even less about the fishery operations on them, such as catch trends. Given these species do not contribute economically in a direct and substantial way to the fishing industry it is likely that the biology and fishery factors will remain unknown to a large extent because priority would be given to research on primary and key secondary species. Consequently, the risk assessment on these bycatch species will be very limited and may overlook potential impacts.

Resilience - biological characteristics

To determine the qualitative level of resilience for these bycatch species there were four main biological characteristics realistically suitable for most species. These characteristics were life history, mode of life, habitat association and depth range (Table B2.25). Geographic distribution was not used because the distribution of all species in the observed list overlapped with fishing areas of the OTF and therefore was not a discriminating character of resilience. The relevant information for each non-commercial bycatch species from the *Kapala* lists and from Liggins (1996) and Kennelly *et al*., (1998) observer data for each characteristic was derived from scientific literature, including journal publications and books. Where information for a particular character was not available for a species either information about the family was used or it was marked as "unknown" (for details see Appendix B2.7).

Table B2.25 Biological characteristics used to determine level of resilience of non-commercial bycatch species in the OTF.

Biological Character	Reason for use	Weighting
Life history strategy	Indication of a species' ability to maintain viable population sizes or rebuild population after depletion	Double
Mode of life - pelagic or demersal	Indicates its vulnerability to being caught by a demersal trawler	Single
Habitat Association	Indicates its vulnerability to being caught by occupying habitats usually trawled by the OTF	Single
Depth range	Indicates its scope to avoid being caught	Single

Eighteen species had risk averse biological characteristics to indicate they had high resilience. Eighteen species of finfish had intermediate-high resilience (Table B2.26). These species had pelagic eggs and larvae, which gives them a greater potential for their populations to recover from depleted stocks due to fishing mortality. Their large depth range means they have substantial area available to decrease their probability of encountering an OTF trawl net Seven species were associated with rocky reef habitat which contributes to lowing their probability of being caught in demersal trawl nets of the OTF relative to other species.

Table B2.26 List of non-commercial finfish bycatch species with intermediate-high levels of resilience from OTF.

Family	Species
OSTRACIIDAE	*Anoplocapros inermis*
AULOPIDAE	*Aulopus curtirostris*
TRACHICHTHYIDAE	*Aulotrachichthys novaezelandiae*
TRICHIURIDAE	*Benthodesmus elongatus*
MACROURIDAE	*Caelorinchus maurofasciatus*
	Caelorinchus parvifasciatus
	Hymenocephalus longibarbis
	Lucigadus nigromaculata
	Malacocephalus laevis
	Ventrifossa nigrodorsalis
TRACHICHTHYIDAE	*Hoplostethus intermedius*
SERRANIDAE	*Lepidoperca brochata*
	Lepidoperca pulchella
LOPHIIDAE	*Lophiodes mutilus*
	Lophiomus setigerus
TRACHICHTHYIDAE	*Optivus cf elongatus*
	Optivus sp. cf. elongatus
PENTACEROTIDAE	*Zanclistius elevatus*

Two species of finfish had low resilience to fishing pressure – *Heterodontus galeatusa, Trygonoptera testacea*. These are elasmobranchs which are primarily demersal and associated with sand substrates making them vulnerable to trawling. Their life history strategy of live bearing, relatively small number of offspring and being moderate to long lived makes their ability to recover their depleted populations very slow if overfishing were to occur. All invertebrate species had either low or intermediate to low resilience due to their demersal mode of life and habitat associations.

The vast majority of the remaining non-commercial bycatch species have pelagic eggs and demersal mode of life giving them a moderate to low or moderate level of resilience to fishing pressure (Appendix B2.7).

Fishery impact profile – fishery factors

Only two factors were used to assess the fishery impact profile on non-commercial bycatch species. These were survival after capture and overlap of fishing depth with range of depth of each species (Table B2.27). Survival after capture included baratrauma (inflation or bursting of their swim bladder as a fish is brought from depth to surface rapidly), handling on deck and predation from marine predators when returned to the water. The probability or degree of survival for teleosts and invertebrates was determined from studies by Hill and Wassenberg (1990a, 2000) and Wassenberg and Hill (1990b) and by consultation with experts with extensive experience in the composition and nature of trawl catches (e.g. K. Graham, pers. comm., NSW Fisheries, 2004). Survival for elasmobranchs was determined from Stobutzki *et al*. (2002). These studies found that almost all teleost bycatch die before being returned to the water. Cephalopod survival was very variable but because most would be eaten by scavengers when returned to the sea their survival overall was considered low. Crustaceans had a moderate likelihood of survival but most had been damaged from being captured (e.g. limbs missing) and therefore their long term survival may be impaired (Wassenberg and Hill, 1989). All other invertebrate groups were considered to have low survival because of their fragile body morphology. Because no species was considered to be able to completely survive handling only two levels of survival were used low (risk prone) and moderate (risk averse).

Table B2.27 Factors used to determine level of fishery impact profile on non-commercial bycatch species in the OTF.

Factor	Reason for use
Survival after capture	Indicates how well they survive after being trawled & handled on deck & returned to the water
Overlap with depth of fishing	Indicates whether the species occupies depths not fished by the OTF and therefore its scope for refuge from fishing

Overlap of fishing depth with depth range was either partial or complete. Partial overlap occurred when either the minimum or maximum depth range of a species was outside the range normally fished in the OTF, therefore providing some refuge from fishing by the OTF. Complete overlap occurred when the normal fishing depth overlapped with the depth range of a species by 100%. This overlap was given a double weighting because it left no opportunity of refuge from being caught for a species. Given the poor understanding we have of the basic biology and ecology of many of these species depth range is only approximate. In addition, we do not have accurate information of where OT fishers actually fish.

A total of 42 finfish species were assigned high levels on their fishery impact profile, which comprised of species suffer either baratrauma or trawl trauma from being confined in a trawl net (Table B2.28). A total of 7 finfish species exhibited low fishery impact profile levels, due to their more robust body form (e.g. Port Jackson shark) that enables them to have a greater survival after capture. Invertebrate species had high or intermediate to high levels of fishery impact due to their soft body forms (e.g. molluscs) or fragile body forms (e.g. crustaceans), which can easily result in death or broken appendages.

Table B2.28 List of non-commercial finfish bycatch species with high levels on their fishery impact profile from OTF.

Family	Species
HEXANCHIDAE	*Heptranchias perlo*
RAJIDAE	*Pavoraja nitida*
	Raja gudgeri
	Raja sp.B
	Raja sp.C
UROLOPHIDAE	*Urolophus bucculentus*
	Urolophus sufflavus
	Urolophus viridis
TRICHIURIDAE	*Benthodesmus elongatus*
MACROURIDAE	*Caelorinchus mirus*
	Caelorinchus parvifasciatus
	Lepidorhynchus denticulatus
CALLIONYMIDAE	*Callionymus calcaratus*
	Callionymus japonicus
	Callionymus moretonensis
	Synchiropus calauropomus
BOTHIDAE	*Chascanopsetta lugubris*
SQUALIDAE	*Etmopterus lucifer*
SCYLIORINIDAE	*Galeus boardmani*
OGCOCEPHALIDAE	*Halieutia brevicauda*
HOPLICHTHYIDAE	*Hoplichthys haswelli*
	Hoplichthys ogilbyi
TRACHICHTHYIDAE	*Hoplostethus intermedius*
	Optivus cf elongatus
	Optivus sp. cf. elongatus
	Aulotrachichthys novaezelandiae
OSTRACIIDAE	*Kentrocapros flavofasciatus*
	Trioris reipublicae
TETRAODONTIDAE	*Lagocephalus sp.*
	Reicheltia halsteadi
	Sphoeroides pachygaster
	Torquigener altipinnis
	Lagocephalus cheesemani
	Arothron firmamentum
TRIGLIDAE	*Lepidotrigla argus*
LOPHIIDAE	*Lophiodes mutilus*
	Lophiomus setigerus
SCORPAENIDAE	*Maxillicosta whitleyi*
	Neosebastes incisipinnis
PINGUIPEDIDAE	*Parapercis allporti*
	Parapercis nebulosa
SYNODONTIDAE	*Trachinocephalus myops*

Risk Levels

Consideration of two factors resulted in the risk assessment of non-commercial bycatch being reported differently from that of primary and key secondary species. First, there are a large and theoretically infinite number of species that can be caught as non-commercial bycatch. This makes it impossible under the given time constraints to assess each species individually. Second, the most effective way to reduce bycatch is for management measures to be directed at the whole of bycatch, not individual species that make them up. Consequently, except for species at the highest level of risk, only the percentage of species in each risk level will be discussed (detailed risk levels for non-commercial bycatch are given in Appendix B2.7)

Ninety five percent of the non-commercial bycatch species (fish and invertebrates) had a high or moderately high level of risk (Figure B2.10). Clearly, the majority of the non-commercial bycatch in OTF appear to be at substantial risk from the activities of the OTF. However, the following two points need to be kept in mind when interpreting the significance of this analysis. First, we do not have adequate quantitative data on the abundance of these species caught by the OTF. Therefore, we don't know the relative proportion of the available biomass of these species that the quantity of non-commercial bycatch represents. If the proportion caught is only a small proportion of the total abundance of the population of a species then those that do not survive discarding will have a negligible impact on the overall population (Kennelly *et al*., 1998). Second, the species on which the risk assessment was done were partly made up from prawn trawling before BRDs were introduced. Therefore, the composition of species caught may have changed and the resultant non-commercial bycatch may have a smaller proportion of species with high risk levels. Given these two points the large proportion of non-commercial bycatch species with high levels of risk may not be a significant problem. However, the lack of information needed to make a more accurate assessment requires that management measures should be precautionary and therefore must aim to maximise reduction in non-commercial bycatch.

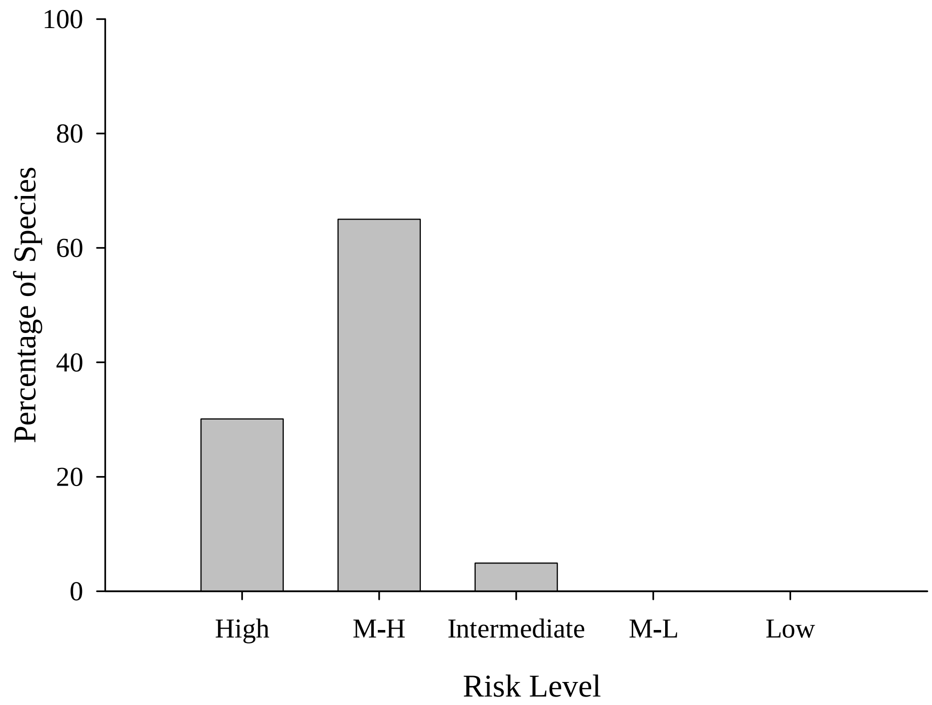


Figure B2.10 Percentage of non-commercial finfish bycatch species in each level of risk.

ii) Risk on non-commercial bycatch species from contact without capture and gear loss

The risk to non-commercial bycatch species from contact with fishing gear, but without capture, and gear loss is exactly the same as for primary and key secondary species (see Section B2.3) because they would interact with these two activities of the OTF in the same way. Therefore, the level of risk to the sustainability of the biomass of non-commercial bycatch species from contact without capture is intermediate and with gear loss is low.

e) Issues arising from the risk analysis on non-commercial bycatch species

Species specific versus whole bycatch approach to management

There are literally hundreds of non-commercial species that could be caught at some stage over the lifetime of a OT fisher as non-commercial bycatch by the OTF (see Appendix B2.6). There is little biological and ecological information about the majority of these species, which will probably remain the case given priority and economic constraints of managing the fishery. The wide range and lack of information about these species means that reducing non-commercial bycatch on a species specific basis will largely be ineffective. Where there is sufficient information about a species and it is at high risk of becoming unsustainable then it would be appropriate to manage it specifically. However, it is likely this will only occur for a minority of non-commercial bycatch species. Therefore, the best approach to managing this type of bycatch for the OTF is to minimise bycatch as a whole. Because of the diversity of the bycatch management should involve more than just one type of control. For example, bycatch reduction devices will help to reduce bycatch of round and flat fish but have little to no effect in reducing catch of non-commercial species of elasmobranchs because of their larger size, swimming motion and body shape. Additional management options, such as seasonal and spatial closures, will be required to provide a more comprehensive approach to minimising non-commercial bycatch.

No quantification of non-commercial bycatch

Determining the combination of multiple management controls to reduce non-commercial bycatch requires certain information that is currently lacking in the OTF. Two factors need to be quantified. First, we need to know the spatial and temporal variability in the abundance and diversity of non-commercial bycatch species. Until this is quantified it will not be possible to determine a suitable course of action to mitigate any potential impacts for non-commercial bycatch. In both ocean prawn and fish trawl fisheries, Kennelly *et al.* (1998) and Liggins (1996) found the composition and abundance of bycatch varied greatly depending on year, season and location. Identifying any spatial and temporal patterns larger quantities of non-commercial bycatch should result in more informed decisions for implementing management controls.

Second, the survival of non-commercial species after they have been discarded and the factors that contribute to their survival (e.g. sorting practices on deck) needs to be quantified. Currently, the only information in Australian fisheries on the survival of discarded bycatch are from tropical trawlers (Hill and Wassenberg, 1990, 2000). Survival in temperate waters could potentially be different for similar groups of species because of different environmental conditions, handling on deck and suite of scavenger species present around trawling vessels in the OTF.

Effectiveness of bycatch reduction devices

As for commercial discards, the effectiveness of the current compulsory BRD used in the fishery needs to be assessed in terms of how well they reduce non-commercial bycatch. There have been no studies done on BRD as they are used under commercial trawling conditions since their compulsory introduction for ocean prawn trawling in 1997 (see also Section B2.3(c)).

Evaluate changes to gear selectivity on changing the quantity and composition of non-commercial bycatch

Any proposed changes to gear selectivity for primary and key secondary species will need to be evaluated in terms of any flow on effects to the quantity and composition of bycatch. Whilst improved gear selectivity should decrease undersized commercial bycatch its effect on non-commercial bycatch species is unknown. Therefore, changes to gear selectivity should be monitored to determine whether it results in either major differences in composition of species and/or changes the quantities of non-commercial bycatch either positively or negatively.

Limited bycatch reduction methods for fish trawling

Currently bycatch reduction devices are only compulsory in prawn trawling. Such devices are unsuitable for fish trawlers because their design would necessarily exclude many of the primary and key secondary species that fishers target. Consequently, different methods of reducing non-commercial bycatch in fish trawling are needed. In a multi-species fishery like the OTF there is no one gear size that minimise bycatch across all species. A better understanding of the variability in the composition and quantity of bycatch caught in fish trawls will enable specific methods to be developed to reduce unwanted catch. For fish trawl such methods will need to take into account the large latitudinal differences in bycatch that were evident from Liggin's (1996) study. These differences, if verified by observer studies, may result in a gradation of methods of bycatch reduction with tighter controls the further south fish trawling occurs. Clearly, without specific information about the quantity and composition of bycatch management measures will either be too weak or too stringent on fishers and hence not effective in reducing the risk to the sustainability of bycatch species.

No knowledge of food provisioning of marine scavengers from discards

There is currently no quantified information on potential effects of discards from the OTF providing a source of food for marine scavengers such as sea birds, sharks and marine mammals. Information is needed to assess whether there are any scavenger species that have become dependent or partially dependent on discards as a source of food, particularly during their breeding seasons. Based on this information an appropriate management strategy, if necessary, can then be developed.

2.5 Risk Analysis of Threatened and Protected Species

Threatened species are protected by state and federal legislation that aims to conserve and promote their recovery. The risk ratings given below, therefore, refer to the risk that any aspect of the fishery would impede the conservation and recovery of a threatened species. The consequence of any impediment to conservation and recovery of the species would range from at best; maintenance of the existing situation, or at worst, further declines in the species.

For this assessment, ‘threatened species’ refers to any species, populations or ecological communities and their habitats as defined under Schedules 4 or 5 of the *Fisheries Management Act 1994* (FM Act), Schedules 1 or 2 of the *Threatened Species Conservation Act 1995* (TSC Act) or subdivisions C or D of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This assessment also includes any species of fish listed as protected under sections 19 (totally protected – not to be taken) or 20 (not to be taken by commercial fishers) of the FM Act.

a) Evaluation of risk to threatened and protected species

The approach taken to the risk assessment for threatened species broadly follows that used for primary and key secondary species. First, aspects of the biology and distribution of the species that influence the population’s vulnerability to the fishery were reviewed and a level of resilience is assigned. Second, information on the fishery impact was reviewed. Unlike the primary and key secondary species assessment, however, quantitative information on the fishery impact for threatened species is not readily available. Reasons for this are, first, because these species are generally not abundant and therefore would rarely be caught by trawlers, and second, because they are not marketable and therefore would usually be discarded. Consequently, other available information on capture of the species, along with consideration of the likely interactions based on habitat use is used to assess the fishery impact profile, which is given a rating (low, intermediate or high). A risk level is then assigned to each species based on the risk matrix (Table B2.26).

i) Evaluation of resilience level

Biological characteristics used to determine the resilience of threatened species to disturbances caused by trawling are the same as those used for the primary and key secondary species. The characteristics are fecundity, life history strategy, geographic distribution, habitat specificity, population size, growth rate, longevity, age at maturity and diet specificity. The resilience level is assigned according to the number of risk prone and risk averse characteristics that a species possess. Resilience level is assigned according to the set of rules found in Table B2.13.

ii) Evaluation of interactions with the fishery

Interaction with the fishery is based on the overlap between the species and the area in which the fishery operates (geographical and habitat), and where data are available, the frequency and/or the nature of the interaction is taken into account. The level of interaction is assigned according to the following guidelines.

None: no interaction with the fishery due to no/extremely rare geographical overlap of historical or present range, or exclusive occurrence in habitats unsuitable for the operation of the fishery, such as rocky reefs. Species in this category are eliminated from further analysis.

Low: some contact with the fishery (including the influence of noise and light), capture or provisioning is possible, but number of individuals encountered is small enough to have a negligible impact and/or the effects of such encounters on individuals is negligible (based on survey information, other observations, geographic range).

Intermediate: contact with a moderate number of individuals or relatively infrequent contact and/or effects moderate (e.g. could affect the growth or longer term survival of those individuals).

High: contact with a large number of individuals, or relatively frequent contact, such that death of the individuals, disruption of breeding, etc. is likely to occur.

iii) Risk matrix

The risk matrix in Table B2.29 provides a means of assigning one of five risk levels to a threatened species. The implications of, and appropriate management responses to the various risk levels are given in Tables B2.30 and B2.31 respectively.

Table B2.29 Risk matrix for the impact of the Ocean Trawl Fishery on threatened species

L = Low, M = Moderate, H = High, L-M = Low to Moderate, M-H = Moderate to High, Int = intermediate

Interaction with the fishery rating	**Resilience level**				
	High	High-Int	Int	Int-Low	Low
Low	L	L	L	L-M	L-M
Medium	L	L	L	L-M	M-H
High	L	L	L-M	M	H

Table B2.30 Interpretation of assigned risk levels

Risk	Outcome for threatened species
Low	Species unlikely to be affected by trawling
Moderately Low	Possible small effects but population unlikely to be affected
Intermediate	Recovery impeded by the activity, further population declines in medium-long term under the existing arrangements
Moderately High	Recovery impeded, further population declines in short-medium term under existing arrangements
High	Recovery impeded, further population declines or extinctions imminent under existing arrangements

Table B2.31 Examples of management actions required to address the various risk levels

Risk	Management response required
Low	None
Low-Medium	None at present, but changes to activity may require re-assessment
Medium	Suspension of trawling in the affected area(s) pending research into impacts and/or implementation of other risk minimisation actions
Medium-High	Suspension of trawling in the affected area(s) pending research into impacts and/or implementation of other risk minimisation actions
High	Suspension of trawling in the affected area(s) pending research into impacts and/or implementation of other risk minimisation actions

b) Risks to threatened species

In the assessment, the phrase "waters off NSW" covers the water out to 80nm from the NSW coastline.

i) Species that may be at risk from the OTF

Based on preliminary assessment, 43 listed threatened marine fish, birds, reptiles and mammals do not require further assessment, because of the very small probability of their interacting with the Ocean Trawl fishery. The species eliminated from further consideration and the reasons why are given in Table B2.32. The remaining species are subject to detailed risk assessment (Table B2.34 and Appendix B2.8).

Birds eliminated from further analysis: The Abbott's booby, Antarctic tern, Australian lesser noddy, fairy prion, heard shag, herald petrel, Macquarie shag, masked booby, Round Island petrel and soft-plumaged petrel are eliminated from further analysis as their range does not include the waters off NSW. The grey-headed and Pacific albatrosses are eliminated from further analysis as they only occur as rare vagrants in the waters off NSW. The tristan albatross and blue petrel are eliminated from further analysis as they are unlikely to be found in the waters off NSW.

Shorebirds species (beach stone curlew, black-tailed godwit, broad-billed sandpiper, great knot, greater sand-plover, hooded plover, lesser sand-plover, painted snipe, pied oystercatcher, sanderling, sooty oystercatcher, and terek sandpiper) have been eliminated from further analysis because they occur on shoreline habitats that are not impacted upon by the deep water trawling activity of this fishery. Species that are predominantly coastal and are usually not observed far from the coast at sea, the little tern and osprey, have been eliminated from further analysis as they generally do not utilise the deeper offshore habitats in which the OTF operates.

Mammals eliminated from further analysis: The fin and sei whales are eliminated from further analysis as there are no confirmed records of these species in the waters off NSW. The sub-antarctic fur-seal and southern elephant seal are eliminated from further analysis as they are predominantly Antarctic and sub-antarctic species that only occur in the waters off NSW as very occasional stragglers.

Reptiles eliminated from further analysis: The olive ridley and flatback turtles are eliminated from further analysis as they are predominantly tropical species that generally do not occur in waters off NSW.

Fish species eliminated from further analysis: Three marlin species (black, blue and striped marlins) are eliminated from further analysis, because they are fast swimming pelagic species and likely to be able to outswim trawlers. None of the above species have been recorded in trawl captures in NSW (Graham *et al*. 1995, 1996, 1997, Liggins 1996). For the remaining species, detailed information is given below.

Other species (plants and invertebrates): There are no listed plant or invertebrate species that occur within the area of operation of the Ocean Trawl fishery.

Table B2.32 Listed threatened species that do not require further analysis

Species	Status	Justification
Fish		
Black marlin	Protected S. 20	Fast swimming, pelagic species, unlikely to be encountered
Blue marlin	Protected S. 20	Fast swimming, pelagic species, unlikely to be encountered
Striped marlin	Protected S. 20	Fast swimming, pelagic species, unlikely to be encountered
Birds		
Abbott's booby	Endangered	Range does not include the waters off NSW
Antarctic tern	Endangered	Range does not include the waters off NSW
Australian lesser noddy	Vulnerable	Range does not include the waters off NSW
Fairy prion	Vulnerable	Range does not include the waters off NSW
Soft-plumaged petrel	Vulnerable	Range does not include the waters off NSW
Round Island petrel	Critically Endangered	Range does not include the waters off NSW
Masked booby	Vulnerable	Range does not include the waters off NSW
Macquarie shag	Vulnerable	Range does not include the waters off NSW
Herald petrel	Critically Endangered	Range does not include the waters off NSW
Heard shag	Vulnerable	Range does not include the waters off NSW
Grey-headed albatross	Vulnerable	Rare vagrant to the waters off NSW
Pacific albatross	Vulnerable	Rare vagrant to the waters off NSW
Tristan albatross	Endangered	Unlikely to be found in the waters off NSW
Blue petrel	Vulnerable	Unlikely to be found in the waters off NSW
Shorebirds (12 species)	Vulnerable (10) Endangered (2)	Species habitat will not be affected by the OTF
Little tern	Endangered	Preferred habitat will not be affected by the OTF
Osprey	Vulnerable	Preferred habitat will not be affected by the OTF
Mammals		
Fin whale	Vulnerable	Seemingly rare in waters off NSW, only two unconfirmed records to date
Sei whale	Vulnerable	Seemingly rare in waters off NSW, only two unconfirmed records to date
Southern elephant seal	Vulnerable	Occasional stragglers to the waters off NSW, only six records to date
Sub-antarctic fur-seal	Vulnerable	Occasional stragglers to the waters off NSW, only seven records to date
Reptiles		
Flatback turtle	Flatback turtle	Generally a tropical species, only recorded off NSW as a rare extralimital vagrant
Olive ridley turtle	Olive ridley turtle	A tropical species that has not been recorded off NSW

ii) Sources of risk

It is important to recognise that several processes operating may pose risks to a threatened species. In addition to the risks posed by trawling identified above, a number of other sources of risk are identified in the species profiles. In particular, various Key Threatening Processes (KTP's) are listed under Schedule 6 of the Fisheries Management Act 1994, Schedule 3 of the Threatened Species Conservation Act 1995 and are required by Section 183 of the EPBC Act. The object of listing key threatening processes under these various Acts is to manage and/or eliminate their impacts. The relevant KTP's for the threatened species considered here are listed below. Terrestrial based key threatening processes (e.g. predation by feral cat) are relevant to the OTF in that these processes may affect nests, eggs, and juveniles of land based threatened species.

Relevant KTP's listed under the FM Act

- Hook and line fishing in areas important for the survival of threatened fish species (henceforth abbreviated to "hook and line fishing"). NB. This is currently a recommendation by the NSW Fisheries Scientific Committee, and is at public consultation.
- The current shark meshing program in NSW waters (henceforth "shark meshing"). NB. This is currently a proposed recommendation by the NSW Fisheries Scientific Committee, and is at public consultation.

Relevant KTP's listed under the TSC Act

* These terrestrial processes are listed because they can impact on nests, eggs and young of land based threatened species.

- Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus (L.)* *
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition*
- Anthropogenic climate change
- Importation of Red Imported Fire Ants *Solenopsis invicta* Buren 1972*
- Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)*
- Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)*
- Death or injury to marine species following capture in shark control programs on ocean beaches has been proposed as a KTP by the NSW Scientific Committee and is pending finalisation
- The entanglement in or ingestion of harmful marine debris by vertebrate marine life is a KTP nomination currently under consideration by the NSW Scientific Committee

Relevant KTP's listed under the EPBC Act

- Competition and land degradation by feral goats (henceforth "feral goats")*
- Competition and land degradation by feral rabbits (henceforth "feral rabbits")*
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees south (henceforth "trawling north of 28° S")
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (henceforth "bycatch by longlines")
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (henceforth "harmful marine debris").

- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gasses (henceforth “greenhouse emissions”)
- Predation by feral Cats*
- Predation by the European Red Fox (*Vulpes vulpes*) (henceforth predation by foxes)*
- Predation, habitat degradation, competition and disease transmission by feral pigs (henceforth “effects of feral pigs”)*
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant) (henceforth “imported fire ants”)*

Other sources of risk

A range of other actual or potential sources of risk to particular threatened species have been identified in various publications including Action Plans, species recovery plans, and the general literature. These are mentioned where appropriate in each of the species profiles.

iii) Risks specific to the operation of the OTF

Table B2.33 summarises areas if risk posed by the activities of the OTF on threatened and protected species. It is important to realise that even a very low incidence of catch of a threatened species could be above their threshold of sustainability. For example, the eastern population of Loggerhead turtles are estimated to be only able to withstand 100 human induced deaths per year (C. Limpus, Qld EPA, pers. comm., 2003). Loggerhead turtles occur in three eastern states (Qld, NSW and Vic.) and are encountered by both State and Commonwealth fisheries. Whilst one fishery, such as OTF, may only encounter these turtles a few times and as a result the turtles die, these deaths may push the human induced mortality over the threshold of 100 and hence impair the recovery of this species. Therefore, it is not sufficient protection for some threatened species to rely solely on the minor incidences of encounters and conclude that no action should be taken to minimise the risks.

Table B2.33 Summary of main areas of risk for threatened and protected species in the OTF.

	Activities of the Ocean Trawl Fishery							
Aspects needed to maintain ecologically sustainable populations	Trawling (physical damage)	Harvest (what is kept)	Discarding (what is put back)	Contact but not capture	Gear loss	Travel to/from grounds	Presence of vessel	Boat maintenance & emissions
Food availability and feeding sites	L	H	H	H				
Species interactions	L	H	H	L	L			
Sustainable levels of spawning biomass & mature biomass		L	H	L	L	M	L	L
Breeding sites & breeding aggregations	H		H	L	L			
Dispersal of juveniles			H			L	L	
Recruitment	H	L	L			L	L	L
Growth		H	H	L				
Distribution/movement	M		L		L			

Activities of the fishery that pose the greatest risk to threatened and protected species

Trawling

Trawling has a direct effect in that it may incidentally catch threatened and protected species when these species are associated with a particular habitat that is being trawled or are feeding on the primary, key secondary or bycatch species taken by OT fishers or feeding from the net itself (e.g. there is evidence of seals entering nets to feed (Shaughnessy and Davenport, 1996). Turtles, sharks and protected finfish (and sometimes seals) are most likely to be directly caught in trawl nets whilst feeding on the finfish species targeted by the OTF, feeding on benthic fauna and/or flora on trawl grounds or whilst moving from one area/habitat to another. Seabirds can become entangled in the net itself or trawl gear such as the floatline or bellylines when they attempt to scavenge from the net as it is hauled in (Wienecke and Robertson, 2002). However such mortality of seabirds by the OTF is likely to be rare, much like that in the neighbouring South East Trawl Fishery in which seabird mortality has been observed to be "virtually non-existent" (Knuckey and Liggins, 1999).

Fishers are obliged to return any captured threatened species to the water. The survival rate of threatened species after incidental capture is likely to differ between different animal groups and be influenced by the duration of time on deck, air temperature, handling techniques and presence of predators in the water surrounding the vessel. Animals that are returned to the water injured or suffering from trauma may not recover from this interaction. For some species, such as turtles, simple on deck rehabilitation methods can be employed by fishers to increase their chance of survival (Leadbitter *et al.*, 1988). Handling of some threatened and protected species on deck to return them to the water can be very difficult due to their size and dangerous demeanour (e.g. sharks). Methods of releasing these species in a way that minimises harm to the fishers and increases their chance of survival are outlined in Leadbitter *et al.* (1988).

Turtle exclusion devices (TEDs) set in prawn trawl nets in Queensland are effective at allowing turtles to escape from nets but these devices are not used in NSW. Seal excluder devices are being developed in those trawling fisheries known to have significant interactions with species e.g. in New Zealand and the Blue Grenadier Fishery off Tasmania.

The noise and light emitted from vessels whilst trawling may be used by threatened species that are adapted to feeding on trawling discards to locate the vessel and approach it at the right time to feed.

Harvesting

Harvesting has an indirect effect on threatened species in that the OTF captures the natural prey species of other animals which may have an impact on those animals by depleting their food resources. The collapse of natural prey stocks of a species can reduce its breeding success, as shown with pelagic feeding seabirds by Barrett and Krasnov (1996). Seals are commonly cited as competing with fishers harvesting activities when feeding with many fishers believing that seals are responsible for depleting fish stocks (Shaughnessy, 1999). Similar interactions may occur for birds, sharks and dolphins, but there is little data. Seabirds are not likely to be directly affected by the OTF in this way as the fishery predominantly harvests demersal species generally beyond the maximum foraging depth of seabirds. It should be noted that provisioning with discards (see below) may offset any reduction in food through capture, but it is not known to what extent this occurs for any species.

Discarding

Discards from trawling activities provide a concentrated food source and can have both a direct and indirect affect. Many species of seabirds, including threatened seabirds, and seals have adapted to this regular food source from trawlers around the world. When feeding on discards, and in the case of seals also actively taking fish from nets, adapted animals regularly follow trawlers. Some seabird species actively feed next to trawlers while others passively feed on the discards that may be floating some distance away (Blaber *et al.*, 1995).

By regularly feeding on trawl discards an animal provisions part of its diet to this ‘unnatural’ food source. This food will mostly be comprised of benthic / demersal species, that are usually not naturally available to pelagic feeding animals such as seabirds. Such species that have adapted to feeding on trawl discards, have modified their diet to do so (Blaber *et al*., 1995; Blaber and Wassenberg, 1989). Discards can form a substantial part of the energy requirements of dependent animals, such as seabirds (Thompson, 1992; Oro and Ruiz, 1997; Walter and Becker, 1997; Martinez-Abrain *et al.*, 2002), and positive benefits such as a reduction in juvenile mortality of some seabird species have been observed (Blaber *et al.*, 1995). By provisioning their diet on this ‘unnatural food’ and becoming dependent upon it to an extent, in the case of dependent seabirds, a reduction in their breeding success and population has been observed in areas where trawling activity has ceased or reduced (Oro, 1996; Oro *et al.*, 1996; Chapdelaine and Rail, 1997).

The OTF has been operating for some time and animals have probably adapted to feeding on its discards. As discussed above for seabirds, such behaviour in dependent populations appears to have positive benefits for the species and negative consequences should only be experienced if trawling activity ceased or was reduced. The species that feed from OTF vessels, including any threatened species, have never been documented. Any species that are currently adapted to feeding on discards from the OTF should not be experiencing any negative consequences from this interaction, as trawling occurs off the whole NSW coast and discards are available throughout the year and the various stages of a species breeding cycle.

A negative aspect of provisioning behaviour in an animal is that it increases the likelihood of vessel-animal collisions. These interactions are further discussed in the section following on ‘Contact but not capture’.

Gear loss

Accidental loss of trawl nets, or ‘hook-ups’, where trawl nets become entangled on the seafloor can result in the input of debris in the form of net fragments into the ocean. Threatened and protected species are affected by marine debris when they ingest or become entangled in it, and this is listed as a KTP. These pieces of netting are probably the single largest source of entanglement of seals. In one Tasmanian study, trawl net fragments accounted for 42% of all seal entanglements in marine debris (Pemberton *et al*. 1992). However, the proportion of seal populations found in NSW waters is probably much less than where this Tasmanian study was conducted (Smith, 2001). Aside from net fragments, the OT fishery is not likely to introduce other harmful debris (e.g. plastic and line) into the marine environment, as trawling is an activity that generally does not generate rubbish. Also, fishers are conscious of gross pollution and generally dispose of non-biodegradable material at land based facilities.

Travel to and from fishing grounds

Many of the threatened and protected species that could be encountered by OT vessels are wide-ranging and highly mobile. In particular turtles and cetaceans are prone to encounters with vessels travelling to and from fishing grounds because their need to breathe air brings them to the surface and there is an overlap between their migration or movement paths with the routes taken by fish trawlers to and from their fishing grounds. If a vessel does come in contact with these species the level of impact on them will depend on the size of the animal, speed of the vessel, what part of the vessel touches the animal and what part of the animal is hit by the vessel. The part of the vessel likely to do most damage is the propeller, which can leave lacerations in the animals skin. Such severe encounters could impair the animal's ability to breed, capture prey or reduce its mobility if a fin is damaged and could result in death. Such encounters with threatened and protected species are reported to be very low, however there is little documentation of such incidences. NPWS have records of some marine reptiles and cetaceans that have died due to boat strike injury. However, the types of boats (i.e. commercial fishing vessels or other) involved in these incidents are unknown.

In addition to collisions, the mere presence of vessels in an area is known to disrupt the behaviour of some marine mammals, especially cetaceans (Clapham *et al.*, 1999). The most likely mechanism of disturbance is noise from the vessel, although visual and other cues may also be involved. The short term reactions to such disturbance range from attraction to avoidance, while the long term effects are largely unknown, but could include abandonment of certain areas if disturbance is severe (Richardson *et al.*, 1995).

The noise and light from OTF vessels when travelling to and from fishing grounds is only likely to disturb seabirds when they are foraging. Little is known of the effects of noise on foraging seabirds, a study on disturbance in a coastal bay found that seabirds (gulls and terns) were the birds least affected by human disturbance and they usually landed where they had been prior to the disturbance (Burger, 1981). As this noise source is a travelling one and is not likely to remain for too long in an area where a bird is foraging, the birds should only experience minor short-term effects. A positive effect for those species that are adapted to feeding from OTF vessels is that they may use the emitted noise and light to locate the vessels.

Contact but not capture

Contact but not capture can occur when a threatened or protected species encounters any part of a trawl net whilst in operation either accidentally or deliberately if it is raiding the net for food (Broadhurst, 1998; Hickman, 1999). Seals in particular are known to raid trawl nets, and may tear nets open with their teeth and then become entangled in pieces of net that are torn off. Due to the mobility of turtles and marine mammals such encounters are difficult to document and hence the level of impact of these contacts between fishing gear and threatened and protected species is unknown. Only when interactions between threatened and protected species with the OTF have been documented can there be a clear picture of the level of impact (if any) by the OTF, which can be determined and acted upon.

Foraging seabirds around trawlers can collide with various parts of the trawl gear, including cables and warps, causing injury or death if the collision is severe (Wienecke and Robertson, 2002). The collision of seabirds with netsonde monitor cables has been documented as the cause of considerable mortality (Environment Australia, 2001a). Netsonde monitor cables are not used on domestic gear in Australian waters, including that of the OTF (Environment Australia, 2001a). Observations on demersal trawling activity in Australian waters that does not use netsonde monitor cables found only low numbers of serious incidences resulting from the collision of seabirds with active trawl gear (Wienecke and Robertson, 2002), or "virtually non-existent" mortality of seabirds from trawling activity (Knuckey and Liggins, 1999). The listing of the collision of seabirds with the cables and warps used on trawl gear as a threat to many seabirds largely results from the use of netsonde monitor cables and is a precautionary measure, as more information is required to determine if trawl fisheries are having an impact on seabird populations (Environment Australia, 2001a). Considering the information from observations in Australian waters, it seems that any seabird mortality resulting from their collision with trawl gear used in the OTF would probably be rare. However, this level of interaction will not be certain until interactions have been documented.

iv) Summary of risk to threatened species

This assessment found all threatened and protected fish species to be at low or moderately low risk. The risk of the OTF impeding the conservation and recovery of threatened marine mammals and reptiles was assessed as low or moderately low, that for threatened seabirds moderately low and that for the endangered little penguin population at Manly moderately low. Risks to each species is summarised in Table 2.36. Detailed information supporting these risk assessments can be found in Appendix B2.8.

Table B2.34. Summary of risks to threatened species from trawling.

Common name	Scientific name	TSC/FM status	EPBC status	Risk level
Endangered species				
Birds				
Gould's petrel	*Pterodroma leucoptera leucoptera*	E	E	Mod. Low
Northern royal albatross	*Diomedea sanfordi*		E	Mod. Low
Southern giant-petrel	*Macronectes giganteus*	E	E	Mod. Low
Wandering albatross	*Diomedea exulans*	E	V	Mod. Low
Mammals				
Blue whale	*Balaenoptera musculus*	E	E	Low
Dugong	*Dugong dugon*	E		Low
Southern right whale	*Eubalaena australis*	V	E	Mod. Low
Reptiles				
Loggerhead turtle	*Caretta caretta*	E	E	Low
Fish				
Grey Nurse Shark (east coast population)	*Carcharias taurus*	E	CE	Low
Green Sawfish	*Pristis zijsron*	E		Low
Endangered population				
Little penguin population	*Eudyptula minor*	EP		Mod. Low

Note: Mod.-Low – moderate low, CE = critically endangered, E= endangered, V=vulnerable, u/c=currently under consideration for listing, P19= protected under Section 19 of the FM Act, P20= protected under section 20 of the FM Act.

Table B2.34 (cont.)

Common name	Scientific name	TSC/FM status	EPBC status	Risk level
Vulnerable species				
Birds				
Antipodean albatross	*Diomedea antipodensis*	V	V	Mod. Low
Black-browed albatross	*Diomedea melanophris*	V		Mod. Low
Black-winged petrel	*Pterodroma nigripennis*	V		Mod. Low
Buller's albatross	*Thalassarche bulleri*		V	Mod. Low
Campbell albatross	*Thalassarche impavida*		V	Mod. Low
Fleshy-footed shearwater	*Puffinus carneipes*	V		Mod. Low
Gibson's albatross	*Diomedea gibsoni*	V	V	Mod. Low
Grey ternlet	*Procelsterna cerulea*	V		Mod. Low
Indian yellow-nosed albatross	*Thalassarche carteri*		V	Mod. Low
Kermadec petrel (western)	*Pterodroma neglecta neglecta*	V	V	Mod. Low
Little shearwater	*Puffinus assimilis*	V		Mod. Low
Northern giant-petrel	*Macronectes halli*		V	Mod. Low
Providence petrel	*Pterodroma solandri*	V		Mod. Low
Red-tailed tropicbird	*Phaethon rubricauda*	V		Mod. Low
Salvin's albatross	*Thalassarche salvini*		V	Mod. Low
Shy albatross	*Thalassarche cauta*	V	V	Mod. Low
Sooty albatross	*Phoebetria fusca*	V	V	Mod. Low
Sooty tern	*Sterna fuscata*	V		Mod. Low
Southern royal albatross	*Diomedea epomophora*		V	Mod. Low
White tern	*Gygis alba*	V		Mod. Low
White-bellied storm-petrel (Tasman Sea), White bellied storm-petrel (Australasian)	*Fregatta grallaria grallaria*	V	V	Mod. Low
White-capped albatross	*Thalassarche steadi*		V	Mod. Low
Mammals				
Australian fur-seal	*Arctocephalus pusillus*	V		Mod. Low
Humpback whale	*Megaptera novaeangliae*	V	V	Mod. Low
New Zealand fur-seal	*Arctocephalus forsteri*	V		Mod. Low
Sperm whale	*Physter catodon*	V		Low
Reptiles				
Green turtle	*Chelonia mydas*	V	V	Low
Hawksbill turtle	*Eretmochelys imbricata*		V	Low
Leatherback turtle	*Dermochelys coriacea*	V	V	Low
Fish				
Black cod	*Epinephelus daemelii*	V		Mod. Low
Great White Shark	*Carcharodon carcharias*	V	V	Low
Whale Shark	*Rhincodon typus*	V	V	Low
Protected fish species (section 19)				
Giant Queensland grouper	*Epinephelus lanceolatus*	P 19		Mod.Low
Estuary cod	*Epinephelus coioides*	P 19		Mod. Low
Elegant wrasse	*Anampses elegans*	P 19		Mod. Low
Eastern blue devil	*Paraplesiops bleekeri*	P 19		Mod. Low
Ballina angelfish	*Chaetodontoplus ballinae*	P 19		Mod. Low
Herbsts nurse shark	*Odontaspis ferox*	P 19		Mod. Low
Weedy seadragon (or common seadragon)	*Phyllopteryx taeniolatus*	P 19		Mod. Low
Protected fish species (section 20)				
Groper, blue, brown or red	*Achoerodus viridis*	P 20		Low

c) Issues arising from the risk assessment for threatened species in the Ocean Trawl fishery

On-going monitoring of interaction between OTF and threatened species

All of the threatened species assessed are considered to be at low or moderately low risk from the operation of the fishery. Species at low risk are not likely to be affected by trawling and do not require further management attention. Those at moderately low risk may be experiencing small effects from trawling, but their population is unlikely to be negatively affected by the operation of the Ocean Trawl fishery. It is considered however, that because these species do interact with the fishery to some extent, ongoing monitoring of these interactions is required to ensure that there are no impacts on these species in future. It is recommended that any on board observer program put in place should include reporting on fishery interactions with threatened species, including bycatch, provisioning and disturbance. This will require observers trained in identification of marine birds, mammals and turtles, and may require additional observers to focus particularly on these taxa from time to time.

Investigation of dependence of threatened species on discards

The possibility of dependence of some threatened species on discards needs to be addressed. Any future changes to fishing practices, such as the closure of some fishing areas could adversely affect threatened species that have become dependent on trawlers as a source of food. More information is needed in order to quantify the importance of trawl discards in the diets of threatened species for this issue to be properly addressed in future. It is recommended that this issue be examined as part of any on board observer program, by quantifying the frequency of feeding on discards and estimating the proportion of the diet that comes from this source.

Mechanism to incorporate future listings of threatened species into management measures

The draft FMS will need a mechanism to incorporate future listings of species under threatened species legislation. For example, the endeavour dogfish currently occurs within the top 99% of the Ocean Trawl catch. The Commonwealth's Threatened Species Scientific Committee is currently considering a nomination to list this species as Vulnerable. The draft FMS for the Ocean Trawl fishery will need to ensure that this or any other species that is regularly caught in the fishery can be adequately protected.

2.6 Risk Analysis of Species Assemblages, Species Diversity and Ecological Processes

Species assemblages covered in this section will be confined to macroalgae and benthic motile invertebrates. All vertebrate assemblages have been covered under sections for primary and key secondary species, bycatch (commercial and on-commercial) and threatened and protected species (see Sections B2.3-5). Sessile invertebrates are discussed under marine habitats as biogenic habitat (Section B2.7). Species assemblages, species diversity and ecological processes will be described and assessed separately.

a) Species assemblages in the OTF

A species assemblage is simply a group of organisms that are present in the same place at the same time (Underwood, 1986). The two main broad groupings of species assemblages relevant to the OTF assessed in this section are macroalgae and benthic motile invertebrates. Determining the types of species assemblages that are present in the area where the OTF operates depends on the spatial and temporal scales at which the assemblages are defined (Underwood and Chapman, 1995). Because the OTF operates over a very large area of the NSW coast (see Chapter B1.2) (with exception of areas closed to fishing) and all year (with the exception of seasonal or flood event closures, see Chapter B1.2) for the purposes of the risk assessment species assemblages are all groups of organisms that occur within the spatial and temporal range of the OTF. Whilst the OTF does not actually trawl in every place and for every available hour in NSW it is important to remember that the activities of the fishery (and other human operations) can have both direct and indirect affects on the marine ecosystem (Hall, 1999). Therefore, it is appropriate to include species assemblages that occur over the entire range of the fishery.

In a general sense species assemblages are associated with different habitats (e.g. sandy substrate, rocky reef) and oceanic environments (e.g. depth, currents) (e.g. Bax and Williams, 2001). As the habitats and/or oceanic environments change the assemblages of species present also change. Spatially there are two main vectors of change in habitats and oceanic environments for the OTF – depth, from the coast to the continental slope, and latitude, from north to south. These two spatial vectors were used to identify the types of species assemblages present within the range of the OTF.

i) Macroalgal species assemblages

Macroalgae only occurs down to about 50m along the NSW coast, being most abundant from the intertidal zone to the shallow subtidal (Underwood and Chapman, 1995). There are four broad groups of macroalgae – foliose (e.g. kelp), turfing (e.g. green filamentose algae *Enteromorpha* spp.), articulated coralline (e.g. *Amphiroa* spp.) and encrusting (e.g. encrusting coralline) (Fowler-Walker and Connell, 2002). Similar groupings have been used extensively in the literature (e.g. Padilla and Allen, 2000). Underwood *et al*. (1991) described several types of habitat which included two with algal species assemblages in their surveys of the NSW coast. 'Turf habitat' was dominated by *Sargassum* and *Dictyopteris* species and "*Pyura* habitat" included large stands of *Ecklonia* or *Sargassum* and filamentous or turfing algae. Harriot *et al*. (1999) in their study of subtidal rocky reefs in northern NSW found diverse and abundant macroalgal species assemblages typical of sub-tropical and temperate environments. There was a difference in the macroalgal assemblages along the inshore to offshore gradient, reflecting a depth related change.

Potential impacts of OTF on macroalgal assemblages

Potential impacts on macroalgal assemblages are similar to those for habitats (see Section 2.7). The activity of trawling has the potential for the greatest impact on macroalgae. Foliose, articulated coralline and turfing algae can be impacted when the trawl net damages plants and/or completely removes their attachment from the substratum. Damaged fronds may reduce the algal assemblage's ability to photosynthesise, decreasing primary productivity in the damaged area. Furthermore, foliose macroalgae provides habitat and is a source of food for a large variety of motile invertebrates (e.g. amphipods, Poore *et al*., 2000). The loss of macroalgae will therefore impact the species assemblages that are dependent on them. Encrusting algae will be least impacted by trawling because of its flat profile and tougher growth form.

The other activities of the OTF **-** harvesting, discarding, lost gear, travel to and from fishing grounds, presence in the area and boat maintenance – all have low to negligible impact on macroalgal assemblages because the level of interaction between these activities and macrolage is very minor compared to trawling.

Risks on macroalgal assemblages from the activities of the OTF

Macroalgal assemblages usually occur on rocky substrata (Walker and Kendrick, 1998) that are difficult to access by the OTF. However, as noted in Section B2.7, use of bobbins on trawl gear enables trawlers to fish over low profile reef and close to the edges of high profile reef where fringing foliose and turfing algae could occur (Bax and Williams, 2001and see discussion in Section B2.7). Consequently, there is a possibility that trawling may be damaging the algal assemblages associated with these reefs in inshore areas. It is this accessibility of macroalgal habitats that puts these assemblages at most risk to becoming unsustainable under the current operation of the fishery within the next 20 years.

Resilience

Resilience of macroalgae was based on one factor, physical resistance. A second factor, regrowth, was considered but was not included because it depends on a number of other elements that are highly variable and act on very localised scales. These elements include presence and density of vertebrate and invertebrate grazers, proximity of adult plants, size of area to recolonise, frequency and magnitude of natural and human induced disturbance (Kennelly, 1987a,b,c; Airoldi, 2000; Dethier and Steneck, 2001). Because it is not possible to know the relative conditions of all these elements for the NSW coast the regrowth was not used to determine resilience. Physical resistance is related to growth form, which consisted of three types – foliose, turfing and encrusting. The levels of resilience are shown in Table B2.35 for each type of macroalgal grouping.

Table B2.35 Levels of resilience for broad groups of macroalgae.

Growth form	Resilience
Foliose	Low
Turfing	Moderate
Articulated coralline	Moderate
Encrusting	High

Fishery impact profile

The fishery impact profile for macroalgae was also based on one factor – accessibility. Accessibility is concerned with whether trawl gear is able to fish very close to or over the top of macroalgal habitat. A second factor, overlap of macrolagal habitat with current fishing grounds was not used because we do not have a clear picture of where trawl grounds are and where macroalgal habitat occurs (see Section B2.7). Table B2.36 summarises the fishery impact profile for the macroalgal groups for the OTF.

Table B2.36 Levels of fishery impact profile for broad groups of macroalgae.

Growth form	Habitat association	Accessibility	Impact Profile
Foliose	High rocky reef	Low	Low
	Low rocky reef	High	High
	Reef edge	Moderate - High	High
Turfing	High rocky reef	Low	Low
	Low rocky reef	High	High
	Reef edge	Moderate - High	Intermediate
Articulate coralline	High rocky reef	Low	Low
	Low rocky reef	High	High
	Reef edge	Moderate - High	Intermediate
Encrusting	High rocky reef	Low	Low
	Low rocky reef	High	Intermediate
	Reef edge	Low	Low

Risk levels

A simplified risk matrix was used to determine levels of risk for macoalgal assemblages. Because there is little data available about macroalgae and its response to trawling activity in the OTF the number of risk levels in the martrix was reduced to three – high, intermediate and low. Foliose and turfing algae associated with low reefs and foliose algae associated with reef edges were at highest risk from the OTF (Table B2.37). These three groups can be easily damaged by trawl gear that use bobbins.

Table B2.37 Levels of risk for broad groups of macroalgae.

Grouping	Habitat association	Risk Level
Foliose	Low rocky reef	High
	Reef edge	High
Turfing	Low rocky reef	High
Turfing	Reef edge	Intermediate
Encrusting	Low rocky reef	Intermediate
Articulate coralline	Low rocky reef	Intermediate
	Reef edge	Intermediate
Foliose	High rocky reef	Low
Turfing	High rocky reef	Low
Encrusting	High rocky reef	Low
	Reef edge	Low
Articulate coralline	High rocky reef	Low

ii) Benthic motile invertebrate species assemblages

Most information about benthic motile invertebrate species assemblages on the coast of NSW are for intertidal and shallow subtidal areas (e.g. Underwood *et al*., 1991; Underwood and Chapman, 1995; Kennelly, 1987a,b,c). The range of invertebrate groups found at these depths include anemones, echinoderms, worms and molluscs. These can occupy a range of habitat types including rocky reefs, sand, mud and gravel sediment (Underwood and Chapman, 1995).

Knowledge of benthic motile invertebrate assemblages deeper than 20m is very patchy and less detailed than shallower habitats. The major groups of invertebrates occurring at these depths are:

- Meiofauna (very small animals that live interstitially in sediment)
- Crustaceans (e.g. hermit crabs)

- Echinoderms (e.g. starfish, sea urchins)
- Molluscs (e.g. bivalves, limpets, nudibranchs)
- Anemones (e.g. burrowing anemones)
- Worms (e.g. polychaetes, flatworms)

Ponder *et al.* (2002) provides descriptions of all the major marine invertebrate groups found in Australian waters, including the continental shelf and slope and abyssal plain. All of the major groups identified above have families of species that occur from the shallowest to the deepest parts of the ocean and in the widest range of habitats from fine muddy sediment to rocky hard substrata and biogenic structures such as sponges (see Section B2.7). There is virtually no habitat type or ocean depth where some groups of invertebrate assemblages are not found.

Potential impacts of OTF on benthic motile invertebrate assemblages

Benthic motile invertebrate assemblages are associated with habitats that are fished by the OTF. Therefore, there is great potential for them to be impacted by the fishery. However, there has been very little work done directly on these assemblages on the extent and magnitude of effects of the activities of the OTF. Table B2.38 summarises the main impacts in general from trawl fisheries but it should be noted that much of this is based on studies done on trawl fisheries in the northern hemisphere.

Table B2.38 Summary of potential impacts on benthic motile invertebrate assemblages from the activities of trawl fisheries.

Fishery Activity	Impact on assemblages	Impact on habitats
Trawling	Disturbance of epibenthic fauna, removal and displacement of individuals	Damage or complete removal of biogenic habitats
	Damage or mortality of benthic fauna in path of trawl	Erosion of low relief hard substrata
	Resuspension of sediment smothering epibenthic fauna	High levels of trawling decrease bottom complexity & habitat heterogeniety
Discarding	Displacement of organisms from refuges to open habitat, increasing vulnerability to predation	Displacement of rocks, rubble and damaged biogenic habitats
	Exposure to surface scavengers	
	Increase in density and populations of invertebrate scavengers from increase supply of food	
Harvesting	Removal of larger species, trophic interactions	Not applicable

Trawling

The activity of trawling has potentially the greatest impact on benthic motile invertebrate assemblages. These impacts are similar to those on habitats (see Section B2.7). Trawl tracks in soft sediment made by otter boards, bobbins and ground chains disturb infauna and damage and expose burrowing invertebrates (e.g. heart urchins) to scavengers (Freese *et al*., 1999; Hall, 1999). Collie e*t al.* (2000) noted that invertebrate assemblages living in naturally stable sediments and biogenic habitats are more adversely affected by trawl damage than those in coarse, more naturally disturbed sediments. They and other authors suggest that the more frequent an area is trawled within a fishing season or year the more likely it is to be maintained in a permanently altered state (Rijinsdorp *et al.*, 1998; Collie *et al*., 2000; Kaiser *et al*., 2000). For the OTF there is currently little to no information on the precise location of trawl grounds nor how frequently they are trawled. Therefore, we cannot determine to what extent the impacts of the activity of trawling are having on benthic motile invertebrate assemblages in the deeper waters of the NSW continental shelf and slope.

Other impacts of the activity of trawling on motile invertebrate assemblages include physical damage and death. It exposes buried infauna to the surface making them vulnerable to scavengers especially if they are damaged and are unable to rebury themselves rapidly (Kaiser and Spencer, 1994). Two benthic species assemblages that appear to be able to withstand the physical impacts of trawling are brittelstars and echiniods. They have often been found to survive trawling partly due to their ability to regenerate and also they are able to slip through the meshes of nets more easily than other macroinvertebrates (Kaiser and Spencer, 1994; Engel and Kvitek, 1998;).

Removal and displacement of habitat by trawling decreases the heterogeneity of habitats leaving lower diversity available for colonisation of juveniles or larvae, fewer refuges from predators, fewer spawning sites and potentially increased competition for limited habitat (Hall, 1999; Bax and Williams, 2000, 2001). These influences may have a combined affect on biodiversity, which will be addressed in the next section.

There have been no studies done in NSW on the direct and indirect effects of trawling on benthic motile invertebrate assemblages on the continental shelf and slope. Bax and Williams (2000) have done a large study of habitats and impacts of trawling on the south east fishery ecosystem (encompassing the southern extreme of the OTF region) which included motile invertebrate assemblages. They found a diverse array of invertebrate assemblages that would be similar to that found in the southern region of the OTF. The lack of information for NSW means that we don't know to what extent the potential impacts observed in other parts of the world (as summarised above) are occurring. But a precautionary approach means we must assume the possibility that the OTF is having these impacts.

Discarding

Discarding can also affect motile benthic invertebrate assemblages. Because the activity of discarding often occurs whilst vessels are steaming, organisms thrown back into the sea are displaced from their place of origin. The organisms discarded that reach the seabed (often crustaceans and starfish) become a source of food for invertebrate scavengers such as crabs, other starfish, polychaetes and nematodes. It has been reported that in some areas this regular supply of food has increased densities and populations of motile invertebrate assemblages therefore changing community structure and composition. However, this is not consistent across all areas (Britton and Morton, 1994; Kaiser and Spencer, 1994; Ramsay *et al*., 1998).

Other activities of the OTF

The other activities of the OTF - harvesting, lost gear, travel to and from fishing grounds, presence in the area and boat maintenance – all have a low to negligible impact on benthic motile invertebrate assemblages because the level of interaction between these activities is minor compared to trawling.

Risk on benthic motile invertebrate assemblages from the activities of the OTF

The great diversity of species assemblages of invertebrates, their extremely diverse body forms, life histories, habitat associations and trophic structures means that determining their levels of risk to becoming ecological unsustainable over a period of time from the current operation of OTF is very difficult. Although motile invertebrates can be divided broadly into epifaunal (living on the surface) and infaunal (living beneath the surface) groups our lack of knowledge about the biology and ecology of motile assemblages in the deeper continental shelf and slope environments means determining their vulnerability or resilience would be too general to be meaningful. Roberts and Hawkins (1999) list biological characteristics of marine invertebrates that could be used to make an assessment of their vulnerability to extirpation or extinction but there is not sufficient information to use these for benthic motile invertebrate assemblages in NSW waters. In addition, as for all other ecological components, lack of knowledge of fishing intensity on fishing grounds makes determining realistic fishery impacts that is relevant for motile invertebrate assemblages not possible. Therefore, the overall level of risk to benthic motile invertebrate assemblages is precautionally determined as high until more specific knowledge is obtained.

iii) Summary of risks for species assemblages

Both groups of species assemblages assessed here are closely associated with the habitats that support primary and key secondary species of the OTF. Therefore, any impact by the fishery on these habitats will also impact these species assemblages although their responses to these impacts may vary. Because we know little about these oceanic assemblages the most precautionary level to assign overall is high (Table B2.39).

Table B2.39 Summary of risks to species assemblages posed by the activities of the OTF.

	Activities of the Ocean Trawl Fishery					
Aspects needed to be sustainable	Trawling (physical damage)	Discarding (what is put back)	Contact but not capture	Gear loss	Travel to/from grounds	Boat maintenance & emissions
Food availability and feeding sites	M	H	L			
Species interactions		H	L	L		
Sustainable levels of spawning biomass & mature biomass		H	L	L		
Spawning sites & spawning aggregations	H		L	L		
Dispersal of propagules/larvae						L
Recruitment	L					L
Growth		H	L			
Distribution/movement	H	H	L	L	L	

b) Species diversity

Biodiversity is defined as the variety among living organisms from all sources including within and between species and diversity of ecosystems (Environment Protection and Biodiversity Conservation Act, 1999). There are several types of biodiversity depending upon the focus of concern. Gray (2000) provides an extensive review of the different types of marine diversity and how they are measured. For the purposes of this report biodiversity will be confined to the variety within and between species.

Marine species diversity in Australian oceanic waters is very rich. At the broad taxonomic level of plants, vertebrate and invertebrate species diversity shows a north/south division. For example, of the 3400 species of marine fish in Australia, over half, 1900 species, occur in northern tropical waters. Many of these are common to the Indo-west Pacific region (Poore, 1995a,b). The southern temperate waters have fewer species but they contain a very high degree of endemic fish species, 85% compared to 10% in the north (Table B2.40) (Poore, 1995a,b).

Table B2.40 Percentage of endemic species found in northern tropical and southern temperate marine waters of Australia for a few broad taxonomic groups.

	Region	
Group	Northern tropical	Southern temperate
Fish	13	85
Molluscs	10	95
Echinoderms	10	90
Sponges	47	71

Other broad taxonomic groups show even stronger north/south patterns of endeminism. Species of molluscs and echinoderms are 95% and 90% respectively endemic to southern temperate marine waters (Poore, 1995a,b; Ponder *et al*. , 2002). Marine macroalgae are 90% endemic to Australian temperate waters (Phillips, 2001). Because the NSW coastal and oceanic waters stretch from the southern temperate region to the northern tropical region it would be expected that these waters would reflect the above broad scale patterns of species diversity, including a high degree of endeminism in the south. Studies of species diversity on the continental slope, shelf and oceanic waters of NSW is very patchy, limited to a few major taxa and localised areas (e.g. fish – Gray and Otway, 1994 & Connell and Lincoln-Smith, 1999; sponges, Roberts and Davis, 1996 & Hooper *et al*., 2002). Apart from these studies there is very little information about the magnitude and characteristics of species diversity for the oceanic waters in which the OTF operates. However, at a broad spatial scale a large proportion of marine species are unique to Australian waters. Added to this is the fact that there are still many undescribed species, especially marine invertebrates (Ponder *et al.,* 2002) and areas of Australia's EEZ that have not been explored (including large parts of the NSW continental shelf and slope), with the high likelihood of many species remaining undiscovered (Ponder *et al.,* 2002). Therefore, the level of species diversity and endeminism could be even in greater in NSW oceanic waters.

Potential impacts on species biodiversity from the activities of the OTF

The impacts of trawl fisheries on species diversity depends on the spatial and temporal scales considered. Studies of trawl fisheries in other parts of the world and Australia have shown that effects of commercial fishing on species diversity differs depending on the taxonomic group, area studied, intensity of fishing, spatial and temporal scale and how diversity was measured (Gray, 2000).

Trawling

The activity of trawling has the potential to have the greatest impact on species diversity because it has a direct affect on habitats that contribute to this diversity. Gray (1997) sites habitat loss as the greatest threat to species diversity. It can both decrease the number of species in a particular habitat type and change the composition of the species in a habitat. For example, trawling over low profile rocky reef can reduce the diversity of sessile species by destroying and removing entire assemblages of these species over a relatively short space of time, particularly if areas are trawled repeatedly in a season or year (e.g. Sainsbury, 1988). Because these sessile species, such as sponges and gorgonians, often provide habitat to other species, such as fish, molluscs and crustaceans, their removal from an area can lead to lower species diversity for a number of taxa and change the composition of other taxa (Gray, 1997). When slow growing species are lost from an area, species diversity may stay permanently depleted of these taxa because regrowth and recolonisation is so extremely low. For example, some sponges may take >100 years to regrow (Leys and Lauzon, 1998).

In soft sediments trawl gear may remove, displace or damage epibenthic organisms and disturb large areas of the seafloor. These disturbed sediments are often colonised by opportunistic species, such as nematodes, particularly in areas that experience low natural disturbance like deep continental shelves and slopes. In cases such as this trawling may not have changed the total number of species present in a habitat or area but has changed the species composition (Callaway *et al*., 2002).

Discarding

Discarding, because it displaces biomass to other areas of the seabed, may also increase or change species diversity by attracting scavenger species to an area to feed. Whilst this may only be sustained for a short period it has been known to increase the number of species of some crustaceans in areas where trawlers regularly discard along a particular route (Hill and Wassenberg, 1990).

Effects of impacts on species diversity

Marine biodiversity is believed to be linked to the proper functioning of ecosystems (Naeem, 2002). Generally, the greater the number of species the greater the capacity of the ecosystem to function normally. Some more strongly believe that species biodiversity is essential for ecosystem functioning (see review by Naeem, 2002). If species diversity is decreased then the ecosystem functions will also be impaired in some manner. However, there are few demonstrated examples of links between species diversity and ecosystem function (see Duarte, 2000 and references therein). Duarte (2000) suggests that ecosystem function is strongly correlated with the types of species in an area rather than numbers of species alone because the functions they provide are species-specific. Duarte (2000) found that it was the variability in species size in seagrass assemblages that was correlated to functional variability in seagrass ecosystems rather than number of species. However, he goes on to point out that diverse assemblages in ecosystems may have many “unrealised functional potentials” that may be essential to the sustainability of an ecosystem in the face of chronic disturbance.

Whilst it is unclear what the actual role of species diversity is in the sustainability of ecosystems, there is sufficient inference to be cautious in allowing activities in oceanic environments that change or diminish this diversity over an extended period of time and space. The risk to the viability of the OTF and of the ecosystem of oceanic waters in NSW is that they may become increasingly less productive. The time and spatial scales over which this may occur is unknown. There is sufficient evidence from other parts of the world with very large trawl fisheries that damage to ecosystems on many fronts may lead to irreversible losses of species diversity including some economically important fish species (e.g. Fu *et al*., 2001). The strong possibility that this could occur in NSW should not be ruled out.

Risk on species diversity from the activities of the OTF

Given the very poor knowledge of the spatial and temporal patterns of species diversity for major groups of biota in marine waters of NSW (including fish, invertebrates, reptiles, marine mammals, algae, protozoa) levels of risk to changes in species diversity can only be determined at the largest scale of ecosystem components (Table B2.41). The three main aspects needed to sustain species diversity are habitat diversity, habitat connectivity and ecological processes. The former two are strongly interrelated and will be considered together. Therefore, levels of risk to species diversity are linked to the risk to habitats and ecological processes. These two components are assessed in the following sections.

Table B2.41 Summary of main areas of risk to species diversity from the activities of the OTF.

	Activities of the Ocean Trawl Fishery		
Apsects needed to sustain species diversity	Trawling (physical damage)	Harvest (what is kept)	Discarding (what is put back)
Habitat diversity & connectivity	H		L
Ecological processes	H	H	H

c) Ecological processes

i) Ecological processes associated with the OTF

The scientific discipline of Ecology is concerned with quantifying the patterns of distribution and abundance of living organisms and the processes that create those patterns. An ecological process, broadly defined, is any process that affects the distribution and abundance of living organisms. Ecological processes can be identified at the level of individual organisms (e.g. interactions such as competition, predation, commensalism, mutualism, parasitism, physiological effects of temperature, light, nutrient availability on individual organisms, to name a few) but ecologists are generally concerned with the cumulative effects of such interactions at the population or assemblage level. Theoretical understanding at the population level is made tractable by distilling the combined effect of many processes into population parameters such as birth rate, mortality rate, and various coefficients of interaction strength (e.g. competition coefficients). Understanding these cumulative effects at the assemblage level becomes an increasingly complex task, because it involves understanding large numbers of ecological processes, each of which may interact with other processes, and each of which is subject to its own natural variability. Another set of ecological processes, often identified at the "ecosystem" level, results from the cumulative effects of individual and population level interactions; this includes processes such as primary production, secondary production, energy flow through the food web, cycling of nutrients, organic matter. These processes cannot be identified at the level of individuals because they are complex, involving multiple interactions between many organisms. Such processes are also difficult to predict based on the structure of the system, and are often referred to as "emergent properties" of the system.

In this document, discussions of certain ecological patterns and processes have been dealt with elsewhere. Direct effects of harvesting on population level processes such as growth, spawning and recruitment are considered in sections on primary, key secondary, bycatch and threatened and protected species. Direct effects of the fishery at the assemblage level are considered in the previous section on assemblages. Effects of fishing on habitat and the indirect consequences of habitat changes are discussed in section B2.7. This section of the EIS considers the indirect or "knock-on" implications of these direct effects to other parts of the system, including species that are not harvested, assemblages that are affected indirectly (may include indirect effects on harvested species), and ecosystem-level processes such as nutrient cycles and energy flow. Assessment of these indirect ecological processes and the patterns they create is important because any change to these processes could have flow on effects to other parts of the system, resulting in undesirable changes to the distribution and abundance of species that are not directly harvested.

Table B2.42 lists and defines the major ecological processes relevant for the Ocean Trawl fishery. Ecological processes provide the link between different states of a species population or assemblage, and between different components of the system. For example, secondary production is the result of consumption of primary producers (photosynthetic organisms) and its conversion into biomass of secondary producers. The process of growth links the state of eggs or larvae of an organism to its juvenile state (see Fig B2.2 in Section B2.1(c)(i)). If these processes are inhibited, impaired or changed in some way there could be knock-on effects to other species, assemblages and ecological processes. For example, frequent disturbance (natural or from trawling) could decrease secondary production through the removal of secondary producers, which would make less food available to higher trophic levels. Figure B2.11 illustrates in a simplistic model how natural events and human activities can influence ecological processes and how they affect species assemblages and populations. The natural event of increasing sea temperatures may act on the eggs of a species by affecting their development and hatching. This may increase the proportion of eggs reaching the larval stage because warmer temperatures may provide a more favourable environment for egg development than cooler temperatures. On the other hand the fishing activity of harvesting will act on the adult spawning stocks of a species by decreasing numbers of fish able to spawn. This may eventually affect recruitment back into the adult population (i.e. replenishing the stocks) because over time there may be a decrease in the number of recruits due to the decrease in the spawning stocks. For convenience, changes in the species populations and/or assemblages of the ecosystem that can be broadly grouped into three categories (Figure B2.11). These categories are arbitrary regions along a gradient, but they provide a useful framework for assessment. Negligible to no change is where the overall composition and structure of populations and assemblages remains within the range of natural variability (e.g. Gray and Otway, 1994). Moderate change occurs when there has been a shift in aspects of a species population or assemblage such as a change in the relationship between predators and prey (e.g. Christensen, 1996; Bulman *et al*, 2001). For example, a predator may have to change the prey it targets, such as from pelagic to benthic prey, as a result of a decrease in abundance of their normal prey items. Major change occurs when there has been a change in the composition of species and structure of assemblages in an ecosystem (e.g. Graham *et al*., 2001, Kaiser *et al*., 2002). For example, the destruction of a large area of habitat may result in a change in the dominance of a species population and a decrease in diversity. Because both natural events and fishery activities can affect ecological processes independently, simultaneously and synergistically, discerning whether the changes observed in an ecosystem are due to natural or human events is an important task for fishery biologists and ecologists (Underwood, 1992, 1996; Linegrath *et al*., 2000). The following section explores in more detail the potential impacts on ecological processes that can occur as a result of fishery activities.

Table B2.42 List of ecological processes relevant to the marine environment and the potential impacts on them from commercial trawling.

Process	Description	Potential impacts from commercial trawl fishing
Nutrient cycling	The release of nutrients, such as nitrate and phosphate, from organic matter by decomposers, to be harnessed by phytoplankton to produce organic matter	Unknown but primarily controlled by large scale oceanic factors such as currents and upwellings (e.g. Cresswell, 1994); cycling could be accelerated from damage to organisms due to trawling and discarding
Primary production	Primary production is a process that converts the sun's energy into carbon compounds that are then available to other organisms. As such it is the single most important factor for potential catches and productivity. Much primary productivity in marine systems is produced by phytoplankton.	Re-suspension of sediment may decrease light availablity; level of primary productivity required to sustain fishery may compete with the requirements of other biota (Trites *et al.* , 1997)
Food webs	The network of feeding relationships within an ecosystem or assemblages of species, e.g. the predator-prey relationships.	Removal of major predators and/or prey may lead to changes in species composition and structure of assemblages; tendency to fish down to lower trophic levels
Species interactions	Positive and negative interactions between species that favour or inhibit mutual growth and functioning of populations. Interactions may take the form of competition, predation, parasitism, commensalism or mutualism.	Reduction of predators may increase prey species which may lead to increased competition within populations and among assemblages; depletion of habitat may intensify species interactions competing for limited food and refuges
Spawning sites & spawning aggregations	The type of habitat required by a fish species for spawning (i.e. release of ova, fertilized or to be fertilized) The process of grouping of fish for releasing of ova and fertilisation	Damage to habitats may reduce availability of spawning and/or pupping sites. Overfishing may decrease proportion of males and females in populations reducing opportunities for fertilisation; decrease densities reducing size and possible effectiveness of aggregations
Dispersal of propagules/larvae	A movement of early life history stages away from its place of birth. This can take place via activie swimming of propagule/larvae or passively via water currents	Unknown but primarily controlled by large and small scale oceanic factors (e.g. Kingsford, 1993)
Recruitment (juvenile/larval recruitment into populations and sub-adult recruitment into fished stocks)	The process by which fish enter the exploitable stock and become susceptible to fishing. The process may be short or take more than one year The process by which juveniles of mobile species become part of an adult population, or by which larvae of sessile species metamorphose into the final development phase.	Severe depletion of spawning stock may reduce number of recruits available to join adult stocks. Removal or damage of habitats suitable for juvniles or larvea to settle and/or reduciton in refuges fome predators
Growth	Annual or seasonal. The increase in weight of a fish per year (or season)	Overfishing of prey species may lead to reduction in food available for growth
Distribution & movement	The movements of fish from feeding ground to spawning ground and back again, from nursery ground to feeding ground, and from spawning ground to nursery ground. This may be seasonal and/or random over various spatial scales.	Reduciton in distribution of habitats may result in species having to travel further to suitable areas, increasing energy expenditure

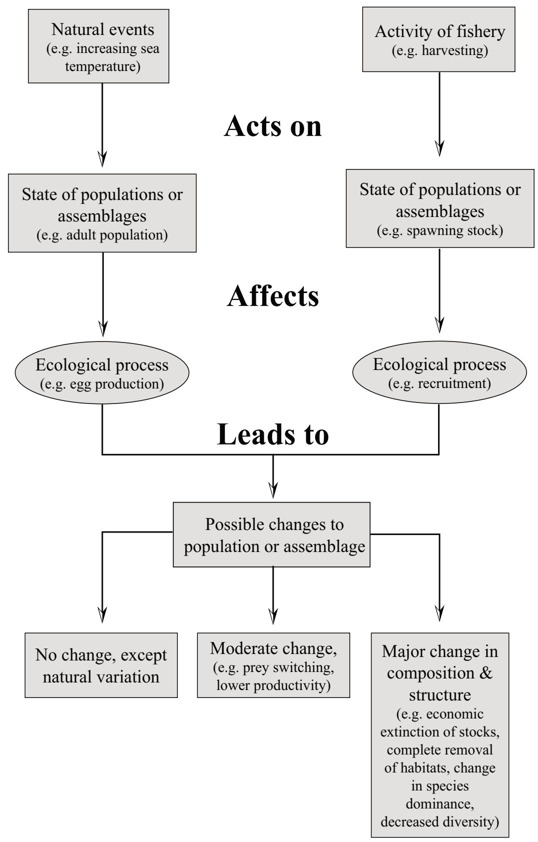


Figure B2.11 Flow diagram illustrating how both natural events and human activities affect ecological processes in the marine environment.

ii) Risk Assessment of Ecological Processes

Context

Ecosystem based fisheries management takes into account the effects of fishing on parts of the system other than the harvested species, and acknowledges that effects on these other parts of the system may also have consequences for target species. The aim of ecosystem based fisheries management is to ensure that the marine ecosystem, including its component populations, habitats and processes, is maintained so that it supports viable and sustainable fisheries (Pitcher and Pauly, 1998). This part of the EIS assesses the risk that the current activities of the OTF will result in the fishery becoming unsustainable because of widespread degradation of particular ecological processes within the next 20 years.

Potential impacts of the OTF on ecological processes

Harvesting

A widely accepted impact of harvesting on ecological processes is a change in predator-prey relationships as a result of the removal or depletion of key species within food webs (the so called “keystone species” model). Removal of top predators that control the abundance of prey species results in an increase in the biomass of prey populations as they are released from predation pressure (Christensen, 1996; Reynolds *et al.*, *2002*.). This model is not always applicable, especially in systems that have diverse trophic pathways and a number of top predators, or those whose structure is governed by “bottom-up” rather than “top-down” processes. Bulman *et al*. (2001) found that the diets and trophic groups of 70 demersal fish species on the continental shelf of southeastern Australia were very diverse. Overall the diet of the fish assemblage was equally split between benthic and pelagic prey species, and there was no one predator species that played a key role in shaping the prey species assemblages. Therefore, unlike predator-prey relationships reported in the northern hemisphere (Christensen, 1996), there does not appear to be a tight coupling of predators and prey among the demersal fish assemblages of the south eastern Australian continental shelf. Consequently, harvesting of certain key predator species may not severely affect trophic relationships in this system. Nevertheless, the removal of a large biomass of predators could be considered likely (without invoking any keystone effect) to have some effect on the biomass of smaller forage fish species, but such effects have not been measured in NSW.

Trawling is a relatively non-selective fishing method that catches a variety of species with a range of life-history characteristics. Such non-selective removal can cause increases in the relative abundance of species with shorter life histories, because species that are larger, slower growing and late maturing (e.g. elasmobranchs) will decline to a greater extent than smaller, faster growing species (Gislason, 2002; Link *et al*., 2002; Kirkwood, *et al*., 1994; Jennings *et al*., 1999). Major changes in demersal fish assemblages consistent with this scenario have occurred off the NSW coast in SEF trawl grounds (Andrew *et al.* 1997). These changes included a major reduction in the total fish biomass and a marked decline in the relative abundances of larger/older fish, and major reductions in the abundance of species with longer life histories, and were attributed to harvesting by the SEF over the past 20 years. There is no equivalent data specifically for the NSW Ocean Trawl fishery, however similar changes are likely to have occurred.

Continued fishing may eventually lead to a practice known as fishing down the food chain, which has occurred in many overseas fisheries (Pitcher and Pauly, 1998). The practice involves harvesting of progressively smaller, less valuable species as the larger species decline, with a number of knock-on effects for other parts of the system. Targeting species at lower trophic levels could reduce the availability of prey, causing further declines in large predator abundance. This can then lead to the release of more fish at lower trophic levels, which may then be targeted by fishers (Pitcher and Pauly, 1998). To determine whether this phenomenon is occurring in the OTF requires thorough analysis of catch data over an extended period of time. Until this is done we can only tentatively conclude that fishing down the food chain is probably unlikely in NSW for several reasons. First, the fish trawl part of the Ocean Trawl fishery targets a range of species at different trophic levels, not just the top predators. Similarly, the prawn trawl component of the fishery already targets particular species (prawns) at low trophic levels. Finally, there is unlikely to be a market for species from lower trophic levels that are not already marketed (Kevin Rowling, NSW Fisheries, pers. comm. 2003).

Interactions between fish, prawns and the prawn fishery may affect ecological processes. It has been suggested that where fish are important predators of prawns, fish bycatch may actually benefit prawns by reducing predation and increasing food supply (through discarding), and therefore that bycatch reduction would be detrimental to prawn fisheries (Christensen, 1996). Other evidence suggests that prawns are not greatly affected by predation by fish, and that discards are unlikely to be consumed by prawns (Christensen, 1996). In the NSW Ocean Trawl fishery, species that consume prawns are probably not abundant enough to have a large influence on prawn stocks, relative to that of the fishery (Kevin Rowling, NSW Fisheries, pers. comm. 2003).

Recruitment of new stock is essential to maintain viable fisheries, however this process is highly variable and not well understood. Although this process has been considered elsewhere for individual primary and key secondary species, one aspect that deserves attention in this section is the spatial structure of the spawning biomass that provides the main source of recruits. For certain species, recruitment to the area of the fishery may derive from elsewhere, while the biomass within the fishery area may contribute little to recruitment into that area. This could occur if the fishery was removing individuals before they spawn, or if the eggs and larvae were transported away from the area. As an example of this, it is thought that the spawning stock of redfish in NSW occurs predominantly on untrawlable ground in the north of the fishery, and this stock provides most of the recruits to the fishery (Kevin Rowling, NSW Fisheries, pers. comm 2003). Therefore, harvesting primary and key secondary species in one area may not necessarily affect recruitment to that area, but may have a large impact on recruitment elsewhere. Similarly, it is thought that the ocean perch population mostly occurs on untrawlable ground and fish are caught only when moving onto trawlable areas (Kevin Rowling, NSW Fisheries, pers. comm 2003). It is vital to protect such refuge areas in order to maintain a sustainable fishery. Using the same reasoning, creation of refuge areas for other species with no natural refuge could increase recruitment into the fishery. The benefits of such areas are becoming more widely recognised (Lubchenco *et al*., 2003), but it should be noted, that the effectiveness of such refuges will depend on the size of the refuge and the biology of the species (Allison *et al.*, 1998).

Trawling

Trawling is the physical disturbance that a trawl net makes when it is dragged over the seabed. Physical disturbances include re-suspension of sediment into the water column, re-distribution of sediment across the seabed and breaking or removing habitat including macroalgae, sponges, gorgonians and rocky reef. Removal of habitat, either physical or biogenic, can have a substantial impact on ecological processes, affecting assemblages and populations (see Section B2.7 for a detailed discussion of impacts on habitat).

The disturbance of soft sediment habitat may impact the epifauna and infauna of these sediments (see previous section on assemblages), which in turn could affect important ecological processes such as secondary productivity and nutrient cycling. In the North Sea, frequent trawling was shown to decrease the faunal abundance, biomass and production relative to areas that received less frequent trawling. Although the relative infaunal production (production per unit of biomass) increased with trawling, the increase was insufficient to offset the overall loss of productivity (Jennings *et al*., 2001b). Such loss of productivity could cause a decrease in the populations at higher trophic levels, including target species and their prey. It should be noted that the study by Jennings *et al.* (2001b) was done in an area that had a long history of trawling, so did not take into account any longer-term changes, such as loss of biogenic habitat, that may have already occurred as a result of the introduction of trawling. Changes to newly established trawl grounds are likely to be far greater than those described by Jennings *et al*. (2001).

Trawling may also provide food in the form benthic organisms dislodged, killed or uncovered following the passage of the trawl net, that would otherwise be unavailable (Kaiser and Spencer, 1994). This may favour species that can use this food source over species that cannot, which could possibly lead to an increase in certain species. It is suggested that this may have happened in the North Sea, where certain benthic scavengers (flatfish and gurnards) have become more abundant with increased trawling (Hall, 1999). It has also been suggested that disturbance of the seabed may redirect carbon flows to the pelagic ecosystem, resulting in greater productivity of the pelagic component of system at the expense of the benthic component (Pitcher and Pauly, 1998). Such a shift in productivity could contribute to declines in demersal target species that depend on benthic production.

The impact of trawling on ecological processes may depend on the type of habitat impacted and the tightness of the relationship between habitats and species assemblages. Impacts on habitats that have very slow recovery times, such as slow growing biogenic habitat including large sponges and gorgonians, means that disruption of ecological processes associated with the habitat could be long term or even permanent (Wassenberg *et al*. 2002). However, impacts on habitats that have a high recovery rate, such as soft sediments in natural frequently disturbed environments, may not be as great because recovery is likely to be more rapid (Christensen, 1996). In the absence of specific information on the nature of habitats or frequency of natural disturbances for NSW Ocean Trawl grounds, it is not possible to assess the impacts of trawling on trophic processes, however a precautionary approach would demand the assumption that there have been some impacts.

Discarding

Discarding can affect ecological processes by the displacement of biomass from the seabed to the sea surface. Sessile and motile invertebrates and non-commercial demersal fish species that are brought to the surface in the trawl net are discarded overboard. This provides food to surface and mid-water scavengers, such as seabirds, sharks and marine mammals (Blaber *et al.*, 1995; Hall, 1999). Thus the diet of these scavengers could be changed as a result of their dependence upon the regular supply of discards as a food source. Similarly, discarded biomass that reaches the seabed but is displaced from its original position, provides food for benthic scavengers such as fish, crabs and starfish (Hall, 1999; Bergmann *et al*. 2002). It is possible that the provision of discards and the availability of food from damage to benthic organisms could cause an increase in the population of benthic scavengers, and such population increases may occur at the expense of demersal fish populations. The extent to which discarding affects the composition and structure of species assemblages is unknown for NSW oceanic waters.

Risk on ecological processes from harvesting, trawling and discarding

Determining the level of risk to ecological processes from the activities of the OTF is hampered by our limited understanding of how ecological processes function in oceanic waters of eastern Australia. For example, we do not know the diversity, extent or distribution of habitats on the continental shelf or what fish populations and assemblages are associated with them (see Section B2.7). Nor do we know the fishing intensity being exerted on these habitats and what effect this may have on ecological processes. This lack of knowledge about the activity and the system in which it takes place means it is very difficult to determine the level of risk posed by the activity.

Given this difficulty it was decided that the risk to ecological processes from the activities of the OTF could not be determined using the risk matrix approach used in the other sections. Instead risk levels at the broad scale were determined from collective expert opinion based on what is known in general about each ecological process and from similar information from trawl fisheries in other parts of the world. Table B2.43 summarises the risk levels to the major ecological processes relevant to the OTF. Five of these processes are at high risk from the three major activities of the fishery – trawling, harvesting and discarding. Four processes are at intermediate risk from the same three activities. The remaining activities of the fishery (e.g. gear loss) were considered to be a low risk to these processes because their interaction with any of the ecological processes would be infrequent and their intensity low.

Table B2.43 Summary of risk levels for ecological processes from the activities of the OTF.

	Activities of the Ocean Trawl Fishery							
Apsects needed to sustain ecological processes	Trawling (physical damage)	Harvest (what is kept)	Discarding (what is put back)	Contact but not capture	Gear loss	Travel to/from grounds	Presence of vessel	Boat maintenance & emissions
Nutrient recycling	I	H	H					
Primary production			L					L
Food webs	I	I	I		L		L	
Species interactions		H	H	L	L			
Spawning sites and spawning aggregations	H	I	I	L	L			
Dispersal of propagules/larvae								L
Recruitment (larval/juvenile recruitment into populations & subadult/adult recruitment into fished stocks)		H	H	L	L			
Growth		H	H	L	L			
Distribution & movement	I		I					

H – high risk, I – intermediate risk, L – low risk.

d) Issues arising from risk assessment of species assemblages, species diversity, and ecological process

Lack of knowledge about the interaction between ecological processes and the primary and key secondary species of the OTF

There is very little specific knowledge on the ecological processes that are important for the ecological sustainability of primary and key secondary species. What little research that has been done has been focussed on obtaining stock assessment information. Knowledge of habitat associations, trophic interactions, intra- and inter-specific competition, distribution and movement is only at a very superficial level. But lack of knowledge on these ecological processes inhibits our ability to manage exploited fish populations and assemblages adequately. This has been clearly demonstrated in the case of the changed composition and structure of the exploited fish assemblage on the North West Shelf of Australia (Sainsbury, 1988; Sainsbury *et al*. 1997) as a result of habitat dependence of some species. Had this habitat dependence been known earlier then not only could major habitat degradation have been minimised but the high value exploitable fish assemblage could also have been sustained for the benefit of the fishery. The long term ecological sustainability of the exploitable fish assemblages of the OTF will be jeopardised without more detailed knowledge of the ecological processes they depend on.

Lack of knowledge about the ecological processes of non-commercial species populations and assemblages

There is even sparser information about the ecological processes that are associated with the non-commercial assemblages interacting with the OTF than for commercial species. Obtaining such knowledge is not irrelevant to the management of the fishery. For example, understanding the larval supply and recruitment dynamics of sessile invertebrates that may provide habitat for exploitable species is required if degraded habitats are to be restored to rebuild exploitable fish populations. Furthermore, with the increase in the advocacy of establishing marine protected areas such information about ecological processes on non-commercial biota will be essential to determine the most appropriate design and management of such areas (Agardy *et al*., 2003).

Conserving ecological processes

Ecological processes both influence and are influenced by the structure of the system. Therefore any change to the structure of the system is likely to alter ecological processes. It has been unequivocally demonstrated that trawling changes the structure of benthic systems and although in many cases, ecological processes have not been measured, it is reasonable to infer that changes to processes have also occurred. The best way to conserve the structure and ecological processes in a given area is not to trawl there. Closure of areas to trawling is probably the only way to protect ecosystem processes from the effects of trawling. This approach has been successfully used in the Georges Bank fishing grounds of North America, where closures of particular areas have been successful in rebuilding fish stocks and protecting non target species (Murawski *et al.*, 2000). Sections of the closed areas have since been re-opened to fishing, and managers are considering a formal "area rotation" for the scallop fishery. The effectiveness of such areas would depend on having clearly articulated goals, supported by research into the best locations, size and duration of closures for meeting those goals.

Place high priority on the conservation of marine habitats in oceanic waters of the OTF

Habitat loss and fragmentation are the greatest threats to biodiversity (Gray, 1997). Furthermore, habitats are very important for maintaining species assemblages and sustainable ecological processes. Therefore, substantial efforts must be made in a number of areas to both conserve and, where appropriate, restore lost habitats due to the activities of the OTF. Habitat conservation must be given a high priority if the risks to species diversity, species assemblages and ecological processes are to be reduced. Conservation will require both modifications to gear that damage habitat as well as ensuring adequate areas are closed to fishing.

Establish specific refuge areas to maintain biodiversity, ecological processes and species assemblages

Until we know the spatial and temporal extent of trawl grounds, what species assemblages are present, the interactions between trawling and ecological processes and the level of intensity of trawling on these grounds by the OTF, oceanic refuges rather than just nearshore refuges will be needed to protect species biodiversity, species assemblages and ecological processes (Hyrenbach *et al*., 2000). These refuges will need to be set aside for the specific purpose of conserving these three important ecological components. Consequently, these refuges may need to have substantially different characteristics from that of refuges for the purpose of protecting target species or spawning and nursery areas. Moreover, refuges will need to be established at both small and large spatial scales because of the differences in species diversity and habitat types along the entire NSW coast. A single refuge area for this purpose will not be adequate. In order for these refuges to be effective at protecting these components of the ecosystem careful attention must be given to a number of specific criteria including where refuges are placed, their size, how they are managed and monitored, connectivity between them and source of supply of recruits (Hyrenbach *et al*., 2000; Botsford *et al*., 2003; Gaines, *et al*., 2003; Agardy *et al*. 2003).

Lack of knowledge for adequate management

In all areas assessed in this section of the report there is an inadequate knowledge base on which to determine effective management action. Research is needed urgently in the following areas:

a) Spatial and temporal distribution and abundance of macroalgae, benthic motile invertebrates and species diversity in the fishing grounds and adjacent areas of the OTF.

b) Understanding the ecological processes that interact between primary and key secondary species and other aspects of ecosystems including biodiversity and species assemblages.

Lack of knowledge in these areas is a major obstacle to reducing risk for these components of the environment of the OTF. Several studies have advocated the use of an adaptive management approach to filling knowledge gaps (Walters, 1986; Williams, 1999; Sainsbury *et al*., 2000). It is essential that major management actions proposed in the draft FMS be approached using a rigorous and robust scientific method, such as that which undergirds adaptive management (Walters, 1986; Underwood, 1995), in order to provide the best opportunity to systematically address knowledge gaps in the OTF as well as undertake precautionary management.

Ensure management measures are sufficiently precautionary

The high level of uncertainty generated from the large knowledge gaps of these ecological components means that management measures must be very precautionary. Consequently, the draft FMS should ensure the proposed management regime will enable the best possible chance of the various components of the ecosystem to recover in the face of an unexpected outcome. Several recent reviews of precautionary management for marine fisheries and how it can be achieved should be used in determining optimal ways this can be done for the OTF (Okey and Harrington, 1999; Auster, 2001; Gerrodette *et al*, 2002; Agardy, *et al*., 2003).

2.7 Risk Analysis of Marine Habitats

a) Marine habitats and their importance to biological communities

Marine habitat may be defined as the geological, environmental and biological structure that supports biological communities self-organised from the available species mix (Bax and Williams 2000, 2001). This broad definition includes three distinct types of habitat structure: (a) geological structures, which include rocky reefs, sediment deposits, submarine canyons, bedrock outcrops; (b) biogenic structures which consist of living biota and any physical structure they create (e.g. sponges, corals, kelp beds, bryozoans, mollusc beds, worm tubes, ascidians, sea pens and sea whips); and (c) the water column.

Seabed habitat is an important factor that influences the composition and distribution of biological communities (Underwood and Chapman, 1995; Glasby, 1998; Bax and Williams 2001). The distribution and composition of fish and invertebrate communities living on the continental shelf of New South Wales are also influenced by factors such as latitude, depth and hydrology (Gray and Otway, 1994, Connell and Lincoln-Smith, 1999, Bax and Williams, 2000, Williams and Bax, 2001). Biological communities, including commercially targeted stocks of fishes and invertebrates, depend on substratum features (geological and biogenic) to provide spawning sites, feeding areas and refuge areas from marine predators and fishing fleets. Bax and Williams (2001) have suggested that existing physical refuges from fishing activities may play an important role in sustaining the productivity of many commercially fished species.

The water column is also an important part of the three dimensional marine environment. The seawater may vary in salinity, temperature, and density, all of which are important factors which influence the behaviour of marine organisms. The oceanic water mass in which marine biological communities exist also contains currents which bring oxygen and food to many species, disperses the pelagic eggs and larvae of many invertebrates and bony fishes away from spawning sites, and currents are used by many species to assist migratory movements. Therefore, it is essential that the quality of the water column is maintained in order to sustain biological communities in the long-term.

b) General Information on Marine Habitats in Oceanic waters of NSW

Despite the importance of habitats to biological communities there has been little work done on describing the spatial distribution of habitat types on the New South Wales continental shelf. Bax and Williams (2001) report the results of a survey designed to map major seabed features and habitats on a megascale (kilometers to tens of kilometers) on the south-eastern Australian continental shelf. The mapped area included a section of the southern New South Wales continental shelf extending from Bermagui southwards to the border with Victoria, and an additional larger area of continental shelf off the Victorian coastline (Bax and Williams, 2001). This part of the south-eastern continental shelf is described as a series of massive sediment flats (soft-grounds - 89%) with reefs and bedrock (prominent hard-grounds – 11%) (Bax and Williams 2000, 2001). The soft-ground habitats included all types of sands, muds and gravels. An important distinction in terms of habitat value was made between hard-grounds having high vertical relief (>2 m) and hard-grounds having low vertical relief (<2 m) because of their different vulnerability to the effects of trawling (Bax and Williams, 2001).

Similar soft-ground and hard-ground habitats to those described by Bax and Williams (2001) are found along the entire New South Wales continental shelf. An area off Sydney was mapped for the deep ocean outfall study (Gordon and Hoffman, 1989) but this was confined to a very small area and did not extend into the deep areas of the continental shelf. Unfortunately, there are no comparable data that can be used to describe the spatial distribution or the relative sizes of similar habitats for the rest of the New South Wales continental shelf. The work done by Bax and Williams (2001) provides important insights for understanding the impacts of commercial fishing operations on soft-ground habitats, hard-ground habitats, biogenic structures and the relationship between fish and invertebrate communities and these habitat structures.

It is recognised that factors external to the operation of the fishery also interact with marine environment and can affect the water quality of the ocean environment. This includes land based run-off, pollution from other commercial and recreational vessels and rainfall. There is very little information about how these factors interact with the oceanic environment and to what extent they affect ocean marine habitats.

c) Risk assessment of marine habitats

i) Risk context

The risks being assessed for marine habitats can be defined as the likelihood that marine habitats will be degraded, by the current activities of the ocean trawl fishery, such that the populations or stock levels of species associated with these degraded habitats will become ecologically unsustainable within the next 20 years. This definition of risk explicitly describes the consequences for which we wish to mitigate risk as being: (a) the widespread degradation of habitats; and (b) ecologically unsustainable populations and communities of biota associated with these habitats.

ii) Risk identification and characterisation

The broad-scale risk analysis (see section B2.2) identified two activities of the Ocean Trawl Fishery that damage habitats and their capacity to support ecologically sustainable populations of commercially harvested fish and invertebrates and biological communities. Table B2.44 provides an expanded view of these sources of risk and identifies the potential impacts of these fishing related activities on habitats.

Table B2.44. Sources of risk and qualitative risk levels for habitats.

Aspects needed to support ecologically sustainable populations of fish and biological communities associated with these habitats	**Activities of the Ocean Trawl Fishery**	
	Physical contact of trawl gear on substrate/habitats	Boat operations & maintenance
Maintain spatial distribution (coverage) of habitats	H	-
Maintain habitat quality (complexity, structure, free of contaminants)	H	L
Regenerative processes	H	L

H – high; L – Low; Dash - negligible

Current activities of the fishery that pose the greatest risk to habitats

Trawling

The use of mobile fishing gear, such as fish or prawn trawls, can impact habitats in many ways. Trawling is known to cause physical damage to habitats by: (a) removing, damaging and/or translocating biota associated with geological habitats; (b) smoothing geological bedforms; and (c) homogenizing mobile sediments (Sainsbury *et al*. 1997, Cappo *et al*., 1998; Jennings and Kaiser, 1998; Rogers, *et al*. 1998, Watling and Norse, 1998, Auster and Langton, 1999, Hall, 1999; Bax and Williams, 2001). These physical impacts of trawling cause structural changes to the quality of habitats by reducing the complexity and vertical relief of seabed features which are used by fishes and invertebrates. Bax and Williams (2001) assessed the vulnerability of different substratum types by incorporating information about their resilience and resistance to the effects of fishing. The resilience of a habitat is defined by its capacity to recover on removal of the modifier (Bax and Williams, 2001), which in this case is trawling. The resistance of a habitat refers to the ability to physically withstand deleterious modification by fishing gear (Bax and Williams, 2001). The resistance of a habitat can be influenced by the degree of hardness, amount of previous weathering/erosion, vertical relief, spatial extent and integrity of habitat patches (Auster, 2001; Bax and Williams, 2001). Low profile limestone reefs were among the most vulnerable to the effects of trawling due to their low resistance and resilience. Trawling over these types of habitats actually does irreversible damage because the time scale of recovery (if at all) for this type of rock is thousands of years.

Boat operations and maintenance

This source of risk contains all aspects involved in the operation and maintenance of fishing boats. Potential impacts to biogenic habitats and contamination of the water column could occur when noxious chemicals are introduced into the environment by way of engine emissions, accidental leaks or spills of fuel and/or oil, and chemicals that leach from anti-fouling paints on the hull of fishing boats. There is a low likelihood that the propagules (eggs and/or larvae) derived from biogenic habitats could be adversely impacted by coming into contact with noxious chemicals in the water column. This contact could reduce the survival rate of the propagules and hence the regenerative capacity of biogenic habitats on a local scale. This in turn could lead to localized reductions in habitat complexity and structure. The likelihood of this type of impact causing widespread degradation of habitats is low because of the relatively small number of fishing boats in the fleet (244 active boats) and the high dilution factor of the vast, oceanic, water mass.

iii) Risk on marine habitats from the OTF

Risk matrix

The impacts of the Ocean Trawl Fishery on habitats were examined and integrated by using a qualitative risk matrix. The x-axis of the risk matrix represents habitat vulnerability which combines the two characteristics of habitats - resilience and resistance (see section below on vulnerability for a detailed description). Thus, the vulnerability axis provides an integrated measure of biological (for biota) and geological (for rock and sediment types) factors for habitats. The biological and geological factors are independent of the fishery, which means that operational changes in the fishery cannot change the vulnerability rating of a habitat. The y-axis of the risk matrix represents the fishery impact profile for habitats (see section below on fishery impact profile for a detailed description), which provides an integrated measure of the operational factors by combining information on fishery impacts (direct and indirect) and identifying knowledge gaps that need to be addressed in order to mitigate risk levels. Therefore, any operational changes in the fishery that have an impact on habitats or any increases in knowledge that allow a better understanding of impacts on habitats will change the fishery impact profile rating for a fishery.

The area within the risk matrix was divided into 5 levels of risk (see Figure B2.7). Justification of the five levels and their arrangement within the matrix was given in Section B2.3(b)(i). The definitions for risk levels were identical to those used in the risk analysis of primary and key secondary species. The following text provides an explanation on how to interpret levels of risk and how to prioritise management responses for habitats by using their risk levels.

The top right hand corner and the bottom left hand corner of the risk matrix represented the highest and lowest risk levels respectively. High levels of risk indicated habitats with higher vulnerability and largest fishery impact profile ratings, whilst low levels of risk corresponded to habitats with lower vulnerability and lowest impact profile ratings. Managers should give greatest priority to habitats with highest levels of risk. These high risk habitats require direct and immediate action that decreases their fishery impact profile ratings. The area in the top left hand corner of the risk matrix indicates habitats that have moderately-high levels of risk because these habitats have relatively high fishery impact profile ratings but medium to low vulnerability ratings. The focus of management action for habitats at this level of risk should be to make changes in the operation of the fishery to decrease their fishery impact profile rating. These habitats with moderately-high risk levels should be given secondary priority for management action because their vulnerability rating is lower than high risk habitats. Intermediate levels of risk indicate habitats with an intermediate fishery impact profile rating and varying vulnerability ratings, ranging from low to high. The management priority for these habitats of intermediate risk level should be lower than that for habitats having high and moderately-high risk levels. Management measures for these habitats having intermediate risk levels should focus on initiatives that reduce their fishery impact profile ratings. Within this intermediate risk level, management priority should be given to those habitats that have the highest vulnerability ratings. The area in the bottom right hand corner of the risk matrix indicates habitats that have moderately-low levels of risk. These moderately-low levels of risk indicate habitats that have lower fishery impact profile ratings but higher vulnerability ratings. These habitats should be given lower priority for management action than habitats regarded as having high, moderately-high or intermediate risk levels. Any management actions directed towards moderately-low risk level habitats should be focused on ensuring the fishery impact profile ratings do not increase for these habitats. Finally, habitats having the lowest risk levels are characterized by having relatively low fishery impact profile ratings and vulnerability ratings.

Vulnerability

The resilience, resistance and vulnerability of important soft-ground and hard-ground habitats, biogenic habitats, and the water column are summarised in Table B2.45.

Table B2.45. An assessment of the resilience, resistance and vulnerability of important habitats occurring in the operational area of the Ocean Trawl Fishery.

Habitats	Resilience	Resistance	Vulnerability
Geological habitats			
Hard-ground substratum (High vertical relief >2m)	Zero	High	Low/Medium
Hard-ground substratum (Low vertical relief <2m)	Zero	Medium	Medium/High
Soft-ground substratum (sands, muddy sediments, gravels)	Medium	Medium	Medium
Biogenic habitats			
Biota of hard-ground substratum (High vertical relief >2m)	Variable (ranging from Medium to High)	Low	High
Biota of hard-ground substratum (Low vertical relief <2m)	Variable (ranging from Medium to High)	Low	High
Biota of soft-ground substratum (sands, muddy sediments, gravels)	Variable (ranging from Medium to High)	Low	High
Water Column	High	High	Low

The widespread use of navigational aids (track plotters and global positioning systems) and trawl gears that can be operated over rough hard-ground has enabled commercial fishers to effectively target hard-ground habitat features that attract fish (Bax and Williams 2000, 2001). Hard-ground habitats have medium to high resistance to the impact of trawl gear (Auster, 2001; Bax and Williams, 2001) but have zero resilience to the impacts of fishing gear (Table B2.45) (Watling and Norse, 1998). That is, the recovery time of a rocky reef is measured on a geological time scale (thousands of years) which means that any damage to this habitat is regarded as being permanent and irreversible. The considerable erosion and degradation of some seabed features that has occurred recently (over the last 20 years) on the south-eastern Australian continental shelf provides evidence that important habitats can be damaged permanently as a direct result of trawling (Bax and Williams 2001). Therefore, hard-ground substratum habitats that have low vertical relief have a medium/high vulnerability to the effects of trawling because it is these types of grounds that are being “opened-up” (or alternatively substitute the term “irreversibly damaged”) by trawlers using bobbins/rollers or other specialized gear designed to allow a trawl net to pass over areas of reef that had been previously inaccessible with standard trawl gear.

Hard-ground habitats that have high vertical relief are regarded as having low/medium vulnerability to the impacts of fishing gear (Table B2.45) because high vertical relief reefs tend to be harder and less weathered than low vertical relief reefs making them more physically resistant. At present, these high vertical relief reefs provide natural refuges from trawling for commercially targeted invertebrates and fish because they cannot be fished effectively and there is a high probability of fouling and losing gear. It is imperative that these refuge areas be maintained to mitigate against the risk of overfishing.

Soft-ground habitats are classified as having a medium vulnerability to the effects of trawling (Table B2.45). Trawling has been shown to be an important factor in disturbing and redistributing some types of sediments (Bax and Williams, 2001; Palanques *et al*., 2001). This physical disturbance of unconsolidated sediment material can have short-term effects in high-energy areas that are characterized by the presence of storm, wind waves and strong currents, and long-term effects in low energy deeper areas which are beyond the influence of waves and have low currents (Bax and Williams, 2001). For example, scoured trawl tracks on sandy sediment in high-energy areas can be covered by ripples in a few hours, whereas, trawl tracks on muddy sediment in a low energy area were still visible 18 months later (Palanques *et al.* 2001 and references therein). The resuspension and redistribution of sediments by trawling may also have deleterious impacts on adjacent habitats. Bax and Williams (2001) cite reports by commercial fishers that indicate that some upper-slope reefs have been smothered by current-borne sediments that were disturbed on the shelf. The periodic burial of reefs in high-energy areas can also be caused by natural events, such as storms, making it difficult to separate the effects of fishing from the effects of these natural events (Bax and Williams, 2001).

Biogenic habitats have been classified as having high vulnerability to the effects of trawling (Table B2.45). All biogenic habitats have low ability to withstand contact with trawl gear. It is well known that trawling can remove, damage and/or translocate biogenic habitats, such as, sponges, corals and ascidians (Sainsbury *et al*., 1997; Auster, 2001; Watling and Norse, 1998). The resilience of biogenic habitats varies greatly. Some deepwater corals and sponges have very slow growth rates and their recovery rates may be measured in terms of decades or centuries (Sainsbury *et al*., 1997; Bax and Williams, 2001). Conversely, there are also many types of epibenthic biota that have relatively rapid growth rates when compared to the slow growing deep-water species, thereby making them more resilient. Sainsbury *et al*. (1997) found that epibenthic organisms took at least 15 years to grow to 25 cm on the North West Shelf of Australia. Sainsbury *et al*. (1997) concluded that “The slow dynamics of habitat recovery, combined with the apparently high probability of the larger elements of the habitat being removed on encounter with a trawl, mean that the protection measures will have to be very effective to provide and maintain the community structure that will support this high-valued yield.” The trawl-induced habitat modification on the North West Shelf had been linked to changes in the relative composition of the multispecies fish community with high-value genera (*Lethrinus* and *Lutjanus*) decreasing in abundance and low-value genera (*Saurida* and *Nemipterus*) increasing in abundance (Sainsbury *et al.*, 1997).

Fishery Impact Profile

The fishery impact profile rating for habitats provides an integrated measure of the operational impacts of a fishery by combining information on known fishery impacts (direct and indirect) and identifying knowledge gaps that need to be addressed in order to mitigate risk levels. Therefore, any operational changes in the fishery that have an impact on habitats or any increases in knowledge that allow a better understanding of impacts on habitats will change the fishery impact profile rating for a fishery. The operational factors and information needs that are required to reduce the fishery impact profile rating and hence, mitigate risk levels, can be influenced by management changes and research initiatives. This is in stark contrast to the biological and geological characteristics of habitats, used to provide a vulnerability rating, which cannot be changed by management intervention.

A series of five basic questions was used to determine whether the available information describing habitats and the fishery-related impacts on habitats were adequate for assessing and mitigating risk levels in the fishery (Table B2.46). Each question required that a qualitative rating of risk prone” or “risk averse” be made when applied separately to each of the seven broad habitat types

(Table B2.46, Appendix B2.9). Each question was given an equal weighting for determining the fishery impact profile rating. A simple decision rule based on the number of risk prone factors was used to assign the qualitative fishery impact profile rating for a habitat (Table B2.47). In general terms, the more risk prone factors present the higher the fishery impact profile rating. It is recognised that the magnitude of an impact is very important in determining the level of risk (Underwood, 1989). However, in a qualitative risk assessment we have no information about the magnitude of an impact on habitats. Therefore, when answering the five questions a precautionary approach was taken and assumed magnitude to be sufficiently large enough to have a substantial affect on habitats.

The fishery impact profile ratings for habitats are summarized in Table B2.47. There was a clear gradation in the fishery impact profile ratings of geological habitats. The hard-ground substratum with low vertical relief habitat was assigned a High rating, the soft-ground substratum habitat (all sediment types) was assigned an Intermediate-High rating, and the hard-ground substratum with high vertical relief habitat was assigned an Intermediate rating (Table B2.47). The biogenic habitats associated with hard-ground substratum with low vertical relief and soft-ground substratum habitats were assigned High ratings (Table B2.47). In contrast, the biota of hard-ground substratum with high vertical relief habitats were assigned an Intermediate rating because little of the Ocean Trawl fishing effort occurs on this type of habitat (Table B2.47). The water column was assigned a Low rating (Table B2.47).

Table B2.46. Basic questions and information needed to determine the fishery impact profile ratings for habitats impacted by the Ocean Trawl Fishery

Basic question	Information needed	Explanation	Rating
Where are the habitats?	Spatial distribution of habitat types	Basic knowledge of spatial habitat distributions is needed for risk analysis of fishery-wide impacts on habitats. Habitat mapping is needed at various spatial scales. Megahabitat scale (km to 10s km) for broad habitat types (e.g. submarine canyons, expanses of sediment flats). Mesoscale (10m to km) mapping is the level of resolution necessary for establishing baseline conditions and for monitoring change over time (Bax and Williams 2001).	**Risk prone** - when distribution of habitats is not known. **Risk averse** - when distribution of habitats is known.
Where does the fishing occur?	Spatial distribution of fishing effort	A direct measure of where the fishery-related impact is occurring. Mapping of fishing effort is needed at various spatial scales. The location and extent of broad "fishing grounds" is needed as a first step. Vessel monitoring data would provide mesoscale information describing where the fishing impact is happening.	**Risk prone** - when distribution of fishing effort is not known. **Risk averse** - when distribution of fishing effort is known.
What overlap is there between the area in which the fishery operates and the distribution of habitat types?	Proportion of available habitat impacted by fishing gear	An indicator of impact effect size on different habitat types. Fishing effort may be concentrated on preferred sub-areas within broad habitat types.	**Risk prone** - when overlap between fishing effort and habitats is not known. **Risk averse** - when overlap between fishing effort and habitats is known.
Do habitats have adequate protection (refuge) from fishing impacts?	Proportion of total habitat which is excluded from fishery impacts	An indicator of refuge availability for habitats. Some habitats may be natural refuges because fishing gear cannot operate on them effectively (e.g. high-vertical relief reef areas foul trawl gear and are currently avoided) whilst other areas may be protected by fishing closures or be included within Aquatic Reserves or Marine Parks. It should be noted that fishing is permitted within Marine Parks - the zoning of these Marine Park areas needs to be considered.	Risk prone - When refuge availability cannot be determined or when refuge availability is assessed as being inadequate. Risk averse - When refuge availability of habitats is determined to be adequate.
Is the use of "high-impact" fishing gear currently permitted in the fishery?	Knowledge of impacts caused by different gear types used in the fishery	An assessment of the need to exclude or modify certain gear types from the fishery. For example, the use of bobbins/rollers to extend trawling onto areas of low vertical relief reef have high-impact because they irreversibly degrade habitat. There are two ways of mitigating risk: (a) modifying the gear to lessen its impacts; or (b) close areas (when gear modification is not possible or impractical).	**Risk prone** - when high-impact gear is used in the fishery. **Risk averse** - when high-impact gear is excluded or not used in the fishery.

Table B2.47. Fishery impact profile ratings for habitats affected by the Ocean Trawl Fishery.

Habitats	Fishery Impact Profile Rating
Geological habitats	
Hard-ground substratum (High vertical relief >2m)	Intermediate
Hard-ground substratum (Low vertical relief <2m)	High
Soft-ground substratum (sands, muddy sediments, gravels)	Intermediate-High
Biogenic habitats	
Biota of hard-ground substratum (High vertical relief >2m)	Intermediate
Biota of hard-ground substratum (Low vertical relief <2m)	High
Biota of soft-ground substratum (sands, muddy sediments, gravels)	High
Water Column	Low

Risk Levels

The vulnerability and fishery impact profile ratings were plotted on the risk matrix (see Figure B2.9) to determine their qualitative risk level. Two biogenic habitats (the biota of hard-ground substratum with low vertical relief and the biota of soft-ground substratum) and one geological habitat (hard-ground substratum with low vertical relief <2m) were assigned the highest risk level (Table B2.48). These three habitat types require immediate management action to reduce their fishery impact profile ratings and hence reduce their risk level.

The soft-ground substratum habitat was assigned a Moderately High risk level (Table B2.48). Improving our knowledge of the distribution of this habitat and the fishing effort expended on it would contribute to reducing its level of risk because management measures could be directed at specific areas and times.

The hard-ground substratum with high vertical relief habitat type and its associated biogenic habitat (i.e. the biota associated with this type of geological habitat) were both assigned an intermediate risk level (Table B2.48). These two habitat types are important natural refuge areas for commercially targeted fish and invertebrates and require some basic monitoring to ensure that the impacts from the operations of the Trawl Fishery are not increased in the future. The water column was assigned a low risk level (Table B2.48).

Table B2.48 Risk levels for habitats affected by the Ocean Trawl Fishery.

Habitats	Risk Levels
Geological habitats	
Hard-ground substratum (High vertical relief >2m)	Intermediate
Hard-ground substratum (Low vertical relief <2m)	High
Soft-ground substratum (sands, muddy sediments, gravels)	Moderately-High
Biogenic habitats	
Biota of hard-ground substratum (High vertical relief >2m)	Intermediate
Biota of hard-ground substratum (Low vertical relief <2m)	High
Biota of soft-ground substratum (sands, muddy sediments, gravels)	High
Water Column	Low

d) Issues Arising from the Risk Assessment on Habitats

Four major impediments to reducing risk levels for marine habitats were identified during the risk assessment process. These main issues were: (i) fishing practices that cause irreversible damage to habitats; (ii) adequate refuge areas are needed to conserve habitats; (iii) inconsistent management regimes among jurisdictions; and (iv) major information gaps. These issues need to be addressed adequately in the draft FMS for the Ocean Trawl Fishery.

Fishing practices that cause irreversible damage to habitats

Trawl gear was originally designed to operate over soft-substratum habitats. It is known that trawl gear damages biogenic habitat structures found on soft-substratum habitats (Sainsbury *et al*., 1997; Bax and Williams, 2001). The recovery of this biota, which includes sponges, corals, bryozoans, sea whips, is typically slow (decades), even in tropical shelf waters where warm waters should promote rapid growth rates (see Sainsbury *et al*., 1997).

The trawl fishery has expanded its operations onto hard-ground substrata habitats that are characterized by having low vertical relief (<2m) by using modified trawl gear that are equipped with large bobbins/rollers. This expansion of the trawl fishery is causing major impacts on habitats. Firstly, the amount of available refuge area for biota associated with these low vertical relief reef areas has been decreased. Secondly, the trawl gear has been shown to erode this low vertical relief geological habitat structure thereby causing irreversible damage to habitat (Bax and Williams, 2001).

If this habitat degradation is allowed to continue it is likely that productivity will decrease and the sustainability of some species may be threatened. Modifying the existing trawl gear to reduce impacts on low vertical relief hard-ground substrata habitats will do little to protect habitat degradation because the time needed for habitat recovery is measured in thousands of years. The feasible, alternative management response, is to restrict trawling to soft-substratum habitat areas. However, habitat distribution data is needed to design appropriate closures to conserve critical hard-ground habitats. This type of data is not currently available. It is recommend therefore the exclusion of bobbins/rollers from all trawl fishing gear and appropriate restrictions on the number and gauge of chains which may be used on the ground rope of trawl nets.

It is also essential to have management responses in the draft FMS that oppose any future fishing practices or gear modifications that enable trawling over these refuge areas.

Adequate refuge areas are needed to conserve habitats

Do habitats have adequate protection (refuge) from fishing impacts? In order to mitigate the risk of fishery related impacts on habitats we need to know the proportion of total habitat that is excluded from fishery impacts. Habitats can be excluded from fishing impacts because of their natural geological features or by management intervention. Some habitats are natural refuge areas because currently-used trawl fishing gear cannot operate on them effectively. For example, areas of high vertical relief reef (>2m) are natural refuges for biogenic habitats and fishes because trawl operators usually avoid them. In contrast, soft-substratum habitats and the biogenic habitats associated with them have no natural features that offer protection from trawling. The effects of trawl fishing on these soft-substratum habitat types is compounded because multiple use zoning plans in Marine Parks usually allow the continuation of trawl fishing on them.

The high risk levels assigned to hard- substratum, low vertical relief (<2m) geological and biogenic habitats indicates that these types of habitats require additional protection from the effects of trawling.

The inevitable conclusion is that soft-sediment habitat types and the low vertical relief (<2m) hard-substrate habitats (geological and biogenic) have little legislative protection from the impacts of fishing. Therefore, there is a need to protect representative areas of these habitats from the effects of trawl fishing.

Inconsistent fishery management regimes among jurisdictions – implications for habitats

Trawl fisheries operating on the continental shelf and slope of eastern Australia and the spatial extent of these fisheries are not restricted to a single jurisdiction. These trawl fisheries are managed by several State agencies and the Federal government and are subject to different management regimes in the various jurisdictions. This means that the effectiveness of management initiatives taken in a single jurisdiction will be undermined by the lack of consistent action in adjoining fishery areas. The implication of this lack of management consistency to habitats is that widespread degradation of habitat structure can continue to occur unless a common approach to fishery management is adopted. Therefore, at the large spatial scales over which these trawl fisheries operate it will not be possible to effectively reduce risk levels for the entire fishery unless increased cooperation and consistent management regimes are implemented.

Major information gaps

Four major information gaps have been identified during the risk assessment. The paucity of information for the four main areas outlined below makes a large contribution to the overall risk levels for habitats. Therefore, it is essential that these information gaps be addressed in the draft FMS.

It is acknowledged that the collection of information requires a long-term commitment of resources. We discuss these four major information gaps in order of their ranked potential for mitigating risk to habitats.

Identification of fishing grounds and mapping the distribution of fishing effort

Where does the fishing occur? Trawling is spatially widespread, occurring throughout NSW coastal waters and in all adjacent jurisdictions. Detailed information that documents the spatial distribution of fishing effort is needed at various spatial scales. Mapping the location and extent of broad "fishing grounds" is a necessary first step for understanding the possible impacts of the trawl fishery on habitats. Vessel monitoring data and detailed records of individual trawl shots would provide mesoscale (10m to km) information about the locations of fishing impacts. This type of detailed information is vital for a more accurate assessment of fishery-related impacts on habitats.

Identification and mapping the distribution of broad habitat types

Where are the habitats? Knowledge about the identification and spatial distribution of important habitat types is the most fundamental piece of information needed to manage fishery-wide impacts on marine habitats. Habitat mapping is needed at various spatial scales. The megahabitat scale (km to 10s km) is a useful spatial scale for describing the distribution of broad habitat types, which include, submarine canyons, expanses of sediment flats and reef areas (Bax and Williams, 2001). Ideally, mesoscale (10m to km) mapping of habitats should be considered because it is the level of resolution at which the trawl fishery operates and is useful for establishing baseline conditions and monitoring change over time (Bax and Williams, 2001). Unfortunately, mesoscale mapping requires considerable scientific effort and resources and it is difficult to apply it over large areas (Bax and Williams, 2001). Even so, mesoscale mapping could be used to investigate areas that have the highest concentrations of fishing effort and it is likely that technological advances may soon reduce the cost of mapping habitats at this spatial scale.

Assessment of the effect size of fishery impacts on habitats

What overlap is there between the area in which the fishery operates and the distribution of habitat types ? The answer to this question would provide a direct measure of the location of fishery-related impacts on habitats. It is known that fishing effort is often concentrated on and around substratum features that aggregate commercial quantities of invertebrates and fish. The frequency and extent of this sort of fishing practice should be documented so that habitat vulnerability can be more accurately determined. An assessment of impact effect size would require inputs of information describing habitat distributions and the detailed distribution of fishing effort.

Lack of biological and ecological knowledge for biogenic habitats

In the area of biological and ecological information for biogenic habitats there is a paucity of knowledge. The taxonomic status of biota that live on geological habitats and that provide additional biogenic habitat structure is poorly known. This lack of taxonomic knowledge has serious implications for any assessment of habitat biodiversity issues. If we cannot adequately assess the biodiversity issues, then how can we understand the ecological and biological relationships of this biogenic component of habitats? Therefore, it is very important to support research in this area with the aim of maximizing our understanding of the biology and ecology of the biota that creates biogenic habitats.

3 Biophysical Environment

The operations of the OTF were assessed to determine whether they were causing a major effect on three components of the biophysical environment – water quality, noise/light regimes and greenhouse gases (including air quality). A risk assessment was done for each component to determine whether further detailed assessment was needed for any components at high risk (see DIPNR Guidelines, 2003). Therefore, the risk assessments for these components will be presented together and then, if necessary, a more detailed assessment for each separately.

a) General Background Information on Biophysical Components

i) Water Quality

The operations of the OTF that could potentially be sources of pollutants affecting water quality are: antifouling agents, discharge of chemicals, fuel or bilge water, discharge/dumping of debri, on-board processing waste and the activity of trawling disturbing sediments on the bottom.

Antifouling agents are painted on boat hulls to reduce marine growth and the consequent loss of performance of the vessel. Over the past two decades, the active ingredient of the most effective antifouling paints – tributyltin (TBT) – has been shown to harm the marine environment (Batley *et al*., 1992; Scammell *et al*., 1991). It accumulates in the food chain, killing and impacting sea life other than that attached to hulls. Now, under a convention passed by the International Maritime Organisation (IMO) in October 2001, antifouling paints containing TBT are not to be applied to vessels less than 25 m in length, and such coatings on vessels longer than 25 m are to be completely removed from service by the beginning of 2008 (www.cmit.csiro.au, 2003). Therefore, all the vessels in the OTF should no longer being using TBT based paints. But it is not known whether the older vessels in the fishery still contain traces of this paint on their hulls, nor what proportion they make up. Vessels in the fishery will generally treat their hulls with antifouling paint (non-toxic) once a year in dry docks. Recently, the federal government has published a Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance (Scammell and Baker, 2003). Whilst the code of practice is not compulsory boat owners who adhere to it will further minimise pollution to the water from anti-fouling paint.

Serious accidental or deliberate discharges of chemicals, fuel or bilge water from OTF vessels are likely to be rare because fishers are very aware of their public image and are careful not to allow discharges of this nature to occur. Modern engines and fuel systems are easily managed so individual spills are only likely to be minor. Some oil and fuel could be spilt during routine maintenance and re-fuelling at ports but these are usually handled by established oil pollution response plans for each port (Waterways Authority, 2003). In fact the Environment Protection Authority (now Department of Environment and Conservation) reported no minor, moderate or major oils occurring from OTF commercial fishing vessels from 1996-1999 (EPA, 2000). All bilge water must be discharged into proper pump-out facilities available at ports from which OTF vessels operate, so spillage of bilge water into the sea is unlikely.

Debris potentially dumped or discharged from vessels could include plastic, paper and pieces of fishing gear. Such material is non-toxic but may injure marine wildlife (Jones, 1994, 1995)*dunno if paper would?*. Some items, like plastic bags, can be ingested by some marine animals mistaking them for food such as jelly fish. Most studies of debris found on Australian beaches have recorded fishing related items (e.g. Cunningham and Wilson, 2003; Hertford, 1997; Kiessling, 2003; Slater, 1991; Whiting, 1998; Haynes, 1997), indicating its presence in the surrounding ocean (Jones, 1995). A study of selected ocean beaches in NSW found 13% of the debris to be fishing related, 60% of which was from commercial origins and the remaining 40% recreational (Herfort, 1997). Amongst the fishing debris recorded on NSW beaches, a noted dominance of prawn trawl debris on the state's northern beaches, fish trawl debris on the southern beaches and recreational fishing gear on beaches around urban centres, especially those on the central coast of NSW, was correlated to the distribution and intensity of these activities along the NSW coast (Herfort, 1997). The study found 134 fishing debris items / km of beach, items included recreational fishing line, floats, commercial netting and ropes (Herfort, 1997). The fishing debris found included items of both commercial and recreational origins that could entangle marine wildlife, such as intact pieces of trawl mesh and recreational fishing line (Herfort, 1997). The recorded fishing debris items that could be ingested by marine wildlife were small fragments of commercial trawl nets and recreational bait bags and lures (Herfort, 1997). Fishing debris items may not be found on every beach in NSW as demonstrated by Frost and Cullen (1997).

As members of the public are very conscious of gross litter, commercial fishers have become increasingly conscious of obvious pollution within their environment and subsequently, any deliberate dumping of debris by the OTF would be minor. However, fragments of trawl nets could unintentionally enter the water column during net hook-ups etc

On-board process waste would come from body parts of fish and shellfish. Prawns are cooked whole on-board vessels. Much of the processing of fish is minimised on vessels by prohibition of finning sharks and filleting species with minimum legal lengths. Therefore, dumping of process waste into the sea is probably minimal.

Sediment resuspension caused by trawling can increase turbidity in the area of the trawl. The extent, duration and magnitude of such resuspension will depend on the composition and size of the particles, speed and frequency of trawling, sediment penetration, water depth and prevailing water currents (Churchill, 1989; Hall, 1999). Resuspension of sediments can decrease water quality by releasing heavy metals into the water column, creating anoxic conditions and decreasing visibility. To what extent these conditions occur and whether they persist long enough to have a lasting effect is unknown in NSW oceanic waters. Studies elsewhere suggest that sediment resuspension from trawling can lead to shifts in benthic flora and fauna and community composition (Churchill, 1989).

ii) Noise and Light

Noise from vessels in the OTF come from the propeller, engine, auxillary engines for winches and in a few cases refrigeration units. The level of noise generated by these sources for OTF vessels is unknown and will depend upon the size of the engines. Based on similar fishing vessels overseas it is likely they contribute to the low frequency spectrum of underwater noise (Mitson and Knudsen, 2002). It is not known how far the noise from these sources penetrate the ocean during a typical day or night of fishing nor the level of noise generated.

There are a range of marine species that potentially could be affected by the noise of OTF vessels including cetaceans, finfish and some marine birds. However, very little is known about the acoustic sensitivity of these animals for Australian waters. Whales and dolphins have been shown to have varying responses to human generated noise overseas (Clark, 1999; Croll *et al*., 2001; Parijis and Corkeron, 2001). Impacts of noise from vessels will depend on the auditory sensitivity of the organism, the frequency level and magnitude of the noise generated by the vessel and frequency and duration of interactions between the fishing vessel and the organism. Noise from OTF vessels could affect wildlife if trawling occurs in areas where noise-sensitive wildlife live. Given trawling in this fishery does not usually occur immediately adjacent to land (unlike the estuary prawn trawl fishery) no land based fauna would be affected. Very little is known about the affects of noise from vessels (including recreational and other commercial) in Australian waters on marine life.

Ocean trawl vessels operate in oceanic waters out to three nautical miles in most sectors, except northern fish trawl, which can operate out to 80 nautical miles. Disturbance to land based residents and wildlife from noise and light would therefore be restricted to leaving and returning to port, consequently having minimal impact.

iii) Greenhouse Gases and Air Quality

Air quality and greenhouse gas emissions are considered together because there is substantial overlap in the gases that contribute to them. The burning of diesel fuel to power engines (including auxiliary engines) and prawn cookers of boats in the OTF generates greenhouse gases, which include carbon dioxide, methane and nitrous oxide. These gases enhance the greenhouse effect of the earth's atmosphere (www.greenhouse.gov.au, 2004). The majority of vessels in the OTF (97%, 237 boats) have diesel powered engines, the remaining operating petrol powered engines. Diesel and petrol fuels have similar CO_2 emission factors (69 kg CO_2/GJ and 65.3 kg CO_2/GJ, respectively). Therefore, they have a similar potential for greenhouse gas impacts, but would vary depending on engine efficiency and size of vessels.

b) Risk Context of Biophysical Components

The risks being assessed for the biophysical environment can be defined as the likelihood that the components of the biophysical environment – water quality, noise and light and air quality **-** will be degraded, by the current activities of the ocean trawl fishery, such that the populations of fauna, flora and humans associated with these components will become ecologically unsustainable or degraded within the next 20 years. This definition of risk explicitly describes the consequences for which risks are to be mitigated being: (a) the widespread degradation of the biophysical environment; and (b) ecologically unsustainable populations and communities of biota and humans associated with this environment.

c) Risk Identification and Characterisation of Biophysical Components

There were three activities of the OTF that potentially affect the components of the biophysical environment and their capacity to support ecologically sustainable populations of biota – trawling, gear loss and boat maintenance and emissions (Table B3.1). Travel and disturbance due to presence in the areas are considered to have a negligible affect on the biophysical environment.

Table B3.1 Activities of the OTF that potentially contribute to impacts on components of the biophysical environment.

Component		**Activities of the Ocena Trawl Fishery**				
Biophysical		Trawling (Physical damage)	Loss of fishing gear	Travel to/from grounds	Disturbance due to presence in the area	Boat maintenance & emissions
	Water quality	L↙	L↙	-	-	L↙
	Noise/Light			-	-	L↙
	Air quality & Greenhouse gases			-	-	L↙

Current activities of the fishery that pose the greatest risk to biophysical components

Trawling

As noted above the physical act of trawling can increase the turbidity of the water column in the vicinity of the trawl. To what extent this turbidity degrades water quality depends on natural levels of turbidity caused by currents and storm generated waves. The medium to high energy environment of the continental shelf along NSW means that the sediments on the inner shelf, at least down to 60m, can be brought into suspension from storm induced wave action (Gordon and Hoffman, 1989). Therefore, there may be low level turbidity occurring in the water column on a semi regular basis. Little is known about natural sediment disturbance on the outer shelf. Furthermore, as discussed under Section B2.7 on habitats, little is known about the composition of the sediment of the continental shelf along the NSW coast, which will influence the duration and magnitude of increased turbidity from trawling. Until we know the composition of soft sediment within the area of the OTF, the levels of natural turbidity, where trawling occurs with respect to these soft sediments and the trawling intensity over these sediments will it be possible to determine more accurately the impact of trawling on water quality. For now it is likely that the risk is low overall, given the small size of the fleet relative to the area of the fishery and median days fished (100 days in 2000/01).

Loss of Gear

Water quality can also be degraded by fishing gear debris. Occasionally, due to snares and tearing, fishers can loose parts of nets or ropes at sea. Where large portions or whole nets are lost, fishers will search to retrieve them, usually successfully (C. Ganassin NSW Fisheries, pers comm., 2004). The quantity of fishing debris washed up on beaches in northern Australia (Kiessling, 2003), south eastern Australia (Slater, 1991) and NSW beaches (Herfort, 1997) has been documented. These studies found substantial amounts of fishing gear lost from vessels. The contribution of the OTF to lost gear compared to other commercial fisheries (e.g. Ocean Trap and Line, Ocean Hauling) is unknown. The OTF fleet operating in NSW is substantially smaller than those operating in northern and south eastern Australia and consequently there would be substantially less gear lost. Therefore, it is likely that the risk of poorer water quality as a result of gear loss due to OTF alone is low.

Boat maintenance and emissions

Boat maintenance, both major and minor, would usually be done at the vessel's home port. Consequently, any oil or fuel spills are contained within the waters of the port, usually small to medium sized harbours. The likelihood of accidental spillages of small amounts of oil and fuel is very low. The EPA (2000) reported no major oil spills from vessels in the OTF causing pollution either at ports or out to sea in the period of 1996-1999. Therefore, the risk of boat maintenance contributing to degraded water quality is low.

Greenhouse gas emissions from the engines of vessels, both main and auxillary, and prawn cookers on prawn trawlers were calculated for vessels operating in the OTF in the 2000/01 financial year. This was based on the number of fishing days reported on the catch returns for that year and used emission factors and energy content for diesel fuel published by the National Greenhouse Office. Emissions from the active OTF fleet were determined to be 0.06 Mt $CO_{2,}$ which is 3.6% of the total emissions from the national domestic marine transport sector in Australia. This contributes 0.08% to the total national transport sector CO_2 emissions and less than 0.02% of the total net national emissions of CO_2 for 2001 (Australian Greenhouse Office, 2001) (Table B3.2). These estimates indicate that the OTF contributes only minimally to the national greenhouse gas emissions. Therefore, the risk of emissions from OTF vessels contributing significantly to the net national emissions of greenhouse gases is very low.

Table B3.2. Summary of greenhouse gas emissions from the vessels in the OTF for 2000/01.

Source: Australian Greenhouse Office, 2001

Component	No. 2000/01	Mt CO_2	% Contribution to GHG
Vessels	244	0.06	
Domestic		1.59	3.57
Transport		72.26	0.08
Net National		377.64	0.02

d) Summary and Justification of Low Risk to the Biophysical Environment

The assessment found that all components of the biophysical environment were at low risk from the operations of the OTF. The primary reasons for this are set out below:

i) Regulations control and define certain activities that minimises or eliminates the potential for contamination of the environment e.g. disposing of bilge water, types of antifouling paint.

ii) Heightened awareness of fishers of gross pollution from their vessels including debri, noise and light. There is also high motivation by fishers to improve the image of their fishery to the general public resulting in diligent self regulation of behaviour among fishers

iii) Small number of boats operating in the fishery compared to other types of craft including recreational, other commercial and larger foreign vessels. Furthermore, because vessels in OTF are not greatly concentrated in any one port, do not always operate at exactly the same time of the day or year and primarily operate away from the coast, greenhouse gas emissions, light and noise disturbance are more dissipated than other fisheries, such as those operating within estuaries.

Therefore, there is no need for further detailed assessment of the risk to the biophysical environment as per DIPNR Guidelines Section B3(b) and there are no issues arising that the need to be addressed by the draft FMS.

4 Economic Issues

This report is a summary of the main report on economic issues undertaken by Dominion Consulting Pty Ltd and presented in full in Volume 4. It has been compiled from a limited amount of existing information augmented by new economic and social surveys by Roy Morgan Research, a number of reports prepared by NSW Fisheries and access to ABS data on NSW fishers.

This section summarises the existing information on:

- Investment in the fishery and businesses associated with it;
- Employment;
- Economic return from the fishery
- Economic multiplier effects, economic rents and community contributions;
- Markets for species harvested in the ocean trawl fishery; and
- Overall risks to the economic viability of the fishery.

The ocean trawl fishery comprises ocean prawn trawl (OPT) and ocean fish trawl (OFT) and was previously managed as two separate fisheries by NSW Fisheries.

The ocean prawn trawl fishery is based predominantly north of Sydney and the ocean fish trawl fishery is based south of Sydney. Out of 311 OPT fishing businesses, 207 were actively fishing in a range of commercial fisheries in 2001-2002 and the remaining 104 were latent. For the 99 OFT endorsement holders, 45 were actively fishing in a range of commercial fisheries in 2001-2002 and 54 were latent.

4.1 Investment in the fishery

The fishery is highly variable in activity and capital investment levels. The capital investment ranges from approximately $70,000 to $850,000 in OPT and from $80,000 to $500,000 in OFT though these would differ with the diversity of businesses activities and assets (Newcastle Marine Brokers, 2000). The average capital investment is approximately $300,000 in the Ocean Prawn Trawl fishery, and $240,000 in the Ocean Fish Trawl fishery (Newcastle Marine Brokers, 2000; 2003). The total capital investment in the 252 active ocean trawl fishing businesses is estimated at approximately $73 million.

More accurate information is needed on fishery licence and investment values. Information on investment in the processing facilities and value adding in the seafood sector is not available.

4.2 Employment in the fishery

The social survey investigated employment in the Ocean Trawl fishery. The prawn trawl fishery is predominantly one person businesses forming into teams, with business partnerships and a limited number of companies. Although most endorsement holders are male dominated, half of the fishers (47% OPT and 55% OFT) have their partners involved in the business. Approximately 13-14% of fishers work in other industries and approximately 803 to 1,314 people are employed in ocean trawl fishing businesses. The estimates of employment need to be seen in the context of all fishing activity state-wide, rather than for each administered fishery and requires further investigation to exclude double counting.

4.3 Economic return from the fishery

The economic survey enabled the economic performance of businesses in the ocean prawn trawl catching sector to be appraised. Survey returns were analysed to measure economic profit and to estimate a net economic contribution to the economy.

The OPT fishery had an annual average revenue of $24.65m in the 1997/98-2001/02 period and was approximately 36% by revenue of the total annual fishery production in NSW. The OFT fishery had an annual average revenue of $4m and approximately 6% of the total NSW revenue.

Estimates of operating profit were made as many operators did not include owner's payment from fishing. The economic costs include operating costs, fixed costs, including opportunity costs of capital, labour and economic depreciation.

In the OPT fishery the top 50% of fishers take 87% of the fishery revenue and the bottom 50% take 13% of revenue. In the OFT fishery, the top 50% of fishers take 93% of the fishery revenue and the bottom 50% take 7% of revenue. This indicates the level of part-time fishing among endorsement holders.

The economic survey for year 1999-2000 indicates that 41% of businesses earned an economic surplus, meeting opportunity costs and economic depreciation assumed for long-term viability. The remaining 59% of operators performed below the long-term viability criteria.

Given the variation in the scale and scope of fishing operations, economic results were divided into three categories: OPT only, OPT/OFT and Others. The mean net economic return across businesses with OPT and OFT fishing endorsements in 1999-2000, was 2% to capital and the median net return was -7%, indicating 50% of operators fell below this level in the single year of operation examined. OPT only businesses had a gross operating profit of 2% and OPT/OFT businesses had a gross operating profit of 10%. OPT and other businesses had an economic rate of return of -24% The results indicate significant long run economic viability issues for those OPT fishers more involved with other fisheries, other than the OFT.

4.4 Economic multiplier effects, economic rents and community contributions

The previous estimate of economic surplus is not an estimate of resource rent in the fishery, which requires a bio-economic study and an estimate of the revenue derived from effort less the total cost of effort across the whole fishery. Existing information indicates that the current management of the Ocean trawl fishery yields less resource rent than could be obtained under a management regime with reduced effort levels.

The contributions to the community can come in several forms. Revenue and employment are generated by those fishing and economic activity contributes to the community. However a long term positive economic contribution of the ocean fishery resources to society can only be realised through management of the fishing industry in order to produce resource rent. Underperformance of management leads to a loss of economic rent from the fishery and hence a loss for society. Currently under category 2 share management, a nominal "rental" payment of $100 per shareholder per annum will be made, irrespective of the level of economic performance in the fishery.

Economic multipliers come from input-output modelling of economies and relate to the flow-on impacts of expenditure within a closed local economy and the revolving benefits of this. The economic significance of an industry, such as commercial fishing, can be measured in terms of direct and indirect effects. The available literature is dated, but enables some discussion of multipliers in four fishing communities in NSW. Both the southern and northern studies indicate that the ratio of all effects, to direct fishing effects, is between 1.5 and 2.0 (Tamblyn and Powell, 1988; Powell *et al.*, 1989). Local multiplier effects are likely to be relatively small at around 1.5 for most fishing activities.

4.5 Markets for species harvested in the ocean trawl fishery

The OPT fishery supplied between 2,226 and 3,607 tonnes of prawns and fish during 1997/98-2001/02. In the same period, the OFT fishery supplied between 1,964 and 1,017 tonnes of fish. NSW Fisheries records indicate that more than 300 species of fish and 80 species of invertebrates were recorded in fish and prawn trawl catches.

Deregulation of fish marketing has brought a new system and granted Fish Receivers certificates to fishers and fishing companies. Under the new system cooperatives have a less central place than before.

The economic survey asked fishers to state their main marketing options by type of fish receiver and does not reflect product volume or value. OPT fishers do not use agents. The ocean trawl fishers tend to supply their prawn/fish to the co-operatives and Sydney Fish Market and shops.

The Sydney price in nominal terms has increased for eastern king prawn from $7.85/kg to $21.05/kg, and for school prawns from $3.30/kg to $7.30/kg, in the 1981-2002 period. In the case of royal red prawn, there has been no considerable increase in the average price (from $3.35/kg in 1985 to $3.90/kg in 2002).

The Sydney price for Silver Trevally in nominal terms has increased from $0.47/kg to $2.48/kg, for Tiger Flathead from $0.88 to $3.46, for Redfish $0.42 to $1.84 and for John Dory $3.5 to $9.30 in the 1981-2002 period (NSWF- Sydney Index).

A small portion of the catch from the ocean trawl fishery is exported. The economic survey estimated an average value of $12,000 per fisher equating to exports of approximately $3.0m from the OT fishery, but this should be treated with caution.

4.6 Overall risks to the economic viability of the fishery

The review of the existing information on the current situation in the ocean trawl industry and existing management arrangements indicates that the fishery is economically under performing and there are a number of risks to the sustainability of the fishery:

- Effort levels are in excess of the profit maximising level and there is significant overcapacity;
- Existing input-based management regulations have been insufficient in restricting effort and in reducing or containing fishing capacity;
- There are no economic incentives to fishers to rationalise their fishing activities to increase economic returns and hence the economic viability of the fishery;
- Limited access security and lack of long term access rights are impediments for fishers to develop long-term business plans and for making large investments;
- Current management arrangements do not recognise or measure the resource rent in the fishery;

- Other risks include inadequate selectivity of trawl gear (for optimal biological and market yield), inadequate monitoring of economic performance and social indicators, and continuing improvements in fishing technologies (effort creep).

In summary, fishing capacity and fishing effort levels must be addressed if a viable fishery is to be achieved in the long term. It is important that the FMS provide for a high level of industry involvement in decision making with regard to structural adjustment and that the decisions to improve long term viability are implemented.

5 Social Issues

5.1 Fishers Social Capital

This section summarises the existing information on fishers and their communities associated with the ocean trawl fishery, focussing on:

- the community values associated with the commercial fishery;
- the community views and perceptions of the fishery;
- the importance of social identity and job satisfaction; and
- the overall social risk to fishers from the current operational arrangements.

a) Community values associated with the commercial fishery

The fishing communities tend to focus around key coastal towns, though a significant number of fishers reside in smaller communities. The OPT and OFT fishers are approximately 33% of all NSW fishers. The social survey identified those fishers using 34 “home ports” in NSW.

OPT fishers are distributed along most districts in the northern region and most numerous in the Clarence district. Most OFT fishers are in the southern districts. Ocean trawl fishers form a substantial part of the NSW fishing community in many postcodes ranging from 4% to 47% of local fisher numbers. Regional unemployment in NSW is higher on the North coast of NSW and areas outside Sydney, and is a significant issue for aging fishers considering alternative employment to fishing. More in depth studies of fishing communities is an area for future work.

It is estimated that between 803 and 1,314 persons (full-time and part-time) were employed in businesses with OPT/OFT endorsements in 2001/02. A social profile of ocean trawl fishers revealed fishers to be an aged (approx. 14% of OPT and 18% of OFT fishers are aged greater than 60 years), highly resident population.

The net taxable income of fishers in 2001-02 from all industries ranged from $48,336 - $65,669 after tax. The average household income was approximately $71,000 indicating the overall contribution of 68–92% by fishers to household income.

About 40% of ocean trawl fishers had dependents – spouses, children, stepchildren, parents, grandparents and others. The total number of dependents on ocean trawl fishers was estimated at approximately 370.

b) Community views and perceptions of the fishery

There is little independent opinion on community perceptions of fishing activities. In a community telephone survey in 1999, there was general concern among a random selection of the population for the well being of the fishery environment and for the need to manage and conserve fish stocks (Roy Morgan, 1999). Other community opinion about fishers is less formal and is an area requiring development. Much commercial fishing activity in the ocean trawl fishery is offshore and is not observed by the public.

c) Importance of social identity and job satisfaction

The ocean trawl fishers have substantial fishing experience and strong family involvement with fishing with 64-79% of fishers having more than 2 generations of family involvement in the fishing industry. Approximately 21-36% of fishers are first generation fishers and 53% OPT and 61% OFT fishers have over 20 years of fishing experience.

In the ocean trawl fishery, fishing forms a significant part of individual income of fishers, with 73% of fishers who responded having 100% of their income from fishing. Part-time fishing involvement is limited. Only 13-14% of fishers worked in other industries. Approximately 28% of OPT and 50% of OFT fisher population could consider working in other industries full-time or part-time. The remaining fishers were insistent about their identity as fishers and they were unable, or unwilling, to consider re-training.

Part of the fishers' lifestyle is that fishing takes more hours than the conventional 40 hour week. The data suggest that normally ocean trawl fishers work approximately 64 hours per week.

There are a number of unresolved issues between ocean trawl fishers and ocean trap and line and lobster fishers regarding access to fishing grounds. These conflicts can arise when fishers work in the same areas and target or incidentally catch the same species.

Recreational fishers are aware of the commercial fishery but have less interaction that in the inshore fisheries. The past management of the Ocean Prawn Trawl and Ocean Fish Trawl fisheries has had Regional Liaison Committees in regions ensuring the views of local people and representatives of Local Councils, National Parks and Wildlife Service, recreational fishers and community groups are incorporated in the management process.

d) Overall social risk to fishers from the current operational arrangements

The overall social risks to fishers from the current operational arrangements in the ocean trawl fishery are summarised below.

Approximately 59% of ocean trawl fishing businesses were not economically viable in the long run in 1999-2000 economic survey. Between 839 and 1,314 persons are directly employed full-time and part-time in ocean trawling fishing businesses. Some fishers face financial problems in supporting their dependents and rely on jobs outside fishing and on social security.

Fishing is a way of life for most ocean trawl fishers and the risk to this way of life is increasing. Fishers were insistent about their identity as fishers and most were unable, or unwilling, to consider re-training. Lack of alternative employment opportunities is a significant issue for both outgoing and aging fishers considering alternative employment.

Institutional issues like frequent changes in fisheries policies, and inconsistencies between State and Commonwealth legislation create uncertainty within the industry.

Such uncertainties are risks to the long-term economic viability of individual fishing businesses.

Information on fishers' views and perceptions towards key issues in the fishery, their behaviour under existing policies, and their ability to participate in management (e.g. co-management arrangements) is also necessary for effective management of the fishery. The collection, analysis and application of socio-economic information has not previously been a priority in the list of fisheries research programs. Consequently there is inadequate monitoring of social aspects of ocean trawl fishers

5.2 Health and Safety

The seafood safety scheme is based on the premise that some species and/or activities represent a potentially higher food safety risk than others. The highest food safety risk is associated with bivalve molluscan shellfish because they can readily accumulate harmful contaminants (bacteria, viruses, algal toxins and heavy metals) from their environment and transmit these to the consumer.

Bivalve molluscs are not retained in the OTF and the species that are targeted in the fishery do not need any special management arrangements. With the introduction of the Seafood Safety Scheme Regulation, responsibility for this fishery in terms of food safety will pass to SafeFood Production NSW.

a) Health risks to fishers

There are a variety of occupational health and safety (OH&S) risks associated with the activity of fishing in the OTF. These are related to the use of machinery, boats, powered winches, etc. Workcover administers the legislation, which controls these activities and protects workers' health. The fishing businesses are required by law to operate in a manner consistent with the OH&S legislation. One area of safety that is of major concern to fishers is collisions with large commercial ships such as coastal tankers, especially at night. There have been a number of reported incidents where trawlers have collided with these types of ships, despite OT fishers displaying the requisite signal lights and other lighting on-board their vessels. Whilst such safety issues are outside the jurisdiction of NSW Fisheries, this EIS draws attention to it to the appropriate maritime regulatory authorities as an important issue to be addressed.

b) Health risks to consumers

As food producers, the provisions of current NSW food legislation, namely the *Food Act 1989* and the *Food Regulations 2001*, bind participants in the fishery. Vessels are included in the definition of "vehicles" in the *Food Act 1989*. There are no specific provisions relating to seafood specifically in the context of this fishery but general requirements about hygiene and cleanliness, keeping good records and keeping products cool apply to the handling of all foods including fish.

The *Food Production (Seafood Safety Scheme) Regulation 2001* requires all seafood businesses including those in the catching/harvest sector to be licensed with SafeFood Production NSW and prepare a Food Safety Program in respect of their activities.

With respect to the fishery, this will apply from the point at which the catch is brought on board the vessel. Where the same business or individual further processes or handles products on shore (after landing) the Food Safety Program will have to encompass each and all of those other activities.

For most participants who simply catch fish and transport them to land, the basic requirements would already be understood and met since they involve good handling and hygienic practices. Given the range of scale and sophistication of vessels and businesses engaged in the fishery, however, some improvements may need to be made, primarily of a minor nature.

Essentially the major food safety requirements on all participants in the fishery are to keep the catch clean, keep it cold and keep good records. The current level of compliance is largely unknown but with the introduction of the Seafood Safety Scheme all participants will be licensed and subject to audit and inspection.

c) Overall risk to health and safety

The risks to the health and safety of fishers, their crew and consumers is low due the highly regulated nature of the of the industry from both Workcover and Seafood Safety Scheme. The draft FMS is not required to provide additional specific management responses to these issues.

5.3 Indigenous peoples

a) The interests of Aboriginal people in the resources and habitats targeted by the Ocean Trawl Fishery

Many Aboriginal people in regional coastal communities of NSW express the view that ocean fishing is part of their cultural identity. Most often, the fishing that is described is inshore fishing, based on beaches or rock platforms, although there is no doubt that some people also fished the ocean from canoes in traditional times and continued this tradition as ocean fishing from small boats in contemporary times. This fishing is for subsistence and socio-cultural purposes. People fish to feed their families, but also to meet obligations for looking after other people in their community, either as part of daily routines, or for special events such as funerals. Aboriginal Elders still pass on stories and information about places and species of traditional importance to their children and grandchildren.

During consultation that has been conducted for this project and other recent research on Indigenous fishing, Aboriginal people have consistently reported:

- strong interests in rights to access ocean resources (including a sense of ‘ownership’ of the seas and their products);
- strong interests in the sustainability of ocean fisheries, drawing on a belief that in the past, Aboriginal people fished for what their families needed, but always left some to ensure that they could come back again in the future;
- that transfer of traditional ecological knowledge from one generation to another is culturally important and is dependent on access to fishery resources extending beyond the concept of recreational fishing; and
- interests in the well being of particular species.

When discussing commercial fishery management, Aboriginal community respondents did not differentiate clearly between one commercial fishery and another, and there was a tendency to bundle all commercial fishery issues up together (eg people commented on pipi restrictions, oysters, abalone and estuarine fishery species as well as ocean species).

b) Sites and places of value to Aboriginal communities

The physical evidence of past ocean fishing practices is (poorly) preserved in midden sites on headlands and behind ocean beaches along the NSW coast. There is minimal risk that the operation of the commercial ocean trawl fishery will impact on these archaeological sites. Some Aboriginal communities (such as Yarrawarra) have documented places of contemporary value, where social activities associated with fishing have occurred within memory and continue to occur. The documentation of these places helps to understand the relationship of local communities to the natural landscape. As with archaeological sites, there is minimal risk that these places of value will be impacted by the operation of the commercial Ocean Trawl Fishery.

There are stories from communities right along the coast of Aboriginal people having a special relationship with dolphins; of women and men calling to (sometimes singing) dolphins from beaches and headlands. On the south coast, this extends to historical accounts of collaboration of Aboriginal people and dolphins in whale hunting and driving fish species close to shore where they could be caught. The operation of the Ocean Trawl fishery will not impact on these values.

c) Potential impacts of the OTF on traditional fishing and access

Schnierer and Faulkner (2002) document the results of consultation with Aboriginal people in coastal communities in NSW, about species targeted by Aboriginal fishers, and the ways in which they utilise aquatic resources for food, medicines and other parts of their daily lives. The research also provides information about the reasons for fishing. It is these reasons, and particularly the cultural identity of Aboriginal fishing, which separate the fishing activities reported by Indigenous people from other fishing in the general community.

Eighty-one per cent of respondents noted that they fished either to supplement their family's diet or to share with their extended family (especially Elders). However, whilst these subsistence/dietary reasons for fishing are clearly important and continue traditional practices, other reasons for fishing indicate particular characteristics of Indigenous fishing that distinguish it from fishing by other groups in the community. These reasons are directly linked to community ties to the land and water 'country' and the passing on of traditional cultural knowledge. No other groups have the cultural ties to the land and water that Aboriginal people express.

The existence of commercial ocean fisheries does not in itself detract from Aboriginal access to traditional fisheries. Community members believe, however, that the low representation of Aboriginal people in the commercial sector, the regulation of the commercial fishery and the imposition of strict bag limits for non commercial fishers disadvantages them and conflicts with traditional fishing customs.

d) Aboriginal participation in the OTF

Only one Aboriginal person is currently known to hold a commercial licence in the Ocean Trawl Fishery and there appears to be little direct engagement between Aboriginal people and the commercial Ocean Trawl sector. People state that they do not participate because they do not have the capital to invest in commercial vessels and equipment and traditional skills have been lost over generations of disadvantage.

During consultation, Aboriginal people have expressed strong views that the wealth generated from use of marine resources (including, but not restricted to the Ocean Trawl Fishery) does not accrue fairly and that Aboriginal people have been disadvantaged in their participation in the commercial sector. Some people argue that there has been a cumulative loss of rights as licensing requirements have changed.

e) Interaction of the OTF and the Indigenous Fisheries Strategy

The Indigenous Fisheries Strategy (IFS) was released in 2002 after consultation with Aboriginal communities at several regional meetings. The Implementation Plan that accompanies the Strategy identified actions for 2003 and 2004, and the progress towards priority actions is monitored by the Indigenous Fisheries Advisory Committee.

The development of mechanisms to maintain and enhance Indigenous participation in the commercial fishing sector generally is a very high priority for the Indigenous Fisheries Advisory Committee, and was the subject of a workshop to develop an action plan during 2003 (see Callaghan and Associates 2003).

Whilst it should not be anticipated that the issue of Aboriginal employment and Aboriginal ownership in the commercial sector can be resolved through the Ocean Trawl FMS alone, Ocean Trawl fishers and the Indigenous community should both participate in discussions about potential changes to the *Fisheries Management Act* and the potential introduction of programs to enhance Indigenous capacity to enjoy their rights to economic independence.

Potential actions that are still being refined through further consultation within and by the Indigenous Fisheries Advisory Group include:

- filling a number of positions for Indigenous people on Fishery Management Advisory Committees (note for instance that there is currently no Aboriginal person on the Ocean Trawl Management Advisory Committee);
- consultation with Aboriginal people about the concept of identification of Indigenous commercial fishers on their licences (and whether Indigenous fishing licences could have special conditions attached to them);
- endorse the goal of retaining Indigenous people in commercial fishing and demonstrate this through investigating options for licence transfers, sub-leasing of licences, and assistance with gaining new licences;
- training for Aboriginal fishers, both to enhance employment prospects as crew and to support operations as licensed fishers; and
- consider new structures and any special training for involving Aboriginal people in Management Advisory Committees, potentially using the models described in the Boomanulla Statement.

f) Overall risks to Indigenous values associated with the operation of the Ocean Trawl Fishery

Table B5.1 presents a simple qualitative assessment and ranking of risks to Aboriginal values that are associated with the existing operation of the Ocean Trawl Fishery. For simplicity, this table will be presented again in Chapter E showing how these risks have been addressed by the draft FMS, where necessary.

Table B5.1 Summary of risks to Indigenous values.

Broad issue/value	Risk – existing management
Aboriginal sites – physical evidence of past Aboriginal landuse	Low (low probability and consequence)
Aboriginal places – the locations that are associated with stories about the landscape or with personal and community totemic associations with the natural world	Low
Aboriginal marine totem species	Moderate
Aboriginal cultural landscapes – the places and species in the landscape that are important to Aboriginal people. As a separate issue from Aboriginal places, this refers to the presence and distribution of Aboriginal foods and medicines in the marine landscape	Low to moderate
Aboriginal socio-economic participation in the commercial fishing sector	Moderate – currently very low participation

5.4 European heritage sites

a) Sites of historic heritage

Approximately 1100 shipwrecks appear to be located within New South Wales non-estuarine coastal waters. Of these approximately 260 are recorded offshore of the coastlines of the Northern Rivers, Mid North Coast, Illawarra and South East regions.

A key constraint to the accurate assessment of risk is that details about the locations and condition of many shipwrecks are poor. It is difficult to pinpoint the locations of these wrecks, or the amount of wreckage that may still remain, with any certainty. For many wrecks, only limited, broadly descriptive information is available, and the extent to which parts of the wreck may be exposed to snagging on nets etc. is difficult to determine. The condition of a shipwreck will depend on the nature of the vessel (size and type of construction), depth of water, circumstances that caused the wreck, subsequent disturbance, and marine processes such as waves, currents and sediment transport. For many shipwrecks, little of this information is known directly.

Almost all the shipwrecks along the NSW coast are protected by either the Commonwealth heritage legislation (*Historic Shipwrecks Act*) or by the *NSW Heritage Act*. For example, of the 260 or so shipwrecks identified in the Northern Rivers, Mid North Coast, Illawarra and South East regions of the coast, less than twenty shipwrecks do not have protection under either the Historic Shipwrecks or NSW Heritage Acts. The *Heritage Act* requires that relics not be disturbed without obtaining a permit. In rare cases, this would mean that trawling in the vicinity of a structure that has been reported to the Heritage Office should cease until the nature and significance of a relic has been investigated and confirmed.

b) Summarise the overall risk to European heritage sites from the current fishery

In broad terms, the potential risks to historic heritage derive from the following aspects of the operation of the fishery:

- direct impacts by vessels on shipwrecks; and
- trawl nets becoming snared or entangled on parts of shipwrecks and affecting the integrity of the heritage structure. In this case, there is also a risk to the safety of licensed fishers and their crew if nets are not easily disentangled from the shipwreck. There are a number of instances of damage to or sinking of trawl vessels after nets became snared on shipwrecks.

These risks are qualitatively assessed in Table B5.2.

Table B5.2 Qualitative risk assessment

Aspect	**Likelihood**	**Consequence**	**Risk**
Trawler navigation – collision with shipwrecks	Unlikely to rare	Moderate	Low
Entanglement of trawl nets in shipwrecks	Possible	Moderate	Low to medium

The risk presented to historic shipwrecks by the activities of the ocean trawl fishery is generally low, extending to medium for snagging in some cases. In this context, the types of response that are appropriate in the Fishery Management Strategy relate to procedures for monitoring (for instance locations, frequency and consequence) and reporting incidents.

Volume 2

This is the second of four volumes
of the
Environmental Impact Statement
on the
Ocean Trawl Fishery

Note: The NSW Department of Primary Industries, incorporating NSW Fisheries, was established on 1 July 2004. Any reference in this document to NSW Fisheries is a reference to the NSW Department of Primary Industries.

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CHAPTER C CONSIDERATION OF ALTERNATIVE MANAGEMENT REGIMES

This chapter highlights a range of high-level alternatives to the existing operation of the fishery described in Chapter B.

1. Alternative: no Ocean Trawl Fishery

This section presents the consequences of not having an Ocean Trawl Fishery (OTF) in NSW waters. The size and scale of the OTF is outlined in Part 1 of Chapter B.

Not having an OTF would prevent the capture of the relevant species through this fishing method and remove the impact of trawling on ocean habitats, which would improve the biomass levels of fish stocks and might improve catches of some species by recreational and Indigenous fishers and in other commercial fisheries.

However, the above potential benefits need to be balanced against the negative impacts of not having an OTF is clear that the fishery forms a significant component of the economy of coastal NSW, and provides a significant quantity of fresh seafood to mainly local but also export markets. The fishery produces about 4,500 tonnes of seafood annually, valued at about $36 million at the first point of sale. This value is considerably increased if the assessment considers supply of goods and services to the fishery, and the value-adding of seafood products through wholesale, retail and restaurant outlets. Not having an OTF would have considerable social and economic impact, not only on the fishing businesses that are endorsed to operate in the fishery, but also on the local and regional economies of some areas of coastal NSW (see below).

a) Supply of seafood to the community

Fresh seafood enjoys a reputation as a healthy source of high-quality protein and beneficial nutrients (e.g. Omega-3 fatty acids). The major products of the OTF, king and school prawns, have a central place in the Australian lifestyle, and are also highly sought by a range of social and ethnic groups in the Australian community. The importance of 'local' seafood to the catering and tourism industries has now been well established (Ruello, 1996; Ruello and Associates, 2000). There is an increasingly strong local demand for most of the products of the OTF, and the rapid increase in this demand is unlikely to slow in the foreseeable future.

Products provided by the operation of the OTF range from large quantities of relatively low value species (e.g. school whiting), to significant quantities of high value species (e.g. eastern king prawns, Balmain bugs) and smaller quantities of highly regarded fish species (e.g. john dory, ocean perch). For most of the species taken by the trawl fishery, it is likely that the local market could not be effectively supplied by catches from other commercial fisheries if trawling ceased, as other commercial fishing methods that have an equivalent or lesser impact on the environment cannot be successfully applied to catching these species. Some species (e.g. silver trevally, blue swimmer crabs and octopus) can be caught in traps, and some can be taken on lines or jigs (e.g. ocean perch and squid), but using these methods to target these species would be considerably less efficient than using trawl methods, and it is unlikely that market demand could be satisfied using these other methods.

It is also unclear if other commercial fisheries in adjoining jurisdictions (such as the Commonwealth South East Fishery for fish or the Queensland East Coast Trawl fishery for prawns) would be able to supply the market currently supplied by NSW OTF. These other fisheries may already have lucrative markets for their product, and in the case of the South East Trawl Fishery increases in catch of the primary species are restricted by the application of Total Allowable Catches in the management of that fishery.

b) Employment considerations

In 2001/02, 218 fishers reported the use of either prawn or fish trawl nets in NSW ocean waters. Taking into account direct and indirect employment, approximately 803 to 1314 people are estimated to be employed in ocean trawl fishing businesses (see Chapter B). The OTF also supports considerable infrastructure ashore for supply of fuel, ice, netting materials, electronic aids etc, for vessel maintenance, and for unloading, handling and marketing of product. The available studies relating to the employment flow-on effects for trawl fisheries in NSW indicate a multiplier factor of 1.6 times, so it is likely that the OTF contributes directly to the employment of 1285 to 2102 people in coastal NSW.

Because many of the fishers endorsed to operate in the OTF participate on a year-round basis, they are, with some exceptions, not generally endorsed for, or involved in, other commercial fisheries. If in future there was no OTF, then the majority of the people directly employed in the fishery would need to seek alternative employment. A high proportion of fishers engaged in the OTF are in the older age brackets (e.g. approximately 16% of fishers surveyed were greater than 60 years of age, and the average age of fishers was 45 years – see Chapter B). A high proportion of fishers responded that they were unable or unwilling to consider re-training in another occupation.

c) Economic considerations

In 2001/02, revenue at first point of sale for seafood caught from NSW waters by ocean trawlers was approximately $36 million. Powell *et al.* (1989) estimated economic flow-on effects of seafood caught by ocean trawlers to be around 1.5 to 1.6 times, so the value of the OTF to the coastal economy of NSW would be realistically estimated at around $50 to 55 million per annum. If there were to be no OTF, the loss of such a significant level of economic activity would be keenly felt by the fishing and associated industries in coastal NSW. A large proportion of the catch from the OTF is sold through the Sydney Fish Market, and there may also be a significant negative effect on the financial position of this company if the trawl fishery ceased operations.

2. No changes to existing management arrangements

The existing management arrangements for trawling in NSW ocean waters are outlined in Part I of Chapter B, and Part II of that chapter identifies the risks associated with the current operation of the OTF.

Should there be no change to the existing management arrangements for the fishery, these significant risks would remain unaddressed, and the fishery will almost certainly become unsustainable and most likely experience a severe reduction in economic viability in the long term.

3. Alternative effort regimes

Currently, fishing effort in the OTF is indirectly controlled by limiting the number of endorsed operators and by the implementation of a set of controls on factors such as boat size and horsepower, trawl net dimensions, fishing closures and trip limits. There is no direct control on the amount of fishing effort that may be exerted by individual operators, however in practice there is an upper limit (albeit variable) due to the above factors and limited fishing opportunities due to weather conditions.

There is a significant problem with the level of latent effort in the OTF and a feasible alternative would be to enhance the current set of indirect controls, and introduce a restructuring scheme to further limit the number of active operators in the fishery. The level of fishing effort necessary to achieve a commercially viable and ecologically sustainable fishery would need to be identified, and as a means of achieving this level, direct control of the number of days or nights fished by individual trawlers could be applied.

It is difficult to propose any other feasible alternatives which would effectively control fishing effort in the OTF, apart from simply being more restrictive on where and how often boats may fish (i.e. a more comprehensive set of spatial and temporal closures). Such an option however would necessarily be based on very limited information, and could lead to major reductions in the economic and social benefits provided by the OTF as outlined in Section 1 above, with no real assurance of meaningful ecological benefits. The effectiveness of such closures would also rely on the implementation of corresponding closures in other fisheries (including recreational and commercial trap and line fishing) and the early installation of a vessel monitoring system (VMS) across the fleet at considerable cost to enable effective enforcement.

An alternative proposal for effort control was suggested by the Ocean Prawn Trawl and Ocean Fish Trawl MACs. The proposal involved reducing effort [i.e. in terms of the number of available entitlements] in the trawl fishery by 15% during the first year of operation of the management strategy. However no details were provided of the actual mechanism by which effort would be reduced, other than by a Government funded buy-back of sufficient endorsements to result in a reduction in effort of this magnitude. Also, it is unclear if the level of effort proposed (15% less than the level in 2003/04) could be regarded as sustainable or commercially viable, or whether any further adjustments would follow. While certainly a move in the right direction, given that the proposed level of reduction in effort (15%) is only about half the level of latent effort in the fishery, this proposal would not appear to adequately address the issue of effort control. However, restructuring programs for fisheries are normally phased in to allow a period for industry to adjust and this option may form a part of the effort control regime provided for under the draft FMS (see management response 5.2(b)).

4. Alternative management responses to address significant areas of risk

The key significant risks identified by the environmental assessment of the OTF include:

- overfishing of primary or key secondary species, including all elasmobranchs
- bycatch,
- habitat damage and
- loss of economic viability.

The following discussion examines broad level alternative management regimes for addressing each of these key risks and assesses. A section is also included on a proposal by the industry members of the Ocean Trawl MAC for addressing the inappropriate selectivity of double braided fish trawl cod-ends that are currently used to target school whiting in some areas, but also catch many of the primary and key secondary species at well below optimum sizes.

a) Alternate regimes to prevent overfishing of primary and key secondary species

Current and proposed management of the OTF is based on the collection of sufficient information to assess the status of the stock for each primary and key secondary species, the implementation of an appropriate size at first capture (ie. gear selectivity), and sufficient additional management measures (e.g. appropriate fishing closures) to prevent the overfishing of each species. Where these measures have not been sufficient to prevent overfishing from occurring, a 'recovery program' is specified to assist the stock to recover. Alternate management regimes to prevent overfishing of the stocks could involve a limitation on catches of each species by means of catch quotas, significant reductions in the number of fishers endorsed to operate in the fishery, or the implementation of much more widespread area and/or time closures to fishing.

Quota management is best suited to fisheries that have the following characteristics: simple jurisdictional arrangements, single method, single species, relatively high value, small number of participants, small number of ports of landing, good stock assessment information, and general industry support. Few, if any, species in the OTF exhibit the range of characteristics that would make them suitable for management under a catch quota regime.

In the absence of accurate assessments of the status of many of the primary and key secondary species, determining appropriate catch quotas would be a somewhat arbitrary exercise. There are several examples of mixed-species fisheries where management by catch quotas has not prevented the overfishing of some of the important species in the fishery (eg. gemfish and silver trevally in the Commonwealth's South East Trawl Fishery). The failure of some quota-managed fisheries has most often occurred because catch quotas only control what is landed by the fishery, not what is actually caught, and do not by themselves address impacts of the gear on broader ecosystem components. Quota management systems do not provide a direct control over fishing effort and in some instances have been criticised for allowing uncontrolled increases in fishing effort (Smith and Wayte, 2002; AFFA, 2003b). Supporting regulations on the selectivity of fishing gear and appropriate closed areas are still necessary to underpin management using catch quotas to achieve sustainable trawl fisheries.

Given the current lack of collated information on habitat types and extent in NSW ocean waters, and the levels of use by the primary and key secondary species of each habitat type, specification of the number and relative size of trawl closures needed to prevent overfishing of these species would also be arbitrary. Even if extensive trawl closures were implemented it would still not be possible to guarantee overfishing of resources did not occur, due to the potential cumulative impacts from other fisheries (e.g. the recreational and ocean trap and line fisheries) or unanticipated natural fluctuations in abundance of the target species.

Minimum size limits represent another management tool that can be used to protect the juvenile fish in a population, thereby increasing the chance of fish reaching spawning size. Indeed size limits are already used on selected primary and key secondary species in the OTF and new size limits appear necessary for some other species, such as silver trevally. The effectiveness of size limits in a trawl fishery can be beneficial in terms of their ability to prevent the intentional targeting of young fish, but can result in significant discarding problems if the selectivity of the trawl gear fails to exclude fish that are smaller than the minimum legal size. As such, a feasible alternative to the existing fishery arrangements is to implement size limits on species where there are problems of overfishing, while at the same time adjusting the selectivity of the fishing gear in an attempt to avoid the capture of undersize fish.

b) Alternate regimes for minimising bycatch

An alternative management approach to minimising bycatch to that currently used (see Chapter B) is to utilise a combination of targeted fishing closures, more selective trawl nets and appropriate bycatch reduction devices. Accordingly, the draft FMS supports and provides for the adoption of a range of enhanced management tools to achieve a reduction in bycatch levels.

Other alternatives involve the use of different fishing techniques, such as trapping for prawns and other crustaceans, and line fishing or fixed nets (e.g. mesh nets) for targeting fish species. All of these alternative methods also have potentially significant bycatch and selectivity issues, and in some cases concerns about the ecological effects of using such gear in ocean waters have led to a ban on their use (e.g. use of mesh nets in NSW ocean waters has been banned for over 20 years). It is highly unlikely that line-fishing methods would provide an economically feasible alternative to the use of properly specified trawl nets for many species able to be taken by both methods, and for a number of species (e.g. school whiting) there exists no feasible alternative harvesting method to trawling.

c) Alternate regimes for protecting key habitats

If key habitat areas are not protected then it is likely that the productivity of the fishery will be reduced due to loss of nursery areas or lack of refuge and spawning areas for adult fish and prawns. The existing fishery is adaptive to the introduction of marine protected areas which aims to set aside representative areas and habitat and biodiversity from the impacts of fishing. This is an essential component in any trawl fishery management regime and its benefits to fish habitat could be significantly enhanced if reef areas (which form significant habitat structures for many oceanic species), as well as any other areas of high environmental sensitivity, were also protected from trawling.

In the United States of America an alternative approach known as ‘mitigation banking’ has been trialed. This approach involves building an equivalent area of similar habitat in an area that cannot be fished. However, the success of such an approach depends on re-creating all the important attributes of the original habitat, which will involve a range of factors, processes and conditions (Fonseca *et al.*, 1985). The interaction between these attributes and the biology of the exploited species is generally poorly understood, so the success of ‘mitigation banking’ as an alternative to habitat protection appears unlikely. It is also noteworthy that the area and description of the ‘key’ habitats within the fishery still need to be known in order to ‘recreate’ them, and once known then it is much more efficient to simply close representative areas to fishing than to go to the expense and difficulty of trying to recreate these habitats somewhere else. Additionally, any areas proposed for ‘mitigation banking’ because they aren’t trawled are likely to have some unique habitat characteristics, which may be impacted in creating the ‘replacement’ habitat, possibly leading to unwanted ecological impacts on some other set of marine species.

d) Alternate regimes for preventing loss of economic viability

The *Fisheries Management Act 1994* aims to promote the economic viability of commercial fishing, within the context of the foundation objectives of conserving fish stocks and promoting ecologically sustainable development. Accordingly, any alternative management regimes proposed to maintain the economic viability of the OTF must not compromise the conservation of fish stocks and ecological sustainability. This approach is consistent with sustaining the resource ‘asset’ base so that it may continue to be harvested over the longer term, as against being ‘mining’ the resource for a short term return.

Results of a survey of economic issues in the OTF (see Chapter B) indicated some significant long-run economic viability issues, especially for those fishers who operated part-time in the OTF and were also involved in other fisheries. This supports advice from industry that, at present, profit margins in the fishery are small.

Currently, the economic viability of fishers in the OTF is assisted by a subsidy provided by the NSW government to help cover the costs of management. Under the principles of ESD a cost-recovery framework should be established, to move towards a situation where the 'attributable' costs of management are born by those who benefit from the management strategy. One alternative would be for the NSW Government to continue subsidising the costs of management of the fishery, however some studies suggest that such subsidies may encourage and aggravate problems of over-capitalization and over-capacity (Greboval and Munro, 1999; Ibsen, 1999; Porter, 1998) and some subsidies may also act against the interests of the environment in the short term or the fishery in the longer term (Pimm, 2001).

An alternative to the existing situation would be to reduce the number of operators in the fishery to a level at which the remaining operators can make a reasonable profit from the available trawl fishery resources. Not enough is known about the economics of individual fishing businesses to be able to identify a target number, however, a program of determining a realistic indicator for individual fishing business viability and a long term restructuring program to reduce the number of fishing entitlements is a feasible and highly recommended approach to resolving this issue. This restructuring could be undertaken through the use of a range of adjustment tools, including minimum shareholdings in the share management plan, higher requirements for new entrants or business transfers, voluntary surrender of entitlements or through targeted buy-backs of fishing entitlements.

e) Alternative industry proposal regarding fish trawl net selectivity

One key issue that has arisen during the review of the existing operation of the fishery is the inappropriateness of the selectivity of cod-ends currently used in the fish trawl sector of the fishery (known as "onion bags"). These cod-ends comply with the existing regulation in that they have a minimum mesh size of 90 mm, however, the material used is double braided twine and the configuration of the cod-end causes the meshes to close up during the trawl. The net is used effectively to target school whiting on selected grounds south of Smoky Cape, but while doing so or when used on other grounds, it catches fish of the primary and key secondary species at well under optimum sizes and contributes to the growth overfishing of those stocks. Problems with net selectivity and consequent discarding of small fish have been well documented for the fish trawl fishery off NSW (see Liggins, 1996 and Knuckey et al. (in prep.)), however these studies preceded the more general adoption of the onion bag cod-end by the fishery, and in the absence of objective data from onboard observers it is suspected that the selectivity/discarding issue may have significantly worsened in recent years.

A proposal put forward by some of the industry members of the Ocean Trawl MAC to address this issue would provide for the use of the existing onion bag cod-end in all waters shallower than 92 metres (50 fathoms). While the proposal would allow fishers to continue to use the cod-end to target school whiting, there are several difficulties with it as follows:

- the majority of school whiting stocks reside in waters less than 55 metres (30 fathoms) in depth, so trawling with the onion bag cod-end in deeper waters is highly likely to continue to catch individuals of the primary and key secondary species at well below the optimum sizes

- the extent of the NSW jurisdictional boundary south of Barrenjoey Point is 3 nm from shore and bathymetric maps indicate that apart from a few areas, the 3 nm line corresponds to about the 55 metre (30 fathom) depth contour. As such, without restricting the use of the gear to specific areas the industry proposal would have little, if any, effect on the existing level of use of the onion bag cod-end in State waters south of Barrenjoey Point.

While in the short term the industry proposal is likely to have higher economic and social benefits for fish trawl operators than the alternatives, it is clear that the proposal would continue to allow onion bag cod-ends to be used to inappropriately select small fish of the primary and key secondary species. Accordingly, the proposal does not satisfactorily address the risk of growth overfishing of the main species in the fishery and is likely to lead to medium to long term declines in the stocks and thus economic viability of the fleet.

5. Alternative performance indicators and monitoring programs

The Fishery Management Strategy for the OTF presented in Chapter D contains seven broad goals, each with a number of objectives and a much larger number of individual management responses, many of which are new responses in the management of the fishery. This extensive set of responses arises because of the significant risks identified in the environmental assessment of the OTF (Part II of Chapter B).

As full cost recovery is introduced into the OTF, the more extensive and costly performance monitoring is, the greater the costs will be to industry. Considering that economic viability has been identified as a significant issue in the future management of this fishery, it is desirable that cost increases be kept to the lowest feasible level. The seven goals proposed in the draft FMS address the major areas of risk identified for the fishery, and monitoring the performance of the fishery against each goal is considered the most cost effective way of measuring performance of the strategy.

The performance indicators outlined in the draft FMS (section 5 of Chapter D) have been identified as the preferred indicators, taking into consideration both the major issues or risks associated with the OTF, and the general costs of monitoring the performance of the strategy. A number of performance indicators proposed in the strategy will act as surrogate indicators until more appropriate alternatives can be developed. For instance, a performance indicator to measure the impact of individual fisheries on the biodiversity of ocean waters cannot currently be specified due to the (generally world-wide) lack of knowledge regarding the dynamics of aquatic ecosystems. Similarly, it is difficult to identify a single performance indicator to measure the economic viability of fisheries or individual fishing businesses (development of such indicator(s) is to be discussed with the OT MAC under management response 5.3a). Alternatives to the proposed indicators would be those that produce a meaningful outcome, and could be monitored without causing significant increases in the cost of management, research or administration.

Whilst ‘adaptive management’ is increasingly accepted as the ideal framework for management and policy development it can be an expensive process (i.e. in terms of both the experimental design and the necessary data collection and analysis). Adaptive management can be broadly defined as “*a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs*” (Bennett and Lawrence, 2002). In an active sense, it involves developing a robust experimental design that drives the monitoring program to determine whether the aims of each management action (i.e. response) are being/have been achieved.

It may be problematic to successfully introduce such a system in the OTF, which captures a large number of different species, and where individual management actions generally assist in achieving more than one goal or objective (or address more than one hypothesis). Application of active adaptive management in the fishery would, in most cases, require a large number of variables to be monitored, leading to significant costs that would need to be borne by the fishery participants. It would also be difficult to determine the cumulative effects of the multiple management responses in achieving each goal or objective.

The management regime outlined in the draft FMS is a 'responsive' program that enables the regime to be changed in response to new information or if the trigger points are breached. It seeks to incorporate the principles of adaptive management, but may not be considered an 'adaptive management' regime in the true sense.

6. Alternative arrangements for the cost-effective delivery of management

Following the risk assessment in Part II of Chapter B, a number of management responses and research programs have been proposed in the draft FMS (see Chapter D) to address major issues and reduce the significant risks that have been identified in the assessment. Many of these are actions or programs that are already underway, or are new responses that will require little, if any, additional resources to implement. Some, however, may require additional resources to implement and alternative cost recovery arrangements and/or sources of funding need to be considered.

There are three broad alternatives to fund the existing management programs or the management responses and/or research programs proposed in the draft management strategy:

1. *All costs subsidised by government* **-** One option is for government to fund the complete costs of management, compliance and research attributable to the OTF. However, cost recovery is a common principle among Australian commercial fisheries and an important component of ecologically sustainable development. The concept of users pays (or 'beneficiary pays' as per the IPART findings) aims to internalise the environmental costs by the proponents whose activities have detrimental impacts on natural resources. To have full government funding would be contrary to contemporary competition policy and natural resource management principles and is not recommended.

2. *All costs funded by ocean trawl shareholders* – This option would see shareholders paying for the full cost of management, compliance and research associated with the fishery, even those services that benefit other fishing sectors or fisheries in other jurisdictions. For the reasons outlined in the report prepared by IPART (see IPART, 1998) this option would be inequitable for ocean trawl shareholders and is not recommended.

3. *Funding from external sources (i.e. other than industry or Government)* – This option entails relying on externally sourced funds to pay for all management, compliance and research costs attributable to the fishery. While an ideal prospect, there can be no guarantee that such funding would be forthcoming and indeed most externally funded projects are discreet projects that have a flow of benefits to other user groups or jurisdictions. For these reasons, this option is not feasible or recommended.

Given that the options described above are not feasible, the best approach to cost recovery is to continue to develop a fair and transparent cost recovery policy, taking into account all relevant issues. However, there will be additional costs associated with addressing the risks identified through the environmental assessment of the fishery, through the implementation of new programs and actions. Immediately increasing charges to individual ocean trawl fishers to cover these costs may place a high financial burden on individual fishing businesses. Taking into account the economic state of the ocean trawl fishery, as identified in this environmental assessment, a progressive cost recovery scheme should be implemented so that charges are passed on to industry in a way that enables commercial fishers to plan their businesses.

Applications should continue to be made to the Fisheries Research and Development Corporation or other funding providers for any research projects identified as eligible for external funding.

In terms of who undertakes the delivery of services for commercial fisheries, a number of alternatives to the current practice are possible. They range from all services being provided by the government to all services being outsourced and managed by the industry, with a number of possible combinations for service provision in between.

A detailed independent study investigating the potential alternative service delivery arrangements for the future management of commercial fisheries in NSW has recently been finalised. The study, conducted by Marsden Jacob Associates, identifies the potential for models that provide for a higher level of involvement by commercial fishing industry in fisheries management, whilst enabling government to fulfil its responsibilities for ensuring the long-term sustainability of commercial fisheries and providing equitable sharing of a community-owned resource. The feasibility of this approach to service delivery, including industry's ability to fund such a model, is currently being investigated. Whatever the outcome of this process, the draft FMS should be sufficiently broad and adaptive such that it can be implemented using any service delivery model.

CHAPTER D THE DRAFT FISHERY MANAGEMENT STRATEGY

1. Introduction to the Ocean Trawl Fishery

Two types of trawling currently operate in ocean waters under NSW jurisdiction, prawn trawling and fish trawling. Both sectors use similar gear, the demersal trawl net, and many of the fishers endorsed for fish trawling are also endorsed to operate in the prawn trawl fishery.

Although the two forms of trawling target different species and are broadly different in operational aspects, they take many common species and have a significant level of geographic overlap. The non-selective nature of trawl nets, and the broad range of substrates over which trawling occurs, results in a large number of finfish and shellfish species being taken. The major species targeted by ocean prawn trawlers vary with the depth of fishing, and include eastern king, school and royal red prawns, and school whiting. Fish trawling mainly targets species such as silver trevally, tiger flathead, southern calamari, school whiting and a number of shark and ray species.

Ocean fish trawl and ocean prawn trawl fisheries are currently managed by input controls, which limit the fishing capacity of the vessels and gear used, indirectly controlling the amount of fish or prawns able to be caught. Input controls include restrictions on the number of licences, the size of boats and their engine power, the design and dimensions of trawl nets, and the locations that may be fished.

There are variations in the level of participation of fishers in the OTF. Many fishers operate in the fishery on a full time basis, while some work in a number of commercial fisheries and participate in the trawl fishery on a part-time or seasonal basis. Table 1 shows a comparison of the ocean prawn trawl and ocean fish trawl fisheries with other commercial fisheries in NSW.

Table D1 Overview of the major marine commercial fisheries in NSW – snapshot as at March 2003.

(Source: Tanner & Liggins, 2001; Kennelly & McVea, 2001; NSW Fisheries Licensing database- March 2003)

	Ocean fish trawl	Ocean prawn trawl	Ocean trap and line	Ocean hauling	Lobster	Abalone	Estuary general	Estuary prawn trawl
Methods	Otter trawl net (fish)	Otter trawl net (prawns)	Demersal trap, Handline, Setline, Dropline, Spanner Crab Net, Trolling Poling	General purpose haul net Garfish haul net Purse seine net	Trap/pot	Diving (hookah)	Handline, Trap, Hauling net, Mesh/gill net, Hand collecting	Otter trawl net (prawns)
Main Species	Silver trevally Tiger flathead Redfish Calamari School Whiting	King prawn School prawn Royal red prawn Balmain bugs Octopus	Snapper, Kingfish, Morwong, Spanner crabs, Silver trevally	Sea mullet Sea garfish Luderick Yellowtail Pilchards	Rock lobster (eastern)	Black lip abalone	Yellowfin bream Dusky flathead Sand whiting Longfinned eels Sea mullet Pipis	School prawn King prawn
Total catch in 2000/01 (t)	1,171	3,411	1,763	3,501	105	305	5,103	582
Est. value in 2000/01 (A$m)	4.0	32	10	5.9	4.5	15.2	19.6	4.2
No. of authorised fishing businesses in March 2003	99	312	528	323	166	49	703	218
Standard boat length (m)	14	14	6-8	4	6-8	6	5	9
General no. of unlicensed crew	2-3	2	0-1	0**	0-1	1	0*	1

* Unlicensed crew permitted only when undertaking boat based prawn seining

** Unlicensed crew permitted in some forms of boat based hauling

2. Relevant Legislation and Policy

a) Ecologically sustainable development

Ecologically sustainable development (ESD) was defined under the National Strategy for ESD as "development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends". It can be achieved through the implementation of the following principles and programs :

- precautionary principle — if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- intra-generational equity — the benefits and costs of pursuing ESD strategies should be distributed as evenly as practicable within each generation;
- inter-generational equity — the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations;
- conservation of biological diversity and ecological integrity — conservation of biological diversity and ecological integrity should be a fundamental consideration;
- improved valuation, pricing and incentive mechanisms — such as user pays and the use of incentive structures to promote efficiency in achieving environmental goals.

b) The Fisheries Management Act

The Fisheries Management Act 1994 (FM Act) seeks to provide for ecologically sustainable development for the fisheries of NSW through the achievement of its stated objectives, which are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In particular the objectives of the Act include:

(a) to conserve fish stocks and key fish habitats, and

(b) to conserve threatened species, populations and ecological communities of fish and marine vegetation, and

(c) to promote ecological sustainable development, including the conservation of biological diversity,

and, consistently with those objectives:

(d) to promote viable commercial fishing and aquaculture industries, and

(e) to promote quality recreational fishing opportunities, and

(f) to appropriately share fisheries resources between the users of those resources, and

(g) to provide social and economic benefits for the wider community of New South Wales.

c) Arrangements with the Commonwealth and other States

The extent and scope of the NSW OTF and any entitlements issued therein are subject to arrangements made from time to time between the State of NSW and the Commonwealth and other State governments over the management of particular fisheries. Section 135 of the FM Act enables the State of NSW to make arrangements with the Commonwealth under the powers of the

Commonwealth *Fisheries Management Act 1991* and section 141A of the FM Act gives the power to enter into agreements with other States. Refer to Part 5 of the FM Act and sections 71-78 of the Commonwealth Act for further information on the power to make (and terminate) arrangements.

Arrangements made under the Act can effectively modify the waters and the fishing methods that fall under the jurisdiction and law of NSW. At the commencement of this management strategy, a series of significant arrangements known as the ‘Offshore Constitutional Settlement’ (initially made in 1991) are in place that cede jurisdiction of trawl fishing for certain species in certain waters beyond 3 nm to the State of NSW – refer to section 4(a)(ii) of this management strategy for a description of the effect of the existing arrangements on the OTF.

The FMS will apply to all waters under NSW jurisdiction following any changes to the arrangements made between NSW and the Commonwealth or other states.

d) Fishery management framework

The OTF is included in Schedule 1 the FM Act and is a share management fishery, with the exception of the southern fish trawl sector which will continue as restricted fishery in pending the resolution of jurisdictional issues with the Commonwealth.

The FM Act requires that a share management plan be developed and implemented for all share management fisheries. A share management plan for the OTF will be prepared as part of the transition of the fishery to a full share management regime and can only occur once the draft fishery management strategy has been subject to an environmental assessment and subsequently approved by the NSW Minister for Fisheries.

The primary role of a share management plan is to provide the legislative framework for the fishery and the rights of shareholders in a share management fishery. The share management plan provides for a range of fishery specific controls to be formalised into a regulation. Examples of these include the species that may be taken, the areas for taking fish, the times or periods during which the fishery may operate, the protection of fish habitat and the use of boats and fishing gear in the fishery.

The share management plan for the OTF may also bring into operation a number of controls in the fishery that are described in this management strategy. One example of this is the penalty points scheme referred to in the management strategy. Whilst the management strategy relies on the penalty points scheme as a compliance mechanism for creating an effective deterrent, the workings and provisions of the scheme will be included in the share management plan for the fishery.

A share management plan must include objectives and performance indicators, which for the OTF will be consistent with the goals and objectives of this management strategy. The share management plan also needs to specify at what point a review of the plan is required when a performance indicator is not being met. The review process to be included in the share management plan will complement the review process outlined in this management strategy. This will ensure that there is a robust review and reporting framework for the fishery that is underpinned by the provisions of the share management plan. In addition to this capacity for 'performance-based' reviews, a share management plan must also be subject to scheduled periodic review.

e) The NSW Environmental Planning and Assessment Act

Division 5 of Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act) requires an environmental impact statement to be prepared for each designated fishing activity described in Schedule 1a of the FM Act, for the purposes of an environmental assessment.

Prior to the environmental impact statement being prepared, a draft fishery management strategy must be prepared under the FM Act. The environmental impact statement assesses the likely impact of implementing the draft FMS on the biophysical, economic and social environments.

Once a management strategy and environmental impact statement has been prepared and subject to a determination by the Minister for Fisheries (under s.115O(4) of the EP&A Act), the requirement to undertake an environmental assessment for each individual fisher's licence issue or renewal does not apply.

f) The Commonwealth Environment Protection and Biodiversity Conservation Act

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) makes it an offence for a person to undertake an action that has the potential to significantly impact on a matter of 'national environmental significance' without first obtaining a permit from the Commonwealth Minister for Environment and Heritage. Matters of national environmental significance include: declared World Heritage areas; declared Ramsar wetlands; listed threatened species and ecological communities; listed migratory species; listed marine species; nuclear actions; and the environment of Commonwealth marine areas.

The EPBC Act was amended in January 2002 to incorporate the provisions of the Wildlife Protection Act (which was repealed at the same time). The new Part 13A of the EPBC Act has the effect of removing the previous blanket exemption from export control for marine species. As a result, the export of all marine organisms will come under the controls of the EPBC Act and be subject to ecological sustainability assessments based on guidelines established by the Commonwealth. To give time in which those assessments may be made, the exemption will continue until 1 December 2004. Until then, current arrangements regarding the export of marine species will remain in effect, that is, the export of most marine fish and the majority of marine invertebrates will continue to be exempt from export controls under the Act.

If a fishery is not assessed as exempt, it will more than likely be able to continue to supply product for export through an approved wildlife trade operation (section 303FN) under the EPBC Act. These declarations will have conditions attached that will bring the management and operations of the fishery in line with the Commonwealth guidelines. Once declarations are made, exporters will need to apply for and obtain a permit from the Department of Environment and Heritage (DEH) to export.

g) The NSW Marine Parks Act

The NSW Government is using a systematic approach to identify sites for marine protected areas and to prioritise new areas for marine biodiversity conservation in NSW waters. There are three types of marine protected areas in NSW - large multiple-use marine parks, small aquatic reserves and the marine and estuarine components of national parks and nature reserves.

Marine Parks aim to conserve biodiversity by protecting representative samples of the habitats in defined 'bioregions'. Zoning and operational plans are used to guide the protection of areas of high conservation value and manage activities that occur within the marine park. Four zones are used in marine parks - sanctuary zones, habitat protection zones, general use zones and special purpose zones.

Consultation occurs with the community prior to the declaration of marine parks. It is also important that the Ocean Trawl MACs participate in the consultation about the selection of marine protected areas, as declaration of such areas can be beneficial to all sectors of the community, including the commercial sector. However, such declarations can also impact on the operations of ocean trawl fishers.

The *Marine Parks Act 1997* was introduced to provide for the declaration of marine parks in NSW. The objects of the Act are:

(a) to conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks

(b) to maintain ecological processes in marine parks

(c) where consistent with the preceding objects:

(i) to provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks, and

(ii) to provide opportunities for public appreciation, understanding and enjoyment of marine parks.

This fishery management strategy has been prepared taking into account, and ensuring consistency with, the objects of the *Marine Parks Act 1997*.

Up to date information on the creation and zoning of marine parks in NSW waters is available on the Marine Parks Authority website: www.mpa.nsw.gov.au

h) Changes to Regulations

Most of the regulations that currently apply to trawling in NSW ocean waters appear in the *Fisheries Management (General) Regulation 2002* (FM Regulation). The FM Regulation sets out the working arrangements that underpin the provisions of the FM Act, and are made pursuant to that Act. For example, an offence appears in the Act for possessing prohibited size fish (section 16), however it is the FM (General) Regulation that prescribes the fish species subject to size limits and what those size limits are (clause 9).

This management strategy includes a number of actions that will impact on the regulations that currently apply to the fishery. Examples of these include restricting different sectors of the prawn trawl fishery to certain depth ranges and introducing new arrangements for targeting school whiting. Where it is necessary to introduce or change controls prior to the development and implementation of a share management plan for the fishery, changes to the FM (General) Regulation will be made.

i) Indigenous Fisheries Strategy

Fishing has been an integral part of the cultural and economic life of Aboriginal communities since they have been in this land. Fishing has been an important source of food, a basis for trade and an important part of cultural and ceremonial life. Traditionally, Aboriginal fishers had responsibility for providing not just for themselves but for family and community. These cultural expectations continue in Aboriginal communities today, particularly in regard to improved access to fisheries resources.

Although Aboriginal participation in the OTF is limited, Aboriginal people have aspirations of becoming more involved in commercial fisheries. Such aspirations were identified as recently as June 2003 during an Indigenous Fisheries Strategy Working Group workshop. The workshop identified fishing closures, licence transfer rules, market value of entitlements and the gradual decline of Aboriginal commercial fishers in the industry as constraints for Indigenous involvement in commercial fisheries.

In December 2002, the NSW Indigenous Fisheries Strategy and Implementation Plan (IFS) was released. The IFS seeks to protect and enhance the traditional cultural fishing activities of Aboriginal communities, and ensure Aboriginal involvement in the stewardship of fisheries resources. There are some issues that will be addressed immediately by the IFS and others that will only be resolved after lengthy negotiation involving Aboriginal communities, the broader community, fishing groups and government agencies. The IFS puts in place a process which will ensure discussion and negotiation can continue, with progressive resolution of problems and challenges (see NSW Indigenous Fisheries Strategy and Implementation Plan, 2002).

While the relationship between Indigenous fishing and the OTF is probably not as direct as with the inland, estuarine or beach-based fisheries, there are possible linkages with many of the species caught by the OTF which spend part of their life cycle in estuaries or nearshore waters. To better understand the linkages between this and other fishing activities to Indigenous issues, a substantial research study has been proposed through the IFS which seeks, among other things, to identify the species, areas and harvesting techniques of cultural importance to Aboriginal people in NSW.

3. Goals, Objectives and Management Responses

This section sets out the vision for the OTF as well as the goals, objectives and management responses for the OTF.

Fishery Vision

The vision for the OTF is:

A profitable OTF which provides the community with fresh local seafood and carries out fishing in an ecologically sustainable manner.

a) A model framework

Figure D1. A model of the framework for a fishery management strategy.

The link between the goals, objectives and management responses is not as simple as that portrayed in Figure 1. The reality is that management responses may assist in achieving more than one goal.

For example, a closure to trawling implemented primarily to protect sensitive habitats and conserve biodiversity may also reduce conflict between resource users, and can provide 'refuge' areas which reduce the impact of trawling on the target fish species or other species (e.g. threatened species). This outcome provides a range of benefits for the fishery over and above protecting habitat (see Figure D2).

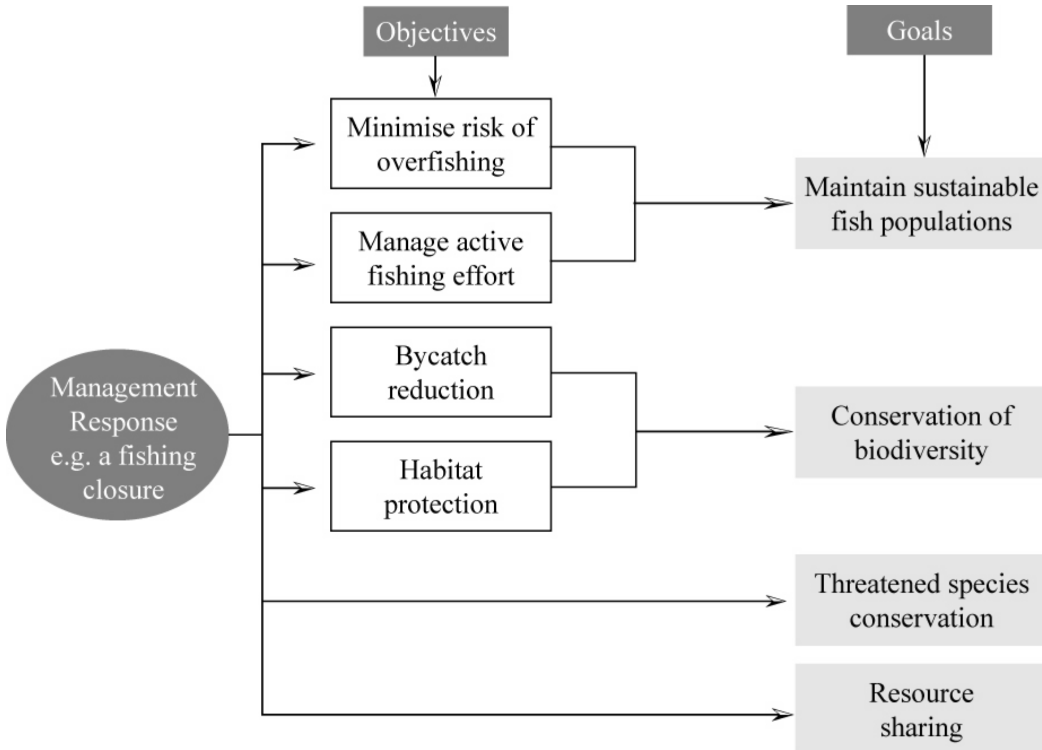

Figure D2 An example of how a single management response affects multiple goals and objectives.

This complex structure has been dealt with in the following section by listing each of the management responses once only, under the objective that the response contributes most towards achieving. Management responses with an asterisk (*) indicate new management actions that are to be implemented to address *inter alia* the outcomes of the risk assessment completed in Chapter B.

Information relating to the implementation of management responses is provided in a table located in Appendix D1. The implementation table outlines the time periods within which each management response is scheduled to be implemented, as well as information relating to the head of power for implementation and the group who has the lead responsibility for carrying out the actions.

The management responses listed in the following section relate to specific actions that directly contribute to meeting the goals and associated objectives defined for the OTF. The overall management regime for the OTF includes the management responses (below), the principles and guidelines contained within the harvest strategy (see section 4 of this chapter), as well as the general requirements of the FM Act and associated Regulations.

b) Goals, objectives and management responses

GOAL 1. Manage the Ocean Trawl Fishery in a manner that promotes the conservation of biological diversity in the marine environment

Objective 1.1 Mitigate the impact of trawling in NSW ocean waters on ecosystem integrity (species, populations, and ecological communities)

*1.1 (a) Define and map the extent of 'trawling grounds' and determine the intensity of trawling on each of these grounds

Background: Currently, the extent of trawl grounds off NSW and the frequency of trawling on each ground are not accurately recorded. New trawl grounds are sometimes 'opened up' by industry and there are presently no controls on this expansion of trawling, with the exception of areas protected within Marine Parks or other fishing closures. The impact of trawling on biodiversity has not been quantified in NSW, however international literature indicates that significant impacts are likely and therefore a cautious approach should be adopted. All fish trawl, prawn trawl and whiting trawl grounds will be accurately mapped and the intensity of trawling on each ground will be quantified to allow an assessment of the impact of trawling on each ground.

*1.1 (b) Implement a series of closures to trawling to protect the range of ocean habitats and associated biodiversity, including closure of all reefs and depths greater than 1100 metres

Background: In the absence of detailed information on the location and extent of the various marine habitat types in NSW ocean waters, the most effective way of addressing concerns about the impacts of trawling on biodiversity is to provide for a series of trawl closures which take in the range of habitat types. Such closures should be regarded as precautionary measures while more detailed information on habitats is assembled, and pending the establishment of the full range of Marine Parks in NSW coastal waters. Marine Parks under NSW jurisdiction only extend 3 nautical miles to sea from the coastline, and it would be consistent with the objectives of this goal to establish trawl closures in waters outside 3 nm to conserve biological diversity on a range of habitats.

It is the intention of this strategy to restrict trawling to areas of soft substrate (eg. sand or mud) where the effects of trawling on the habitat are less significant than on harder substrates and where the target species predominantly occur. Reef areas (where the seabed is comprised of hard rock) are in practice infrequently trawled, are areas of high biological diversity and provide refuge areas for finfish species. Such habitats take a long time to recover from the effects of trawling, and it is important for the maintenance of ecosystem health that such areas be protected from trawling (or allowed to recover if they have been previously trawled).

The closure of reef areas to trawling will also assist in resolving many of the social conflicts that can occur between the OTF and the Ocean Trap and Line Fishery, Lobster Fishery and the recreational fishery.

Under this management response, 75 percent of all State waters located south of Barrenjoey Point will be closed to all trawling. Industry representatives and NSW Fisheries will work together to identify and map those areas, and the reef (i.e. hard rock) areas in waters north of Barrenjoey Point.

Note: management response 6.3c outlines a process for working with industry to rationalise the 'package' of closures applying to the OTF, taking into account the environmental outcomes sought and the impacts on commercial fishing at a regional level.

1.1 (c) Continue the prohibition on using fish trawl nets north of Smoky Cape, and implement additional Bycatch Reduction Device requirements for prawn trawl nets south of Smoky Cape (to minimise the incidental catch of fish in prawn trawl nets used in this area)

Background: The use of fish trawl nets is prohibited north of Smoky Cape (South West Rocks) in recognition that trawling in this area is primarily targeted at prawns. However, finfish of species that are subject to a minimum length, but are greater than this length, may be retained when taken in a prawn trawl net north of Smoky Cape.

Currently it is prohibited to take fish that are subject to a 'minimum legal length' using prawn trawl nets in waters south of Smoky Cape and such fish if taken must be returned to the water (with unknown chance of survival). The requirements to be introduced south of Smoky Cape will encourage the use of effective Bycatch Reduction Devices to minimise the incidental catch of finfish in prawn nets. Once it can be demonstrated that effective BRDs are being used in the fishery, the current prohibition on the retention of fish with a minimum legal length may cease in order to avoid wastage (see also management response 2.1i. The package may also include a limit on the carriage of a single net type – prawn or fish trawl – aboard the vessel.

1.1 (d) Promote research and collaborate with research institutions to improve our understanding of ecosystem functioning and how it is affected by trawling

Background: There is a general lack of knowledge about the way in which biodiversity in marine ecosystems is affected by fishing and how to measure those effects. This is especially true for diverse and complex systems like the environment in which the NSW OTF operates. A better knowledge of how these ecosystems function is needed to understand the effects of trawling upon these systems, although this is inevitably a long term aim. NSW Fisheries has recently commenced a collaborative research program on 'Ecologically Based Fishery Management' with the University of British Columbia. The results of this study, and other studies currently being undertaken on the effects of trawling in other Australian fisheries, will be discussed with the Ocean Trawl MAC, with a view to identifying additional research that may need to be undertaken to better evaluate the impacts of trawling in NSW ocean waters.

Objective 1.2 Mitigate the impact of the Ocean Trawl Fishery on non-retained species

*1.2 (a) Design and implement an industry funded scientific observer program to document the degree of interaction of commercial designated fisheries, including the Ocean Trawl Fishery, with non-retained and threatened species and to collect information on the use and effectiveness of Bycatch Reduction Devices

Background: Onboard observer studies were carried out in both prawn trawl and fish trawl sectors of the fishery in the late 1980s and early 1990s, however fishing practices and gear have changed significantly since these studies (e.g. by the introduction of mandatory Bycatch Reduction Devices in ocean prawn trawl nets). Also, significant changes in the areas in which different fishing gears may be used are proposed in this strategy, which will necessitate an updated assessment of the incidental catches taken with each type of trawl gear. Previous studies have demonstrated that the most cost-effective way of obtaining rigorous estimates of incidental catches of a fishery is through a properly designed onboard observer study. The part of the observer study relevant to the OTF will be designed in consultation with the Ocean

Trawl MAC. The observer program should also include observations on the use and effectiveness of Bycatch Reduction Devices, gear selectivity for retained species (e.g. silver trevally) and any interactions with threatened or protected species.

1.2(b) Refine and improve methods for reducing incidental catches, including the introduction of more effective Bycatch Reduction Devices for prawn trawl nets, and phase out the use of the 'square-mesh panel' Bycatch Reduction Device

Background: The National Policy on Fisheries Bycatch provides a national framework for coordinating efforts to reduce bycatch. It provides options by which each jurisdiction can manage bycatch according to its situation in a nationally coherent and consistent manner.

One of the eight approved Bycatch Reduction Devices (BRDs) for the NSW ocean prawn trawl fishery, the square mesh panel, is a less effective version of the composite square mesh panel developed by NSW Fisheries during the early 1990's for the NSW ocean prawn trawl fleet. When BRDs became mandatory in June 1999 the square mesh panel was introduced instead of the composite panel to minimise the impact that mandatory use of BRDs would have on catches of school whiting. This strategy proposes the development of alternative management arrangements and trawl gear for fishers who wish to target school whiting, allowing the less efficient square mesh panel to be removed from use in ocean prawn trawl nets. As part of the observer program planned for the fishery, data will be collected on the levels of use of the approved BRDs and the resulting reductions in bycatch. Analysis of the effectiveness of each of the BRDs approved for use in commercial trawling operations will be discussed with the Ocean Trawl MAC, with the longer term aim of ensuring that the most efficient BRDs are implemented in prawn trawl nets in the NSW OTF.

1.2 (c) Investigate alternative handling practices to improve survival of incidental species that are to be returned to the water, and in particular:

i) prohibit the at-sea finning of sharks and discarding carcasses

ii)* ban the "riddling" of prawns

iii)* restrict the use of "spikes" to those times when other handling methods would present an unacceptable occupational health or safety risk

Background: In addition to modifying fishing gear and managing the spatial and temporal distribution of fishing in order to minimise incidental catch, various techniques have been developed in recent years to maximise the survival rate of incidental catch that is returned to the water (i.e. discards). These techniques and alternative handling practices will be investigated and implemented where appropriate to further minimise the impact of trawling on biodiversity. The finning of sharks and the discarding of carcasses is prohibited because it is a wasteful practice, and this prohibition will continue.

Fishers sometimes use a device known as a riddler to grade the sizes of prawns. In response to industry concerns about the practice of riddling, the discarding of cooked prawns was prohibited in January 2003 because it is a wasteful practice. Riddlers are not often used in the ocean prawn trawl fishery and with regard to the improvements in gear selectivity in this strategy, riddlers will be prohibited in the OTF upon commencement of the management strategy.

Fishers often use a "spike" to sort and remove catch from the sorting table or deck of the boat. A spike generally consists of a piece of timber with a nail through it and is used by piercing incidental catch and flicking it overboard. Under the management strategy the use of spikes on *fish to be discarded will be restricted to only those species that can harm skippers or crew and for which no alternative handling technique is available (the list of harmful species will be developed in consultation with the OT MAC).*

*1.2 (d) Develop a Code of Conduct for ocean trawl fishers to:

i) encourage the effective use of Bycatch Reduction Devices and avoid fishing in areas and/or at times when juvenile or small fish are abundant

ii) promote best practice handling of bycatch and achieve a premium quality product for the retained catch

iii) minimise the accidental capture of marine mammals and any threatened or protected species (and advise of the appropriate way in which to deal with any such interactions);

iv) minimise the levels of pollutants associated with the fishing operation, including exhaust, noise and fuels and oils in bilge water

v) assist in reducing the amount of marine debris by retaining for disposal onshore any rubbish recovered during fishing operations and unwanted fishing gear (eg. off-cuts), and

vi) respect the rights and recognise the needs of people operating in other fisheries or undertaking other ocean based boating activities.

Background: Codes of Conduct will be developed under the management strategies for all designated commercial fisheries, and will contain voluntary measures to encourage appropriate behaviour to complement other regulatory controls in each fishery. Fish trawl operators who are also endorsed to operate in the Commonwealth-managed SETF abide by an "Industry Code of Conduct for Responsible Fishing in the South East Trawl Fishery" and a "Code of Fishing Practice to Minimise Incidental By-Catch of Marine Mammals in the South East Trawl Fishery", developed by SETFIA (South East Trawl Fishing Industry Association). Such codes of conduct provide a guide to fishers concerning socially and environmentally acceptable behaviour, and are especially useful for encouraging such behaviour in cases where ensuring compliance with regulations may be extremely difficult or overly expensive. A code of conduct for trawling in ocean waters off NSW will be developed in consultation with the Ocean Trawl MAC.

*1.2 (e) Identify areas and/or times of problem incidental catch to target catch ratios and restrict trawling appropriately. In particular, implement closures to trawling around river entrances during times of high river discharge in accordance with the program described in Appendix D2

Background: Incidental catches of juvenile fish and prawns and estuarine fish species are generally greater when trawling around river entrances during times of high river discharge (i.e. during and after flood conditions). This strategy incorporates the introduction of pre-defined closures around river entrances during times of high river discharge. The closures would be triggered using river discharge information provided by the Bureau of Meteorology or if trial shots show that incidental catch is unusually high. The program will be implemented upon commencement of the management strategy for the fishery and is subject to further review by the Ocean Trawl MAC.

Objective 1.3 Mitigate the impact of the Ocean Trawl Fishery on ocean habitats and their associated biota

1.3 (a) Require the use of trawl gear designs that minimise impacts on habitats and associated biota, and in particular:

i) prohibit the use of bobbins on the ground ropes of fish trawl nets north of Seal Rocks

ii) pending the closure of reef areas, limit the maximum size for bobbins used on fish trawl nets south of Seal Rocks 100 mm diameter

iii) restrict trawl nets to a single ground chain of no greater than 12mm gauge*

iv) make "droppers" such as the 'Texas' drop mandatory for ocean prawn trawl nets*.

Background: 'Bobbin' gear refers to rollers or round bobbins placed on the ground rope of trawl nets to facilitate fishing on more uneven bottoms than could be fished with nets rigged with chains or wire rope alone. Restrictions on bobbin gear were first introduced during 2001. Bobbin gear is prohibited in waters north of Seal Rocks and bobbins of up to 100 mm (4 inches) may be used south of Seal Rocks. The reason for permitting 100 mm bobbins is for the protection of ground gear when trawling over harder bottom, while preventing the fitting of large bobbins that would allow trawlers to fish very rough bottom. The continued use of bobbin gear in the fishery will be reviewed following the introduction of trawl closures under management response 1.1b.

Heavy ground gear and chain can increase the impacts of trawl gear on benthic habitats. To minimise this impact, the gauge of ground chain is to be restricted. In Queensland only one ground chain of no greater than 10 mm is permitted in the inshore fishery and in the offshore fishery the gauge of chain is restricted to 12 mm.

"Droppers" provide a gap (10 to 20 cm) between the foot rope of the net and the ground line, enabling bottom dwelling fish species such as flathead and flounder to escape beneath the net, whereas the target species (prawns) jump up in the water column and are captured in the net.

Objective 1.4 Prevent the introduction and translocation of marine pests and diseases by fishing activities

1.4 (a) Implement, in consultation with the relevant MACs, measures required in accordance with any marine pest or disease management plans

Background: The Minister for Fisheries or other authorities may alter management arrangements from time to time to minimise or mitigate the impact of marine pests and diseases. Recent examples of outbreaks were the suspected incidence of white spot disease in NSW prawns and the mass mortality of pilchards across southern Australia. At times it will be a requirement for the commercial fishing industry to respond to such outbreaks by modifying fishing practices. Proposed measures will be discussed with the Ocean Trawl MAC prior to implementation.

GOAL 2. Maintain stocks of primary and key secondary species harvested by the Ocean Trawl Fishery at sustainable levels

Objective 2.1 Prevent overfishing of the stocks of primary and key secondary species by ocean trawl fishers

*2.1 (a) Monitor the quantity, length and/or age and sex composition of the primary and key secondary species taken by commercial designated fishing activities, including the Ocean Trawl Fishery, as part of the overall stock assessment system

Background: In addition to the collection of information about activities in the fishery, it is necessary to collect relevant information about the composition of the catch of the important species exploited by the fishery. During the development of this strategy a total of 28 species and species groups were identified as primary or key secondary species for ocean trawling in NSW. For many of these species there is currently little or no information available about the size or age composition of the exploited population, and for some groups (e.g. octopus and cuttlefish) there is little information about which species comprise the bulk of landed catches. A catch monitoring program will be established as part of the management strategy, to provide sufficient information to support an assessment of the status of the stocks of the primary and key secondary species taken in the fishery.

*2.1 (b) Develop a system for and conduct stock assessments for each of the primary and key secondary species taken by commercial designated fishing activities, including the Ocean Trawl Fishery, and review the assessments at least every three years thereafter

Background: The quantity of information available to assess fish stocks varies for each primary species, ranging from having completed major projects to having little information to include in an assessment beyond catch and effort information. For many primary species, stock assessments will allow a change from landings-based monitoring to the use of biologically based reference points for monitoring stock status and fishery performance, and will provide for more accurate determination of sustainable harvest levels for those species. For the key secondary species the short term aim will be to gather and analyse information which will enable an initial assessment of the status of the stock to be completed (often for the first time). More details about the methods to be used to develop and undertake these stock assessments can be found in Scandol (2003b)

It is important to note that stock assessments are done on a species basis and are therefore reliant on harvest estimates from all sectors and adjacent jurisdictions. Furthermore, the scope and reliability of the assessments will vary for each species depending on its life history, biological characteristics and availability of research and monitoring information. In the short term, an important part of the process for reviewing the status of each species in will include reviewing the trigger catch levels for each species (see management response 2.1c and Appendix D6). The results of stock assessments will be fed into decision making processes about sustainable levels of catch and/or effort, for example, for priority species including eastern king prawns and school prawns (see also management strategies for the Estuary General and Estuary Prawn Trawl fisheries).

A periodic review of stock assessments is important for ensuring ongoing improvement in the assessments and the programs providing information for them.

*2.1 (c) Monitor the annual landings of primary and key secondary species, for comparison against "reference" levels set out in Appendix D6 as part of the overall stock assessment system

Background: As a cautionary measure, annual landings of primary and key secondary species will be monitored to detect unusual trends in catches. Both increases and declines in catches will be assessed in relation to pre-determined 'trigger catch' levels set with regard to historical annual landings by the OTF. Primary and key secondary species will be monitored at the individual species (or species group) level. The results from this monitoring will also be used in the determination of a species status as part of the overall stock assessment system.

*2.1 (d) Monitor the commercial landings of all secondary species (other than the key secondary species) taken in the fishery annually for comparison against an historical range for each of those species or groups of species, as part of the overall stock assessment system

Background: It is important that available resources for stock assessment are directed towards assessing the primary and key secondary species (note that stock assessments will be undertaken for some species that are considered 'secondary' in the OTF because they are 'primary' species in another designated fishery).

The catch of secondary species (other than the key secondary species) will be monitored to determine if it is outside the range of catches (i.e. lowest and highest annual catches) within the period 1984/85 to 2001/02. This ensures species that are less widespread in the fishery will still be monitored at a broad scale. This monitoring will aim to detect unprecedented changes in landings of the species taken in very small quantities by the OTF. Given the number of species involved, the 'other secondary' species may be monitored in groups as appropriate.

*2.1 (e) Ensure that the selectivity of the gear used in the fishery (apart from gear used in designated whiting areas – see provisions in Appendices D3 and D5) is appropriate in relation to the biology of the species being targeted. In particular:

i) restrict prawn trawl net cod-ends to a maximum of 150 meshes round (hanging ratio of 1:1), constructed with single twine of maximum 4 mm diameter, and with mesh size between 40 and 50 mm

ii) restrict fish trawl net cod-ends to a maximum of 100 meshes round (hanging ratio of 1:1), constructed with single twine of maximum 6 mm diameter and with a mesh size of at least 90 mm

iii) review and modify the restrictions applying to prawn trawl and fish trawl nets on the basis of research results on the selectivity of trawl nets, including assessment of mesh size and shape

Background: The restrictions (eg. size of mesh) applying to fish and prawn trawl nets were introduced on the basis of research conducted many years ago, and the nets currently used in most sectors of the fishery may not provide the optimum selectivity for species targeted by that sector. A recently completed research project in the Commonwealth South East Fishery demonstrated that fish trawl gear in use in the fishery at that time (2001/02) had 50% selection lengths for some of the important species which were much smaller than the optimum sizes for these species (e.g. 50% selection of tiger flathead at 23 cm, redfish at 14cm, ocean perch at 18cm and ling at 43 cm). As a result of this work, SEF trawl fishers are being encouraged to use cod-ends with larger mesh sizes or with square mesh when targeting some species.

Numerous studies have demonstrated that the 40 mm mesh used in conventional prawn trawl cod-ends (with circumferences of 100 to 200 meshes) is inappropriate for selecting the target prawn species at the optimum sizes.

NSW Fisheries is currently undertaking several research projects on the selectivity of prawn and fish trawl nets and alternative designs (eg. square mesh cod-end) to enhance selectivity. The results of these projects will be discussed with the Ocean Trawl MAC, with a view to implementing more selective trawl nets for use in both the fish and prawn trawl sectors. The intent of this management response is to encourage an improvement in the selectivity of trawl nets used in the fishery in the short term, until the results of current or future research are considered and net configurations with better selectivity for the target species are formulated. If net configurations with better selectivity are available in the short term, these will be implemented instead of the requirements in i) and ii).

Appendices D3 and D5 also outline a research program that will be conducted over the next three years to design and implement single and triple rig trawl nets to target school whiting with minimal bycatch.

*2.1 (f) Maintain and enhance the effectiveness of the "juvenile king prawn" closures, and in particular:

i) modify the juvenile king prawn closure off South West Rocks to minimise the harvesting of juvenile king prawns between the beach and the inshore boundary of the closure, and investigate the potential for similar changes to other juvenile king prawn closures.

ii) make all juvenile king prawn closures year-round closures, except in areas and at times when, following authorised trial shots, the Director-General, NSW Fisheries, determines that sufficient quantities of school prawns are present, the size of the school prawns exceeds that which produces a count of 100 prawns per half-kilogram and bycatch levels are acceptably low, and

iii) investigate the need to extend juvenile prawn closures to be adjacent to the mouths of all major estuaries along the NSW coast, taking account of the aim of harvesting prawns at a size greater than that which produces a count of 50 king prawns or 100 school prawns per half-kilogram.

Background: The Ocean Prawn Trawl Fishery has progressively introduced spatial and temporal closures since 1982 to protect small or juvenile prawns, for example most recently off Crowdy Head. There are now nine "juvenile king prawn" closures off the NSW coastline (three of which are year-round closures), and some additional closures proposed by industry are still under consideration.

Whilst an adjustment to juvenile king prawn closures will be made to apply year-round, the management strategy takes account of the need to trawl those areas occasionally to harvest school prawns by permitting trawling in those areas provided certain opening criteria are met (see point (iii) in the response). The opening criteria will ensure that trawlers do not operate in those areas at times when the prawns are below optimum size or when bycatch is abundant. The threshold bycatch levels that will apply will be set in consultation with the Ocean Trawl MAC. These factors will be reviewed and updated in light of any future gear selectivity changes.

This strategy will also investigate the need for an expansion of the juvenile king prawn closures and be guided by the objective of harvesting prawns above the minimum sizes specified. The *prawn counts will also be used to guide the definition of any other closures applicable to the fishery and will be reviewed by July 2007 when the results of a three-year research project on the growth and mortality of school prawns become available. See also management response 6.3c for information about the process of rationalising the 'package' of closures that apply to the OTF.*

*2.1 (g) Develop strategies to establish 'refuge' areas and spawning closures for species targeted by trawling

Background: Indications from recent research are that the establishment of 'refuge' areas (where the effects of fishing are minimised or removed completely) can contribute significantly to the sustainable operation of commercial fisheries. There is considerable potential to better manage the spatial and temporal distribution of trawling in ocean waters to promote a sustainable trawl fishery, protect habitats and to mitigate conflicts with other stakeholders. In conjunction with the definition and mapping of trawl grounds, the Ocean Trawl MAC will discuss strategies for defining and establishing 'refuge' areas for the important species taken in the fishery. These closures will be established to protect any vulnerable life history stages of fish and prawns (and their associated habitats) from the effects of trawling.

Taking into account the outcomes from management response 1.1b, and relevant research information on the species caught, marine ecosystems, interactions with other fishing sectors, and the economic implications for commercial ocean trawl fishers, a mechanism and criteria will be developed for listing areas that are open or closed to trawling on a temporary or indefinite basis. The lists will be reviewed and updated every five years, in order to provide improved resource security for fishers and an orderly process for implementing any necessary management changes. See also management response 6.3c for information about the process of rationalising the 'package' of closures that apply to the OTF.

Note: management response 6.3c outlines a process for working with industry to rationalise the 'package' of closures applying to the OTF, taking into account the environmental outcomes sought and the impacts on commercial fishing at a regional level.

*2.1 (h) Investigate the cost effectiveness of using fishery independent surveys to provide abundance indices and other information for stock assessment of the primary species taken in the Ocean Trawl Fishery

Background: One of the key pieces of information needed to develop quantitative stock assessments is a time series of relative abundance estimates. Due to changes in fishing practices and varying catchability of different fishing gears, this can be difficult to obtain from commercial landings data. Fishery independent surveys can be designed to reduce biases due to the above factors, however such studies are expensive to implement and need long-term commitment to funding. In the OTF it is likely that fishery independent surveys may only be appropriate for a small number of primary species (e.g. eastern king prawn assessments may benefit from fishery independent surveys, however the usefulness of such surveys for school prawn and royal red prawn assessments may be limited). It is important to assess the potential usefulness of such studies for the stock assessment of ocean trawl species, and whether the fishery independent surveys being conducted in estuaries will be likely to provide sufficient information for some species in the OTF.

*2.1 (i) Review the efficacy of minimum size limits for fish species taken in the Ocean Trawl Fishery, including the need for minimum legal sizes to be implemented for additional species, and the regulations pertaining to fish with a minimum legal length that are captured in prawn trawl nets south of Smoky Cape

Background: Legal minimum lengths are used to prevent the retention of small and immature fish and some crustaceans. This assists to conserve stocks and promote recruitment to the spawning population so that the risks of recruitment overfishing are minimised. Size limits already apply to many species of fish taken in the OTF, and need to be responsive to new scientific information. There are a number of primary and key secondary species in the fishery that are not currently subject to a minimum legal size (e.g. fiddler shark, angel shark). The efficacy of minimum size limits should be reviewed following the implementation of effective Bycatch Reduction Devices in prawn trawl nets and addressing selectivity issues in fish trawl nets, in consultation with the Ocean Trawl MAC. Additionally, the prohibition on landing any species with a minimum legal length from prawn trawl catches south of Smoky Cape will be reviewed in conjunction with the implementation of more effective Bycatch Reduction Devices for prawn trawl nets, to ensure the optimum utilisation of the resources.

*2.1 (j) Utilise onboard observers to collect additional biological information, including size at maturity and fecundity/brood size data, for the important elasmobranch species taken by the fishery

Background: A public consultation draft of an Australian National Plan of Action for the Conservation and Management of Sharks was released in July 2002. This document sets out the need for concerted national action to reduce the risks of commercial and recreational fishing to the variety of shark species found in Australian waters. Two of the primary recommendations found in the plan involve improving the identification of captured sharks, thereby increasing the accuracy of reported catch data, and undertaking targeted research on shark species. Elasmobranchs are also an important traditional target species for Indigenous fishers.

In addition to the size and sex composition data collected for primary and secondary species under management response 2.1a it is necessary that data be obtained on the important biological characteristics governing maturation and fecundity for those elasmobranch species which are significant in trawl catches. The generally slow growth rates and low reproductive rates of elasmobranchs make them particularly susceptible to overfishing. The paucity of relevant biological data for the main species taken in the trawl fishery needs to be addressed in order to determine if any of these species require more targeted management actions to prevent overfishing of the stocks. This work is best done by onboard observers as shark species are generally cleaned aboard the catching vessel prior to landing.

Objective 2.2 Promote the recovery of overfished species

*2.2 (a) Where the Ocean Trawl Fishery is a major harvester of a species determined as overfished in NSW (recruitment overfished or growth overfished) develop and implement a recovery program for that species as detailed in the harvest strategy, and in particular:

i) develop and implement a reco

ii) very program for silver trevally (growth overfished)

ii) determine if a recovery program is required for any other species identified as 'high risk' in the environmental assessment conducted in conjunction with the development of this strategy or subsequent research, and implement necessary actions.

Background: There are two recognised types of overfishing, recruitment overfishing and growth overfishing. Recruitment overfishing occurs where insufficient spawning stock remains *to ensure adequate recruitment of young fish into the stock. Recruitment overfishing requires urgent attention, usually in the form of fishery closures to allow the mature population to rebuild. Growth overfishing occurs when fish are harvested at a size much smaller than the optimum size for maximising biological and economic returns. Addressing this problem generally requires an adjustment of the selectivity of the fishing gear used to take that species, and the setting or adjustment of a minimum legal length for the species. It should be noted that development of a recovery program is not required for all species determined as growth overfished, providing certain circumstances apply – refer section 4(vi) of the harvest strategy for details.*

As the OTF is a major harvester of silver trevally in NSW, the recovery program for silver trevally will be developed as part of the OTF Management Strategy, and will specify:

- a minimum legal length for silver trevally of 30 cm (total length)
- a minimum cod-end mesh size of 90 mm and other requirements for fish trawl nets as specified in management response 2.1e.

Data from the onboard observer program will be used to assess the effectiveness of the recovery program in preventing the capture and marketing of large numbers of small trevally, including the recording of any discarding of trevally smaller than the new minimum legal length. Over time, information from associated research and the observer program will be used to determine if a more appropriate cod-end mesh size needs to be implemented when fishers are targeting silver trevally.

*2.2 (b) Where the fishery is a minor harvester of an overfished species, contribute to the development of any recovery programs for that species, and adopt any measures required by a recovery program, in particular:

i) determine if additional measures are needed to improve the selectivity of fish trawl nets for redfish (considering the cod-end regulations to be introduced as part of the recovery program for silver trevally)

ii) implement the provisions of the recovery program for gemfish to be developed under the Ocean Trap and Line Fishery Management Strategy.

Background: The stock assessments available for redfish taken in the Commonwealth SEF indicate the stock is growth overfished. Redfish are a slow growing, long lived (>30 years) species. The cod-end regulations to be introduced as part of this management strategy should assist in addressing the growth overfished status of redfish, as far as trawlers operating in the NSW OTF are concerned. The impact of these changes will be assessed as part of research and monitoring associated with the silver trevally recovery program, and any additional measures that may be necessary will be discussed with the Ocean Trawl MAC.

Arrangements are already in place to assist the recovery of gemfish (in NSW a 'trip limit' of 50 kg applies to all commercial methods). These will be reviewed and a recovery program for eastern gemfish will be developed under the Ocean Trap and Line Fishery Management Strategy. Ocean trawl fishers will need to contribute to and comply with provisions contained in that recovery program.

GOAL 3. Promote the conservation of threatened species, populations and ecological communities likely to be impacted by the operation of the Ocean Trawl Fishery

Objective 3.1 Identify and minimise or eliminate any impacts of fishing activities on threatened species, populations, ecological communities and habitats (including mammals, birds, reptiles, finfish, shellfish and other invertebrates, and vegetation) and promote their recovery

*3.1 (a) Modify, in consultation with the Ocean Trawl MAC, the mandatory reporting arrangements to enable collection of information on interactions with or sightings of threatened or protected marine species, and gear interactions with other threatened or protected species

Background: The guidelines for 'ecologically sustainable' fisheries approved by the Commonwealth under the Environment Protection and Biodiversity Conservation Act 1999 include a requirement to collect information on interactions with endangered, threatened or protected species and threatened ecological communities. These species, populations and communities are listed in the FM Act, Threatened Species Conservation Act 1995 and the EPBC Act. Information on interactions with threatened species will come from the modified reporting arrangements, observer studies and any other verifiable interactions with threatened or protected species.

It is important that fishers are able to distinguish threatened and protected species from similar species in order to correctly identify and where possible avoid interactions with them. An example of this type of information is the grey nurse shark identification material. For this purpose, information will be disseminated to endorsement holders to assist them in identifying and avoiding protected and threatened species.

3.1 (b) Implement, in consultation with the Ocean Trawl MAC, the provisions of any relevant threatened species recovery plan or threat abatement plan, including the protection of identified 'critical habitat' areas

Background: Once a species, population or ecological community has been listed as threatened, a recovery plan must be developed. These plans are designed to return the species, population or ecological community to a point where its survival in nature is assured. The recovery plans referred to in this response could include those being developed under the Fisheries Management Act 1994, the Threatened Species Conservation Act 1995 or other State or Commonwealth legislation.

Additionally, threatened species legislation requires the development of a threat abatement plan for any listed key threatening processes. A threat abatement plan outlines actions to eliminate or manage the key threatening process, and identifies the authorities responsible for carrying out those actions. Such plans may include the protection from fishing of areas or habitats designated as critical for the survival of threatened species.

This response recognises that the statutory provisions of a threatened species recovery plan or threat abatement plan must be implemented and given precedence over the provisions of this management strategy.

*3.1 (c) Using the code of conduct, promote the use of fishing techniques that avoid the capture of or interaction with protected fish and fish protected from commercial fishing

Background: 'Protected fish' refers to species of fish that are protected from all forms of fishing. 'Fish protected from commercial fishing' as the name suggests, refers to species of fish that are protected from commercial fishing only. Protected fish includes species identified as threatened, endangered or vulnerable under the FM Act. A range of measures could be included in the code of conduct that will minimise interactions with or impacts on protected fish and fish protected from commercial fishing such as the times and areas worked, the length of trawl shots, and promoting best practice handling techniques. It is already unlawful for any person to retain a protected species and as such the focus of this response is to encourage fishers to avoid interactions with species that have 'protected' status.

*3.1 (d) Determine, through the on-board observer program, the level of interaction between the fishery and marine turtles and seals (protected under the *Threatened Species Conservation Act 1995*) and assess the need to introduce Turtle or Seal Excluder Devices, or other measures to minimise impacts on these species

Background: The NSW ocean prawn trawl fishery interacts with various species of turtle, particularly in waters north of South West Rocks. The level of interaction is thought to be low, however it is not monitored or accurately recorded. Many fishers are aware of how to revive and release turtles that have been taken in nets. Turtle Exclusion Devices are mandatory in the Queensland East Coast Trawl Fishery, but not in NSW.

Fish trawlers in the Commonwealth SEF have documented interactions with seals, and depending on the outcomes of negotiations about jurisdiction for the fish trawl fishery south of Barrenjoey Point, it may be appropriate to also consider seal interactions and exclusion devices under this response.

The Ocean Trawl MAC will consider the outcomes of relevant data and risk assessments to determine the need for implementation of TEDs and SEDs in defined sectors of the OTF.

GOAL 4. Appropriately share the resource and carry out fishing in a manner that minimises negative social impacts

Objective 4.1 Provide for appropriate access to the fisheries resource by other stakeholders (eg. recreational, Indigenous), acknowledging the need of seafood consumers to access quality shellfish and finfish

*4.1 (a) Estimate the total catch of 'primary' and 'key secondary' species in the Ocean Trawl Fishery, taking account of the recorded commercial catch and estimates of recreational, Indigenous and illegal catch

Background: Estimates of harvest rates from all sectors are vital for stock assessments and to ensure access to resources is appropriately shared. Information on the recreational and Indigenous catch will be drawn from the results of the National Recreational and Indigenous Fishing Survey, related studies to be undertaken in NSW and information obtained from other sources such as charter boat logbooks. (note: some Indigenous communities have expressed concern over the research methods used in the survey for collecting information on Indigenous catches). Information on illegal catches will come mainly from the results of compliance actions and associated intelligence.

Objective 4.2 Provide for fair and equitable sharing of the fisheries resources with other commercial fisheries (NSW, interstate and Commonwealth)

*4.2 (a) Monitor management arrangements and the annual landings of key ocean trawl species in fisheries that are outside NSW jurisdiction but which impact on stocks shared with the NSW Ocean Trawl Fishery, as part of the stock assessment system

Background: Many of the primary and key secondary species in the OTF are also significant in landings of fisheries under other jurisdictions. Increased targeting or harvesting of particular species can have implications for sustainability and sharing of access to that stock. Monitoring changes in harvest levels by other fisheries can allow implications arising from increased targeting or landing to be detected early and appropriate action to be taken.

*4.2 (b) Monitor the annual landings of all secondary species within each sector of the Ocean Trawl Fishery, as part of the stock assessment system

Background: A large number of species are taken incidentally in the OTF, and while quantities landed are small this response, in conjunction with the trigger points in Appendix D6, seeks to identify and limit any unusual increases in landings of secondary species. Some of these species are significant in landings of other commercial or recreational fisheries.

4.2 (c) Use cross-fishery and cross-jurisdictional consultation to discuss and then manage issues relating to, but not limited to, the multiple use of specific fishing grounds, collaborative research, fair and equitable access to stocks, complementary management arrangements and other interactions between fishing sectors

Background: There have been recent examples of interactions between the trawl fishery and the lobster and trap and line fisheries where cross-fishery consultation provided a useful mechanism to resolve conflicts. There will be times when direct consultation between fishers *within NSW and/or with other jurisdictions (such as Queensland and the Commonwealth) is required. Cross-fishery and cross jurisdictional consultation and the management tools in this strategy will be used to provide for fair and equitable access to fisheries resources.*

The existing Management Advisory Committee (MAC) and Advisory Council processes are typically used for cross-fishery consultation however the Minister may at times establish working groups to address specific cross-fishery issues. An example of this is the Juvenile Prawn Summit Working Group that was formed during 2000 to provide advice on harvesting the State's prawn stocks.

Objective 4.3 Provide for the fair and equitable sharing of the fisheries resource within the Ocean Trawl Fishery

*4.3 (a) Limit operations of 'offshore' prawn trawlers to depths less than 150 fathoms (275 m), and limit operations of 'deepwater' prawn trawlers to depths between 200 and 600 fathoms (365 to 1100 m), and close depths between 150-200 fathoms to prawn trawling

Background: Offshore prawn trawling and deepwater prawn trawling both take place in waters outside 3 nautical miles. Offshore prawn trawlers generally target king prawns out to the edge of the continental shelf (approximately 230 metres or 125 fathoms), whereas deepwater prawn trawlers take species of deepwater prawns at depths in excess of 310 metres (approximately 170 fathoms). Under this response prawn trawlers in each sector will be limited to operating in the depth ranges specified (to be defined by GPS co-ordinates), and trawling will be avoided in other depths. In addition to sharing the resource within the fishery, this response will provide a reasonable area of deepwater habitat that is protected from the impact of trawling.

*4.3 (b) Respond to information about significant changes in relative catches of the primary and key secondary species taken in each of the major sectors of the Ocean Trawl Fishery

Background: To ensure fair and equitable access to and sharing of the resource amongst fishers in the OTF, the catch by species within the main sectors of the fishery (fish trawl, prawn trawl and deepwater prawn trawl) will be monitored as part of the stock assessment system. Should variations in relative catches exceed pre-determined levels (see Appendix D4) the possible reasons for such variations will be discussed with the MAC, and if due to increased targeting then measures will be implemented as required to manage the issue, possibly returning catches to their previous levels.

4.3 (c) Manage the multiple use of trawl grounds within the Ocean Trawl Fishery and minimise adverse interactions

Background: Similar to interactions between trawlers and other sectors of the industry, there are sometimes adverse interactions between trawler operators. For example there have been interactions between trawlers targeting whiting during the day and those targeting prawns on the same or nearby grounds the following night. Information on the frequency of trawling on particular grounds will be discussed with the MAC and measures implemented as required to minimise adverse interactions.

Objective 4.4 Identify and mitigate any negative impacts of the Ocean Trawl Fishery on Aboriginal, cultural or other heritage

*4.4 (a) Manage the Ocean Trawl Fishery in a manner consistent with the Indigenous Fisheries Strategy and Implementation Plan

Background: The Indigenous Fisheries Strategy and Implementation Plan (IFS) was released during December 2002. The IFS puts in place a process that will ensure discussion and negotiation to resolve problems and challenges in relation to Indigenous involvement in the fisheries of NSW. A funding application is being developed to conduct a significant research program that would determine the fish species, areas and/or harvest techniques of cultural importance to Aboriginal people, so that any interactions with the OTF may be identified. Such a program may identify species that are taken in ocean-based commercial fisheries but spend part of their life cycle within estuaries or near-shore waters where cultural fishing practices are more common.

4.4 (b) Modify the activity, where relevant, in response to new information about areas or objects of cultural significance in order to minimise the risk from fishing or fishing activities

Background: Fishers in the OTF must respond appropriately to any new information about items or locations of Aboriginal and other cultural significance (e.g. a recently discovered shipwreck), and this management response seeks to reinforce that intention.

Objective 4.5 Provide for resolution of conflicts between the Ocean Trawl Fishery and other community interests

4.5 (a) Modify the activity, in consultation with the Ocean Trawl MAC, to respond appropriately to conflicts that arise between ocean trawl operators and other members of the community

Background: Conflict between ocean trawl fishers and other community members may not always revolve around conflict over the fish resources. Other conflict issues may include spatial conflicts (e.g. concern over the operation of prawn trawlers in near-shore areas). This response provides a means of resolving such conflicts by measures such as improved data collection, improved communications or small spatial and temporal closures to trawling.

GOAL 5. Promote a viable Ocean Trawl Fishery, consistent with ecological sustainability

Objective 5.1 Manage the harvesting of the primary and key secondary species to achieve the best outcome in terms of optimising biological yield and maximising economic return

*5.1 (a) Determine and implement arrangements to optimise the biological yield for the primary and key secondary species taken in the fishery

Background: Results of research into the selectivity of gear used in the Commonwealth South East Fishery have shown that many important fish species (including tiger flathead, redfish, ocean perch and ling) are being taken at sizes well below the optimum size for the species. For many of the important species taken by trawling in NSW ocean waters, given some knowledge of the biology, growth and mortality rates of individuals in the population, it is possible to determine the 'optimum' biological size to harvest each species. This generally corresponds with the size that will, on average, produce the maximum yield (in weight) for a catch of a given number of fish of that species. However, to guard against recruitment overfishing, the reproductive biology of the species also needs to be taken into account to ensure individuals are not subject to excessive harvesting prior to the size at maturity. Priorities will be set taking account of the large number of primary and key secondary species harvested by the OTF, which complicate the determination of the requirements for optimum yield. The outcomes will inform decisions to optimise the gear and harvest strategies in the fishery. See also management response 5.1b with regard to optimising yield for market requirements.

*5.1 (b) Identify and implement strategies to maximise the economic return to the fishery, taking into account the conditions required to optimise the biological yield for the range of species taken

Background: In addition to determining the optimum gear and harvest strategies to address the biological characteristics of the main species taken by the fishery, it will be necessary to assess the economic factors relevant to these species, and to take these into account in any consideration of appropriate gear and harvest strategies. This would also include the costs incurred by fishers in any change from the existing regulations to alternative gear or harvest regimes.

*5.1 (c) Implement suitable gear, area and operational specifications for targeting school whiting, and define appropriate minimum and maximum annual catch levels that will trigger a review of management arrangements (see specific controls in Appendix D5 and catch triggers in Appendix D6)

Background: The implementation of effective Bycatch Reduction Devices in ocean prawn trawl nets (see response 1.2b) is expected to significantly reduce the quantity of school whiting taken in these nets. Additionally, the introduction of appropriate gear specifications for improving the selectivity of fish trawl nets (response 2.1e) is also expected to significantly reduce catches of school whiting in fish trawl nets. In order to ensure an ongoing yield of school whiting to help meet local marketing and processing needs, a trawl net (or nets) specifically designed to catch school whiting (and minimise the incidental catch of other species) needs to be implemented as part of this management strategy.

In order to satisfy environmental assessment guidelines and maintain annual landings of school whiting at about recent levels (c 1,100 - 1,300 t), the use of this gear will have to be regulated *(area and times of permitted operation will be specified) and adequate reporting and observer coverage will be required to accurately assess the level of incidental catch taken when using this new gear. Minimum and maximum catch 'triggers' will be specified such that a review of management arrangements for school whiting will be undertaken if annual landings fall below or rise above recent levels.*

These arrangements will be reviewed on an ongoing basis and corrective action will be taken to address any problems, including consideration of implementing a separate limited entry fishery (using validated catch history or otherwise) if the gear controls do not sufficiently limit the fishing capacity.

Objective 5.2 Establish a level of fishing effort to achieve a fishery that is commercially viable (and ecologically sustainable) over the longer term

*5.2 (a) Manage fishing effort in the Ocean Trawl Fishery by:

(i) limiting the number of each endorsement type so as to minimise the potential activation of latent fishing effort

(ii) maintaining the hull capacity, engine power and net length restrictions that apply to the offshore sector of the Ocean Prawn Trawl Fishery and extend these rules (as detailed in Appendix B1.2) to the other sectors of the Ocean Trawl Fishery (i.e. inshore prawn trawl, deepwater prawn trawl, northern fish trawl and southern fish trawl)

(iii) establishing a maximum level of fishing effort for each sector of the Ocean Trawl Fishery to be achieved within 10 years of the commencement of the share management plan, and

(iv) investigating the efficacy of limiting the number of days/nights each boat may work in the prawn trawl and fish trawl sectors of the fishery

Background: It is the intent of this management response to reduce the total fishing effort to a level that is ecologically sustainable and commercially viable. The desired level of fishing effort will be determined in consultation with the Ocean Trawl MAC, and can be adjusted using tools such as minimum shareholdings and changes to the unitisation system, and can take account of any other supplementary options to facilitate an orderly process of structural adjustment. The program will establish effort milestones to be achieved over the restructuring period.

With respect to point (i) of this response, latent fishing effort includes endorsements that are never used or used at very low levels. There is a high level of latent fishing effort in each sector of the OTF that, if activated, could have a significant adverse impact on the commercial viability of fishing businesses that are reliant on the fishery. Minimum shareholding requirements and other tools can be used to restructure each sector of the fishery, and the rate of restructure can be adjusted over time if required.

Regarding point (ii), input controls including restrictions on hull size, engine power and net length are used to limit the fishing capacity of commercial fishing boats, indirectly controlling the level of fishing effort able to be applied to the target fish stocks. Boats authorised for the offshore sector of the ocean prawn trawl fishery have been subject to hull, engine and net length restrictions since 1985. This process is known as 'unitisation'. Units have recently been allocated to all other boats endorsed in the OTF and upon commencement of the strategy restrictions will apply consistently across all sectors of the fishery.

Point (iii) involves defining a desired level of total fishing effort and requires consideration of the extent to which vessels are used (i.e. both the number of entitlements and time at sea) and the capacity of those vessels (i.e. a measure of the capability to catch fish or prawns). The number of entitlements and time at sea can be controlled through minimum shareholding requirements and/or limits on the number of days/nights fished, and the fishing capacity can be controlled through the unitisation scheme. However, irrespective of the mechanism being used for effort reduction, there is a need to define the overall target for effort levels in the longer term, and how it will be achieved.

In addition or as an alternative to restricting the total number of operators and vessel capacity, fishing effort could be managed by limiting the total number of days or nights fished in the prawn trawl and fish trawl sectors of the fishery, as noted in point (iv). Before deciding to change to a new effort control system, issues such as the efficiency, cost effectiveness, equity, complementarity with other jurisdictional management arrangements and enforceability will need to be examined. The Ocean Trawl MAC and broader industry will be fully consulted in the development of the approach.

5.2 (b) Maintain the prohibition on trawling south of Byron Bay for vessels with a P4 offshore prawn trawl endorsement

Background: NSW and Commonwealth signed an Offshore Constitutional Settlement in December 1990 that gave NSW jurisdiction over prawn trawling in waters more then 3 nautical miles from the coast. To minimise the impact upon Queensland based boats that worked in New South Wales waters before the agreement came into effect, under reciprocal arrangements NSW granted these boats concessional access to NSW waters. There are currently five P4 offshore prawn trawlers and these vessels are restricted when working under the authority of an offshore prawn trawl endorsement to waters north of Cape Byron (Byron Bay). This arrangement will remain under this management strategy.

Objective 5.3 Promote the economic viability of the Ocean Trawl Fishery, and assess the economic benefits of the fishery to the community

*5.3 (a) Refine the performance indicator for monitoring trends in the commercial viability of fishing businesses within each designated commercial fishing activity, so as to be based on net returns

Background: This management strategy includes a performance indicator for monitoring economic viability of fishing business with ocean trawl endorsements, using gross returns. However, net return rather than gross return is a better indicator of economic performance as it accounts for changes in fishers' costs over time. . An understanding of the average net return across fishing businesses requires data on seafood prices, as well as the cost of inputs such as fishing gear, fuel and bait. A process will be developed in consultation with the MACs to determine how best to collect data on the costs of going fishing, taking into account confidentiality/privacy concerns and the cost-effectiveness of the data collection methods. Once this process is developed, the performance indicator can be modified accordingly.

*5.3 (b) Investigate the data available to assess the economic multiplier (flow-on) effects of commercial fishing, including the Ocean Trawl Fishery, to the broader community, and develop strategies to improve the quality / usefulness of such data

Background: There have been few detailed assessments of the economic benefits of commercial fishing, in terms of flow-on effects for local and regional economies, or returns to the broader community for access to a community owned resource. Fishing activities (and in this case expenditure and income associated with the activity of trawling in ocean waters) are believed *to be important to many local economies (e.g. Evans Head). There is no doubt that some coastal communities derive significant economic benefits from trawling in ocean waters, not only from direct employment but also from the provision of ancillary services. There may be some areas where the economic impacts of proposed management changes need to be directly assessed, taking account of the actions in this strategy. Advice will be sought from the MACs and experts in economic analysis on the best data to use to describe the multiplier effects of the commercial fisheries, and to assess any significant impacts.*

5.3 (c) Identify and promote post-harvest practices which will ensure the best return in dollars per kilogram for product of the fishery

Background: The economic viability of the fishery is dependent on obtaining the best return possible for the product landed. There will be many examples of where the economic return to the fishery can be increased by improving handling practices or value adding (especially when combined with appropriate gear selectivity measures), and it is in the interests of the fishery to widely promote such practices. Good post-harvest practices can be promoted through the Code of Conduct to be prepared for the fishery. See also management responses concerning optimising biological and economic yield, and gear selectivity.

5.3 (d) Develop a cost recovery framework, in consultation with the MAC and the Ministerial advisory body relating to commercial fishing

Background: A cost recovery framework is currently being developed and will be subject to consultation with industry advisory bodies. The framework will allow for the fair charging of the costs of management and access rights and give industry a greater ability to plan. See section 4c(xv) for further information on the cost recovery policy.

Objective 5.4 Provide secure fishing entitlements for ocean trawl fishers

5.4 (a) Implement the share management provisions of the *Fisheries Management Act 1994* for the prawn trawl sector of the fishery and the fish trawl sector north of Barrenjoey Point

Background: The category 1 share management provisions allow for the allocation of shares in perpetuity, with the payment of statutory compensation for the market value of the shares if the Government decided to close the fishery and cancel the shares. Category 1 share management provides a secure property right and a stronger incentive for business investment and resource husbandry.

Pending resolution of jurisdictional arrangements with the Commonwealth, the fish trawl sector of the fishery south of Barrenjoey Point will continue as a restricted fishery.

Objective 5.5 Manage food safety risks in the harvesting of shellfish and finfish in the fishery

5.5 (a) Co-operate with Safe Food Production NSW in the development and implementation of food safety programs relevant to the fishery

Background: Food safety plans covering the production and distribution of seafood in NSW are currently being developed and implemented by Safe Food Production NSW. These plans may impose statutory requirements on fishers to comply with the approved standards. Supporting food safety programs is an effective way of promoting consumer confidence in products harvested by the fishery and contributing to the future viability of the industry.

GOAL 6. Facilitate effective and efficient compliance, research and management of the Ocean Trawl Fishery

Objective 6.1 Promote and maximise compliance with the provisions contained in the Ocean Trawl Fishery Management Strategy

*6.1 (a) Develop, implement and monitor a compliance plan for commercial designated fishing activities, including the Ocean Trawl Fishery

Background: Currently, compliance plans are developed by NSW Fisheries compliance officers at the district level. Relevant aspects of these plans will be reviewed and combined into a compliance plan for commercial designated fishing activities, including the OTF, on a state-wide basis. The Ocean Trawl MAC will regularly review the operation of the parts of the compliance plan relevant to each of the fishery sectors.

Compliance with the management strategy can be encouraged through participation of fishers in decision-making. The cost of compliance with provisions in the FMS will be minimised if fishers are involved in the development of those provisions and understand the potential benefits. Such participation should seek to encourage the flow of information between fishery operators and their representatives on the MAC, and an appropriate level of explanation to all endorsed fishers about the reasons for decisions regarding management of the fishery.

*6.1 (b) Review developments in electronic vessel monitoring systems (VMS) and associated catch and effort reporting systems, with a view to implementing a cost-effective VMS system for the fishery

Background: NSW Fisheries and the MAC have been monitoring developments in Vessel Monitoring Systems (VMS) in other States and countries over the last few years with a view to introducing a cost effective system in NSW. Some NSW trawl fishers with Commonwealth entitlements already have a requirement to install VMSs on their vessels as part of the Commonwealth management arrangements

VMS uses satellite technology to report the position, speed and other information on commercial fishing vessels. A VMS would enhance management flexibility and compliance with regard to jurisdictional boundaries, inter-fishery boundaries, juvenile king prawn closures, Marine Park zoning schemes and any other spatial closures. A suitable adjunct to the VMS allows for enhanced catch and effort reporting, communication between fishers, NSW Fisheries and markets (via computer) and can provide valuable information on the spatial distribution of commercial fishing. However, VMS systems are currently relatively expensive to implement and maintain.

6.1 (c) Implement a penalty points scheme (incorporating endorsement suspension and share forfeiture for serious offences and habitual offenders)

Background: It is crucial that effective deterrents are in place to discourage illegal activity in the fishery, especially given the difficulty in enforcing compliance at sea. The penalty points scheme will be similar to the demerit points scheme used by the RTA for driver's licences and will be applied across fisheries. The detail of the scheme will be developed in consultation with industry and implemented through regulation or in the share management plan.

6.1 (d) Develop strategies to support appropriate practices and behaviour in commercial fisheries, including development of training and accreditation courses in core competencies and the introduction of fit and proper person requirements

Background: The minimum qualifications will aim to ensure that skippers have a sound understanding of the fishery and the rules that apply, including the need for provision of accurate data. Increasing the professionalism of skippers can provide long-term benefits to the industry.

Some fisheries currently have fit and proper person requirements to ensure that reputable persons continue to operating in those fishery. The OTF can benefit from similar requirements.

Objective 6.2 Identify research priorities required to provide for the sustainable operation of the Ocean Trawl Fishery

*6.2 (a) Develop and implement a Research Strategic Plan for designated commercial fishing activities including the Ocean Trawl Fishery, taking account of the priorities for research outlined in the harvest strategy

Background: Draft research plans have previously been prepared and discussed with the ocean trawl MACs, along with the assignment of priorities to research proposals. Such plans will be reviewed in consultation with the MAC, to ensure their relevance and efficacy in relation to the goals and objectives of the approved Fishery Management Strategy and the priorities outlined in the harvest strategy. A new Research Strategic Plan for the fishery, detailing the priorities and possible sources of funding, would then be developed. Development of the plan will be informed by the risk assessment and identification of knowledge gaps in the Environmental Impact Statement.

Objective 6.3 Ensure effective and efficient management of the Ocean Trawl Fishery

*6.3 (a) Develop and implement the fishing business (skipper) card system

Background: Only one person may be nominated to hold endorsements in respect of a fishing business. The FM Act limits the number of people able to hold endorsements in respect of a fishing business to one, except in the case of skipper endorsements where multiple endorsements can be issued although they are often linked to the boats attached to a specific business. Under current circumstances, for a skipper to work another boat, a new licence with endorsements must be issued; a process that can take several weeks to complete.

To increase the flexibility for business owners to acquire a skipper at short notice a new system will be developed; the fishing business card system. Under this system the owner of a fishing business with entitlements in the OTF will be issued a Fishing Business Card. The fishing business owner can then register a pool of appropriately licensed fishers associated with their business. A registered person is deemed to be endorsed with respect to that business when they are in possession of the card. They may operate in all fisheries specified on the card. The fisher may also be restricted to the vessel specified on the card. In the event of a business owned in partnership by two licensed fishers, two fishing business cards could be issued. All registered persons and those in possession of the card must abide by all rules and regulations that would normally apply to the endorsed fishing business owner.

*6.3 (b) Modify the arrangements for trawling in the area south of Barrenjoey Point (within 3 nautical miles) to achieve greater complementarity with the management of the adjacent Commonwealth

Southern and Eastern Scalefish and Shark Fishery and to manage fish stocks in State waters on a sustainable basis and minimise other environmental impacts, as provided for in Appendix D3

Background: On the south coast fish trawling inside 3 nautical miles is managed by the State and fish trawling outside 3 nautical miles is managed by the Commonwealth, with linkages between the fishery resources and respective management regimes. A consultation paper was distributed to southern fish trawl endorsement holders during November 2002 detailing three proposals; (A) prohibit fish trawling inside 3nm, (B) hand over jurisdiction of major fish trawl grounds to the Commonwealth and close other waters to trawling or (C) maintain the current agreement. At the time, fishers responded with significant support for a 'single jurisdiction' to cover trawling under option B. More recently however, the MAC representative for the southern trawl sector has advised that fishers now seek to retain NSW jurisdiction in these waters, and as such appropriate management arrangements are required. Appendix D3 outlines the range of measures that will apply to waters south of Barrenjoey Point under NSW jurisdiction. It should be noted that this FMS does not prevent these waters from being transferred to Commonwealth jurisdiction at a later time if so agreed by the State and Commonwealth governments.

*6.3 (c) Rationalise the areas closed to trawling (as outlined in this management strategy) taking account of the combined effect of fishing closures, addressing the environmental risks identified in the EIS, and the implications for trawling operations at a regional level

Background: There is a range of closures to trawling that currently apply and will apply under the management strategy. Many closures are established to achieve a particular outcome, including juvenile king prawn closures, marine protected areas (e.g. Marine Parks), flood bycatch closures, etc, yet provide benefits to several other aspects of environmental management. There should be opportunities to rationalise the closures that apply to ocean trawling while still achieving the aim and overall environmental protection provided by the 'package' of closures. NSW Fisheries will work with fishers at a regional level to identify any opportunities for rationalisation. Any rationalisation would need to ensure that the range of benefits afforded by the closures are achieved, either collectively or individually.

Objective 6.4 Provide effective and efficient communication and consultation mechanisms in relation to management of the Ocean Trawl Fishery

*6.4 (a) Establish the Ocean Trawl Management Advisory Committee, with the services of an 'independent' Chairperson, as the primary consultative body for issues affecting the fishery

Background: A proposal for a single Ocean Trawl MAC has received support from industry provided the relativity of representation is appropriate for the mix of endorsements in the fishery. The implementation of 'independent' Chairs to each of the commercial Management Advisory Committees in 2000 has been very successful in promoting full and informed discussions at MAC meetings, and in effectively presenting industry views to the Minister and NSW Fisheries. The MAC can include recreational fishing and Indigenous community members to promote cross-sector input, and the Indigenous Fisheries Strategy provides support for improving indigenous participation in the MAC process.

Objective 6.5 Implement this strategy in a manner consistent with related Commonwealth and State endorsed programs aimed at protecting aquatic environments and achieving the objectives of ecological sustainable development

6.5 (a) Manage the Ocean Trawl Fishery consistently with other jurisdictional or natural resource management requirements, such as the marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy, compliance and other relevant strategies

Background: The management strategy will be operating alongside other programs relating to the management of marine resources, and in most instances must be consistent with those programs. The management strategy must be adaptive if inconsistencies between the programs become apparent. This response enables a whole of Government approach to management of the marine environment.

6.5 (b) Provide for the issue of permits under Section 37 of the *Fisheries Management Act 1994* authorising the use of modified fishing practices to assist research programs or for purposes consistent with the vision and goals of this management strategy

Background: Permits are required to use fishing gear in a manner that is different to that specified in this management strategy, or the associated regulations. This response allows approval to be given to industry members who are participating in research programs to trial new approaches to fishing gear design.

GOAL 7. Improve knowledge about the Ocean Trawl Fishery and the resources on which it relies

Objective 7.1 Improve the community's understanding and public perception of the Ocean Trawl Fishery

*7.1 (a) Promote awareness of the Ocean Trawl Fishery as part of the overall communication strategy across all commercial designated fishing activities by:

i) implementing issue-focused education programs, including an education program on school whiting

ii) educating ocean trawl fishers about the potential impacts of trawling on ocean habitats and ecosystems, and the need for ecologically sustainable fishing practices

iii) arranging for media releases, educational material for schools and public meetings and other relevant publications advocating pro-active industry initiatives, the benefits of protecting fish habitat and nursery grounds, and how the OTF is managed to remain ecologically sustainable.

Background: The Ocean Trawl MAC and NSW Fisheries will develop and monitor these proposals to ensure they are effective. As an initial step, the Fishery Management Strategy and the Environmental Impact Statement and any resulting reports will be made available to the public by placing them on the NSW Fisheries website, providing copies at NSW Fisheries Offices and doing targeted mail-outs to key stakeholder groups.

Objective 7.2 Promote scientific research to collect relevant information about the biology of the primary and key secondary species, the impact of trawling on other species and the environment, and the status of the fishery as a whole, including economic and social factors

*7.2 (a) Promote and support targeted research projects that are relevant to:

i) the biology or stock assessment of the primary and key secondary species in the Ocean Trawl Fishery

ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats

iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and 'refuge' areas, and research into the use and effectiveness of approved Bycatch Reduction Devices in reducing unwanted bycatch)

iv) economic and social factors affecting the fishery.

Background: The current level of knowledge about most of these proposed areas of research is much less than needed to properly understand the functioning of this fishery. In particular, the extent of different habitats and the potential impacts of trawling on these habitats, is poorly known for the waters off NSW. It would be advantageous to support research proposals aimed at improving our knowledge of the extent of the various habitat types, their importance to fish resources, and any possible impacts that trawling might have. Some initial work on identifying habitats associated with trawl grounds will be conducted in conjunction with industry as part of the definition and mapping of trawl grounds (management response 1.1a).

The MAC, through the FMS and contributing to a Research Strategic Plan, should identify and promote the research projects outlined in this response, and offer whatever assistance can be practically provided by fishers or others connected with the fishery. Ideally, the MAC will also be pro-active in the development of necessary research projects, and in supporting such projects to obtain competitive funding.

7.2 (b) Implement targeted surveys of endorsement holders to obtain more accurate information on the economic and social status of commercial fisheries, including the Ocean Trawl Fishery

Background: Historically, there has been little data collected which would assist in monitoring the economic and/or social factors that affect commercial fisheries. This response seeks to establish a method to conduct surveys on an episodic basis to provide this kind of information. The approach to be taken will be developed in consultation with the MACs. The findings of this work will be used to progressively inform decisions on targets for structural adjustment and refinement of the economic performance indicators for commercial fisheries.

Objective 7.3 Improve the quality of the catch and effort information collected from endorsement holders

7.3 (a) Periodically review the mandatory catch and effort return forms submitted by ocean trawl fishers and implement changes if:

i) the data are perceived to be of poor quality or insufficient for the purpose of conducting stock assessments or an environmental assessment, or

ii) the forms are found to be exceedingly complex for fishers to complete, ensuring an emphasis on quality rather than quantity of information collected.

Background: Ocean trawl fishers submit a catch and effort return form to NSW Fisheries each month and the information is used to increase our understanding of the fishery and the resources on which it relies. An informal working group involving commercial fishers and NSW Fisheries staff has been established to periodically review the current catch and effort return forms. The working group will make recommendations for changes that are considered necessary to improve the quality of data collected. Any recommendations of this working group will be discussed with the Ocean Trawl MAC.

It is desirable that ocean trawl fishers complete a catch and effort return that provides more useful information than is currently the case (e.g. a daily summary or 'shot-by-shot' logbook). The information to be collected in such a format needs to be discussed with the Ocean Trawl MAC as part of the initial review.

*7.3 (b) Assess the accuracy of the current catch recording system, and species identification in catch records, and provide advice to industry to make needed changes

Background: Correct species identification is critical to the performance of many areas of the management strategy. Most species in the fishery are accurately reported, however some species are not (e.g. shovel-nosed sharks are reported as fiddler sharks; pink tilefish are reported as 'moonfish' and are recorded in the catch database as 'opah'). The onboard observer study will provide first hand information on local names for fish and any patterns in the use of those names. This information will also be used to ensure that industry education is appropriately targeted.

4. The Harvest Strategy

a) Extent of the Fishery

i) Number of fishers

At February 2003, NSW Fisheries licensing database showed that 344 fishing businesses held entitlements to operate in the OTF, with some businesses holding multiple endorsements within this fishery or in other fisheries. The number of fishers entitled to operate in the fishery fluctuates slightly over time, due to a number of factors including the transfer and amalgamation of fishing businesses and late payments on renewal of fishing licences. In 2001/02 the number of fishers who reported trawling in ocean waters was 46 for fish trawl, 214 for prawn trawl and 23 for royal red prawn trawl.

ii) Area of operation

The boundaries of the fishery extend from the NSW coastal baseline seaward to the 4,000 metres isobath (approx. 60 to 80 nm offshore) between Barrenjoey Point and the Queensland border. In ocean waters south from Barrenjoey Point to the Victorian border, trawling is currently managed by the State from the NSW coastal baseline seaward to 3 nautical miles offshore only (see Figure D3), and the Commonwealth retains jurisdiction for trawling outside 3 nautical miles to the edge of the Australian Fishing Zone. Note that the jurisdiction for trawling on some grounds inside 3 nautical miles south of Barrenjoey Point may transfer to the Commonwealth Government under this management strategy (see background information to management response 6.3b).

Trawling is carried out on suitable grounds in ocean waters off the entire length of the NSW coast. Trawling cannot be successfully conducted on areas of rocky reef, or where there are obstacles that could snag the net or attached gear (such as shipwrecks or undersea cables). Trawling is prohibited near shipwrecks with heritage values, the positions of which are listed by the NSW Heritage Office.

Ocean trawlers work out of most of the major ports along the length of the NSW coast (see Figure 3). Most trawlers operate for the majority of the time from a single 'home' port, although a number of trawlers regularly operate from a number of ports, depending on the season, the availability of target species and the endorsements attached to the business. Apart from the area closures to commercial fishing such as those in marine protected areas including marine parks and aquatic reserves, there are currently a number of time and area closures in place which impact on the operation of trawlers (see section 4.c.x for further information on time and area closures).

Trawling for eastern king prawns is concentrated mainly off the north coast of NSW, with the majority of fishing occurring north of Newcastle, in depths from 20 to 200 metres. Trawling for school prawns occurs mainly in shallow waters adjacent to the north coast estuaries, although some fishing also occurs seasonally on southern grounds. Trawling for royal red prawns and associated species occurs on a limited number of grounds in depths of 365 to 1100 metres, between 29°S and the boundary of the fishery east from Barrenjoey Point.

Trawling for fish species occurs on continental shelf and slope grounds between Smoky Cape (approx. 31°S) and the Victorian border. Depending on the season and the species mix being targeted, trawling for fish can occur in water depths from 10 metres to around 1000 metres. Trawling targeted at school whiting occurs year round on sandy bottoms in depths of 20 to 80 metres, mainly north of Sydney. Targeted fishing for whiting occurs mainly in those areas located close to processing plants or the Sydney Fish Markets.

Fishermen's Co-operatives are located at many of the major ports and undertake low levels of fish processing for local markets. More significant processing facilities are located at Iluka, Tuncurry, Newcastle, Wollongong and Eden.

Currently, very little information is available on the boundaries of individual trawl grounds, and the intensity of trawling on each ground. This management strategy seeks the accurate mapping of trawl grounds, and for the frequency of trawling on each ground to be recorded as part of the normal catch and effort monitoring undertaken for the fishery.

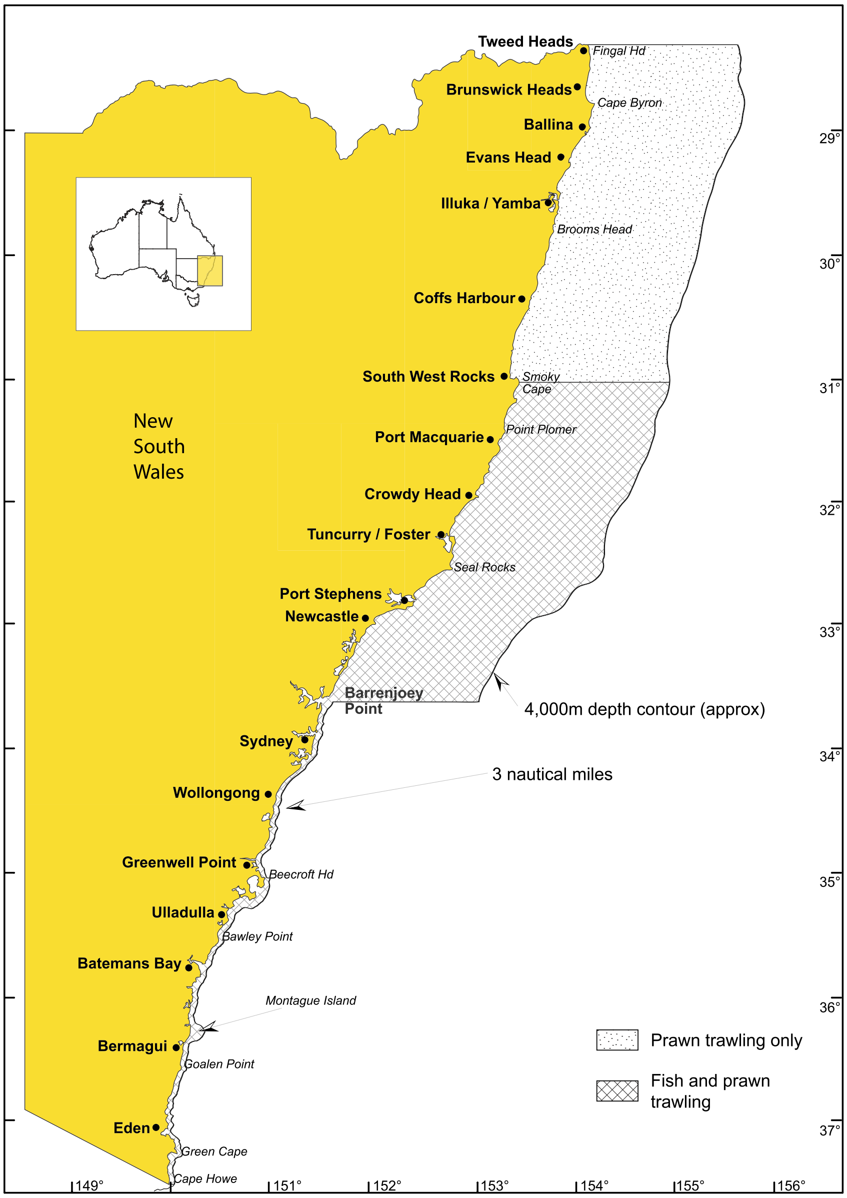

Figure D3 Map of the area of the OTF including identification of major ports.

Habitat management

Habitat management guidelines and plans have been and will continue to be prepared under the Fisheries Management Act 1994 to prevent or minimise the impact of all types of activities on fish habitat. Habitat management plans can potentially close areas to commercial fishing and other activities. The Ocean Trawl MAC will provide advice and contribute to any reviews of NSW

Fisheries habitat management policy and guidelines or habitat protection plans, where they relate to ocean waters fished by trawlers.

Commercial fishers are often aware of the key habitat areas for fishery production. This knowledge can assist NSW Fisheries to identify and prioritise sites that may benefit from rehabilitation and potentially contribute to increased fishery production. Such information will be documented as part of the mapping of trawl grounds and will be utilised in the identification of areas available to trawling (management responses 1.1a and 1.1b). This management strategy also supports continued restrictions on the use of bobbin gear and the modification of trawl gear as required to minimise impacts on habitat.

iii) Activities endorsed in the fishery

The fishery is categorised into a number of endorsement types that determine the areas and types of fishing gear each fisher is allowed to use, and in some cases the species to be targeted. Table D2 lists the endorsement types available in the fishery and details the activity that is authorised by each endorsement. For example, only fishers with an ocean prawn trawl (deepwater) endorsement on their fishing licence are permitted to use a prawn trawl net to take deepwater prawns from NSW waters. This management strategy provides the tools to reduce the number of endorsements in each category over time in order to achieve a lesser number of more viable operators.

Table D2 Numbers of Fishing Businesses (FBs) by endorsement type in the ocean trawl fisheries (as at February 2003).

Endorsement Type	Endorsement Description	Number of FBs Endorsed
Ocean Prawn Trawl- Inshore	This endorsement authorises the holder to use an otter trawl net (prawns) to take fish (other than deepwater prawns) for sale from inshore waters*	267
Ocean Prawn Trawl- Offshore	This endorsement authorises the holder to use an otter trawl net (prawns) to take fish (other than deepwater prawns) from offshore waters**, or from such offshore waters as may be specified in the endorsement by the Minister for Fisheries	238
Ocean Prawn Trawl- Deepwater	This endorsement authorises the holder to use an otter trawl net (prawns) to take deepwater prawns from offshore waters**	63
Ocean Fish Trawl- Northern	This endorsement authorises the holder to use an otter trawl net (fish) to take fish (other than prawns) for sale from ocean waters that are north of a line due east from Barrenjoey Headland (other than waters in which use of an otter trawl net (fish) is prohibited under clause 39 of the FM (General) Regulation)	62
Ocean Fish Trawl- Southern	This endorsement authorises the holder to use an otter trawl net (fish) to take fish (other than prawns) for sale from ocean waters that are not more than 3 nautical miles from the natural coast line and are south of a line drawn due east from Barrenjoey Headland	47

* Inshore waters means ocean waters that are not more than 3 nautical miles from the natural coastline.

** Offshore waters means ocean waters that are more than 3 nautical miles from the natural coast line and north of a line due east from Barrenjoey Point.

Note: Some Fishing Businesses may hold multiple endorsements in the fishery.

iv) Fishing gear used in the fishery

Currently, all trawling in ocean waters off NSW is carried out with demersal 'otter' trawl nets. These nets are fished by being towed along the sea floor, with the net being held open by the shearing action through the water of two "otter boards" which are set at an angle to the direction of travel of the net over the bottom. "Sweep" refers to a length of wire or wire rope that connects one end of the net to an otter board (one 'sweep' on each side of the net).

The sweeps used on fish trawl nets are much longer than those used on prawn trawl nets, up to a maximum of about 274 metres or 150 fathoms. The otter boards are attached to the towing vessel by means of long wires, called ‘warps’, which are wound onto the drums of the trawl winch. Different designs of ‘trawl gallows’ are used to direct the warps from the water to the winch and to keep the warps and net clear of the boat’s propeller and superstructure when the gear is being set and retrieved. Various designs of net are used to target different fish and prawn species, however the general characteristics of each type of net are similar. Regulations prescribe a minimum 'mesh size' for trawl nets (which is the internal diameter of individual meshes of the net, measured when stretched using an approved net measuring device), and in some cases the dimensions of the overall net and any attachments to the net are also regulated.

Following are the descriptions of each net type allowed to be used in the fishery at the commencement of the management strategy (note that these descriptions may be subject to change as the strategy is progressively implemented, and although ‘Danish seine’ nets are specified, none are currently in use in the fishery):

i) **Otter Trawl Net (Prawns)** – has a mesh size of not less than 40 mm and not more than 60 mm, except for the “cod-end” (the rear end of the net where the catch accumulates as the net is being trawled) which must have a mesh size of not less than 40 mm and not more than 50 mm. The total length of the headline of the net(s) is not to exceed 33 m, unless a different maximum length is specified in the boat licence of the vessel from which the net is being fished. The length of each sweep is not to exceed 5 m, or the distance from the trawl gallows to the stern of the boat (whichever is the greater).

ii) **Otter Trawl Net (Fish)** – has a mesh size of not less than 90 mm throughout. The length of the headline of the net and the length of sweep is not specified. In waters south of a line drawn due east from Seals Rocks (approx. 32° 30' S latitude), ‘bobbin gear’ up to 100mm in diameter may be used on the ground rope of fish trawl nets. In waters north of the Seal Rocks line, the use of bobbin gear is prohibited. ('Bobbin gear' describes the use of round or cylindrical rollers on the ground rope of a trawl net, which allows the net to ride up and over small variations in bottom topography, which might snag a conventional ground rope. This type of gear is used on harder bottoms comprising low relief rocky slabs or small protruding rocks. It will not allow the net to be successfully worked over rocky reefs with large protruding rocks or boulders, or in areas with high relief e.g. the sides of undersea canyons or pinnacles.)

iii) **Danish Seine Net (Fish) –** has a mesh size of not less than 83mm throughout. The length of the headline of the net is not specified. Danish seine nets do not utilise otter boards or sweeps, but have a long length of rope attached to each end of the net by means of short bridles. The gear is set in a large triangular shape on the bottom, and the ropes are slowly retrieved, closing the gear and herding the fish into the path of the net.

This strategy aims to improve the selectivity characteristics of trawl nets by ensuring that cod-ends are constructed with a "hanging ratio" to the body of the net of 1:1 (generally 100 meshes round). Consideration will also be given to introducing square mesh cod-ends on prawn trawl nets, based on the results of research being conducted during 2003 and 2004 to examine the selectivity of nets used by industry and novel net designs (see management response 2.1e). An additional trawl net type for targeting school whiting will also be considered, based on the results of trials being conducted to minimise the incidental catch in such a net (management response 5.1c).

v) Boats used in the fishery

Boats used in the fishery range from 9 to 27 metres in length (subject to current management rules), with displacement hulls constructed from timber or steel. They are powered by single or twin diesel main engines of 60 to 400 kilowatts (80 to 540 horsepower). Smaller auxiliary diesel engines provide electric power and drive hydraulic pumps that operate the trawl winches. Modern electronic navigation and fish-finding equipment is now found universally on ocean trawl boats in NSW, and some vessels which operate under other jurisdictions also carry satellite-based vessel monitoring systems.

The number and size of boats that may be used in the offshore prawn trawl sector of the fishery are restricted, and replacement boats are limited in hull capacity and engine power (300 kilowatts or 400 horsepower) to prevent increases in fishing capacity. Currently, replacement boats in other sectors of the fishery must be within 1 metre or 10% of the length of the boat being replaced, whichever is the lesser, however the management strategy introduces consistent controls on the replacement of trawlers throughout all sectors of the fishery. These controls will be based on the rules currently applying to endorsed offshore prawn trawlers and include restrictions on hull capacity and engine power.

b) Species

i) Species allowed

The OTF is a multi-species fishery. A total of about 130 - 150 species of fish, crustaceans and molluscs are retained for sale, although many species are taken sporadically and in very small quantities. This management strategy categorises retained species as “primary”, “key secondary” or “secondary”, depending on the quantity and relative value of that species taken by trawling. A description of these categories is provided below. A total of 28 species or 'species-groups' are listed as primary or key secondary species in this fishery (Table D3), and in 2000/01 these species comprised 97% of the total landed catch of the trawl fishery. A summary of the fishery and biological data available for each primary or key secondary species (or species group) is included in Appendix D7.

Primary species

Primary species are the target species of the trawl fishery, or those species that are landed in large quantities or are economically very significant to the fishery. The twelve 'primary' species comprised 86% of reported landings by the ocean trawl fisheries in 2000/01 and are considered to be of major importance to trawl fishers. Consequently the primary species receive a higher management and research priority within this management strategy. Initially, individual trigger points have been developed for the primary species to help determine if a species is likely (or not) to become overfished (see Appendix D6 for further information). However, the strategy requires the development of a stock assessment for each of the primary species (management response 2.1b).

Table D3 Primary and key secondary species in the Ocean Trawl Fishery.

	Common name	Scientific name	Taxonomic Family / Class name
Primary Species	Eastern King Prawn	*Penaeus plebejus*	PENAEIDAE
	School Prawn	*Metapenaeus macleayi*	PENAEIDAE
	Royal Red Prawn	*Haliporoides sibogae*	SOLENOCERIDAE
	Balmain Bug	*Ibacus* spp	SCYLLARIDAE
	Octopus	*Octopus* spp	OCTOPODIDAE
	Cuttlefish	*Sepia* spp	SEPIIDAE
	Southern Calamari	*Sepioteuthis australis*	LOLIGINIDAE
	School Whiting	*Sillago flindersi* and *Sillago robusta*	SILLAGINIDAE
	Tiger Flathead	*Neoplatycephalus richardsoni*	PLATYCEPHALIDAE
	Sand Flathead	*Platycephalus cearuleopunctatus*	PLATYCEPHALIDAE
	Silver trevally	*Pseudocaranx dentex*	CARANGIDAE
	Fiddler Shark	*Aptychotrema rostrata* and *Trygonorrhina* species A	RHINOBATIDAE
Key Secondary Species	Blue Swimmer Crab	*Portunus pelagicus*	PORTUNIDAE
	Squid	Various	LOLIGINIDAE & OMMASTREPHIDAE
	Gurnard / Latchet	*Chelidonichthys kumu* *Pterygotrigla polyommata* *Pterygotrigla andertoni*	TRIGLIDAE
	John Dory	*Zeus faber*	ZEIDAE
	Angel Shark	*Squatina australis, Squatina* species A	SQUATINIDAE
	Flounder (mixed species)	Various	PLEURONECTIDAE / PARALICHTHYIDAE
	Red Mullet	Various	MULLIDAE
	Redfish	*Centroberyx affinis*	BERYCIDAE
	Leatherjacket (mixed species)	Various	MONACANTHIDAE
	Ocean Perch	*Helicolenus barathri*	SCORPAENIDAE
	Mirror Dory	*Zenopsis nebulosus*	ZEIDAE
	Sole (mixed species)	Various	CYNOGLOSSIDAE / SOLEIDAE
	Morwong, Rubberlip	*Nemadactylus douglasii*	CHEILODACTYLIDAE
	Moonfish	*Branchiostegus wardi*	MALACANTHIDAE
	Boarfish	*Paristiopterus labiosus*	PENTACEROTIDAE
	"Sharks" (mixed species) *	Various	Various

* "Sharks (mixed species)" includes catches reported as 'unspecified sharks', and also includes catches reported under other categories including whaler and dogfish groups, and saw, hammerhead, mako, carpet and ghost sharks (see Appendix D7 for more details).

Key Secondary species

Sixteen species have been identified as "key secondary" species because, although not generally targeted, they are an expected catch of trawling and provide significant economic benefit to the fishery. The key secondary species comprised 11% of reported landings by the ocean trawl fisheries in 2000/01. These species are therefore subject to more rigorous monitoring requirements than the remaining secondary species, including the development of trigger points for monitoring catches by the fishery (see Appendix D6). Stock assessments will also be undertaken on these species, though at a more rudimentary level than for the primary species.

Secondary species

Secondary species are categorised as those that are retained by the fishery but which do not fall under the primary or key secondary categories described above. These 'secondary' species are taken incidentally during trawling operations. In 2000/01 secondary species numbered 95 and contributed around 3% of the total weight of reported landings by ocean trawlers. This strategy contains measures to ensure the catch of secondary species by ocean trawlers remains low and within the range of historic levels.

Many species taken in the NSW ocean trawl fisheries are also taken in other NSW commercial fisheries, by other sector groups and by fisheries managed under the jurisdiction of the Commonwealth or other States. The FM Act establishes a system of advisory bodies who provide advice to the Minister for Fisheries on cross-fishery management issues. NSW Fisheries management and research staff will also meet periodically with staff from adjacent jurisdictions to consider consistent management regimes for shared species and to discuss initiatives such as stock assessment, complimentary size limits, monitoring programs and recovery programs for overfished species. Cross-jurisdictional collaboration has occurred often on an as-needed basis in the past, however, a more formalised approach to joint management will now be undertaken.

ii) Bycatch species

Bycatch consists of those animals that are discarded from the catch or retained for scientific purposes, and that part of the “catch” that is not landed but is injured or killed as a result of interaction with fishing gear. Fish that are landed are sometimes discarded because there is no market for that type (or size) of fish, or because the regulations prevent the fish from being retained (e.g. if it is smaller than the minimum legal length).

Demersal otter trawl nets of the types used in the ocean trawl fisheries are considered to be a relatively unselective fishing method, capturing most of the mobile species in the path of the net which are of a size that cannot escape through the meshes of the net. Trawl nets have been shown to have varying efficiencies for capturing the large range of species likely to be encountered, and the selectivity of a trawl net for an individual species also depends on the behaviour exhibited by that species in the path of the net.

The major part of the discarded fish catch (83% by weight) observed from fish trawls in the northern sector of the NSW fishery (Newcastle to Forster) in 1993–1995 comprised small non-commercial species. However, about 17% of discards (by weight) comprised small individuals of commercial species, chiefly redfish, tiger flathead and snapper (Liggins, 1996). Incidental catches that were discarded from ocean prawn trawl catches during 1990-92 comprised mostly small commercial and non-commercial species of finfish and invertebrates (Kennelly *et al*., 1998). Following the introduction of Bycatch Reduction Devices (BRDs) for prawn trawl nets used in the fishery, in recent years the quantity of incidental catches taken by prawn trawlers has declined. However observer studies have not recently been repeated and quantitative data on recent bycatch levels are not available. There have also been significant changes in the design of fish trawl nets used in NSW ocean waters since the study of Liggins (1996). To ensure the effectiveness of changes to the selectivity of trawl nets, this strategy outlines a means to obtain data on current levels of discarding throughout the trawl fishery through an onboard observer study.

Bycatch reduction devices

All prawn trawl nets must be fitted with a bycatch reduction device that has been approved for use in the fishery. Bycatch reduction devices reduce the incidental capture of finfish in prawn trawl nets. There are eight bycatch reduction devices approved for use in the fishery at the commencement of the strategy, including:

- Nordmore grid
- Blubber chute
- Square mesh panel (modified)
- Composite square mesh panel

- Diamond
- V-cut
- Fish eye
- Big eye

[Note: the management strategy modifies the specifications for the 'square mesh panel' – see Appendix B1.1.]

Turtle and seal exclusion devices are not mandatory in NSW ocean trawl nets. Based on previous observer studies and advice from industry, interactions with turtles and seals are believed to be low. Data on interactions between ocean trawling and turtles/seals will be obtained through changes to reporting forms and through onboard observer studies. The strategy is designed to be responsive if the level of interaction is found to be, or becomes, unacceptably high at any stage.

iii) Size limits

Size limits apply to a number of species taken in the OTF. Clause 9 of the FM (General) Regulation lists the minimum legal lengths that apply to species permitted to be taken in the fishery. The strategy includes an evaluation of the appropriateness of existing minimum size limits for ocean trawl species, and an assessment of whether minimum size limits should be specified for any other ocean trawl species (see management response 2.1i). Information will be collected as part of the onboard observer program to assess the effectiveness of changes to trawl net selectivity, having regard to existing (and potential) minimum legal sizes for ocean trawl species.

In the case of prawns it is difficult to manage a legal minimum length because of the small size of the prawns and the quantities that are landed. A maximum count of prawns (number to the ½ kilogram) can be used as an alternative. Following recommendations by the Juvenile Prawn Summit Working Group in 2000, counts for king prawns and other prawn species will soon be adopted. These counts will apply to all sectors, including estuarine fishers, and will provide for some ongoing harvest of prawns that are smaller than those taken in the ocean prawn trawl fishery. This strategy adopts counts of 50 king prawns and 100 school prawns per half-kilogram to be used to guide the design of gear selectivity changes and when defining fishing closures in the fishery.

iv) Protected species

Commercial fishers are not permitted to take either protected fish or fish protected from commercial fishing. These species are listed in clause 6 and clause 7 of the FM (General) Regulation.

A range of threatened species, other than fish, are protected by other legislation including the NSW *Threatened Species Conservation Act 1995*, the NSW *National Parks and Wildlife Act 1974*, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Such species may be classified as threatened, endangered or vulnerable and cannot be retained by commercial fishers.

Interactions with threatened species and species of public concern

Although interactions with threatened species have not been commonly recorded in this fishery, this management strategy contains two direct measures to obtain data on any such interactions. The first of these measures is a modification to the catch reporting system which will incorporate mandatory reporting of fishers' interactions with threatened species during fishing operations (see management response 3.1a). Secondly, the implementation of an observer-based survey will inter alia collect data on occurrences of threatened species in catches (see management response 1.2a).

A number of management responses also appear in section 3 of this management strategy aimed at minimising impacts on threatened species. These measures include educating fishers in the identification/avoidance of threatened species, using fishing closures and modifying gear use to minimise known interactions with threatened species, and implementing the provisions of any threatened species recovery plans and threat abatement plans (management response 3.1b).

v) Status of species within the fishery

The determination of the status of the primary and key secondary species is central to the sustainable operation of the OTF, and is a key component of the strategy. NSW Fisheries uses a standardised method of reporting on the exploitation status of fish stocks across all commercial fisheries. Stock status is described using the terms defined in Table D4. Where available, data on the recreational harvest, including charter boat catch, and catch from other sectors are also taken into consideration when determining exploitation status. This allows a species based management approach where all known impacts on a species are considered.

Table D5 outlines the exploitation status of the primary and key secondary species for the ocean trawl fisheries. A number of species are classified as 'unknown" or "uncertain", and the management strategy includes responses to measurably improve the quality of reported information and knowledge of stock status for these species. Appendix D6 provides details of the methods to be employed to detect undesirable changes in stocks of primary and key secondary species, prior to the development of more detailed stock assessments.

vi) Overfished species

If a species taken in this fishery is determined as ‘overfished’, this management strategy requires the implementation of, or assistance in developing, a recovery program for that species (see objective 2.2 and related management responses in section 3 of this management strategy). However, a recovery program is not required for species that are determined as growth overfished if the Director-General, NSW Fisheries, considers that the combination of the existing harvest strategy and life history characteristics of the species provides sufficient protection for the stock from the effects of fishing.

The process of developing a recovery program for an overfished species initially involves NSW Fisheries preparing a summary of the known factors that have led to the determination of ‘overfished’ being made. In addition to the summary, a range of management options will be identified and outlined. Consultation will then formerly commence with the relevant MACs and advisory bodies. The recovery program will be developed under the management strategy for the fishery that is the key harvester of the species concerned, and must include a description of the actions proposed to return to acceptable levels those parameter(s) that have led to the determination of the species being ‘overfished’. The recovery program will also set out a timeframe for that process (including annual reviews) and may specify further appropriate action should recovery targets not be met.

Definitions of overfished status

There are two types of overfishing which, when detected, in most cases require management action. It is important to note that the two types of overfishing are not mutually exclusive. “Growth overfishing” occurs when individual fish are typically harvested under the size that takes best advantage of the species growth in relation to expected natural mortality. "Recruitment overfishing" can be far more serious and occurs when fishing pressure has reduced the ability of a stock to replenish itself.

Designating a species as overfished

The information needed to clearly determine that a species has been growth overfished is more likely to be available than the information needed to detect recruitment overfishing (in the absence of an obvious stock collapse). Most formal definitions of recruitment overfishing are determined on the basis of an understanding of relative rates of fishing mortality, population growth and population biomass as well as the relationship between spawners and recruitment (e.g. Hilborn and Walters, 1992). Even for the most studied species taken by the OTF information may not be available on all these topics.

Table D4 Definitions of exploitation status of fish stocks.

Exploitation status	Definition
Under fished	The appraisal of a fish stock that suggests that the stock has the potential to sustain catches significantly higher than those currently being taken
Moderately fished (sustainable)	The stock is assessed to be fished at levels which would probably allow only limited increases in catches
Fully fished (sustainable)	The appraisal of a stock which suggests that current catches are sustainable and close to optimum levels (the definition of which may vary between fisheries; e.g. catches are close to maximum sustainable yield, or fishing effort is close to a biological reference point). In a fully fished fishery, significant increases in fishing effort above current levels may lead to overfishing
Overfished (growth/recruitment)	The appraisal suggests that current fishing levels may not be sustainable, and/or yields may be higher in the long term if the fishing level is reduced in the short term. This may be due to recruitment overfishing, growth overfishing and/or as a result of habitat degradation Growth overfishing occurs when individual fish are typically harvested under the size that takes best advantage of the species growth in relation to expected natural mortality. Recruitment overfishing occurs when fishing pressure has reduced the ability of a stock to replenish itself.
Uncertain	There is little or no information about the status of this stock (e.g. no catch data or only very recent catch data)
Unknown	The only information about the status of this stock is long term fishery dependent catch data

Table D5 Exploitation status of primary and key secondary species taken in the Ocean Trawl Fishery.

Primary/ Key Secondary	Species	Exploitation Status
Primary Species	Eastern King Prawn	Over Fished (Growth)
	School Prawn	Over Fished (Growth)
	Royal Red Prawn	Moderately Fished
	Balmain Bug	Fully Fished
	Octopus	Uncertain *
	Cuttlefish	Uncertain *
	Southern Calamari	Unknown
	School Whiting	Fully Fished
	Tiger Flathead	Fully Fished
	Sand Flathead	Fully Fished
	Silver trevally	Over Fished (Growth)
	Fiddler Shark	Uncertain *
Key Secondary Species	Blue Swimmer Crab	Fully Fished
	Squid (mixed species)	Uncertain *
	Gurnard, Latchet	Uncertain *
	John Dory	Fully Fished
	Angel Shark (2 species)	Uncertain *
	Flounder (mixed species)	Uncertain *
	Red Mullet (2 species)	Uncertain *
	Redfish	Over Fished (Growth) #
	Leatherjacket (mixed species)	Uncertain *
	Ocean Perch	Moderately Fished
	Mirror Dory	Fully fished
	Sole (mixed species)	Uncertain *
	Morwong, Rubberlip	Fully Fished
	Moonfish	Unknown
	Boarfish	Unknown
	"Sharks" (mixed species)	Uncertain *

* - Species composition of the catch needs to be determined before any assessment of status can be made.

- Redfish is considered to be 'growth over fished' in the Commonwealth managed SEF - implications for the NSW fishery are unclear, but the large decline in catch since the 1980s suggests a significant impact.

NSW Fisheries will consider advice from fisheries scientists as part of the annual assessment of the status of fish stocks in NSW, or as a result of a review arising from a breach of the catch triggers (see Appendix D6). That advice could result from the findings of monitoring and research conducted by scientists employed by NSW Fisheries, or from other agencies or institutions doing research that is relevant to the assessment of species harvested in NSW. If the species is the subject of a formal stock assessment process, the indication of overfishing is likely to come from having a performance indicator outside acceptable parameters. Other species' status will be reviewed on the basis of the best available biological and catch information.

A stock that has had sufficient fishing mortality to cause a reduction in recruitment requires effective remediation. However, information that clearly demonstrates that a species' recruitment has been impacted by fishing is difficult and expensive to collect, and likely to be rare. Management responses will need to be precautionary and are likely to draw inference from catch and catch composition, rather than from direct measurements of recruitment. For example, rapid declines in catch (especially when the species is targeted in a spawning aggregation), increases in average size or missing year-classes in age compositions are all indicative of potential problems with recruitment.

When new information that is likely to change the present status of a fish species is received by NSW Fisheries, NSW Fisheries scientists will review the status determination for that species against the criteria specified in Table D4 and report on the updated status in the “Status of Fisheries Resources” report. If a species is designated as overfished, a recovery program involving all harvest sectors will be developed.

Appropriate management responses for different types of overfishing

Growth overfishing generally implies the productivity of a stock is sub-optimal due to the harvesting of fish at too young an age. Fish stocks that are growth overfished are not necessarily in danger of imminent collapse and populations can be growth overfished and still be stable. However, growth overfishing may increase the risk to the population of subsequent recruitment failure arising from increased fishing pressure or external factors. The typical and most appropriate response to growth overfishing is to increase the average size at first harvest. This is commonly done by imposing a minimum size limit or increasing an existing one. The efficacy of such a response depends largely on the methods of capture and whether the selectivity of those methods can be appropriately altered to match the new size limit, to prevent the wasteful discarding of large numbers of undersized individuals. Careful thought must be given to changing size limits where there are problems in adjusting the selectivity of the primary fishing methods for that species.

Recovery programs for species suspected of having depressed recruitment due to overfishing must include strong precautionary action. Actions could include (but may not be limited to) temporary fishery closures or caps on either catch or fishing effort. Recovery programs for recruitment overfished species may also include changes to the monitoring program for that species and/or require targeted research to improve the assessment of risk to the species in critical areas.

vii) Species in the fishery determined as being overfished

Eastern king prawn (*Penaeus plebejus*) – growth overfished

Although total NSW commercial catches of eastern king prawns have been relatively stable around 800 to 1100 t per annum for the past two decades, size composition data suggest a significant proportion of the catch (by all fisheries) is comprised of prawns smaller than the optimum size at first capture (Montgomery, 2000). Improvements in trawl net selectivity for eastern king prawns and the adoption of a 'prawn count’ principle (50 per half-kilo), the expansion of the closures protecting juvenile king prawns, the collection of representative size composition data throughout the fishery, the development of a more detailed population model and the application of total effort levels in accordance with the process in the Estuary General and Estuary Prawn Trawl fishery management strategies, will all assist in addressing the 'growth overfished' status of the stock as far as the ocean trawl fishery is concerned.

School prawn (*Metapenaeus macleayi*) – growth overfished

Commercial catches of school prawns are variable, and depend significantly on environmental factors, especially rainfall and resulting river discharge levels. In the past decade the majority of school prawns have been taken from estuaries by the Estuary Prawn Trawl and Estuary General fisheries, while catches from ocean waters have comprised about 20% of the total for NSW. Size composition data suggest that catches of school prawns from some estuaries contain a significant proportion of prawns that are less than the biological optimum size (Montgomery, 2000). A research program aimed at a more detailed assessment of the status of school prawn resources is underway, with results expected by 2007. Changes being pursued by this management strategy to introduce closures to trawling during times of high river discharge, improve cod-end selectivity and utilising a 'prawn count' of 100 per half-kilo to guide gear selectivity changes and closures and should assist in addressing any growth overfishing in the OTF in the interim.

Silver trevally (*Pseudocaranx dentex*) – growth overfished

There has been a significant decline in commercial landings of silver trevally since the 1980s, and a recent study (Rowling and Raines, 2000) concluded that the stock was growth overfished. Significant quantities of silver trevally are landed by the Ocean Trap and Line Fishery, the Estuary General Fishery (prior to Botany Bay becoming a recreational fishing haven) and the Recreational Fishery, however more than 50% of commercial landings are taken by ocean fish trawlers. Significant quantities are also taken in the Commonwealth South East Fishery. A recovery program for silver trevally will therefore be developed under this management strategy. The recovery program will include the imposition of a minimum legal length of 30 cm (total length) for silver trevally in NSW, and changes to the selectivity of fish trawl cod-ends to allow trevally smaller than the minimum legal length to escape from the net.

Redfish (*Centroberyx affinis*) – growth overfished

The majority of the redfish catch (about 1500 t per annum) is taken by fish trawlers operating in the Commonwealth managed South East Fishery, south of Sydney. About 50 t of redfish are caught annually by commercial fisheries under NSW jurisdiction, the majority being taken in the OTF. Redfish in the SEF have been shown to be growth overfished (Rowling, 2000; BRS, 2003). While only a relatively small proportion of the redfish catch is taken by trawlers operating under NSW jurisdiction, it is important that action is taken to identify and ameliorate any growth overfishing in the NSW fishery. The selectivity changes proposed for cod-ends of fish trawl nets should significantly address any growth overfishing of redfish by NSW trawlers. Onboard observer data will be used to assess the effectiveness of the selectivity changes.

Gemfish (*Rexea solandri*) – recruitment overfished

The eastern stock of gemfish underwent a collapse in recruitment in the late 1980s, and the stock has failed to show any significant recovery since the mid 1990s (Rowling and Makin, 2001). Eastern gemfish has been nominated for listing as an endangered species under the EPBC Act, and a decision regarding the nomination is pending. All NSW commercial fishers are currently subject to a 50 kg trip limit for eastern gemfish, to discourage targeted fishing for the species. Current regulations will be reviewed as part of the development of a recovery program for eastern gemfish, which will occur under the Ocean Trap and Line Fishery Management Strategy. NSW ocean trawl fishers will be required to comply with any amended restrictions that might result from the recovery program. If eastern gemfish is listed as a threatened species under the EPBC Act, consideration will need to be given to more conservative management measures, such as precautionary closures to trawling in areas where pre-spawning aggregations of gemfish are likely to be found.

c) Management controls and administration

There are two broad types of fishery management controls, known as input controls and output controls. Input controls limit the amount of effort commercial fishers put into their fishing activities, indirectly controlling the amount of fish caught. They need to continually be modified in response to fishing technology. Input controls can include restrictions on the number of licences, the size and engine capacity of boats, the length and mesh size of nets, and the areas and times that can be worked.

Output controls, on the other hand, directly limit the amount of fish that can be landed and are well suited for single species, high value fisheries using single gear types (Goulstone, 1996).

The OTF in NSW is managed predominantly by input controls. The following section describes in broad terms the diverse range of controls that apply to activities in the fishery. The general rules applying to commercial fishing and the specific rules for this fishery, such as gear specifications, are detailed in the Fisheries Management (General) Regulation 2002. It should be noted that the preceding and following text represents the position at the commencement of the management strategy, however, some of these provisions will change as the strategy is progressively implemented.

i) Limited entry

The OTF is moving towards a category 1 share management fishery. Access to the fishery has been limited to eligible fishers since the restricted fishery regime commenced on 1 March 1997.

ii) Commercial fishing licences

A commercial fishing licence is required by an individual before they can take fish for sale or be in possession of commercial fishing gear in or adjacent to waters. The licence only authorises activities that are covered by the endorsements, issued in respect of each part of the fishery and specified on the licence. Conditions may be placed on licences in order to restrict fishers' commercial activities where required.

Commercial fishing licences are currently available to:

- persons who held a licence immediately prior to the commencement of the Fisheries Management Act 1994
- owners of a recognised fishing operation (RFO) which includes a business that holds an offshore prawn trawl endorsement or contains a minimum level of validated catch history
- in the case of an offshore prawn trawler, the skipper of the vessel or the nominated fisher of an RFO, or
- individuals who are the holder of shares in a share management fishery.

This last provision will become the more relevant requirement as the OTF moves toward full implementation of category 1 share management.

Fishing endorsements

It is important to identify the difference between endorsements and entitlements in the fishery and how they relate to commercial fishing licences.

Entitlements in the fishery are associated with fishing businesses, while endorsements appear on commercial fishing licences of individuals and authorise the use of specific gear or taking of certain species. Some fishing businesses can be owned and held in the names of more than one individual (including company or partnership names) and therefore, an entitlement associated with a business may entitle more than one person's licence to be endorsed to operate in the fishery. However, in the ocean trawl fisheries, only one person can be nominated to hold the primary endorsement in respect of a fishing business - other licensed fishers may hold separate endorsements in the form of a skipper's endorsement.

In the case of the offshore prawn trawl endorsement, in addition to the operator of the vessel holding a commercial fishing licence with an offshore prawn trawl endorsement, the boat also needs to be endorsed for the offshore prawn trawl fishery. This rule supports the unitisation scheme applying to the offshore prawn trawl sector and will apply to all other boats in the OTF as the unitisation scheme is extended to the other sectors within the fishery.

Five classes of endorsement will exist in the fishery at the commencement of the management strategy. Table D2 lists the endorsement types and the gear able to be used by virtue of holding each endorsement type.

The eligibility to hold endorsements on a commercial fishing licence in a share management fishery is based on the shareholder holding the minimum number of shares specified in the share management plan for the fishery. Separate minimum shareholdings may apply to each endorsement.

Minimum shareholdings can be an effective way of managing fishing effort in the OTF. Shares could be linked to endorsement numbers or more direct effort controls (eg. days/nights fished, amount of net able to be towed, etc) in the share management plan. If linked to endorsement numbers, the restructuring would normally occur over a longer time period and alternative effort controls would need to be used to address short term effort issues. If a direct link is made between shares and fishing effort, a minimum shareholding requirement would be an effective tool to control fishing effort in the short term. In either case, minimum shareholdings is a tool that can be used to reduce total fishing effort in the OTF as anticipated by management response 5.2(a).

Nomination policy

Part of the introduction of the restricted fishery regime was the creation of rules to allow the endorsements of a fishing business to be nominated to a person. This was necessary due to fishing businesses being held in company or partnership names, and because fishing licences can only be issued to natural persons.

This management strategy adopts a new approach to the issuing of endorsements that will reduce administration and associated costs and make it easier for business owners to obtain skippers at short notice. It involves issuing a ‘fishing business card’ in respect of each fishing business that details the endorsements that may be activated by the licensed fisher in possession of the card. This program will replace the current endorsement nomination and skipper policies.

iii) Fishing boat licensing

In addition to each fisher having to be licensed, every fishing boat used in connection with the OTF must also be licensed. There has been a cap on the total number of general boat licences since 1984 (includes boats used in all fisheries) and this restriction will remain under the management strategy.

Boats that may be used in the offshore sector of the prawn trawl fishery have been restricted since 1985. These boats are recognised by an OP1 endorsement that appears on the boat licence and strict boat replacement rules apply (i.e. the unitisation scheme). These boats are subject to one of four different boat licence conditions (P1, P2, P3 and P4) that establish the waters the boat may work, whether access to the offshore sector of the prawn trawl fishery is transferable with the licence (refer to sections 6b(v) and 6b(viii) in Chapter B) and if the boat may be upgraded:

P1 - the boat may be upgraded and the offshore prawn trawl entitlement is ‘transferable’

P2 - the boat cannot be upgraded, but the offshore prawn trawl entitlement is ‘transferable’

P3 - the boat cannot be upgraded, and the offshore prawn trawl entitlement is not ‘transferable’

P4 - the boat is restricted to operating in offshore waters north of Cape Byron, cannot be upgraded and the offshore prawn trawl entitlement is 'transferable' subject to the parallel transfer of the Queensland fishing entitlement allocated to the boat.

The process of restricting hull capacity, engine power and net length in the offshore prawn trawl fishery is known as 'unitisation' because the allowable hull capacity, engine power and net length for each boat is expressed in terms of 'units'. Engine units and net units can be increased (i.e. upgraded) by amalgamating two or more boat licences with a P1 condition. This is one of the programs used to restructure the number of boats operating in the fishery.

All other ocean trawlers (i.e. those not endorsed for offshore prawn trawling) are currently subject to boat length restrictions. Engine power has not historically been restricted in these sectors of the industry. These boats have recently been 'unitised' and will become subject to the same vessel capacity restrictions as the boats endorsed for offshore prawn trawling as part of the implementation of the management strategy (see management response 5.2a and Appendix B1.2). The current boat capacity and net length restrictions are further explained below.

Hull size

In the offshore prawn trawl sector the hull capacity of a replacement boat must not exceed the hull capacity of the replaced boat. Hull capacity is defined in terms of 'hull units', which are calculated using the following formula;

Hull units = length x depth x beam x 0.6 / 2.83.

A maximum length of 20 m also applies. For consistency, the dimensions of a boat must be specified in a survey and are determined using the Uniform Shipping Laws Code method for measuring boats. Hull units cannot be amalgamated for the purpose of increasing hull capacity.

Engine controls

In the offshore prawn trawl sector a fisher must request approval from the Director of Fisheries before replacing the engine in a trawler. The power rating of a replacement engine, or the engine in a replacement boat, must not exceed the engine units allocated to the licence. A 10% tolerance applies in some instances. For consistency, the continuous brake kilowatt power rating published by the manufacturer and endorsed by NSW Fisheries is used when assessing applications for engine replacement (for a given engine, the number of engine units is equal to the manufacturer's published power rating in Kw). All boats used in the OTF will become subject to the same controls on replacement as part of the implementation of the management strategy.

Nets

Trawl nets do not need to be registered and a detailed description of the net types is provided in section 4a(iv). To limit fishing effort on prawn stocks the headrope length of prawn trawl nets is restricted to 33 meters, unless otherwise specified on the boat's licence. Limiting the headrope length restricts the size of the net that can be used, indirectly limiting the area of sea floor that can be covered during each trawl shot. Boats endorsed for the offshore prawn trawl sector have the allowable headrope length recorded on the boat's licence. Headrope lengths in this sector of the fishery range from 33 metres to a maximum of 60 metres. Following the transfer or amalgamation of a boat licence, or upon replacing a boat or its engine, the maximum allowable headrope length for the boat is reduced to 55 metres.

Net units (i.e. net length) in the offshore prawn trawl sector are based on the 'Total Units' of the boat, using the following method:

Total Units = Engine Units + Hull Units

For each ‘total unit’ up to 100, 0.275 net units are allocated,

then 0.183 net units are added for each total unit between 101 and 200,

and 0.092 net units are added for each total unit over 200.

1 net unit equates to 1 metre of headrope length allowed for the trawl net.

In other sectors of the prawn trawl fishery the maximum headrope length is 33 metres, but this will change for each boat as the process of unitisation is implemented in these sectors of the fishery. The headrope length of fish trawl nets is currently not restricted, however this management strategy proposes the introduction of a maximum headrope length of 60 metres in respect of fish trawl nets.

Sweeps are used to herd fish into the path of a trawl net. Sweeps on prawn trawl nets are restricted to a maximum of 5 metres, or the distance between the trawl gallows and the stern of the boat, whichever is the greater. The length of sweeps on fish trawl and Danish seine nets is not regulated, however the size of the trawl gear able to be towed effectively by a trawler is dependent on the size and horsepower of the vessel, factors which will be regulated for all trawlers under the management strategy.

iv) Renewal of licences

Commercial fishing licences and fishing boat licences must currently be renewed annually. Fishers are sent renewal application forms approximately one month before the expiry date on the licence. If a commercial fishing licence is not renewed within 60 days of the expiry date on the licence, the renewal application is taken to be an application for a new licence. Additional fees apply to late renewal applications.

Abeyance period for fishing boat licences

Fishing boat licences can be held in abeyance for a period of up to two years from the date of expiry of the licence or when advised in writing by the owner. Fishing boat licence fees are not payable during the period of abeyance, but the full amount due is payable if the licence is reinstated within the two years specified. The share management plan may remove the requirement to place fishing boat licences endorsed in the OTF into abeyance.

v) Transfer policies

Transfer of licensed fishing boats

Boats used in the ocean trawl fisheries are classed as “boat history” vessels, which cannot be transferred separately to the fishing business. The Licensing Branch at NSW Fisheries can advise a fishing boat owner whether a boat has been classed as a ‘boat history’ or general purpose vessel. Any transfer of a fishing boat licence must first be approved by the Director-General of NSW Fisheries.

Transfer of fishing business entitlements

Commercial fishing licences and endorsements to participate in a fishery are not freely transferable. Currently, commercial fishing licences and endorsements only become available to a new entrant if they acquire a fishing business with the required level of validated catch history or particular fishing entitlements.

Offshore prawn trawl endorsements are transferable if the boat licence associated with the business has a P1, P2 or P4 entitlement. Offshore prawn trawl endorsements associated with P3 prawn trawlers are non-transferable. Other ocean trawl endorsements are only available to a new owner of the fishing business if the business has at least $30,000 worth of validated catch history in any two years between 1986 and 1990 and in one year between 1991 and 1993.

In addition to acquiring a RFO in order to be eligible for a commercial fishing licence, Table B1.10 in Chapter B outlines the criteria that apply to transfers of fishing business entitlements relevant to trawling in ocean waters off NSW. A restrictive transfer policy is necessary to prevent endorsements that were granted under a low entry criteria from being issued to new owners of fishing businesses and utilised at much higher levels of fishing effort.

Under the current Licensing Policy, fishing businesses must be sold as an entire package (i.e. the catch history, boat history vessels and/or endorsements associated with boats cannot be split). Proposals regarded as licence splitting, or contrary to the intention of the Licensing Policy are not approved.

Under the management strategy, transfer arrangements will be specified by the share management provisions of the share management plan.

National licence splitting policy

The Commonwealth and State Governments have a long-standing nationally agreed policy in place on "licence splitting". The policy seeks to prevent entitlements held by one person or entity, and issued by more than one jurisdiction, from being split and transferred separately. In NSW the transfer of a fishing business is not approved unless all entitlements issued to the business by other jurisdictions are also transferred to the same person or surrendered, unless the separate transfers have been approved by all agencies involved.

Where fishing effort has been historically ‘shared’ across a number of entitlements held by a person, the National licence splitting policy seeks to prevent any increase in effort in each of the respective fisheries that might occur following the splitting of the entitlements. A closure came into force on 8 August 2003 to provide a specific basis on which NSW fishing activities can be prohibited if the licence splitting policy is breached.

Specific guidelines have been developed that provide for the transfer of Queensland fishing entitlements (including ‘nights’) separate to NSW fishing entitlements in some situations. These guidelines allow for the transfer of up to 20% of the nights originally allocated to the Queensland licence, or the transfer of all nights and entitlements if the boats original allocation was less than 30 nights.

vi) Appeals mechanisms

Fishers may lodge an appeal to the Administrative Decisions Tribunal (ADT) against a decision to refuse to issue or renew, suspend, cancel or place conditions on a commercial fishing licence (or an endorsement on that licence) or a fishing boat licence.

The main role of the ADT is to review administrative decisions of New South Wales government agencies. To lodge an appeal with the ADT, a request must first be made to NSW Fisheries for an internal review of the decision, then a written application should be lodged with the ADT no more than 28 days after the internal review is finalised.

The ADT can make various orders concerning an appeal application including:

- upholding the original decision
- reversing the decision completely or in part
- substituting a new decision for the original decision
- ordering the agency to reconsider the decision in light of the ruling.

For further information, refer to the Administrative Decisions Tribunal Act 1997 or the following website: http://www.lawlink.nsw.gov.au.

vii) Special arrangements for skippers

The introduction of the restricted fishery required the creation of rules to allow skippers to continue operating in the industry as employees. To acquire this type of skipper endorsement the person must have skippered another person's boat in the fishery immediately before it became a restricted fishery (i.e. during 1996).

Because only one person may be nominated to hold the endorsements in respect of a fishing business, new rules were introduced so that part owners of a fishing business could continue to work in the industry. To acquire this type of skipper endorsement the person must have owned a business in partnership and held an unrestricted commercial fishing licence in 1996.

There is a third provision that allows for 'conditional' skipper endorsements to be issued in respect of the offshore sector of the ocean prawn trawl fishery. To acquire conditional skipper endorsements the person must be employed to skipper an offshore prawn trawler (P1, P2 and P4 only) and the owner must agree to surrender any entitlements to the Estuary General Fishery and Ocean Hauling Fishery while the skipper is employed.

Under the management strategy new arrangements will be developed for ensuring a minimum level of qualifications for skippers in the fishery (see management response 6.1d) and for a 'fishing business card' system (management response 6.3a) to allow alternative skippers to operate a fishing vessel.

viii) Provisions for unlicensed crew

The holder of a commercial fishing licence or fishing boat licence endorsed for the OTF may apply for an authorisation to employ unlicensed crew (commonly referred to as a "block licence") or may employ a person who is registered with NSW Fisheries themselves as crew.

A licensed fisher employing crew must maintain records about her/his crew. Information relating to crew must be recorded on the mandatory catch and effort returns submitted by the licence holder.

ix) Code of conduct

Fish trawl operators who are also endorsed in the Commonwealth managed South East Trawl Fishery abide by an "Industry Code of Conduct for Responsible Fishing in the South East Trawl Fishery". Copies of this code of conduct are available from the South East Trawl Fishing Industry Association (email: trawline@tassie.net.au). This strategy promotes the development of a code of conduct for all trawl operators, to encourage responsible fishing practices (see management response 1.2.d).

x) Time and area closures

The FM Act provides for the use of fishing closures in the OTF to, among other things:

- protect and conserve areas of key habitat
- manage the amount of fishing effort in an area/region
- manage conflicts between stakeholders over the use of the resource and to ensure it is equitably shared
- minimise bycatch and the impacts of the fishery on threatened and protected species.

Fishing closures can be established on a seasonal, time, area, operator or gear specific basis. Fishing closures are required to be published in the NSW Government Gazette, however, if the Minister for Fisheries considers that a fishing closure is required urgently, the Minister may introduce the closure and advise the public through media outlets and by displaying prominent signs in areas adjacent to the waters affected. In the case of an urgent closure, the Minister is to publish the closure in the Government Gazette as soon as practicable.

Table B1.11 in Chapter B lists closures currently in place that limit fishing in the prawn trawl sector of the fishery. Closures impacting on the fish trawl sector currently include the closure to fish trawling of all waters north of Smoky Cape (approx. 31°S latitude) and a closure to trawling in waters between Red Pt and Windang Island, off Lake Illawarra. All forms of trawling are excluded from areas declared as 'sanctuary' and habitat protection' zones in marine parks and grey nurse critical habitat areas. This strategy promotes the identification and mapping of habitat types in NSW ocean waters, with the intention of restricting trawling to soft sediment habitats, and implementing trawl closures in areas with hard bottom where more biologically diverse faunas are generally found.

Details on up-to-date fishing closures that apply to the OTF can be found on the NSW Fisheries' website at: www.fisheries.nsw.gov.au

xi) Zoning

The five endorsements relevant to trawling in NSW ocean waters establish not only the methods that may be used, but also the area in which fishing may be conducted under that endorsement. The following summarises the fishing 'zones' for each endorsement type:

1. Ocean Prawn Trawl (Inshore) – waters between the coastal baseline and 3 nautical miles to sea, from the Queensland border in the north to the Victorian border in the south.

2. Ocean Prawn Trawl (Offshore) – waters between 3 nautical miles and the 4000 metre depth contour (approximately 80 nautical miles to sea), from the Queensland border in the north to a line drawn due east from Barrenjoey Point (Sydney) in the south. Offshore prawn trawlers with a P4 boat licence condition are restricted to waters north of a line drawn due east of Cape Byron, Byron Bay.

3. Ocean Prawn Trawl (Deepwater) - waters between 3 nautical miles and the 4000 metre depth contour (approximately 80 nautical miles to sea) from the Queensland border in the north to a line drawn due east from Barrenjoey Point (Sydney) in the south (for particular species only).

4. Ocean Fish Trawl (North) – waters between the coastal baseline and the 4000 metre depth contour (approximately 80 nautical miles to sea), from a line drawn due east of Smoky Cape (South West Rocks) in the north to a line drawn due east of Barrenjoey Point (Sydney) in the south.

5. Ocean Fish Trawl (South) – waters between the coastal baseline and 3 nautical miles to sea, from a line drawn due east of Barrenjoey Point (Sydney) in the north to the Victorian border in the south.

xii) Permits

Section 37 of the *Fisheries Management Act 1994* allows for permits to be issued for research or other authorised purposes. These permits provide a legal framework for activities that fall outside the normal operating rules set out in the Act or its Regulation. Each permit sets out a number of conditions, which vary depending on the purpose of the permit. These conditions ensure that permits are used only for the purpose intended, and are often used to limit the extent of the permitted activity.

Permits issued under section 37 of the *Fisheries Management Act 1994* are only valid insofar as they do not conflict with approved determinations of native title made under the Commonwealth Native Title Act 1993. Permits are valid for the period specified on the permit, and may be suspended or cancelled at any time by the Minister for Fisheries. Permits are not transferable.

xiii) Catch limits or quotas

"Trip limits" apply to some species taken by trawl fishers in NSW ocean waters that are managed by way of Total Allowable Catch Quotas in the Commonwealth South East Fishery (see Table B1.14 in Chapter B). Details of up-to-date trip limits applying to the OTF can be found on the NSW Fisheries' website at: www.fisheries.nsw.gov.au

xiv) Seafood safety programs

Food safety programs which relate to the ocean trawl fisheries are administered by SafeFood Production NSW under the *Food Act 1989*. Food safety programs for all commercial fisheries are currently being prepared by Safe Food Production NSW and will be supported under the management strategy (see management response 5.5a).

xv) Cost recovery policy

NSW Fisheries recoups some of the costs that are attributable to industry through a cost recovery policy. Cost recovery is a common principle among Australian commercial fisheries and an important component of ecologically sustainable development.

NSW Fisheries is in the process of implementing cost recovery in a progressive manner, so that all charges are not passed on to industry immediately. In November 2000, the Government announced a new cost recovery policy. Over the next five years the Government will develop and implement a cost recovery framework for category 2 share management fisheries. This framework will be subject to extensive industry consultation. During this period, the total amount of money collected for NSW Fisheries, for its existing management services, will not increase without the support of the relevant management advisory committee. After five years, the costs that have been identified as attributable to the industry will be progressively introduced over a further three-year period.

It is important to note that new services required to be implemented under the management strategy as a result of the environmental assessment process will need to be fully funded by the fishery participants.

As stated in the "Vision for the NSW Seafood Industry" a cost recovery framework will be finalised in consultation with industry by 2005.

A range of regulatory and administrative fees are payable by fishing business owners in the OTF. The management strategy does not, in itself, set the charges, or limit or otherwise govern the way fees are charged.

d) Compliance

NSW Fisheries has approximately 90 fisheries officers responsible for coordinating and implementing compliance strategies in NSW. These strategies include:

- maximising voluntary compliance
- providing effective deterrence for offences
- providing effective support services.

Approximately 65 of these fisheries officers are located in areas along the NSW coast where trawlers fish in ocean waters. Their general duties include conducting patrols, inspecting commercial fishers and fishing gear, and recording rates of compliance.

A compliance strategic plan is to be developed that will provide the direction for education, advisory and enforcement services provided by NSW Fisheries for the OTF (see management strategy response 6.1.a in section 3 of this management strategy). To ensure that compliance service is delivered in a consistent manner, quality inspection guidelines are being developed. These guidelines will set out a procedural approach to be adopted when undertaking inspections of fishers and fishing gear in the OTF. The quality inspection guidelines will ensure that all issues requiring compliance by commercial fishers under this management strategy are subject to a compliance program.

A penalty points system

A penalty points scheme linked to endorsement suspension and share forfeiture provisions will be introduced under the management strategy and developed as a regulation or as part of a share management plan for the OTF (see management response 6.1c in section 3 of this management strategy).

The OTF generally has a high compliance rate, however, despite the relatively large number of potential offences and the maximum penalties specified in the FM Act and Regulation, there may still be a small number of fishers who regularly operate beyond the rules. The penalty points system will provide a clear deterrent to fishers who are considering breaching the provisions of the management strategy or associated rules, as well as guiding the courts with a regulated management plan that reflects the serious nature of some fisheries offences.

Similar to the motor vehicle licence demerit points scheme (administered by the Roads and Traffic Authority), the system will provide for a list of penalty points assigned to the more serious offences. If a fisher accrues a certain level of penalty points by breaching the rules applying to the fishery, the endorsement or fishing right will be subject to predetermined periods of suspension or cancellation. The points attributable to each offence will need to be included in the share management plan, as will the threshold levels for endorsement suspension and share forfeiture.

e) Research

NSW Fisheries has developed a strategic research plan covering priorities across all fisheries which is responsive and takes account of the research requirements identified under each fishery management strategy.

i) Proposed research areas

Research necessary for the OTF can be categorised into six broad topics:

- stock assessment of primary and key secondary species

- quantification and reduction of 'bycatch'
- the impact of trawling on key secondary species, especially elasmobranchs
- the economic viability of trawl fishing and flow-on effects to the community
- effects of trawling on ocean ecosystems (including habitat and trophic interactions) and the effectiveness of management measures in addressing these impacts, and
- interactions of trawling with threatened species.

The first three topics above are considered to be the highest priority for research relevant to the ecological sustainability of the OTF, while research on the economics of the fishery is important to provide better information on fishing business viability that can be taken into consideration in future management of the fishery. The impact of trawling on ocean ecosystems represents a very broad area for research, which will require significant resources and a long-term approach. The available data and anecdotal evidence suggests that trawling in ocean waters off NSW has a low level of impact on threatened species, with the priority at present being to obtain more accurate information about the level of interaction, rather than undertake research projects on the impacts (it is likely that threatened species recovery plans will specify any research to be undertaken in this area).

Outlined below are those strategies by which research into these priority areas should proceed.

Stock assessment of primary species

The twelve species (or species groups) that have been identified as 'primary' species for the OTF include some species for which considerable information is available regarding the status of the stock, a number of species for which there is some information regarding stock status, and some 'species groups' where there is a requirement to determine the species composition of trawl catches with more accuracy before any assessment of stock status can be developed.

A number of the primary fish species taken in the OTF are also landed by trawlers working in the Commonwealth South East Fishery, which has a dedicated fishery assessment group process (see Smith and Wayte, 2002). Stock assessments with varying degrees of detail have been undertaken as part of this process for tiger flathead, school whiting, silver trevally and royal red prawns (however, with the exception of silver trevally, none of these species had a full stock assessment available in 2003). Significant work has been done in both NSW and Queensland towards developing assessment models for eastern king prawns (Gordon et al., 1995; Courtney, 1997) however there is considerable work still to be done to combine these assessments to cover the full range of the stock.

Other primary species for which there is some information that could be used in an assessment of the status of the stocks in NSW include Balmain bugs, southern calamari, school prawns, sand flathead and school whiting. For these species there is a need to collect and analyse appropriate information from NSW fisheries, to review available information on the species from other jurisdictions, and to develop preliminary stock assessments that will specify what further research or monitoring is required to improve the quality of future assessments.

For fiddler shark, octopus and cuttlefish the species composition of trawl catches needs to be determined, and relevant biological data collected, before any assessment of the status of the stocks can be attempted. This can be achieved through a combination of onboard observer studies and market sampling, and is a necessary first step in defining those species which will require the development of more detailed stock assessments under this fishery management strategy, and what biological data and fishery monitoring is required to support those assessments.

Priority ranking for assessment of primary species in the Ocean Trawl Fishery.

1. **Eastern king prawn.** By far the most economically important species to the OTF. The high price per kg will encourage targeting even at low abundance levels. Very significant landings of mature prawns are made by trawlers off southern Queensland, and there are significant commercial and recreational landings of immature prawns from many NSW estuaries. Existing population models need to be updated and extended across jurisdictions and to all sectors which exploit the species.

2. **School prawn.** Stock probably comprises a number of discrete populations, but very limited biological information is available. Very significant commercial landings of small prawns are made in some estuaries. Catches of larger prawns from ocean waters have declined markedly since 1980s. Currently the subject of a 4-year FRDC-funded research program.

3. **School whiting.** The most valuable finfish species in the OTF, with recent catches exceeding 1000t per annum. Includes both red spot and stout whiting (2 similar species), with limited biological data available. Specific gear is being developed under this strategy for targeting school whiting. Close monitoring and assessment of stock status is needed to evaluate the effects of gear change.

4. **Fiddler shark.** The bulk of the catch is shovel-nosed shark, but banjo shark are also included. A large elasmobranch with limited fecundity, the relatively high landings and a lack of relevant monitoring and biological data increase the priority to assess the status of the shovel-nosed shark resource.

5. **Sand flathead.** Very important inshore flathead species caught almost entirely off NSW, with a significant recreational catch. A poorly studied species with limited information about the species' biology and some sporadic monitoring data - therefore a moderate priority for assessment.

6. **Balmain bug.** Economically important, relatively long-lived crustaceans. Two significant species (not distinguished by fishers) caught almost entirely by trawling. Limited information is available about the species' biology, and there is minimal monitoring data available. Recent decline in catch preceded the imposition of a minimum legal size of 100 mm carapace width.

7. **Royal red prawn.** A significant deepwater prawn species sometimes taken in large catches. Targeting can be influenced by market demand. Also taken in the Commonwealth south-east trawl fishery where catches are generally well below the TAC. Research suggests that grounds north of Sydney may contain a large proportion of the mature population. A relatively long-lived (3+ yrs) prawn species.

8. **Tiger flathead.** A relatively deepwater flathead, and a major species in the Commonwealth south-east trawl fishery, south of Sydney. Limited biological and monitoring data are available from NSW catches. The stock has been overfished before and therefore it is important to assess the current level of utilisation by NSW trawlers.

9. **Octopus.** At least ten species of octopus are taken in trawl nets off NSW, although data from research vessel catches suggest landings may be dominated by a smaller number of species. No monitoring data are available for this group, except total catch of 'octopus', which is relatively stable at around 500 tonnes per annum. The biology of most species is poorly

known. A better description of catch-by-species is required before any assessment can be contemplated.

10. **Cuttlefish.** Again a number of species are known to occur in trawl catches off NSW, but a quantitative estimate of the species composition of the commercial catch is not available. Cuttlefish are thought to be short-lived (1-2 years maximum). Reported landings in NSW have declined since 1994/95.
11. **Southern calamari.** A widely dispersed and quick growing species (maximum age less than 18 months), which occurs in very shallow inshore waters as well as on deeper trawl grounds. Calamari is an important species in the Newcastle/Port Stephens area, where it is a significant component of trawl catches. The species has been much studied off southern Australia, however few monitoring or biological data are available for NSW.
12. **Silver trevally.** An assessment of the status of the silver trevally stock has previously been completed (Rowling and Raines, 2000), and responses in this management strategy will address the 'growth overfished' status of the stock. The effectiveness of the recovery program needs to be closely monitored, but the results will take some time to become apparent in the population structure and there is no immediate need to update the stock assessment for silver trevally.

Quantification and reduction of bycatch

One of the major concerns about the operation of demersal trawl nets is the fact that the net may catch a large number of non-target organisms, which are then returned to the water with unknown survival rates. Significant research has been undertaken to develop methods to minimise the quantities of bycatch taken by nets used in this fishery and, based on the results of this research, this strategy promotes additional modification of trawl nets to further reduce bycatch. It is important that the results of bycatch reducing modifications be monitored, and this can only be effectively done by onboard observers. Research is continuing into more effective bycatch reduction using trawl net modifications (e.g. square-meshed cod-ends for prawn trawl nets), and as more effective means are developed, they will be introduced to the fishery. It is also important that the spatial and temporal distribution and abundance of bycatch be documented by onboard observers, to assist in identifying strategies for minimising bycatch of fish trawling, where the use of bycatch reducing gear modifications is more problematic. There will therefore be an ongoing need for onboard observer presence in this fishery, to gauge the effectiveness of bycatch reduction modifications and strategies in commercial operations.

The impact of trawling on key secondary species

Of the 'key secondary' fish species taken in the OTF, redfish, john dory, mirror dory, ocean perch and some shark species are managed by a system of Total Allowable Catches in the Commonwealth SEF, and have at least rudimentary stock assessments carried out on an annual basis (Smith and Wayte, 2002). However, with the exception of redfish and gummy and school sharks, none of these species could be said to have an adequate stock assessment available in 2003. Many of the remaining key secondary fish species are also taken in varying quantities by trawlers fishing in the SEF, however as they are not managed by Total Allowable Catches, little in the way of monitoring or stock assessment has been undertaken for these species. For a number of these species (e.g. Angel sharks, red mullet and moonfish), trawling is the only fishing method that takes significant quantities, so it is important to effectively monitor the impact of the trawl fishery on these resources as part of this management strategy. The catches of some other key secondary species groups (e.g. squid and "sharks") comprise a number of species, some of which are taken by other fisheries, so initially it is important to identify and quantify the species mix taken by trawling, before the impact of trawling can be assessed on the individual species. Specific attention will be paid to the "sharks" to accurately describe the species taken by trawling, and collect important biological data on the sex ratio, size at maturity and fecundity of the important species.

The correct identification and reporting by fishers of all the key secondary species will be a high priority, as will the collection of representative size composition data of the catch of each species, by both onboard observers and shore-based monitoring programs.

Economic research

To address the economic objectives of the management strategy, research will be needed to assess the economic viability of businesses endorsed in the OTF, and to quantify the flow-on effects from trawling activities to the economies of coastal communities.

Previous studies of the economic viability of trawl operators relied on the results of a survey of a sample of businesses for the 1999/2000 financial year (Roy Morgan, 2001). As the financial situation of fishers is likely to have changed, a further survey is required to provide updated information. Additional information should also be collected on variations in prices according to the type of 'fish receiver' or market chosen by fishers through which to sell their product.

Currently, there are only limited data available on the flow-on (or multiplier) effects from the trawl fishery, which includes not only the direct employment, income and expenditure generated by participants in the fishery, but also those benefits indirectly generated as a result of inputs and other ancillary services provided to the trawl fishing fleet. Study of flow-on effects should be undertaken at the regional level and would ideally be linked with regional economic assessments.

Impacts of trawling on ocean ecosystems (including habitat and trophic interactions) and the effectiveness of management measures in addressing these impacts

The structure and functioning of ocean ecosystems and the myriad of ecological processes that occur in them, underpin the sustainability of the fisheries that depend on the fish, crustacean and mollusc resources of NSW ocean waters. Research on Australian and overseas trawl fisheries has shown that demersal trawling has the potential to significantly modify some ocean habitats (Sainsbury et al., 1993; Kaiser and de Groot, 2000). However, similar research has not been done off the NSW coast, and accurate descriptions of the distribution of various habitat types are not currently available for NSW ocean waters. Initially, this strategy aims to accurately map trawl grounds and to gather information on habitat types on and near these grounds. Information on the frequency of trawling on individual grounds will also be collected (recorded on a daily basis on a re-designed fisher catch and effort return form). A number of research projects studying the effects of trawling on ocean habitats are currently underway in Australia (FRDC Projects 2002/102 and 2003/023). The results of these and previous research will be discussed with the OT MAC with a view to implementing trawl gear designs that minimise impacts on ocean habitats, and/or closing areas with sensitive habitats to trawling.

Little directed research has been done anywhere to assess the impacts that fishing has on the structure of oceanic ecosystems, although a number of recent reviews which assembled data from many diverse studies suggest that the impacts of fishing may be severe (Jennings and Kaiser, 1998; Hall, 1999; Myers and Worm, 2003; Christensen et al., 2003). There is a need to develop biodiversity indicators for the ecological system in which the OTF operates. Research to provide such indicators will likely be long-term, and will need to draw on a variety of expertise and knowledge. This management strategy promotes initiatives in research and monitoring that will significantly improve the working knowledge of the fishery in its environment. These initiatives, such as the mapping of trawl grounds and associated habitats, improvements in the accuracy of catch returns, the quantification of discards by the observer program and doing fishery-independent surveys, could provide a basis for future studies aimed at developing appropriate indicators for monitoring biodiversity. NSW Fisheries has also recently commenced research, in collaboration with the University of British Columbia, that will use trophodynamic ecosystem modelling to describe ecosystem interactions in NSW marine waters.

This strategy aims to establish a series of closures to trawling to protect a representative range of ocean habitats and their associated biota, in addition to those that are already protected within the boundaries of Marine Parks or permanent trawl closures. Included in this approach will be the closure of areas with 'hard' bottom habitats, which are at risk of being permanently modified by the effects of trawling. In the longer term, closures to trawling may be implemented to provide 'refuge' areas for species targeted by trawling as scientific information becomes available - these areas could include specific closures to protect habitats considered to be critical to the survival of any life-history stage of species taken by trawling. Research projects could be conducted to evaluate the effectiveness of these closures with respect to the aims of conserving biodiversity, reducing the impact of trawling on ocean ecosystems and providing refuge areas for species taken by trawling. Specific research funding would be required over an extended period to undertake such studies.

Impact of fishing on threatened species

Little is known about the biology and ecology of many of the species listed as threatened, and the potential impacts of commercial trawling on these species are also poorly understood. This strategy seeks to improve the accuracy of information available on interactions between the OTF and threatened species. The Recovery Plans that are required to be prepared for each relevant threatened species should drive research on such issues, and determine specific projects to be targeted at the species of concern. Such studies would involve examining the biology and ecology of threatened species to assess the potential impact of a variety of threats, including trawling. A project assessing the broad-scale interactions between fishing and marine mammals, reptiles and avifauna in NSW marine waters commenced recently. This project will identify specific issues and research needed to address any significant interactions between ocean trawling and threatened species. Based on the outcomes of this project, further funding will be sought to conduct the necessary research.

ii) The Conservation Technology Unit

In March 2001 NSW Fisheries established a Conservation Technology Unit to examine conservation-based gear technology in commercial and recreational fisheries. This focussed research initiative will help address gaps in knowledge including the selectivity of trawl gear used in the OTF. The research will also assist in identifying the most appropriate gear to be used in the fishery and ensure that future changes to gear regulations can be based on accurate scientific information. The development of new and innovative fishing techniques will help minimise unwanted catches, discarding and impacts on the environment.

iii) Catch monitoring

Fishers in the OTF will continue to be required to submit records on a monthly basis detailing their catch and fishing effort, however it is intended that recording of fishing activities and catches be done on a daily basis. The information required will include the general location or fishing ground worked, the catch for each species, and the effort expended (i.e. hours trawled) for each gear type to take the catch. This information will continue to be entered onto a database by NSW Fisheries, to allow for analysis of fishing activity, catch and effort levels. The entry of catch return information onto the database will be subject to stringent control procedures including deadlines for data entry following the receipt of a catch return by NSW Fisheries. A policy will be developed to manage the timely receipt and entry of commercial catch return data into the commercial catch records database, and the provision of these data for analysis as part of the fishery review process. A number of initiatives are contained in this strategy to improve the quality and reliability of the information provided by ocean trawl fishers on catch returns.

To maximise the accuracy of the data collected on monthly catch returns a range of quality-control procedures are currently in place or scheduled for implementation in the near future. A brief synopsis of these quality control procedures is provided here:

- Every return is scanned for errors when received by the “Commercial Catch Records” section in NSW Fisheries, and suspected omissions or errors are queried with fishers (by phone and/or written correspondence) and corrected if necessary
- Logical checks of data accuracy (range, consistency and validity checks) are performed automatically by computer during data-entry. Likely errors are queried with fishers (by phone and/or written correspondence) and corrected if necessary
- Data from the commercial catch statistic database “FINS” is regularly downloaded to a database “COMCATCH”, which can be accessed or queried by scientific staff and managers responsible for individual fisheries. Subsequently, any problems with data identified by these officers are queried and may be corrected by the commercial catch records section after consulting fishers where necessary
- A previous pilot survey was undertaken to assess the accuracy of data entry with respect to the catch records. The results showed that data-entry errors by staff were of minimal significance. Errors were rare and generally concerned minor species. It is planned to repeat this survey to provide ongoing monitoring of the quality and accuracy of data entry
- Following implementation of routine reporting of the quantities of fish handled by registered fish receivers in NSW, it will be possible to compare the quantity of catch (by species) reported by fishers on catch returns with the quantity handled by fish receivers in NSW. This will provide a cross-validation of weights of individual species caught and handled in NSW
- The information collected on catch returns and options for improving the catch return forms (and increasing the reliability of data) will be reviewed periodically by the management advisory councils and annually by the “Catch and Effort Working Group” which comprises industry representatives from each fishery.

All existing and proposed procedures attempt to maximise data quality. It is, however, inevitable that the accuracy of data supplied by fishers cannot be directly verified and has sometimes been variable, particularly with respect to fishing effort data. Consequently, the commercial catch statistics supplied by fishers and maintained in the commercial catch records database are most accurately described as representing “reported landed catch”.

f) Consultation

A range of consultative bodies has been established in NSW to assist and advise the Minister and NSW Fisheries on fisheries issues. There are committees that are established to provide advice on specific issues as well as bodies that advise on matters that cut across different fisheries or sectors.

i) Management Advisory Committees

Share management and major restricted fisheries in NSW each have a Management Advisory Committee (MAC) that provides advice to the Minister for Fisheries on:

- the preparation of any management plan or regulations for the fishery
- monitoring whether the objectives of the management plan, strategy or those regulations are being attained
- reviews in connection with any new management plan, strategy or regulation
- any other matter relating to the fishery, including advice about responding to negative impacts on the fishery due to the effects of any activities external to the fishery.

Each MAC comprises industry members and members representing the recreational fishing sector, indigenous and conservation interests and NSW Fisheries. The MACs provide advice to NSW Fisheries and the Minister on the development of a management plan for their respective fishery, and on changes to Regulations and policy affecting the fishery.

Currently there are two MACs for the OTF, the Ocean Prawn Trawl MAC and the Ocean Fish Trawl MAC. Table B18 in Chapter B details the current membership of the MACs. The industry members of the MACs comprise representatives that are elected by endorsement holders in the respective fishery sectors. The members hold office for a term of three years, however, the terms of office are staggered and the terms of half of the industry members expire every 18 months.

The non-industry members on the MACs representing recreational fishers, conservation groups and NSW Fisheries, are appointed by the Minister for Fisheries and also hold terms of office of up to three years. The number of non-elected members in the MAC must be less than the number of elected members.

At least two meetings are to be held each year, unless otherwise determined by the MAC. Although the MAC receives advice from NSW Fisheries observers on research, compliance and administration issues relating to the fishery, only members of the MAC have voting rights on the decisions of the MAC.

The actual composition and role of the MAC is set by the FM Act and its regulations and may be altered from time to time. For reasons of efficiency and cost-effectiveness, this strategy promotes an amalgamation of the two MACs into a single Ocean Trawl MAC, with an appropriate representation of elected members.

ii) Ministerial advisory councils

Three Ministerial advisory councils are currently established under the FM Act. The Councils provide advice on matters referred to them by the Minister for Fisheries, or on any other matters the Councils consider relevant. They report directly to the Minister for Fisheries.

The Ministerial advisory councils currently established are:

- Advisory Council on Commercial Fishing (ACCF)

- Advisory Council on Recreational Fishing (ACoRF)
- Advisory Council on Aquaculture (ACoA)

The Ocean Prawn Trawl and Ocean Fish Trawl fisheries and each of the other major share management fisheries have representatives on the ACCF. These representatives are nominated by each of the respective management advisory committees and appointed by the Minister for Fisheries.

A "Discussion paper on the advisory structures in the NSW seafood industry" was distributed in December 2003 and is likely to result in changes to the existing advisory structure. The name and composition of Ministerial advisory councils are determined by regulations under the FM Act, and may be altered from time to time.

iii) Indigenous Fisheries Strategy Working Group

The Indigenous Fisheries Strategy Working Group (IFSWG) was established in 2002 upon the commencement of the Indigenous Fisheries Strategy (IFS) and includes representatives from Indigenous agencies and community groups as well as Indigenous persons involved in the commercial fishing industry.

The IFSWG's ongoing role is to assist in the implementation of the IFS and provide advice and recommendations to NSW Fisheries about fisheries issues that affect Indigenous people in NSW. The IFSWG will contribute to the development and implementation of the fishery management strategies being prepared under the FM Act, in conjunction with other key stakeholders.

5. Performance Monitoring and Review

a) Performance monitoring

Many of the management responses listed in section 3 of this FMS assist in achieving multiple goals. Therefore, rather than examining the performance of each individual response or objective, it is more efficient and appropriate to measure the performance of the management strategy against the seven goals (i.e. the major objectives). A periodic report will, however, be prepared (as outlined later in this section) detailing the progress made in implementing each of the management responses.

i) Performance indicators

The performance indicators provide the most appropriate indication of whether the management goals are being attained. A number of monitoring programs are to be used to gather information to measure performance indicators. These performance indicators are detailed in Table D7. It should be noted that a number of relatively direct performance indicators have been selected rather than using a large number of surrogate indicators, in order that the limited resources available for implementation of the management strategy can be most effectively utilised. These will be further refined in light of the practical implementation of the management strategy.

Data requirements and availability

The data requirements and availability for each performance indicator in Table D7 relate to the collection of information used to measure the performance indicators and the data that are available. The data requirements may be specific to the fishery, or encompass cross-fishery interactions such as the catch of a species by several commercial fisheries or harvest sectors.

Robustness

The robustness ratings applied to each performance indicator in Table D7 have been selected using the definitions outlined in Table D6 below.

Table D6 Robustness Classifications (source: Fletcher *et al*., 2002)

Level	Description
High	The indicator is a direct measure of the goal, or if indirect, is known to closely reflect changes in the issue of interest
Medium	The indicator is suspected to be reasonably accurate measure against the goal, or the known error is in the conservative direction
Low	The degree to which the indicator measures against the objective is largely unknown, or known to be low. Often this will involve surrogate indicators

ii) Trigger points

The trigger points specify the point when a performance indicator has reached a level that suggests a potential problem with the fishery and a review is required. The review will determine the suspected reasons for the breach of the trigger point and whether any action is required (see section 5c for further information on reviews in response to trigger points).

Table D7 establishes the performance indicators and trigger points that will be used to measure whether each of the management goals described in section 3 of this management strategy are being attained.

b) Predetermined review of performance indicators and trigger points

It is likely that changes to the activities authorised under the management strategy will evolve over time. It is also possible that better performance indicators will become apparent over the course of the next few years and it would then be an inefficient use of resources to continue monitoring the performance indicators that appear in the management strategy. If new information becomes available as a result of research programs, more appropriate performance indicators and trigger points can be developed and the Minister for Fisheries may amend the management strategy accordingly.

A comprehensive review of the appropriateness of all performance indicators and trigger points will be carried out not more than two and a half years from the commencement of the management strategy, in consultation with the Ocean Trawl MAC.

As new or improved guidelines for fishery reporting become available, such as those being considered in the *'National ESD Reporting Framework for Australian Fisheries – the how to guide for wild capture fisheries report'*, they will be taken into account to promote continuous improvement in the management of the fishery.

Table D7 Performance indicators, monitoring programs and triggers points to measure the success of each of the goals of the fishery.

GOAL 1. Manage the ocean trawl fishery in a manner that promotes the conservation of biological diversity in the marine environment					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	Species composition (for all retained and bycatch species) in the fishery	Quantitative landings and discard data from fisher logbooks and onboard observer program	Significant shift in species composition as determined by the "Large Area Species Richness" index (Gray, 1997)	Medium	It is difficult to directly measure the impact of this fishery on biodiversity in the ocean environment. Research aimed at developing more appropriate indicators is proposed in the FMS. Until an appropriate baseline or reference point is established, interpretation of changes in the species composition of catches will not be able to be clearly linked to changes in fishing practices
2	The proportion of the total trawl catch which is discarded, and the species composition of the discards	Estimates of discarded catch (by species) from onboard observers, and information on the type of BRDs in the net	The 'species richness' and quantity of discards does not on average decrease from the implementation of BRDs and/or the commencement of the FMS	High	Continuous improvements in BRD design and efficiency are a feature of the FMS. Operation of the various approved BRDs will be examined using data from onboard observers. As above, until an appropriate baseline is established, interpretation of changes in the discarded component of catches will not be able to be clearly linked to improvements in BRDs
3	Response of the fishery to marine pest and disease incursions	Reports on the monitoring of marine pests and diseases are needed and will be provided to the Ocean Trawl MAC through the Marine Pest Management Program	Guidelines specified in any Marine Pest and Disease Management Program are not adhered to in the ocean trawl fishery	Medium	Marine Pest and Disease Management Programs are responsible for monitoring marine pests and diseases (e.g. noxious fish), and developing contingency plans in the event of new incursions. This performance measure provides that management of the fishery will be responsive to existing or new marine pest or disease incursions that may threaten the biodiversity in the marine environment
4	Areas closed to trawling in NSW ocean waters, and the proportion of representative habitat types included in the closed areas	Data on habitat types will be required for all closures (including marine parks, aquatic reserves and relevant fishing closures) and will be compiled in conjunction with the management responses that seek to map trawling areas and identify habitat types	Areas closed to trawling become open after the commencement of the FMS and the percentage of closed areas with adequate descriptions of habitat types is unknown or does not increase within 5 years	Medium	Closing areas to trawling prevents any direct impacts of the fishery on biodiversity in those areas, thus potentially limiting the impact of trawling on biodiversity at the regional and state scale. [Note: even when closed to trawling some habitats can take a very long period to regenerate.] Current knowledge about the distribution of ocean habitats is poor, and this indicator allows 3 years for collection of better data then 2 years for implementation of closures to protect representative habitats

Table D7 (cont)

GOAL 2. Maintain stocks of primary and key secondary species harvested by the ocean trawl fishery at sustainable levels					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	Exploitation status of primary and key secondary species	Landings data, onboard observer data, biological catch sampling data and any fishery independent data; analyses of landings data against the catch triggers in Appendix D6; resulting stock assessments prepared by NSW Fisheries scientists	The number of primary or key secondary species determined as 'overfished' (other than those already identified in the FMS) is more than one in any year	High	The management responses under Objective 2.2 already provide for the development of a recovery program in the event that a species is identified as 'overfished'. The purpose of this indicator and trigger point is to detect an increase in the number of primary or key secondary species being identified as overfished, as that may indicate that the management strategy is not moving the fishery towards a sustainable basis
2	Ratio of total annual landings of all secondary species taken by the prawn and fish trawl sectors of the fishery to primary and key secondary species (combined) taken by those sectors	Requires commercial landings data for all species taken in each sector of the fishery. Data will be obtained through mandatory catch reporting by endorsed ocean trawl fishers	Contribution of secondary species to total trawl landings exceeds 5% in any one year	Low	This indicator does not measure sustainability levels per se, but might indicate shifts in targeting or sudden declines in catch of primary / key secondary species or increases in catch of secondary species. Normal ratios are around 3%. The fish trawl and prawn trawl sectors will be analysed separately

GOAL 3. Promote the conservation of threatened species, populations and ecological communities likely to be impacted by the operation of the ocean trawl fishery					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	Number and degree (including captures) of reported interactions with threatened species, populations or ecological communities	Data will be obtained through reports provided by endorsed trawl fishers and also by onboard observers, including information on spatial overlaps and the degree of any observed interactions between ocean trawl fishers and threatened species, populations or communities	Following an assessment of the current level of interaction, the proportion of reported interactions with negative degree does not decrease between successive surveys	High	Currently, very little information is available on interactions between the trawl fishery and threatened species, but limited observer data suggest a low level of interaction. An initial assessment of the level of interaction during the first year of the FMS will be conducted, and information from any targeted research programs or threat abatement plans for threatened species will also be utilised.

Table D7 (cont)

GOAL 4. Appropriately share the resource and carry out fishing in a manner that minimises negative social impacts					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	Proportion of primary, key secondary and secondary species taken by fishery (including commercial, recreational and Indigenous)	Requires commercial landings data by fishery and information (or estimates) of catches by other sectors. Data will be obtained through mandatory catch reporting by endorsed ocean trawl fishers, and through any recreational or Indigenous fishing surveys, and compliance observations	Relative catch between fisheries shifts by 25% between year 1 and year 5 values following commencement of the FMS and then every 5 year period thereafter	Moderate	Further research is required to define the appropriate share of the resource for each fishery, and what might be considered as negative social impacts. In the interim, a trigger point that will detect a relative shift in catch between sectors needs to be set

GOAL 5. Promote a viable ocean trawl fishery, consistent with ecological sustainability					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	Median gross return of fishing businesses with ocean trawling endorsements	Data on average market price of fish (CPI adjusted) and commercial landings by endorsement fishers are required. Average price data are available from the Sydney Fish Market and landings data are available through the catch returns submitted by fishers	Median gross return has not increased by at least 20% four years after the commencement of the share management plan	Medium	This indicator provides a measure of the central tendency of gross returns from fishing (i.e. the median), rather than the average return, because of the tendency for the average to be skewed by more extreme observations (i.e. the distribution of fishing returns is non-normal). Gross, rather than net return, is used because data on the costs of fishing are not readily available. This indicator and trigger point should not be interpreted as the gross return of individual businesses increasing by that amount
2	Average market value of ocean trawl shares when traded	The market value of shares will be collected and recorded by the Share Registrar upon each share transfer	Trigger to be determined within two years of the commencement of the share management plan	Medium	Market value of shares provides a general indication of investor's confidence in the economic viability of participating in the ocean trawl fishery, as it takes account of a range of contributing factors

Table D7 (cont)

GOAL 6. Facilitate effective and efficient compliance, research and management of the ocean trawl fishery					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	The percentages of total inspections which result in the detection of minor or major offences	Data requirements include a record of the number and types of offences detected-and the number of inspections. Data concerning the number and types of offences detected by Fisheries Officers are held in records kept by NSW Fisheries. Data concerning compliance effort are not currently analysed but will be in future in regard to monitoring the compliance plan for the fishery	Percentage of detections of minor offences is >20%; detection of major offences is >10%	Low	This indicator provides a simple low cost measure of compliance by ocean trawl fishers with management rules. Differentiation between major and minor offences will be made during development of the penalty points scheme as part of the compliance management plan
2	Number of Ocean Trawl MAC meetings held each year	The number of Ocean Trawl MAC meetings held is available through records kept by NSW Fisheries	Number of Ocean Trawl MAC meetings is less than 2 in any calender year	Low	Holding two Ocean Trawl MAC meetings per year helps to ensure that regular consultation is taking place and is currently a requirement of the Regulation.
3	Reviews and outcomes of strategic plans for research and compliance in the ocean trawl fishery	Data about the frequency and outcomes of reviews are required - available through records kept by NSW Fisheries	The research or compliance strategic plans expire without being reviewed by NSW Fisheries, or the strategic plans are not modified consistent with the approved outcomes of a review	Medium	Strategic plans focus research and compliance activities and help to ensure efficiency and cost effectiveness of the programs undertaken. It is important that they are reviewed and updated within the timeframes specified therein

Table D7 (cont)

GOAL 7. Improve knowledge about the ocean trawl fishery and the resources on which it relies					
No.	**Performance indicator**	**Data requirements and availability**	**Trigger point**	**Robustness**	**Justification/comments**
1	An appropriate scientific observer program is operated in accordance with the specifications developed to meet the requirements of the relevant management responses	Detailed specifications for an appropriate observer program (these will need to be based on FMS requirements) and an analysis of achievements of the observer program against specifications	Observer program does not meet specifications	High	An appropriate onboard observer survey is fundamental to the success of the FMS. The first step will be the development of specifications that outline the standard of information required, taking account of the range of program aims. The second phase will involve the carrying out of the surveys in accordance with the established specifications. This performance measure seeks to ensure that the observer program is supplying data to the standard sought by the specifications. Note: a review is triggered under the management strategy if the observer program is not implemented within the specified timeframe
2	The number of research projects underway which have a flow of benefits to the ocean trawl fishery and fill information gaps identified by the environmental impact assessment for the fishery	Relevant data will be held by NSW Fisheries and/or external funding bodies	The number of research projects relevant to identified information gaps falls to less than two during any one year	Medium	This is a general indication of the minimum commitment consistent with improving the knowledge base relating to the fishery. Note: the number of research projects does not include routine monitoring and observer programs
3	Accuracy of catch return (or daily logboook) data	Requires commercial landings, marketing data and information on species identification. Information available from catch returns submitted by fishers, Registered Fish Receiver data and through the observer program	The percentage of species records with poor reporting does not decline after 1 year of operation of new reporting procedures	High	Improving the accuracy of data, in terms of quantity of product retained and species identification, is important for improving the knowledge base. This performance indicator picks up on the re-design of the 'returns' form (including possible daily log books) and the accuracy of reporting of both quantity retained and species identification

c) Reporting on the performance of the management strategy

There are two types of performance monitoring reports to be prepared under this management strategy. One is a performance report, which reports generally on the performance of the fishery with respect to the management strategy. The other type of report is a review report, which is to be prepared if a performance indicator for the fishery is breached. Both types of reports are discussed in further detail below.

i) Performance assessment and report

A performance assessment examining each performance indicator will be undertaken annually and a report on the performance indicators will be submitted to the Minister for Fisheries within two years of the commencement of the FMS, and biennially thereafter. The report is the formal mechanism for reporting on performance indicators and trigger points, and will be made publicly available. It will also include a review of progress made in implementing each of the management responses. The performance report may be submitted to the Minister for Fisheries in conjunction with performance reports for other relevant fishery management strategies.

The vast majority of management responses in the management strategy are linked to specified implementation timeframes. If the performance report identifies that any specified target timeframe has not been met, a review will be undertaken and any necessary remedial measures recommended to the Minister for Fisheries[1].

The fishery will continue to be regarded as being managed within the terms of the management strategy whilst any remedial measures associated with breaches in timeframes or triggering of performance indicators are being considered through the review process and/or by the Minister for Fisheries.

ii) Review report in response to trigger points

If the trigger point for a performance indicator is breached, a review is to be undertaken of the likely causes for the breach. Any such review is to include consultation with the Ocean Trawl MAC. In some circumstances, the breach may be related to a performance indicator that measures broader cross fishery issues and will require consultation with other management advisory committees or the Ministerial advisory councils. Cross fishery issues are most likely to involve catch levels of a species that is harvested in more than one fishery.

NSW Fisheries will collect and analyse information relevant to the performance of the fishery, such as compliance rates, economic data, catch data and other statistics as the information becomes available and prior to the preparation of reports relating to performance monitoring in the management strategy. This does not, however, prevent a review from being conducted at any other time should it become apparent that a performance indicator has breached a trigger point.

Once the relevant information is obtained an initial analysis against the trigger points will be undertaken by NSW Fisheries. Where the data or information indicate that a trigger point has been breached, details will be provided to the relevant fishery MACs and the relevant Ministerial advisory councils. Consultation will then occur with the Ocean Trawl MAC and other relevant advisory bodies either through a meeting or out of session. During this consultation, advice will be sought on the

[1] In some circumstances a required action may be completed outside the scheduled timeframe, but prior to the commencement of the review (e.g. an action was due for completion by September 2005, but it is actually completed in October 2005). When this occurs, it is not necessary to proceed with a review.

suspected reasons for any breaches. During this consultation the MAC will also be able to provide advice on the preparation of any review reports that are required.

A review report outlining the remedial actions recommended in response to trigger point breaches, is to be provided to the Minister for Fisheries within 6 months of the trigger point being breached.

Reviews arising from landings data exceeding trigger points should consider, but not be limited to, the following factors:

- changes in the relative catch levels among harvest sectors (including those beyond NSW jurisdiction)
- new biological or stock information (from any source) available since the most recent review of the species
- changes in the activities or effectiveness of fishing businesses targeting the species
- changes in principal markets or prices for the species
- environmental factors.

Review reporting should include whether the suspected reasons for the trigger point being breached are the result of a fishery effect or an influence external to the fishery, or both.

If a review concludes that the reasons for the trigger point being breached are due to the operation of the fishery, or if the fishery objectives would be compromised if the fishery continued to operate unchanged, management action must be taken with the objective of returning the performance indicator to an acceptable range within a specified time period. The nature of any remedial action proposed may vary depending on the circumstances that have been identified as responsible for the trigger point being breached.

If a review considers that the management objectives or performance monitoring provisions are inappropriate and need to be modified, the management strategy itself may be amended by the Minister for Fisheries. If the reasons are considered to be due to the impacts on the resource from factors external to the fishery, these factors should be identified in the review and referred to any relevant managing agency for action.

A review may recommend modifications to any fishery management strategy that allows harvesting of that species. This approach to the review process will avoid triggering multiple reviews for a species that is caught in multiple fisheries.

All review reports will be publicly available.

External drivers

External drivers are factors that are known to potentially impact on the performance of the fishery but which are outside of the control of NSW Fisheries or the commercial fishing industry (e.g. market prices, pollution etc.). Any external influences that may contribute to a trigger being breached will be identified during the review and, if necessary, referred to any relevant managing agency for action.

Accordingly, there may be circumstances where no change to management arrangements or the management strategy is deemed necessary following the review. For example, a review could be triggered because the landed catch of a species declines. However, there would be little cause for concern over the performance of the management strategy if the decline in landed catch of a species was clearly caused by a drop in market prices. Any price fluctuations can result in fishers adjusting their activities.

d) Contingency plans for unpredictable events

In addition to the circumstances outlined above, the Minister for Fisheries may order a review and/or make a modification to the fishing regulatory controls, administrative arrangements or the management strategy in circumstances declared by the Minister for Fisheries as requiring contingency action, or upon the recommendation of the Ocean Trawl MAC. In the case of the former, the Minister for Fisheries must consult the Ocean Trawl MAC on the proposed modification or review.

These circumstances may include (but are not limited to) food safety events, environmental events, results of research programs or unpredictable changes in fishing activity over time. The Minister for Fisheries may also amend this fishery management strategy if matters identified during the finalisation of any other fishery management strategy indicate that a modification is necessary.

Notwithstanding the above, the Minister for Fisheries may also make amendments to the management strategy that the Minister considers to be minor in nature at any time.

e) Monitoring performance of stock assessment

Stock assessment involves the use of various statistical and mathematical calculations to make quantitative predictions about the reactions of fish populations to alternative management choices (Hilborn and Walters, 1992). These calculations can vary from simple graphical presentations of commercial landings to sophisticated computer models that predict the biomass of the stock under various harvest regimes. The data and the scientific expertise required to apply these methods varies enormously. Stock assessment processes for the OTF need to be defined to suit the resources available. To achieve this, short-term and long-term approaches will be applied.

The short-term approach will be to use landings of primary and key secondary species to monitor the performance of the fishery. This approach, which involves the use of 'trigger' levels of commercial landings to help determine a species status, is explained in more detail in Appendix D6.

Within 12 months of the commencement of the management strategy a stock assessment strategy for primary species will be developed. Because of the relatively large number of primary species, and the range of knowledge about these species or species-groups, the stock assessment strategy will need to be appropriately based on the level of existing knowledge, the data likely to be available, and the value of the fishery. A long-term approach will be used to assess the status of the primary and key secondary species. Two principles will apply to the long-term proposal for stock assessments:

- assessment methods will be consistent with the data (i.e. the assessment program design will not rely on data sources that are not funded)
- assessment methods will be at least equivalent to approaches for fisheries of similar value in other Australian jurisdictions.

The exact methods applied to assess the state of a stock may require the development of novel approaches. Performance indicators and trigger points will be an integral component of the stock assessment proposal and, where possible, the robustness of the indicators and trigger points will be evaluated. An independent review of the assessment methods will be completed within three years of the proposal being developed, with the following terms of reference, to:

- report upon the technical soundness of the assessment methods proposed
- report upon the cost-effectiveness of the assessment methods proposed
- indicate if the assessment process will be likely to provide timely information for the management of the fishery
- report upon the conditions where the assessment process is likely to be unsatisfactory
- recommend revisions to the proposed approach including additional data collection strategies that should be considered.

The schedule for providing stock assessments cannot and should not be the same for all primary and key secondary species. Priorities for each species should be determined in consultation with the fishery scientists and the appropriate MACs.

CHAPTER E ASSESSMENT OF THE DRAFT FMS

The aim of this section of the EIS is to assess the draft FMS to determine whether it will effectively reduce the intermediate to high risks to the ecosystem components of the OTF identified in Chapter B2 and ensure that the fishery continues to operate in an ecologically sustainable manner for at least the next five years. As was described in the risk analysis framework in Chapter B2, this chapter is a theoretical appraisal of the measures proposed in the draft FMS. Only by monitoring the implementation of these measures will it be possible to fully determine whether they are sufficient to reduce risks in the OTF.

The role of the FMS is to outline the long term approach to management of the fishery. Accordingly, the strategy does not include full details for the implementation of specific management changes. Ultimately, the FMS will be implemented through various supporting documents and operational plans, such as the share management plan and research and compliance strategic plans, which will establish the specific mechanisms for implementing and monitoring the changes foreshadowed by the FMS. Many of the detailed actions will require consultation with affected stakeholders so as to obtain the support that is often necessary to achieve effective implementation and compliance with the new rules.

1. Ecological Issues

1.1 Outline of the Process used to Assess the Draft Fishery Management Strategy for the Ocean Trawl Fishery

a) Introduction

In assessing the draft FMS for the OTF the two primary objectives are to determine a) whether the issues identified in the risk assessment have been addressed and b) to what extent the risks have been reduced. A secondary objective is to determine whether the proposed management responses increase the risk to any of the components in the ecosystem. Reduction in risk in the context of this EIS is defined as the decrease in the likelihood that a component of the ecosystem will become ecologically unsustainable over a five year period. Risk was determined by a combination of the fishery impact profile and the qualitative resilience of the component. From Section B2.3(b) risk had five levels – low, moderately low, intermediate, moderately high and high. Because resilience was a function of the combined biological characteristics of a component it cannot be directly changed by the proposed management strategy to reduce risk. Only the fishery impact profile can be altered by the proposed FMS because it comprises the actions of the fishery that can be changed.

Reduction in risk is difficult to determine in a qualitative risk assessment approach (as used for this EIS) because there are no quantitative measures of the magnitude or extent of the impacts. Furthermore, it is difficult to make predictions as to the outcome of various management measures as yet to be implemented. Therefore, a qualitative process of risk management was developed to assess the adequacy of the draft FMS in addressing issues and reducing risk.

b) Stages in qualitative risk management

The risk management process consisted of three stages (Table E1.1). In Stage 1 the required information to address an issue of risk is obtained. This stage can have any one or more of the following methods – regulation review, basic studies and experimental studies. Regulation review is simply a review of the current regulations in the fishery management strategy to determine if they are appropriate or not. Basic studies are specifically designed to collect certain information for a particular purpose and as such should adhere to robust scientific sampling designs, including clearly stated hypothesis to be tested (e.g. Underwood, 1990). Research that collects basic biological information about a species and an observer survey to quantify interactions with threatened species are two examples of this type of study. Experimental studies are also specifically designed to test a proposed hypothesis about how some aspect of a component of the ecosystem works but, unlike basic studies, usually involve manipulations within the context of robust experimental design (Underwood, 1990). For example, testing the hypothesis that there is a significant difference in the growth and mortality of a species among areas could involve a tag and recapture study. Gathering this type of information is distinctly different from information obtained from monitoring (Stage 3), because it doesn't involve monitoring the outcomes of an implemented management action. The information gathering stage does not, on its own, reduce risk but it does provide essential data in refining the level of risk which best fits a component and may provide the foundation for more appropriate and effective management measures, such as the location and timing of closures.

Table E1.1 Stages in risk management for a qualitative risk analysis framework

Stage	Sub-stage	Rating	Potential influence on actual risk reduction
1. Required Information	Regulation review	1A	Negligible on its own; identifies regulations that need to be revised to reduce risk
	Basic studies	1B	Negligible reduction on its own; provides information that more precisely determines levels of risk that either upgrades or downgrades it
	Experimental studies	1C	Negligible reduction on its own; provides information about aspects of the ecology of the ecosystem or species group.
2. Implementation	Commitment to act without a control mechanism identified	2A	Minimal reduction; with no identified mechanism the adequacy of the control mechanism cannot be determined
	Commitment to act with an identifed control mechanism	2B	Substantial reduction; the adequacy of identifed control meachanism can be assessed and it provides a concrete action(s) that can be tracked when implemented
3. Monitoring	Passive	3A	In conjunction with any in stage 2, substantial reduction; provides feedback information on whether implementation of management measures are reducing risk and refining risk analysis
	Active (i.e. adaptive management)	3B	In conjunction with any in stage 2, substantial reduction; testing alternative management measures provides more precise information of what is most effective management to reduce risks; involves deliberate set up of management measures in an experimental design to test pre-defined hypotheses

Stage 2 of risk management is implementation. This stage has two types – commitment to implementation without a specific control mechanism (e.g. to reduce bycatch) and commitment to implementation with an identified control mechanism (e.g. to reduce bycatch by introducing bycatch reduction devices). A control mechanism is simply a tool of management that is the means by which a management response will be achieved (Table E1.2). Management controls are either output focused or input focused (Walters and Pearse, 1996). Output controls place limitations on how much can be taken out of a resource, such as quotas. Input controls place limitations on the effort to catch fish, such as restrictions on number of days fished, gear specifications and closures. Usually a fishery management strategy will use a combination of management controls because of the complexities of the ecology, economic and social structure of a fishery.

Table E1.2 Different types of management controls used in fisheries management

TAC – total allowable catch; MPA marine protected area

Control	What the control does	Measures of the controls	Used in draft FMS
TAC quota [Output]	Limits the quantity of landings a fisher may have for a species in a given year.	- TAC level compared to. known spawning & maturing biomass - % of quota met/yr by fishery - % compliance to quota	No
Protected species [Output]	Prevents landings of selected species	- Zero landings of listed protected species	Yes
Trip limits [Output]	Limits quantity caught on a daily or some other basis	- Quantity permitted to be caught per trip - Proportion of catch made up of trip limited species	Yes
Effort caps [Input]	Limits the amount of fishing effort that can be applied to catch fish	- Number of days/nights fished - Number active fishers & vessels	Yes
Restrict catch to part of the population [Input]	Reduces fishing mortality on vulnerable parts of a species population, e.g. juveniles	- Size selectivity of gear - Number seasonal & area closures & proportion of population protected reasons for closures - Minimum legal lengths	Yes
Bycatch reduction devices [Input]	Allows small fish and organisms to escape being caught, reducing fishing mortality; can also be used to allow large marine animals to escape e.g. turtles	- Type of BRD used & their effectiveness - Compulsory or voluntary	Yes
Code of Conduct [Input]	Reduce mortality and/or damage to non-retained species and the envionment by specifying ways fishers should conduct themselves whilst doing their fishery operations, e.g. prohibiting use of spikes	- % of fishers adhering to Code of Conduct if voluntary - Survival of discards	Yes
Limit fishing efficiency [Input]	Limits the power of fishing vessels and fishing equipment to make them less efficient in catching fish, decreases fishing mortality and fishing pressure	- Hull units, including net units - Engine units	Yes
Refuge areas (like MPA) [Input]	Designated areas in the sea that represent a range of marine habitats and organisms that are proctected from fishing, removes fishing pressure and provides a potential suppply of recruits of organisms (larvae, juveniles or adults) for surrounding unprotected areas	- Number & position of MPA or other reserves with respect to trawl grounds - Effectivness monitored	Yes
Restoration areas - stock re-building, habitat re-building etc [Input]	Designated fishing grounds (or other uses) closed to fishing to enable habitats and the ecosystem of an area to rebuild - Protection of spawning sites of target species to secure recruitment supply	- Number & position of closed trawl grounds & other commercial fishing areas; - Recovery monitored	Yes

Depending upon the management response proposed, Stage 2 measures or controls can have a substantial influence on reducing the risk to a component (Table E1.1). Clearly, implementation with an identified mechanism will have a greater influence on reducing risk than one without a mechanism. The implementation stage can occur on the basis of relevant information (from Stage 1) or in the absence of relevant information. The latter may occur as a result of invoking the precautionary principle, which states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (NSW *Protection of the Environment Administration Act 1991*).

Implementation of a proposed management response via a specific control mechanism is not the end of determining whether risk has been appropriately addressed. Determining whether the action was effective in actually reducing the risk is also needed. Stage 3, therefore, involves monitoring the implemented controls. Monitoring can be either passive or active (Sainsbury *et al.*, 2000). Passive monitoring is the routine collection of information about a fishery, such as weights of landings, lengths and sex of species caught. The information is used to update resource assessments but doesn't specifically change management procedures (Sainsbury *et al*., 2000). Active monitoring, also referred to as adaptive management (Walters, 1986; Sainsbury *et al*., 2000) or responsive management, intentionally sets up management controls to test specific hypotheses about the effectiveness of alternate management strategies or action. Such active monitoring or responsive management must also adhere to rigorous experimental design (Walters, 1986; Peterman and McAllister, 1993; Underwood, 1990). Whatever form of monitoring is used it is important that there is a review of the information/data at predetermined frequencies so that the information/data is analysed and interpreted in light of the purpose of the management controls and/or strategy. Management controls that are implemented need to be assessed in some way as to their effectiveness in reducing risks. The proposed FMS is most likely to reduce the risks to a component of the ecosystem if it contains management responses that encompass all three stages of risk management.

Figure E1.1 illustrates theoretically how the different aspects and stages of risk management are linked. Information gathered about the fishery and/or species flows into formulating management actions. Implemented management actions reduce risk. Monitoring of implemented management actions assesses their effectiveness in reducing risk. This leads to improved and/or changed management actions, which are then implemented and the cycle continues. The influence on reducing risk increases with each succeeding stage.

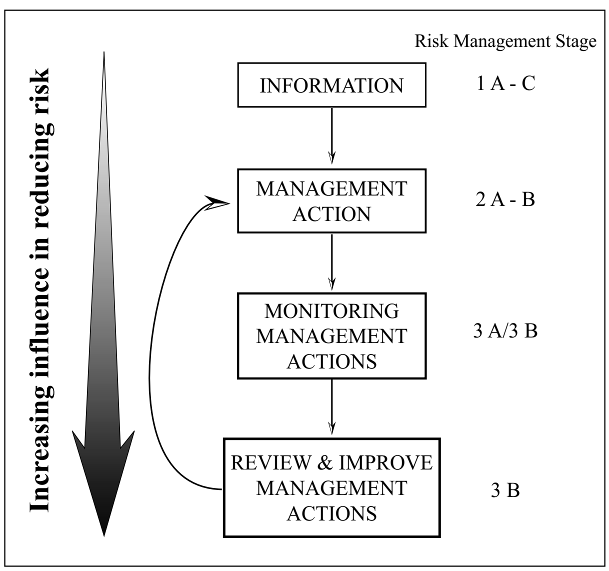

Figure E1.1 Stages and process involved in reducing risk for OTF

1.2 Primary, Key Secondary and Secondary Species

The goals, objectives and management responses (MR) dealing with issues for primary, key secondary and secondary species of the OTF are summarised for each issue in Tables E1.5-11. There were nine major issues (see Section B2(c)) arising from the risk assessment of the primary, key secondary and secondary species. If these issues are adequately addressed in the draft FMS then theoretically the risk to primary, key secondary and secondary species of becoming unsustainable over a five year period should be reduced. An overall assessment of the risk reduction for these species is presented first. Then each issue will be discussed in detail with respect to how well it has been addressed by the draft FMS in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to species at high, moderately high and intermediate risk

The OTF is a diverse multispecies fishery and requires more than one type of management control to reduce the risks to individual species. The extent to which the risks overall have been reduced for the primary, key secondary and secondary species will depend on the effectiveness of the combined management controls in the draft FMS.

The strength of the draft FMS is that it uses multiple management controls on all species without relying on any one in particular. For species at highest risk (elasmobranchs) three types of controls are proposed – refuge areas, recovery programs and limited fishing effort (Table E1.3). These controls combined with the information gathering management responses result in a minor reduction in risk for elasmobranchs (Table E1.3).

Species at moderately high and intermediate risk are influenced by seven management controls and include all those used for elasmobranchs as well as juvenile prawn and spawning closures and effort controls (Table E1.4). Combined with the information gathering management responses these result in a moderate to major reduction in risk for a few species e.g. silver trevally, and minor reduction in risk for other species (Table E1.4).

Some of the controls in the proposed FMS don’t go far enough in reducing risk. Many of the management controls that are at the implementation stage of risk management (see Table E1.1) don’t give enough details of the specific mechanism, (although it is acknowledged that determining the specific details in some circumstances is dependent on firstly improving knowledge of the fishery and some of its effects, e.g. mapping trawl grounds, is necessary before some area closures can be determined). A lot rests therefore on the assumption that whatever the details are they will be adequate to reduce risk. However, given the complexity of the oceanic environment and high uncertainty involved in managing the OTF such assumptions limit assessment of the adequacy of the draft FMS. Therefore, the draft FMS would be strengthened if it demonstrated an understanding and commitment to applying the details of important principles needed in implementing some management controls to make them effective. For example, understanding the differences in the requirements of closures for elasmobranchs and teleosts.

Table E1.3 Summary of management controls in the draft FMS used to reduce risk for species at high risk.

	Management control proposed	Potential Risk Reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Closed areas	Moderate	2A	Depends on where & how closures are established	MR 1.1(b) 2.1(f)
	Recovery programme	uncertain	2A	Effective if an appropriate process is used for sharks to determine details of programme	MR 2.2(a)
	Minimise latent fishing effort	no change	2A	No commitment to mechanism to manage fishing effort; Investigate cost effectiveness of day/night allocations; Set overall effort level target within 10 years with interim milestones	MR 5.2(a); Harvest strategy
Information	Monitoring composition of landings	Minor	1B	Essential information for other management controls to be effective	MR 2.1.(a)
	Monitoring landings of primary & key secondary species	Minor	1B	Essential information for other management controls to be effective, e.g. effort controls	MR 2.1(c)(d)
	Research to fill information gaps	Moderate	1C	Essential information to reduce uncertainty and improve effectiveness of management controls	MR 2.1(j), 7.2(a)

Overall risk reduction for species at high risk	**MINOR**

Table E1.4 Summary of management controls in draft FMS used to reduce risk for species at moderately high and intermediate risk.

	Management control proposed	Potentail risk reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Closed areas	Moderate	2A	Depends on where & how closures are established	MR 1.1(b)
	Refuge areas & spawning closures	uncertain	2A	Details of criteria to establish refuge areas to be developed	MR 2.1(g)
	Juvenile prawn closures	Major	2B	Details provided, anecdotal evidence from fishers current closures are working	MR 2.1(f)
	Recovery programmes	Major - silver trevally, uncertain - rest	2A/B	Details only given for silver trevally	MR 2.2(a) & (b)
	Gear selectivity	Major - some species	2B	Improved gear sectivity will substantially benefit some species, but not all	2.1(e) 2.2(a)
	Minimise latent fishing effort	No change	2A	No commitment to mechanism to manage fishing effort; Investigate cost effectiveness of day/night allocations; Set overall effort level target within 10 years with interim milestones	MR 5.2(a); Harvest strategy
Information	Monitoring composition of landings	Minor	1B	Essential information for other management controls to be effective, e.g. exploitaiton status	MR 2.1.(a)
	Monitoring landings of key secondary species	Minor	1B	Essential information for other management controls to be effective, e.g. effort controls	MR 2.1(c)(d)
	Research to fill knowledge gaps	Moderate	1C	Essential information to reduce uncertainty and improve effectiveness of management controls	MR 2.1(j), 7.2(a)

Overall risk reduction for species at moderately high & intermediate risk	**MODERATE - MAJOR few species**
	MINOR - most species

Overall, the draft FMS will potentially have a minor effect in reducing the risk for those species at high risk, a moderate to major effect in reducing risk for a few species (e.g. juvenile king prawns, silver trevally) at moderately high risk and a minor effect in reducing the risk for the other species at moderately high and intermediate risk.

b) Evaluation of management responses addressing issues from the risk assessment for primary, key secondary and secondary species

i) Direct action for elasmobranchs

Elasmobranchs were at the highest level of risk of becoming ecologically unsustainable under the current management regime (Table B2.18). Their different biology, ecology, life history strategies and movement patterns from teleost species means that several actions may be necessary to reduce the fishery impact on them in the OTF. There was only one management response specifically aimed at elasmobranchs but eight other responses were also relevant to them in the draft FMS (Table E1.5). The management responses fell into four broad sets – information, spatial restrictions, effort control and miscellaneous.

Management response 2.1(j) commits to collecting essential basic biological data of the important elasmobranch species of the OTF. Information about fecundity, size at maturity, length/age and sex structure will contribute substantially to understanding these species. This will be in addition to the usual information obtained from catch monitoring programs (Table E1.5, MR 2.1(a,c)). The basic catch composition of primary and key secondary species of elasmobranchs will provide specific information to use in some form of stock assessment. Together this information will be used to determine some of the basic biological characteristics of the elasmobranch species of the OTF, which will enable more specific management measures to be formulated and implemented. Whilst collecting this information is crucial, it will not in itself reduce the high risk to five species of elasmobranchs from the OTF. Furthermore, because the data will include spatial information it will address some aspects of the ecology of these species that would assist in setting aside refuges for them (see Section E5.2(b) for review of research plan).

The second set of management responses could potentially have the largest influence on reducing risks to elasmobranchs. These management responses propose to establish closed areas from fishing (Table E1.5). These areas seek to protect habitat, create refuges for adult populations and for reproduction from the effects of fishing mortality. These responses are an important first step in contributing to the sustainability of elasmobranch species of the OTF. Some management responses will contribute more than others in providing this protection. The proposed exclusion of all trawling from depths greater than 1100m will make little difference to the current situation because OTF does not normally trawl at these depths due to the limitations of the technology of the gear, but does prevent future expansion into these habitats. It is important to recognise that any actions to reduce risks to elasmobranchs will likely have a long response time because of the biological characteristics of those species. Consequently, uncertainty around the effectiveness of the management measures will be prolonged.

Table E1.5 Summary of management responses relating to elasmobranchs at high risk in the OTF. Responses covering common areas are grouped . See text for explanation.

Risk assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Direct action on elasmobranchs	2	2.1	*a) Monitor quantity, length and/or age and sex composition of primary & key secondary species taken by all commercial designated fishing activities in NSW*	1B
			c) Monitor annual landings of primary & key secondary species, compare against "reference" levels in Appendix D6	1B
			j) Collect additional biological information for important elasmobranch species taken by fishery, including size at maturity and fecundity/brood size data, via observer program	1B
	1	1.1	*b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, closure of all reefs and depths > 1100 metres*	2A/ B
	2	2.1	*g) Develop strategies to establish 'refuge' areas & spawning closures for species targeted by trawling*	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A
	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by: (i) limiting the number of each endorsement type so as to minimise the potential activation of latent fishing effort*	2A
			(ii) maintaining the hull capacity, engine power & net length restrictions to offshore sector of the Ocean Prawn Trawl Fishery; extend these rules to other sectors of the ocean trawl fishery	2A
			(iii) establishing a maximum level of fishing effort for each sector of ocean trawl fishery within 10 years of the commencement of the share management plan	2A
			(iv) investigating the efficacy of limiting the number of days/nights each boat may work	2A
	2	2.2	*a) Major harvester of overfished species in NSW - develop and implement a recovery program for that species as detailed in the harvest strategy, & in particular: ii) determine if a recovery program required for any other species identified as 'high risk & implement necessary actions*	2A
		2.1	*b) Develop system for and conduct stock assessments for each of primary & key secondary species taken by all commercial designated fishing activities in NSW; review the assessments at least every three years thereafter*	3A

By eliminating fishery induced mortality these closed areas would contribute to reducing the fishery impact on elasmobranchs. Potentially this could allow populations to be re-structure more in accordance with natural ecological processes (Jennings, 2001). However, the refuge areas would only effectively reduce the fishery impact on this group of organisms if they were specifically designed to do so. The life history strategies and movements of elasmobranchs are different to that of teleost species. Therefore, the diverse and specialised life styles of sharks will play an important role in applying the principles of refuge area design to this group and will have different design requirements to that of teleosts. Bonfil (1997) discussed how the general principles of designing refuge areas fit the requirements for protecting elasmobranchs. For example, for refuge areas to be effective stand-alone management tools they need to be able to support viable populations and so include a range of habitats that provide protection to all stages in a species life cycle (Bonfil, 1997). But very little is known of the life cycle, habitat associations and movement patterns of the five species of elasmobranchs at highest risk in the OTF. Therefore, it is difficult to determine where, how large and how many refuge areas there should be for this group of finfish.

In determining a strategy for establishing refuge areas for elasmobranchs consideration should be given to how this is being done for the endangered Grey Nurse Shark in NSW. Otway and Parker (2000), based their recommendations for areas to be protected from fishing on known areas of aggregation, habitat associations and the proportion of the population occurring in the area of study. Furthermore, they recommended that the initial small size of the refuges be followed up with research into the localised movements of the sharks to assess whether the areas are of a sufficient size. Their approach is one of gradual development of the refuge areas as more information is obtained through pre-planned and deliberate monitoring of the animals in the designated areas.

The draft FMS does not include details as to how the strategies for establishing closed areas and refuges will be developed. The background to management response 1.1(b) is not clear whether the proposed closure of 75% of state waters south of Barrenjoey Point will focus on current trawling and trawlable grounds or areas in general. Unless the 75% includes some trawlable and currently used grounds it will only partially aid in reducing the risk to elasmobranchs.

The draft FMS also does not include details of whether the different requirements of elasmobranchs and teleosts will be considered in designing refuges from trawling. In addition, the type of protection any reserve would provide is not discussed in the draft FMS. Otway and Parker (2000) discuss the advantages and disadvantages of three types of protection available to NSW Fisheries – sanctuary zones within Marine Parks, fishery closures and aquatic reserves. For Grey Nurse sharks aquatic reserves were deemed to provide the most protection to this elasmobranch species because they were permanent, provided protection from all forms of fishing activity (both recreational and commercial), protected habitat and were more cost effective to monitor and enforce. However, it is important to note that other closure mechanisms, such as fishing closures under section 8 of the FM Act, can provide an equivalent high level of protection. (See judgement in *Professional Fishers Association v Minister for Fisheries* at NSWLEC 15)

Because there is a lack of detailed information about the nature of the proposed refuge areas and how they are to be established, it is not possible to determine whether the risk to elasmobranchs will be reduced as a result. However, if adequate attention is given to the design requirements and level of protection needed for elasmobranchs at high risk then this would be a very effective means of reducing the fishery impact, and therefore risk, on these species. The risks to elasmobranchs otherwise will not be reduced effectively.

The third set of management responses relevant to elasmobranchs relates to fishing effort (Table E1.5, MR 5.2(a)(i-iv)). The overall intent of the draft FMS is to reduce total fishing effort (see MR 5.2(a)(iii) and associated background notes). Whilst this intention is positive, there is no clear commitment to a mechanism by which this could be achieved, and the response is focussed on reducing total effort (comprised of currently active plus latent effort), not reducing the currently active level that the risk assessment identified as posing a threat to elasmobranchs. To effectively reduce the risk to elasmobranchs, the FMS would need to reduce the maximum number of endorsed businesses below the currently active level of approximately 252 endorsements.

Management response 5.2(a) (Table E1.5) suggests four controls by which fishing effort could be managed - limiting the number of each endorsement type, maintaining fishing capacity, establishing a maximum level of fishing effort and investigating limited day/night allocation. Limiting the number of each endorsement type seeks to minimise the potential activation of latent effort (MR 5.2(a)(i) Table E1.5), but it will not reduce the risk to elasmobranchs because it does not change active effort levels, upon which the risk assessment was based. Similarly maintaining fishing capacity at current levels (MR 5.2(a)(ii)) will bring no change to the current level of risk for elasmobranchs.

Establishing a maximum level of fishing effort (MR5.2(a)(iii)) will only be of benefit if it is a) below current active levels and b) flexible enough to respond to changes in abundances of species. To establish this maximum level of fishing effort the draft FMS (Section D4(c)(ii)) suggests that minimum shareholdings could be used, although it makes no clear commitment to using this mechanism. There are a number of ways minimum shareholdings could be applied to control fishing (as indicated in the Harvest Strategy of the draft FMS, Section D4(c)(ii)). However, its effectiveness in reducing the risk to elasmobranchs would depend on which way is chosen. Minimum shareholdings that take a long term approach to reducing effort may not be effective for long lived species such as elasmobranchs. In any case, management response 5.2(a)(iii) has placed a 10 year timeframe on establishing maximum effort levels, and this may be too long to derive any benefit for elasmobranchs at high risk because these species are already depleted, have slow growth rates and low fecundity. The interim effort milestones to be established within the 10 year period will need to be sufficiently precautionary to ensure this species group can benefit from reduced fishing effort over the long term.

The part of the management response that seeks to investigate the efficacy of limiting the number of days/nights a vessel may fish (Table E1.5, MR 5.2(a)(iv), the fourth proposed control) could substantially decrease fishing effort on elasmobranchs. However, the management response does not explicitly commit to introducing a limitation on the number of days/nights fished, only that it will be investigated. Given there is little certainty that the other management responses controlling effort will contribute to reducing the risk to elasmobranchs, this part of the management response may be the most efficient and effective way of providing the necessary protection for elasmobranchs. Therefore, a stronger commitment in the draft FMS to limiting the number of days and nights that vessels may fish in the short term is highly recommended.

Although it is the intent of the draft FMS to reduce total fishing effort it does not give any real assurance that current (active) effort levels will not increase given the number of latent entitlements that exist in the fishery. There is also no assurance given that the potential activation of latent effort will be minimised, because it does not specify how many endorsements the fishery will be limited to nor whether the level of access available through each endorsement will change. There is also concern that limiting the effort through endorsement numbers without additional effort controls could result in an increase in effort in the short term as fishers strive to meet potentially higher management costs. Furthermore, while some potential mechanisms for effort reduction are outlined in the background note, the draft FMS does not determine with certainty what mechanism would be used to achieve the effort level subsequently decided upon. This assessment concludes that the risk to elasmobranchs will not be reduced as a consequence of the effort management controls proposed (MR 5.2(a)) being insufficient.

The fourth set of management responses applicable to elasmobranchs concern developing recovery programs and a stock assessment system (Table E1.5, MR 2.1(b), 2.2(a)). Fiddler shark, angel shark and saw shark are primary and key secondary species of whom the OTF is a major harvester. These species are at high risk and therefore would be candidates for recovery programs. There are no legislative guidelines for recovery programs. The harvest strategy of the draft FMS gives details for a recovery program for silver trevally and it is assumed that a similar appropriate process to develop a plan for the elasmobranchs at high risk. On this basis it is assumed that the recovery program developed for fiddler, angel and saw sharks would contribute to reducing their risk.

Developing and conducting a stock assessment system for primary and key secondary species will benefit fiddler, angel and saw sharks. This will not in itself reduce the risk to these species. However, it will alert the management agency to any potential problems with these stocks and may prompt mitigative action and could assist in establishing a maximum level of fishing for the management response 5.2(a)(iii).

Finally, the draft FMS does not directly address the issues that arose from the draft National Action Plan on Sharks (2002) but does so indirectly (e.g. through collection of biological information).

ii) Direct action for species at moderately high risk

Seven species of teleost finfish and two species of shellfish were at moderately high risk of becoming ecologically unsustainable. There were several management responses that addressed the risk to this group of species (Table E1.6) either directly or indirectly. Of the four species that have an overfished exploitation status (silver trevally, redfish, eastern king prawns and school prawns) three management responses deal directly with these species whilst the remaining management responses are applicable to all species in the moderately high risk category. The management responses fell into five broad sets – recovery programs, spatial restrictions, information, effort control and miscellaneous.

Table E1.6 Summary of management responses relating to species at moderately high risk in the OTF. Responses covering common areas are grouped . See text for explanation.

Broad Management Sets	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Recovery programmes	2	2.2	*a) Major harvester of species overfished in NSW develop & implement recovery program in particular: i) silver trevally (growth overfished) ii) determine if recovery program required for any species identified as 'high risk' ; implement necessary actions*	2B/2A
			b) Minor harvester of overfished species, contribute to development of any recovery programs for that species; adopt any measures required by a recovery program, in particular: i) determine if additional measures needed to improve selectivity of fish trawl nets for redfish ii) implement provisions of recovery program for gemfish developed under Ocean Trap & Line Fishery Management Strategy	2A
Spatial restrictions	1	1.1	*b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, closure of all reefs & depths > 1100 metres*	2A/ B
	2	2.1	*f) Maintain & enhance effectiveness of "juvenile king prawn" closures; in particular: i) modify juvenile king prawn closure off South West Rocks ii) make all juvenile king prawn closures year-round closures, except when Director-General, NSW Fisheries, determines iii) investigate need to extend juvenile prawn closures to be adjacent to mouths of all major estuaries along NSW coast*	2B
			g) Develop strategies to establish 'refuge' areas & spawning closures for species targeted by trawling	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A
Effort controls	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by: (i) limiting the number of each endorsement type to minimise potential activation of latent fishing effort*	2A
			(ii) maintaining the hull capacity, engine power & net length restrictions to offshore sector of Ocean Prawn Trawl Fishery; extend these rules to other sectors of the ocean trawl fishery	2A
			(iii) establish maximum level of fishing effort for each sector of ocean trawl fishery within 10 years of commencement of share management plan	2A
			(iv) investigate efficacy of limiting the number of days/nights each boat may work	2A

Table E1.6 cont'd

Broad Management Sets	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Information	2	2.1	*a) Monitor quantity, length and/or age & sex composition of the primary & key secondary species*	1B✟
			b) Develop system for & conduct stock assessments for each primary & key secondary species; review the assessments at least every three years thereafter	3A✟
			c) Monitor annual landings of primary and key secondary species; compare against "reference" levels set out in Appendix D6	1B✟
			d) Monitor landings of all secondary species; compare against an historical range for each species or species group	1B✟
			h) Investigate cost effectiveness of using fishery independent surveys to provide information for stock assessment	1C✟
Miscellaneous	2	2.1	*e) Ensure selectivity of gear used is appropriate to biology of species targeted*	2B❖
	4	4.3	*b) Respond to information about significant changes in relative catches of the primary and key secondary species taken in each of the major sectors of the ocean trawl fishery*	2A✟

✟ - discussed under Section E1.2(b)(iii); ❖ - discussed under Section E1.2(b)(iv)

A recovery program for silver trevally will be developed (Table E1.6, MR 2.2(a)(i)). The plan will do at least two things. First, it will establish a minimum cod-end mesh size to exclude small individuals. Second, it will specify a minimum legal length of 30 cm total length for silver trevally. The aim of these measures is to increase the mean size being landed toward an optimum size. The change in mesh size is expected to decrease fishery impact on juvenile silver trevally. Sometimes the imposition of a minimum legal size can lead to increased discard mortality of smaller fish as fishers must discard any undersize fish they catch. However, if the gear selectivity is appropriate then discard mortality should be relatively small or eliminated as a result of the minimum legal length rule. It will be essential that the observer program evaluates the effectiveness of these measures for silver trevally. The instigation of a recovery program for silver trevally is a positive step in improving the management of this species and should lead to a decrease in its level of risk.

Redfish are a minor harvested species in the OTF but a quota species in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF). Changes to cod-end mesh sizes for silver trevally are also expected to reduce the fishery impact on small individuals for redfish (MR 2.2(a)(ii)). Commitment is given to further changes in gear selectivity for this species if either state or Commonwealth research deem it is required. At present the (SESSF) does not have a recovery program for redfish. Consequently the changes made in the OTF to reduce the fishery impact on juvenile redfish will, in itself, have little effect in lowering the risk of unsustainability for this species from all fisheries.

Eastern king and school prawns are fished as adults by the OTF. Reducing the risk on these species will primarily require the protection of juveniles and their habitats. Research has found that during periods of high discharge (i.e. high rainfall) late juvenile prawns emigrate from estuaries out to sea due to changes in salinity (Glaister, 1978; Staples *et al*., 1984; Vance *et al*., 1985). This mass movement of prawns from estuaries to sea increases the landed catch of juvenile or small prawns by the OTF operating in close vicinity of these estuaries. The harvest strategy (see Section D4(b)(vii)) and management responses (Table E1.6) propose six measures (five direct and one indirect) to address the growth overfished status of these prawn species.

Improvements to net and cod-end selectivity should reduce the capture of juvenile prawns. The adoption of minimum prawn counts as a means to establish closures when small prawns are abundant will decrease the fishery impact on these primary prawn species when they are vulnerable.

Closures will be the most effective way of protecting juveniles of these species. All current closures for juvenile eastern king prawns are situated at the mouths of rivers/estuaries. The management response 2.1(f) will modify some existing closures to make them more effective. The intention to make all juvenile king prawn closures permanent enhances the reduction in risk to this species. These closures will be in addition to the flood bycatch closures off major rivers along the coast, which will also benefit juvenile prawns. Although the closures are specifically for juvenile eastern king prawns, school prawns are believed to have a similar pattern of movement in response to high discharge (Montgomery, 1999) and therefore would also benefit from the closures.

The remaining two measures for eastern king and school prawns concern the collection of data on population dynamics and catch composition to develop better population models (see Section D4(b)(vii)). These models will assist in determining better management regimes for these species. Therefore these models should make a contribution to the long term management to reduce their risk of becoming ecologically unsustainable.

Reduction in risk for the remaining species at moderately high risk is addressed in six management responses outlined in Table E1.6. These management responses also contribute to reducing risk for species with intermediate levels of risk. The two most important management responses will be discussed here. The others will be discussed under the relevant issues that follow.

Implementation of closed areas (MR 1.1(b), 2.1(e)(f)) and establishment of refuge areas (MR 2.1(g)) would have a significant affect in reducing the fishery impact on these species provided they are appropriately designed. There are three purposes for the proposed closures – habitat protection, refuges for adult/juvenile populations and protection of spawning areas. Closures to protect habitats will benefit species at moderately high (and intermediate) risk by reducing the indirect effects of fishing on them. Protecting habitat will potentially allow ecological processes, such as food webs and species interactions, to occur with minimal impairment. It will also protect the sources of food of primary and key secondary species. These indirect benefits will contribute to the reduction of risk of all species at high, moderately high and intermediate risk.

Closures to provide refuges for adult and juvenile populations of primary and key secondary species will reduce the direct effects of fishing on these species. Protecting a proportion of their populations should at the minimum maintain the size of the current and future spawning stocks, but for species with moderately high levels of risk the higher priority should be to increase the size of spawning stocks. Therefore, these types of closures will not only address risk reduction now but also into the future. A similar reduction in risk for species with moderately high levels of risk should result from closures to protect spawning areas. Maintenance of spawning areas is essential for helping to ensure primary and key secondary species have adequate recruitment to their exploited populations.

The effectiveness of the proposed closures in reducing the risk to primary and key secondary species is dependent on the number, size and placement of the closures (Gaines *et al*., 2003; Shanks *et al*., 2003). Research has shown that patterns of recruitment into a population and larval retention have a significant bearing of the design and effectiveness of refuge areas (e.g. Carr and Reed, 1993; Allison *et al*., 1998; Walters, 2000; Warner and Cowen, 2002). Therefore, information about the timing, duration and location of spawning, larval development, larval dispersal patterns and distance, adult growth rates, movement and patterns of recruitment and habitat associations will be needed in the long term to ensure the proposed closures achieve their purposes. However, for most of the teleost and shark species at high and moderately high levels of risk such information is largely unknown. Therefore, a highly precautionary approach to the design of the closures is required. The proposal to close 75% of state waters south of Barrenjoey Point is precautionary provided the closures include trawlable and currently trawled areas.

Except for juvenile king prawns there are no details given in the management responses about the design of the proposed closures. What is proposed is a good first step. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. However, some closures could be established as an interim step. This would require the application of a precautionary approach to the detailed design of the closures, with a subsequent adaptive approach for further refinement. Such an approach should include closures that cover continuous areas of habitat across a range of depths, such as several strip closures that extend from the coast out to the lower continental slope. Only closures that demonstrate a high level of precaution until the necessary information required for specific designs is obtained will adequately contribute to reduction in risk to the primary and key secondary species. The effectiveness of these management responses in reducing the risk to the teleost species is uncertain but for juvenile king and school prawns the closures will be substantially effective. It will be important that any strategies in developing closures should make use of the substantial scientific literature in the area (e.g. Botsford *et al*., 2003; Gaines *et al*., 2003; Hastings and Botsford, 2003). Furthermore, establishment of closures should incorporate research with a robust monitoring component to assess their effectiveness in reducing the risk to species at moderately high and intermediate risk (e.g. McAllister and Petermen, 1992; Underwood, 1992).

Measures to control fishing effort relevant to species at moderately high risk were proposed in management response 5.2(a). The evaluation of this response given in the previous section for elasmobranchs (Section E1.2(b)(i) applies equally to species with moderately high levels of risk. It is worth reiterating that even though the species at moderately high risk are more biologically resilient than elasmobranchs, the proposed effort controls (MR 5.2(a)(i-iv)) do not make a clear commitment to a mechanism that will reduce current active effort. Therefore the assessment cannot be confident that this management response will reduce the risk to species at moderately high risk.

iii) Stock assessments for primary and key secondary species

Stock assessments will be undertaken for all primary and key secondary species across all fisheries in NSW (Table E1.7, MR 2.1(a)). In which class of stock assessment (Scandol, 2003a) each species will be assessed will depend on the availability and reliability of data. Clearly the proposed catch monitoring program (MR 2.1(b)) will be essential in providing some of this information on a long tem basis. The management response will assist in determining when levels of effort need to be reduced to lower the risk of the primary species becoming ecologically unsustainable. Therefore, this management response will contribute substantially to controlling the level of risk to primary and key secondary species in the OTF. Because conducting stock assessments on all the primary and key secondary species will take time, it is proposed to monitor the landings of these species and compare them with set reference levels (Table E1.7). This will enable unusual trends in the data to be detected and responded to (a fuller evaluation of the trigger levels is presented in Section E5.1). This type of monitoring will contribute to managing the levels of fishery impact on these species and therefore assist in managing their levels of risk.

To address difficulties in determining relative abundances needed for stock assessments it is proposed to investigate the cost effectiveness of fishery independent surveys (Table E1.7). It is acknowledged that fishery independent surveys in the oceanic environment are very difficult and costly and may not be suitable for all species. But methods to obtain better estimates of abundance should be pursued wherever practicable. This will increase the reliability of stock assessments and hence aid in improving ecologically sustainable management of the primary and key secondary species of the OTF. Any insights from the FRDC project (FRDC 2002/059) on fishery independent surveys in NSW estuaries should be considered.

Table E1.7 Summary of management responses relating to stock assessment for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Stock assessments for primary and key secondary species	2	2.1	*a) Monitor quantity, length and/or age and sex composition of the primary & key secondary species*	3A
			b) Develop system for & conduct stock assessments for each primary & key secondary species; review the assessments at least every three years thereafter	3A
			c) Monitor annual landings of primary & key secondary species; compare against "reference" levels set out in Appendix D6	3A
			d) Monitor landings of all secondary species; compare against an historical range for each species or species group	3A
			h) Investigate cost effectiveness of using fishery independent surveys to provide information for stock assessment	1C

iv) Gear selectivity

Improvements to the selectivity of trawl gear will be made by the proposed changes to construction of the cod-ends in both prawn and fish trawl nets (Table E1.8, MR 2.1(e)). Reducing the cod-end circumference and twine thickness and increasing the hanging ratio will maximise the lateral openings of cod-end meshes during trawling. Studies have shown that reducing the circumference of the cod-end of prawn trawl nets from 200 to 100 meshes increases the lateral openings of diamond meshes, allowing more fish to escape (Armstrong *et al*., 1990; Reeves *et al*., 1992; Broadhurst and Kennelly, 1995, 1996). Larger circumferences, lower hanging ratios and thick twine result in the meshes becoming closed with the increasing weight of catch in the cod-end, thus preventing the escape of smaller fish (Broadhurst and Kennelly, 1995). The maximum circumference of prawn trawl cod-ends will be 150 meshes but increasing the hanging ratio to 1:1 should still allow smaller fish to escape. Fish trawl cod-ends will be reduced to 100 meshes round with a 1:1 hanging ratio which will also be effective in reducing catches of undersize commercial species.

The effectiveness of the changes to gear selectivity are complicated by the proposed regime for targeting school whiting set out in Appendices D3 and D5. It is proposed that for fish trawl, the current gear with poor selectivity (with 150 to 200 meshes round and a hanging ratio of less than 1:1) will be permitted to fish for whiting in certain areas until more appropriate gear can be developed (see Appendices D3 and D5).

Between Barrenjoey Point and Smoky Cape fishers can use this gear anywhere in waters less than 55m (30 fathoms) deep. These depths contain the juveniles of many of the primary and key secondary species of the OTF, including those at moderately high risk (Kailola *et al*., 1993). Consequently, the draft FMS is proposing that fish trawl gear with poor selectivity be used in waters that contain a large proportion of juveniles of the primary and key secondary species and other small fish that are most vulnerable to being caught by this gear. Areas less than 55m deep are the very places where small fish are abundant (Bax and Williams, 2000). While an improvement to the current situation, the proposal assists little in achieving Goal 2 of the draft FMS that seeks to maintain stocks at sustainable levels. The use of the current fishing gear in these areas is only interim and a research program will be undertaken within three years to identify appropriate gear and/or areas for trawling for whiting. The possibility that the current gear will continue to be in use for a further three years reduces the effectiveness of the FMS. The draft FMS would be strengthened if it were to expedite the development of the new gear and shorten the timeframe for its implementation, preferably to a maximum of one year from the commencement of the FMS.

South of Barrenjoey Point the current gear, with its poor selectivity, will be permitted only in designated whiting grounds that are yet to be determined (Appendix D5). Restricting the use of this gear will reduce the risk to bycatch species to some extent (both commercial and non-commercial). However, assessing the effectiveness of this management measure is difficult because it depends on the number, size and placement of the whiting grounds. For example, if these areas are primarily in depths less than 55m and there are a substantial number of them, then this management measure will not contribute to reducing the risk to juvenile commercial and non-commercial bycatch species. As for the arrangements for waters between Barrenjoey Point and Smoky Cape, this proposed regime could result in permitting gear with poor selectivity to be used in areas that have abundant small fish and therefore be largely ineffective in achieving goals 1 and 2 of the draft FMS. Until the specific whiting grounds south of Barrenjoey Point are identified, a precautionary assessment approach would conclude that the reduction in risk from this proposal is very minor.

Overall, management response 1.2(e) will be effective in reducing the risk on a range of primary and key secondary species that occur in waters deeper than 55 metres and will primarily benefit teleosts and prawns. However, the arrangements for targeting whiting outlined in Appendices D3 and D5 limit the level of risk reduction that could be achieved through gear selectivity changes, and the risk would be far more effectively reduced if the arrangement proposed to be applied beyond 55 metres were extended further inshore.

Table E1.8 Summary of management responses relating to changes in gear selectivity for primary and key secondary species in the OTF.

Risk assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Poor gear selectivity	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular: i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40-50 mm*	2B
			ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm	2B
			iii) review & modify the restrictions applying to prawn trawl & fish trawl nets on the basis of research results on the selectivity of trawl nets, including assessment of mesh size & shape	3B
			Different gear arrangements for targeting whiting in designated whiting areas – see provisions in Appendices D3 and D5	2B*
		2.2	*a) Major harvester of a species develop & implement a recovery program (detailed in the harvest strategy); in particular: i) develop and implement a recovery program for silver trevally - changes to fish trawl cod-ends*	2B

* indicates management measures are in appendices are not appropriate, see text for details

v) Discarding of commercial species

This is discussed in Section E1.3. and addresses issues 5 and 6 of the risk assessment (see Section B2.2).

vi) Inconsistent management regimes between adjacent jurisdictions

There were three specific management responses proposed to address the issue of inconsistent management regimes across jurisdictions (Table E1.9). The majority of the primary and key secondary species in the OTF are considered to be of common stock across several jurisdictions. Inconsistency in management approaches between jurisdictions poses a substantial problem to the ecological sustainability of important fish stocks. It increases the uncertainty of the effects different management regimes have on primary and key secondary species and therefore there is a greater risk of common stocks becoming unsustainable (e.g. Mitchell, 1997; Hoel, 1998). To address the overlap and inconsistent management approaches between adjacent fishery agencies on these common stocks more effective consultation with other jurisdictions (MR 4.2(c)) and monitoring management arrangements and landings in adjacent fisheries is proposed (MR 4.2(a)). Commitment to this consultation process should result in better management of the stocks of primary and key secondary species and hence decrease their risk.

Management response 6.3(b) proposes to achieve “greater complementarity” between the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) and the OTF. Appendix

D3 sets out three management measures south of Barrenjoey Point to do so – closing 75% of state waters to trawling, capping the catch of fishers based on past landings data and monitoring vessel movements using a vessel monitoring system (VMS).

Closing 75% of state waters south of Barrenjoey Point (Appendix D3(1)) might substantially reduce the area that could be trawled and therefore may reduce the risk of the effects of fishing. This part of the proposal will not make the State arrangements more complimentary with the SESSF but it may improve the management of the OTF provided appropriate enforcement structures are applied. Improved management will also depend on the placement and size of the areas closed.

Capping the total catch of individual fishing businesses south of Barrenjoey Point and adjusting the caps annually in light of the Commonwealth's TAC determinations (Appendix D3(3)) would result in greater complementarity in management arrangements than is currently the case. However, the introduction of the cap will restrain harvesting but does not necessarily ensure ecological sustainability of the fish stocks. Currently, the SESSF operates under an individual transferable quota scheme for 16 species and has few input controls. The NSW fishery operates predominantly under an input control system, apart from fishery-wide daily trip limits that apply to each of the Commonwealth's quota species in order to reduce incidences of quota evasion by dual licensed operators. To date, the State trip limits have not been regularly adjusted to account for changes in the Commonwealth TACs. The proposal in the draft FMS would result in individual catch limits being applied to each business under both jurisdictions, with those limits being closely linked. However, there are some difficulties with the proposal that would need to be overcome in order to make it effective, as outlined below.

Firstly, the cap on catches would need to be implemented at a species level in order to operate cohesively with the Commonwealth TAC regime. A single 'total catch' cap for a NSW vessel would allow the operator to take increased catches of an individual species in State waters, even if the Commonwealth TAC for that particular species is declining. Note that the setting of the Commonwealth TAC would need to take account of all relevant biological and stock assessment information, including catches taken in other jurisdictions (including NSW waters, where the caps should be at the species level).

Secondly, the proposal to set the initial level of the cap on the average of landings taken between 1999 and 2003 assumes that the catches by NSW operators in those years are sustainable. The EIS has concluded that the existing operation of the fishery is not ecologically sustainable, although this is due to a number of factors, with catch levels being only one. A review of the fishery's catch level across those years should be undertaken prior to committing to this period because if the recent catch levels are deemed to be a significant inhibiting factor for the ecologically sustainability of the primary and key secondary species, they may need to be set lower in the first instance. This review of factors affecting ecological sustainability should include discard levels of commercial species, habitat issues and ecological impacts. Furthermore, the proposed arrangements assume that the TAC levels set by the Commonwealth are set based on stock indicators alone, however the size of the Commonwealth fleet and its fishing practices also effect how the TACs are set in the SESSF. Any adjustments in the State caps should be based predominantly on stock assessment or stock status information.

Thirdly, using a capped level of catch as a management control for only this sector of the OTF (i.e. south of Barrenjoey Point) produces different management regimes within the OTF as the same management control is not proposed for fish trawlers between Barrenjoey Point and Smokey Cape.

Care would need to be taken to ensure that the different regimes between north and south of Barrenjoey Point did not create inconsistencies in the management regimes which carries the risks discussed in section 2.3 of Chapter B. Furthermore, the fishing dynamics of the SESSF are substantially different from the OTF. The size of their fleet, fishing effort, fishing practices etc are different and these differences effect how the TAC is set in the SESSF. Therefore, increases or decreases in the TAC are unlikely to be equivalent to changes in capped catches in the OTF.

Accordingly, the setting of a capped catch level for the OTF south of Barrenjoey Point has the potential to assist in risk reduction with respect to the primary and key secondary species, subject to the satisfactory resolution of the issues outlined above.

Monitoring the movement of vessels in designated whiting grounds via VMS would provide information on the frequency of trawling in the designated grounds and be a useful tool to aid compliance by NSW vessels with the new closed areas. However, the use of VMS is unlikely to provide any information on the use of the whiting net versus the general trawl net and given the complexity of the proposed arrangements (e.g. use of different gear in different areas) effective surveillance and monitoring of fishers is essential and will need to extend beyond tracking movements of vessels.

Table E1.9 Summary of management responses relating to inconsistent management regimes for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Inconsistent management regimes between adjacent jurisdictions	4	4.2	*a) Monitor management arrangements & annual landings of key ocean trawl species in fisheries outside NSW jurisdiction but impact on shared stocks*	1B
			c) Use cross-fishery & cross-jurisdictional consultation to discuss and manage issues relating to, multiple use of fishing grounds, collaborative research, fair & equitable access to stocks, complementary management arrangements & other interactions between fishing sectors	2B
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2B

vii) Data quality

The risk assessment identified the poor quality of the catch database information as a major obstacle to reducing the risk to primary, key secondary and secondary species (Section B2.3(c)). Two management responses address the issue of improving the data quality of the catch database and information for stock assessments (Table E1.10). Reviewing the adequacy of the data provided on the catch and effort returns for the different purposes in the draft FMS (MR 7.3(a)) will be essential to reduce uncertainty in management decisions. This review should be started on the commencement of the FMS so that improvements to data recording by fishers can be incorporated as soon as possible. Implementing changes to the way fishers report their catch will be essential for the on-going monitoring of the status of the stocks. Changing from monthly to daily catch reporting should be given a higher priority in the implementation of the FMS. Improving the accuracy of fisher's species identification will also improve the quality of database, which should enhance stock assessments for some species and should be incorporated at the start of the management.

Table E1.10 Summary of management responses relating to poor data quality for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Poor data quality	7	7.3	*a) Periodically review mandatory catch & effort returns; implement changes if:* *á data are perceived poor quality or insufficient for stock or environmental assessments* *á forms are exceedingly complex for fishers to complete, emphasis on quality rather than quantity of information collected*	1A
			b) Assess accuracy of current catch recording system, & species identification in catch records, provide advice to industry to make needed changes	1A

viii) Information gaps

There were three management responses relating to the issue of information gaps in the OTF (Table E1.11). Overall the management responses acknowledge the need for research to fill information gaps in a number of critical areas for the OTF including the biology of primary and key secondary species, including elasmobranchs (MR 7.2(a)(i)). They make a commitment to promoting and supporting research relevant to the fishery. Furthermore, the management responses have picked up specific areas highlighted by the risk assessment as important information gaps, such as the biology of primary and key secondary species and identification of habitats. A detailed assessment of these research priorities and plan is given in Section E5.2. Overall there is an acknowledgment in the management response to conduct research on direct and indirect effects of fishing on primary and key secondary species which is a substantial step forward.

Table E1.11 Summary of management responses relating to information gaps for primary and key secondary species in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Information Gaps	1	1.1	*d) Promote research & collaborate with research institutions to improve understanding of ecosystem functioning & how its affected by trawling*	1B
	6	6.2	*a) Develop & implement a Research Strategic Plan; using priorities for research outlined in the harvest strategy*	1B/3B
	7	7.2	*a) Promote and support targeted research projects relevant to: i) biology or stock assessment of the primary & key secondary species ii) distribution of marine habitats off NSW & potential impacts of trawling on habitats iii) impacts of trawling on biodiversity & environment (including mapping of fishing grounds, the effectiveness of trawl closures & 'refuge' areas, use & effectiveness of approved Bycatch Reduction Devices in reducing unwanted bycatch)*	3A/B

1.3 Bycatch – commercial and non-commercial species

For the purpose of assessing the draft FMS, bycatch will include all discarded catch including undersized commercial species and all non-commercial species. Threatened and protected species will be discussed in a separate section. The goals, objectives and management responses dealing with bycatch issues in the OTF are summarised in Tables E1.13-17.

There were seven major issues arising from the risk assessment of bycatch (both commercial and non-commercial) from Sections B2.3(c) and B2.4(d). If these issues are adequately addressed in the draft FMS, then theoretically the risk to bycatch species becoming unsustainable over a five year period should be reduced. An overall assessment of the risk reduction for bycatch is presented first, then each issue will be discussed in detail with respect to how well it has been addressed by the draft FMS in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to bycatch species

There were six types of management controls proposed in the draft FMS to reduce risk to bycatch species (Table E1.12). Of these, fishery closures and improved BRD will provide the greatest reduction in overall risk to bycatch. Gear selectivity are effective measures for a portion of bycatch species. The code of conduct will contribute the least to reducing risk as it will largely be voluntary and compliance will be difficult to monitor. Because so little is known about bycatch species and discarding patterns, observer programs will play a key role in determining the likely reduction risk for these species.

Table E1.12 Summary of management controls in the draft FMS used to reduce risk for all bycatch species.

	Management control proposed	Potential Risk reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Fishing closures	Major to moderate	2A, B	Some specific areas identified or being considered	MR 1.1(c) 1.2(e)
	Improved BRDs	Moderate	2B	Specific BRD already in use to be tested but currently most effective BRD not promoted	MR 1.1 (c), 1.2(b), Appendix D3
	Gear selectivity	Minor for some; may also increase discards for other commercial species	2B for some species, 2A rest	Depends on which species; will not benefit all	MR 2.1(e)
	Interim gear modifications for targeting whiting	Minor	2B	Continued use of current gear in areas with small fish not precautionary	Appendices D3 & D5
	Recovery programmes	Moderate	2B for some species, 2A rest	Details for some species	MR 2.2.(b)
	Code of conduct	Uncertain	2B	Depends on level of compliance	MR 1.2(d)
Information	Observer programmes	Minor to major	1B, 3A	Essential information for developing effective management controls	MR 1.2(a)
	Review MLL	Negligible	1A	Essential information to determine if contributing to undersized commercial bycatch	MR 2.1(a)

Overall risk reduction for bycatch	**MINOR to MODERATE**

The strength of this section of the draft FMS is the greater use of management responses that identify and use a specific control mechanism, i.e. Stage 2B in risk management. This makes it potentially more effective in reducing risk. Overall therefore, risk to bycatch species in the OTF could potentially be reduced from a minore to moderate extent.

b) Evaluation of management responses addressing issues from the risk assessment for bycatch species

i) Whole bycatch approach

With the exception of minimum legal lengths all of the management responses relating to bycatch approach it as a whole rather than splitting it into species specific management responses (Table E1.13). Such an approach will aid in reducing the risk of bycatch becoming unsustainable provided the individual responses are effective.

Table E1.13 Summary of management responses relating to holistic approach to bycatch in the OTF.

Bycatch Issue	Goal#	Objective #	Abbreviated Management Response
Whole approach to bycatch	1	1.2	*a) Design and implement an industry funded scientific observer program to document the degree of interaction with non-retained...species; collect information on use & effectiveness of Bycatch Reduction Devices*
			b) Refine & improve methods for reducing incidental catches; introduction of more effective Bycatch Reduction Devices for prawn trawl nets
			c) Investigate alternative handling practices to improve survival of incidental species returned to sea; in particular: i) prohibit finning sharks & discarding carcasses ii) ban "riddling" of prawns iii) restrict use of "spikes" to times when other handling methods are a occupational health or safety risk
			d) Develop a "Code of Conduct" for ocean trawl fishers
			e) Identify areas and/or times of problem incidental catch to target catch ratios and restrict trawling appropriately. In particular, implement closures to trawling around river entrances during times of high river discharge

ii) General lack of quantification

Three management responses address the issue of lack of information about bycatch in the OTF (Table E1.14). Design and implementation of observer programs onboard ocean prawn and fish trawl (MR 1.2(a)) vessels will quantify a number of important areas of bycatch. Information on the spatial and temporal variability of the abundance and diversity of both undersized commercial and non-commercial species will be essential in aiding the reduction of risk to all bycatch species. For example, it will help identify times and locations of large abundances of juvenile commercial species which will allow more effective area and/or seasonal closures to be implemented to protect them. This is reflected in management response 1.2(e). In addition, quantification of the non-commercial component of bycatch will enable a better understanding of magnitude, its spatial and temporal variability and what proportion is made up of vulnerable species such as elasmobranchs. The observer program to collect biological information on important shark species should be extended to include species that are discarded (both undersize commercial and non-commercial) due to their high level of vulnerability to fishery impacts (MR 2.1(j)).

Collecting this information is an essential first step to reducing risk on all bycatch. As outlined in the performance monitoring section of the draft FMS, the results of these studies will be fed back to develop better management measures. One important outcome of these observer studies is that they may reveal other species or areas of risk in the fishery that were previously unknown due to lack of data (e.g. interaction with a non-commercial species with a very restricted range). The draft FMS allows for the possibility of modifying the management strategy when new information like this comes to light (see Section D5(d)).

Table E1.14 Summary of management responses relating to lack of information about bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Lack of information about bycatch	1	1.2	*a) Design and implement scientific observer program to document the degree of interaction with non-retained*	1B
			e) Identify areas &/or times of problem incidental catch to target catch ratio, e.g. flood closures	2B
	2	2.1	*j) Use observer prgramme to collect additional biological information; important elasmobranch species*	1B

iii) Effectiveness of bycatch reduction devices currently used in ocean prawn trawls

There were three management responses relating to the effectiveness of bycatch reduction devices (BRD) used on prawn trawlers (Table E1.15). The proposed observer study on prawn trawlers (MR 1.2(a)) to examine the effectiveness of BRD currently used on these trawlers and those proposed in Appendix D3 and D5 will be essential in refining their use in this sector of the OTF. The study needs to be designed so that data are collected to account for the spatial, temporal and environmental variability (such as high river discharge) in abundances and diversity of bycatch species. It would be insufficient to conduct the observer study in a limited number of places and times of year because there is an indication that BRD work differently depending on the environmental conditions (Ashby, 1999,) and also of the highly variable nature of marine assemblages.

Management responses 1.1(c) and 1.2(b) provide for the modification of BRD permitted to be used in the fleet based on data retrieved through the onboard observer program and a minor modification to the existing square mesh panel. Those BRD found to be more effective at reducing bycatch without significant loss of primary and key secondary species will be promoted to fishers as the best options to use. This will have a substantial influence on reducing risk on bycatch because the specific mechanism proposed (effective BRD) will be underpinned by rigorous research.

Under the proposed arrangements for targeting whiting with prawn trawl nets, a modified square mesh panel BRD will still be permitted (Appendices D3 and D5). It is acknowledged in the draft FMS that this BRD is less effective in reducing bycatch (MR 1.2(b)) than the composite square-mesh panel BRD (Broadhurst and Kennelly, 1997) and the modifications proposed would have a negligible effect on the risk to bycatch. Broadhurst *et al*. (2002) found that the important factor in enabling more bycatch to escape via the square mesh panel BRD is its position in the cod-end. For the most effective reduction in bycatch the panel should be placed at least 1.2 m anterior to the last row of meshes in the cod-end which maintains an acceptable catch of prawns while still allowing large numbers of small fish to escape. Panels positioned at 1.6 m from the end of the cod-end reduced overall bycatch by 20.3% compared with panels located at 1.2 m which reduced overall bycatch by 32.8% (Broadhurst *et al*. (2002)). When calculated up, this would represent a large difference in the total tonnage discarded between these two configurations across the entire prawn trawl fleet over the course of a year. Appendices D3 and D5 include rules relating to the position of the square mesh panel in the cod-end (ie. to ensure it is anterior of and in the top of the cod-end and within certain limits from the end of the cod-end), but enables the panels to be positioned beyond 1.2 m from the end of the cod-end. Consequently, the proposed rules for positioning the square mesh panel are less effective than they should be based on the available scientific research (and, as noted above, far less effective than use of the composite square mesh panel).

The arrangements specified in the Appendices D3 and D5 reflect the current arrangements regarding the way in which the panel must be sewed into the net (ie. the bating arrangements) and ensure the meshes in the panel remain square and open during trawling, thereby aiding bycatch reduction.

Appendices D3 and D5 allow the use of a BRD that is known to be less effective in reducing bycatch than other scientifically tested designs (see Broadhurst and Kennelly, 1997, Broadhurst *et al*., 2002). This seems contrary to the intent of the management response to "refine and improve methods for reducing incidental catches, including the introduction of <u>more effective</u> Bycatch Reduction Devices". Broadhurst *et al*. (2002) clearly state that "the composite square-mesh panel is currently <u>the most appropriate behavioural-type BRD</u>" for the OTF. Yet nowhere in the draft FMS is this particular BRD promoted as the best one to use for the OTF. Whilst it does make clear that other approved BRD can be used, it does not advocate the more effective composite square-mesh panel BRD, which does not promote the intent of Objective 1.2 and Goal 1. Moreover, it brings into question the value of undertaking future research into more effective BRD (MR 1.2(b)) when in the past the results of such research (e.g. Broadhurst *et al*., 2002) have not been implemented to improve management measures. Therefore, the proposed requirements of the BRD in Appendices D3 and D5 need substantial revision before they can be regarded as meaningfully reducing the risk to bycatch species.

Table E1.15 Summary of management responses relating to effectiveness of BRD in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Effectiveness of BRD used in prawn trawls	1	1.1	*c) Implement additional Bycatch Reduction Device requirements for prawn trawl nets south of Smoky Cape*	2B/3B
		1.2	*a) Design and implement scientific observer program to..…collect information on the use and effectiveness of Bycatch Reduction Devices*	3A
			b) Refine & improve methods for reducing incidental catches, including the introduction of more effective Bycatch Reduction Devices for prawn trawl nets; modified square mesh panel BRD	2B
	2	2.1	*e) Appendix D3(6), D5(1)(4) dimension of modified square mesh panel BRD when targeting whiting*	2B*

* indicates management measure is not precautionary

iv) Discarding of undersized commercial species

Discarding of undersized commercial species is addressed in eight management responses (Table E1.16). The importance of improved BRD (MR 1.1(c), 1.2(b)) (except when targeting whiting) was discussed in the previous section and will obviously have benefits for reducing impacts on undersized commercial bycatch caught in prawn trawl nets. The introduction of an effective observer program, also discussed previously will improve our understanding of the extent, magnitude and temporal and spatial variability of undersized commercial bycatch (MR 1.2(a)). Reviewing the regulations on minimum legal lengths (MLL) (MR 2.1(i)) for many primary and key secondary commercial species will help identify whether they are suitable. It is proposed to introduce a MLL for silver trevally because it is growth overfished. However, MLL can be the cause of excessive discarding of undersized commercial species, therefore increasing discarded bycatch (Cook, 2001). In reviewing MLL for primary and key secondary species attention should be given to the effect these regulations might potentially have on this component of bycatch in the OTF, and this is foreshadowed in MR 2.2(a).

A more effective mechanism for reduction of risk on under-sized commercial bycatch species is improved gear selectivity of both prawn and fish trawl nets (MR 2.1(e)). This will be especially effective in fish trawl gear because, unlike prawn trawlers, they cannot use the conventional BRD due to the wide range of species taken as landed catch by fish trawlers. But as noted earlier whilst current gear is permitted to be used in expansive areas for targeting school whiting (see Appendices D3 and D5) this will do little to contribute to reducing risk to under-sized commercial and non-commercial bycatch species in these areas. Improved gear selectivity for fish trawlers on its own will not be sufficient to reduce risk to undersized commercial species because some species will have different body shapes and modes of swimming and changed mesh size will have no impact. For example, unmarketable John and Mirror dories will likely still be caught because of their elongated dorsal spines and flattened dorsal-ventral shape. Elasmobranchs also have a body shape that makes them prone to being trawled. Therefore other mechanisms are required in addition to changes in gear selectivity for fish trawlers to reduce undersized commercial species. This will primarily be achieved through the use of appropriately designed closures that are proposed in the draft FMS (MR 1.1(b)).

There are three types of closures in particular that will aid in reducing discard mortality of undersized commercial species – flood closures, closing 75% of state waters south of Barrenjoey Point and continued bans on fish trawling north of Smoky Cape (MR 1.2(e), 2.1(f), 1.1(c)(e)). During high river discharge as a result of flooding, a number of studies (Glaister, 1978) have shown that there is an increase in abundance of juvenile prawns and many estuarine finfish species at river mouths, thereby increasing the catch of unmarketable commercial species and potentially increasing discarding. Closures near the mouths of rivers during these floods will reduce catches of the undersized commercial component of bycatch. On-going monitoring (Stage 3A of risk management) to determine the effectiveness of these flood closures in reducing the risk to this component of the bycatch (MR 1.2(e)) will be essential.

Contributions to recovery programs for species of which OTF is a minor harvester (MR 2.2(b)) have the potential to address the capture of unmarketable individuals of redfish and gemfish. Until details of these recovery programs are known it cannot be determined how effective they will be in reducing the risk to this component of bycatch.

If limitations on fishing effort in the form of allocated days/nights fished are introduced (MR 5.2(a)(iv)) there could be an indirect affect on the discarding of unmarketable commercial bycatch. Reducing fishing effort overall, provided this includes current active effort, should have corresponding effects of reducing bycatch. But this will only be valid if there are no changes in how the fishing fleet proportionately targets each part of the fishery complex (Stratoudakis *et al*., 1998; Sampson, 1994). Limiting the time available to fish can give incentive to fishers to increase efficiency and thus catchability (Sampson, 1994). This could result in an increase in discarding of unmarketable commercial bycatch because fishers have a greater ability to catch larger abundances of the target species with a larger range of sizes. Consequently, a greater proportion of the discards could be unmarketable commercial species (Sampson, 1994). Improved gear selectivity (MR 2.1(e)) should contribute to minimising this type of problem. Limited time available to fish may also lead to high-grade discarding where in order to maximise their revenue fishers only keep the most valuable fish including those of a larger size and discard the rest (Gillis *et al.*, 1995; Cook, 2001). This could lead to an increase in the fishery's impact on primary and key secondary species. Therefore, whatever mechanism is proposed to reduce effort (e.g. allocation of limited nights and days) it will be essential that it is followed-up with an appropriately designed monitoring program to determine whether it has led to an increase in discarding of undersized commercial species.

The introduction of a Code of Conduct (MR 1.2d(i),(ii)) is likely to have a minor influence in reducing risk on discarding of unmarketable commercial species since compliance to the Code will be largely voluntary and monitoring the rate of compliance would be difficult.

Table E1.16 Summary of management responses relating to discarding of under-sized commercial species in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of undersized commercial bycatch	1	1.1	*b) Implement series of closures to trawling .. including closure of all reefs & depths greater than 1100 metres*	2B
			c) Continue prohibition on using fish trawl nets north of Smoky Cape; implement additional BRD requirements for prawn trawl nets south of Smoky Cape	3B
		1.2	*a) Design & implement scientific observer program to collect information on the use and effectiveness of Bycatch Reduction Devices*	3A
			b) Refine & improve methods for reducing incidental catches; introduction of more effective BRD for prawn trawl nets	2B
			d) Develop a "Code of Conduct" for ocean trawl fishers to: i) encourage use effective BRD, avoid fishing in areas &/or at times when juvenile or small fish are abundant ii) promote best practice handling of bycatch	2A
			e) Identify areas and/or times of problem incidental catch to target catch ratios & restrict trawling appropriately; implement closures to trawling around river entrances during times of high river discharge	2B
	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular: i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40- 50 mm ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm*	2B/3B
			f) Maintain & enhance the effectiveness of the "juvenile king prawn" closures; in particular: iii) make all juvenile king prawn closures year-round closures, except when sufficient quantities of school prawns are present if size of school prawns exceeds a count of 100 prawns per half-kilogram and bycatch levels are acceptably low iv) investigate need to extend juvenile prawn closures adjacent to mouths of all major estuaries along the NSW coast, aim of harvesting prawns at size greater than 50 king prawns & 100 school prawns per half kilogram	2B
			i) Review the efficacy of minimum size limits for fish species taken in the ocean trawl fishery, including need for minimum legal sizes to be implemented for additional species; regulations pertaining to fish with a minimum legal length captured in prawn trawl nets south of Smoky Cape	1A

Table E1.16 Cont'd

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of undersized commercial bycatch	2	2.2	*b) Minor harvester of an overfished species, contribute to the development of any recovery programs for that species, adopt measures required by recovery program, in particular:* *i) determine if additional measures are needed to improve the selectivity of fish trawl nets for redfish* *ii) implement the provisions of the recovery program for gemfish to be developed under the Ocean Trap and Line FMS.*	2A
	5	5.2	*a) Manage fishing effort in the ocean trawl fishery by:* *iv) investigating efficacy of limiting number of days/nights each boat may work in the prawn trawl and fish trawl sectors of the fishery.*	2A

v) Discarding of non-commercial bycatch

Discarding of non-commercial species is addressed in six management responses (Table E1.17). Quantification of the non-commercial component of bycatch via well designed observer studies will also be an essential precursor to reducing risk to this component of bycatch (see discussion E1.3(a)). Introduction of the most effective BRD (MR 1.2(b)) will reduce impacts on non-commercial bycatch in the prawn trawl sectors (with the exception of BRD used when targeting whiting, as discussed in Section E1.3(b)(iii)). Not all groups of species will benefit from the BRD. As noted earlier elasmobranchs are particularly prone to being caught in trawl nets because of their larger size, body shape and swimming behaviour. Liggins (1996) found that approximately, 12% of the non-commercial bycatch was made up of elasmobranchs in fish trawls and this is likely to be an underestimate. The most effective management of elasmobranch bycatch is to avoid catching them. Results from the observer program (MR 1.2(a)) on the spatial and temporal variability of catch composition will aid in determining the most effective means to (MR 1.1(b)) reducing the impact on this group of species. The Code of Conduct should include specific methods for handling shark bycatch to aid the survival of shark species on returning to the water. In addition, survival of discarded non-commercial species should also be investigated to provide information on reducing the risk to bycatch.

Table E1.17 Summary of management responses relating to discarding of non-commercial species in reducing bycatch in the OTF.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Discarding of non-commercial bycatch	1	1.1	*c) Continue prohibition on using fish trawl nets north of Smoky Cape; implement additional BRD requirements for prawn trawl nets south of Smoky Cape*	2B
		1.2	*a) Design & implement scientific observer program to collect information on the use and effectiveness of Bycatch Reduction Devices*	3B
			b) Refine & improve methods for reducing incidental catches; introduction of more effective BRD for prawn trawl nets	2B
			c) Investigate alternative handling practices to improve survival of incidental species returned to sea; in particular: i) prohibit finning sharks & discarding carcasses ii) ban "riddling" of prawns iii) restrict use of "spikes" to times when other handling methods are a occupational health or safety risk	2A
			d) Develop a "Code of Conduct" for ocean trawl fishers to: i) encourage use effective BRD, avoid fishing in areas &/or at times when juvenile or small fish are abundant ii) promote best practice handling of bycatch	2A
	2	2.1	*e) Ensure selectivity of gear is appropriate to biology of species targeted. In particular: i) restrict prawn trawl net cod-ends to 150 meshes round (hanging ratio of 1:1), single twine maximum 4 mm diameter, mesh size 40- 50 mm ii) restrict fish trawl net cod-ends to 100 meshes round (hanging ratio of 1:1), single twine maximum 6 mm diameter, minimum mesh size 90 mm*	2B

The continued ban of fish trawling north of Smoky Cape ensures there will be no expansion of discarding from fish trawling and therefore not increase the risk to non-commercial bycatch species. The discussion evaluating the effectiveness of a Code of Conduct for undersized commercial bycatch also applies to the non-commercial bycatch (see Section E1.3(a)(iv)).

Alternative handling practices from the use of spikes for sorting catch on board vessels could increase the survival of some non-commercial species. However, this management measure is likely to have only a minimal affect on reducing the risk to non-commercial bycatch for two reasons. First, spikes will continue to be used on the most dangerous species, such as some stingrays, and therefore the survival of most elasmobranchs caught will not be improved by this management measure. Second, there is no information about the rates of survival of non-commercial bycatch species, including elasmobranchs, after being discarded in the OTF. Studies done in other trawl fisheries on survival of discards have shown that the time spent on the deck is important in determining a species' ability to survive discarding (Hill and Wassenberg, 1990; Stobutski *et al*., 2002). However, these studies have only been done in tropical waters of northern Australia which clearly have different environmental conditions (e.g. warmer air temperatures and shallower depths) than those in the OTF. There is no research proposed in the draft FMS to investigate the survival of discards, including the survival from being spiked. To effectively reduce the risk, the draft FMS would need to prevent the use of spike on all bycatch, and alternative discard methods should be used instead. There appears to be few species normally discarded using a spike that could not be discarded using an alternative, less harmful implement.

Improving the gear selectivity of trawl nets for commercial species (MR 2.1(e)) could potentially change the quantity and composition of the non-commercial bycatch positively or negatively. When such improved gear selectivity is introduced monitoring any changes in the bycatch (via the observer studies) will be essential.

Bycatch reduction methods in fish trawls are much harder to determine than in prawn trawl because of the wider range of species targeted. Closures are the most effective at reducing risk to bycatch since it excludes all form of fishing induced mortality. The draft FMS seeks to reduce bycatch of non-commercial species in fish trawls using closures in two ways (MR 1.1(b), MR 1.2(e)). The proposed closure of 75% of state waters south of Barrenjoey Point would provide a substantial reduction in risk to bycatch in fish trawlers as long it included current trawling grounds. The effectiveness of temporary closures around river entrances during periods of high flow will depend on how "unusually high" the ratio of incidental to target catch is defined. Whilst it is recognised that there will be substantial spatial and temporal variability in this ratio, it is very important for this ratio be determined for each river mouth to ensure adequate risk reduction.

vi) Knowledge of food provisioning by the OTF bycatch

There are no management responses in the draft FMS on gaining knowledge of whether discards are a substantial source of food for marine scavengers. While it would be limited to surface-dwelling scavengers, some data on provisioning could be included in the proposed observer programs (MR 1.2(a)). Research investigating the diet of marine scavengers around trawl vessels is recommended.

1.4 Protected and Threatened Species and Communities

a) Overall effectiveness of proposed mitigation measures

In summary, the measures proposed to mitigate risk to threatened and protected species in the Ocean Trawl fishery are focused on obtaining better information on interactions between these species and the fishery. The development of a code of conduct based on that used in the Commonwealth South East Fishery may also reduce the risks to these species. Given the relatively low levels of risk to threatened species identified in Section B2, the proposed mitigation measures are considered adequate. It will be important, however, as provided for in the draft FMS, to ensure that information gathered is fed back into the management of the fishery in a timely manner, so that effective measures (e.g. closures) are used to manage any risks that are identified in future.

b) Likely changes in risks to threatened species

In general, risks to threatened species from trawling under the present management arrangements are low or moderately low and there is no change to these risks under the draft FMS. Risks to threatened species that are moderately low do not require a direct management action, but need ongoing monitoring to ensure that risks do not increase as activity changes. Furthermore, the risk assessment identified a lack of information about fishery interactions with many threatened species. To address this lack of information, the draft FMS proposes several mechanisms for obtaining better information. The measures contained within the harvest strategy and the research plan satisfy the requirements for ongoing monitoring of interactions and gathering of new information. The specific measures are listed below.

Harvest strategy

- Data on interactions between ocean trawl fishers and turtles will be obtained through changes in reporting forms and through onboard observer studies.
- Modification to the monthly catch return forms which will incorporate mandatory reporting of fishers' interactions with threatened species during fishing operations (see MR 3.1(a)); it should be noted that mandatory reporting carries with it an element of potential bias against mentioning them at all; therefore it will require careful policing and verification from the observer program
- The implementation of an observer-based survey that will *inter alia* collect data on occurrences of threatened species in catches and feeding on discards (see MR 1.2(a)) of the draft management strategy).
- Advice from fishers via the Ocean Trawl MAC about negative impacts from external activities could alert NSW Fisheries to potential threatened species issues outside the fishery, however, any action to deal with such impacts is probably beyond the scope of the FMS. Cross-jurisdictional collaboration to consider consistent management regimes would promote consistency in policies for reducing harm to threatened species. This could reduce risks to threatened species, but to what extent risk would be reduced cannot be determined.

Research plan

- The strategy seeks to improve the accuracy of information available on interactions between the ocean trawl fishery and threatened species using research projects undertaken through threatened species recovery plans.

The proposals listed above would contribute to the protection of threatened species through the improvement of knowledge on how the fishery interacts with threatened species. Provided this information is fed back into the management of the fishery and action to reduce any risks identified are implemented, the measures would reduce the risk to threatened species.

Management responses

Goal 3 of the draft FMS is specifically aimed at conserving threatened species, and has its objective to: "Identify and minimise or eliminate any impacts of fishing activities on threatened species, populations, ecological communities and habitats...and promote their recovery".

Specific management responses proposed to achieve this objective are:

3.1(a) - Modify reporting arrangements to enable collection of information on interactions with or sightings of threatened or protected marine species, and gear interactions with other threatened or protected species;

3.1(b) - Implement the provisions of any threatened species recovery or threat abatement plan;

3.1(c) - Promote the use of fishing techniques that avoid the capture of or interaction with protected fish and fish protected from commercial fishing;

3.1(d) - Determine, through the on-board observer program, the level of interaction between the fishery and marine turtles and seals (protected under the *Threatened Species Conservation Act 1995*) and assess the need to introduce Turtle or Seal Excluder Devices, or other measures to minimise impacts on these species

Management response 3.1(b) is a continuation of existing management arrangements and therefore does not contribute to any reduction in immediate risk, but ensures that the FMS is responsive to new recovery plans, including newly identified "critical habitat" areas. Responses 3.1(a) and 3.1(d) address the need for more information and therefore could contribute to risk reduction, provided that any issues identified are acted upon. Management responses 3.1(c) and 3.1(d) are a practical measures that could lead directly to reduced catches of (or other negative interactions with) threatened species, and increased survival of certain threatened species that are caught by trawlers (e.g. turtles).

In addition to the management responses dealing directly with Goal 3, certain management responses under Goals 1, 2, and 4 are listed in the draft FMS as also contributing to Goal 3. These are discussed below.

Management responses under Goal 1

1.2(a) Design and implement a scientific observer program to document the degree of interaction of trawl fishing with non-retained species, and obtain other important data.

1.2(d) Develop a "Code of Conduct" for ocean trawl fishers.

Response 1.2(a) addresses knowledge gaps with regard to capture rates of threatened species and has the potential to document other interactions such as the species feeding on discards, etc. Provided that it is fed back into other management responses (e.g. 1.1(b)) - closure of areas to fishing) and used to reduce impacts, gathering such information would contribute to reduction of risk. The "Code of Conduct" (MR 1.2(d)) would contribute to reducing the risks to threatened species assuming there was substantial voluntary compliance.

Management responses under Goal 4

4.3(a) Restrict ‘offshore’ prawn trawlers to depths less than 150 fathoms (275 m), and ‘deepwater’ prawn trawlers to depths between 200 and 600 fathoms (365 to 1100 m).

Although not intended for protection of threatened species, this response would reduce the area available for prawn trawling (i.e. no trawling between 150 and 200 fathoms), and thus may incidentally provide a refuge for some threatened species (e.g. Herbst’s nurse shark) in these areas. Given a lack of knowledge about the biology of these species, it is unclear to what extent the risk would be reduced.

Management responses under Goal 6

6.3(b) Modify the arrangements for trawling in the area south of Barrenjoey Point (within 3 nautical miles) to achieve greater complementarity with the management of the adjacent Commonwealth Southern and Eastern Scalefish and Shark Fishery and to manage fish stocks in State waters on a sustainable basis and minimise other environmental impacts, as provided for in Appendix D3.

The closure of 75% of state waters south of Barrenjoey Point will substantially reduce the probability of vessels interacting with threatened and protected fish, marine mammals and reptile species provided that the closed areas correspond to areas these species are likely to be found and include some current trawl grounds.

c) The Eight Part test

A summary of the eight-part test for threatened and protected species is provided in Table E1.18.

Factors to be considered in the 8-part test.

1. “In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,... ”

Evaluation of the likelihood of a local extinction occurring as a result of the activity is based on the risk assessments for threatened species if the draft FMS were implemented (Table E1.18). Viable local populations of a threatened species are likely to be placed at risk of extinction if the risk level is intermediate or greater (see Table B2.27 for interpretation or risk levels). None of the threatened species considered had intermediate or greater levels of risk. Information supporting the risk levels assigned to threatened species can be found in Section B2.4.

2. “...in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,...”

Disruption of the viability of an endangered population as a result of the activity is based on the risk assessments for threatened species under the draft FMS (Table E1.18). Any assigned risk level of intermediate or greater is considered likely to significantly compromise the viability of the population (see Table B2.27 for interpretation or risk levels). Information supporting the risk levels assigned to endangered populations can be found in Section B2.4. The only endangered population that may be disturbed by the OTF is the Little penguin colony at Manly in Sydney Harbour (see Appendix B2.10). However, it is considered that any interactions between the OTF and the endangered population of little penguins at Manly should only have a negligible impact on the population as a whole, resulting in a low level of interaction with the fishery (for details see Appendix B2.10).

3. "...in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,..."

Proposed trawling activities as set out in the draft FMS are not considered to modify the habitat of any threatened species, with the possible exception of Herbst's nurse shark, for which there is little information on habitat use. Therefore, for Herbst's nurse shark the answer to this question cannot be determined.

4. "...whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,... "

The activity of trawling as set out in the draft FMS is unlikely to isolate areas of habitat.

5. "...whether critical habitat will be affected,..."

Critical habitat has been declared for four of the species considered here (wandering albatross, shy albatross, grey nurse shark and little penguin). Except for the grey nurse shark, this habitat is mostly terrestrial (extending to 50 m from shore, both inland and out to sea, for the little penguin), therefore would not be affected by the fishery. Grey nurse sharks have 10 designated areas of critical habitat along the NSW coast. These habitats are all complex rocky reefs, which are unsuitable for trawling. Therefore, it is unlikely that they will be affected by the OTF even though trawling is not among those activities prohibited from occurring within the sanctuary zones of grey nurse critical habitats. The remaining species have no declared critical habitat, so this question is not applicable. When additional critical habitats are declared the FMS should review whether trawling is likely to impinge on these habitats.

6. "...whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,..."

Many of the species considered here travel long distances in search of food or as part of their natural migration. Included in this group of highly mobile species are the birds, mammals, turtles and sharks (with the possible exception of Herbst's nurse shark, for which there is little information on movements). While they may occur in conservation reserves at times, it is likely that, for the majority of the time, these species would be very poorly represented in nature reserves. In fact, for such highly mobile and wide-ranging species, it has been argued that marine reserves are necessary but not sufficient to protect the species from the processes that threaten them (Allison *et al*., 1998). Therefore the majority of species are not considered to be adequately represented in conservation reserves.

Species of fish that are represented in conservation reserves are the black cod, blue groper, weedy seadragon and the grey nurse shark. Black cod and grey nurse shark are known from Cook Island Aquatic Reserve, Solitary Islands Marine Park, Jervis Bay Marine Park, Cape Byron Marine Park, and Lord Howe Island Marine Park. Grey nurse are also known from Long Reef Aquatic Reserve and the other areas of critical habitat not covered in marine parks, namely Fish Rock (South West Rocks), Green Island (South West Rocks), The Pinnacle (Forster), Big and Little Seal Rocks (South of Forster), Little Broughton Island (North of Port Stephens), Magic Point (Maroubra), Bass Point (Shellharbour), Tollgate Islands (Batemans Bay) and Montague Island (Narooma). The restrictions in force around these areas include a ban on fishing with bait from anchored or moored vessels within 200 metres, and a ban on commercial drop, drift and set line fishing within 1000 metres of the site.

Blue groper and a variety of the other rocky reef fish are likely to occur in many of the marine protected areas that contain rocky shores, and juveniles of the species are likely to occur in marine protected areas containing seagrass beds. The weedy seadragon occurs in Halifax Park Aquatic Reserve (Port Stephens), and Jervis Bay Marine Park.

7. “...whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process...”,

No aspect of the Ocean Trawl fishery constitutes a recognised threatening process for any of the species considered here. (Note that trawling north of 28°S is a key threatening process for marine turtles, but the Ocean Trawl fishery does not operate north of 28°S).

8. “...whether any threatened species, population or ecological community is at the limit of its known distribution.”

Several of the species considered here are at the limit of their distribution.

Table E1.18 Summary of the results of eight-part tests for the impacts of the Ocean Trawl fishery on threatened and protected species listed under the FM Act, TSC Act and/or EPBC Act.

Information supporting the answers to each part can be found in Section B2.5 or Appendix B2.10. Answers that would contribute towards a determination of a significant impact on a threatened species are shaded. n/a indicates that the particular factor is not applicable to this species.

Species common name	**Factors considered in the 8-part test**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Endangered species								
Fish								
Grey Nurse Shark	no	n/a	no	no	n/a	yes	no	no
Green Sawfish	no	n/a	no	no	n/a	no	no	yes
Birds								
Gould's petrel	no	n/a	no	no	n/a	no	no	yes
Northern royal albatross	no	n/a	no	no	n/a	no	no	yes
Southern giant-petrel	no	n/a	no	no	n/a	no	no	no
Wandering albatross	no	n/a	no	no	no	no	no	no
Mammals								
Blue whale	no	n/a	no	no	n/a	no	no	no
Dugong	no	n/a	no	no	n/a	no	no	yes
Southern right whale	no	n/a	no	no	n/a	no	no	no
Reptiles								
Loggerhead turtle	no	n/a	no	no	n/a	no	no	yes
Endangered population								
Little penguin population	n/a	no	no	no	no	no	no	yes
Vulnerable species								
Fish								
Black cod	no	n/a	no	no	n/a	yes	no	yes
Great White Shark	no	n/a	no	no	n/a	no	no	no
Whale Shark	no	n/a	no	no	n/a	no	no	no
Birds								
Antipodean albatross	no	n/a	no	no	n/a	no	no	yes
Black-browed albatross	no	n/a	no	no	n/a	no	no	no
Black-winged petrel	no	n/a	no	no	n/a	no	no	yes
Buller's albatross	no	n/a	no	no	n/a	no	no	yes
Campbell albatross	no	n/a	no	no	n/a	no	no	yes
Fleshy-footed shearwater	no	n/a	no	no	n/a	no	no	no
Gibson's albatross	no	n/a	no	no	n/a	no	no	yes
Grey ternlet	no	n/a	no	no	n/a	no	no	no
Indian yellow-nosed	no	n/a	no	no	n/a	no	no	yes
Kermadec petrel (western)	no	n/a	no	no	n/a	no	no	yes
Little shearwater	no	n/a	no	no	n/a	no	no	no
Northern giant-petrel	no	n/a	no	no	n/a	no	no	no
Providence petrel	no	n/a	no	no	n/a	no	no	no
Red-tailed tropicbird	no	n/a	no	no	n/a	no	no	no
Salvin’s albatross	no	n/a	no	no	n/a	no	no	no
Shy albatross	no	n/a	no	no	no	no	no	no
Sooty albatross	no	n/a	no	no	n/a	no	no	yes
Sooty tern	no	n/a	no	no	n/a	no	no	yes
Southern royal albatross	no	n/a	no	no	n/a	no	no	yes
White tern	no	n/a	no	no	n/a	no	no	yes
White-bellied storm-petrel	no	n/a	no	no	n/a	no	no	yes
White-capped albatross	no	n/a	no	no	n/a	no	no	yes

Table E1.18 Cont'd

Species common name	Factors considered in the 8-part test							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Vulnerable species								
Mammals								
Australian fur-seal	no	n/a	no	no	n/a	no	no	yes
Humpback whale	no	n/a	no	no	n/a	no	no	no
New Zealand fur-seal	no	n/a	no	no	n/a	no	no	yes
Sperm whale	no	n/a	no	no	n/a	no	no	no
Reptiles								
Green turtle	no	n/a	no	no	n/a	no	no	yes
Hawksbill turtle	no	n/a	no	no	n/a	no	no	yes
Leatherback turtle	no	n/a	no	no	n/a	no	no	no
Species protected from fishing (FM Act, Section 19)								
Ballina angel fish	no	n/a	no	no	n/a	no	no	yes
Eastern blue devil fish	no	n/a	no	no	n/a	yes	no	yes
Elegant wrasse	no	n/a	no	no	n/a	yes	no	yes
Estuary cod	no	n/a	no	no	n/a	yes	no	yes
Giant Queensland groper	no	n/a	no	no	n/a	yes	no	yes
Herbst's nurse shark	yes	n/a	§	no	n/a	no	no	no
Weedy seadragon	no	n/a	no	no	n/a	yes	no	yes
Species protected from commercial fishing (FM Act, Section 20)								
Groper, blue, brown or red	no	n/a	no	no	n/a	yes	no	no

Note: § - Herbst's nurse shark too little information to determine an answer. Answers that would contribute towards a determination of a significant impact on a threatened species are shaded. n/a indicates that the particular factor is not applicable to this species.

1.5 Species Assemblages, Species Diversity and Ecological Processes

The goals, objectives and management responses (MR) dealing with issues for species assemblages, species diversity and ecological processes of the OTF are summarised for each issue in Tables E1.19-20. There were four major issues arising from the risk assessment of these ecological components. If these issues are adequately addressed in the draft FMS then theoretically the risk to these components of becoming unsustainable within 20 years should be reduced. Each issue will be discussed with respect to how well it has been addressed by the proposed management responses in terms of the stages in risk reduction outlined in Section E1.1.

a) Evaluation of management responses addressing issues from the risk assessment for species assemblages and species diversity

i) Priority on conservation of marine habitats

Conservation of marine habitats is a key issue in reducing the risks to species assemblages, diversity and ecological processes. There were six management responses that contribute to the conservation of marine habitat (Table E1.19). These are discussed in detail in Section E1.6. Overall, they show a commitment to conserving marine habitats, especially management responses 1.1(a, b) and 7.2(a). However, details are lacking to determine whether the closures and research are sufficiently specific and adequate to mitigate risks to species diversity, assemblages and ecological processes. Limiting the size of bobbins on fish trawl gear south of Seal Rocks pending the introduction of reef closures (MR 1.3(a)) will reduce trawling on high profile reefs but continue to enable trawling on low profile reefs. However, this management response will be superseded by the closure of all reef areas under MR 1.1(b). This issue is further discussed in Section E1.6.

Table E1.19 Summary of management responses relating to conservation of marine habitat.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Place high priority on conservation of marine habitats in oceanic waters	1	1.1	*a) Define & map the extent of trawling grounds & determine intensity of trawling on each ground*	1C
			b) Implement a series of closures to trawling to protect a range of ocean habitats & associated biodiversity, including closure of all reefs and depths greater than 1100 metres to all trawling	2A/2B
		1.3	*a) Require the use of trawl gear designs that minimise impacts on habitats & associated biota*	2B
	4	4.3	*c) Manage the multiple use of trawl grounds within ocean trawl fishery & minimise adverse interactions*	2A
	6	6.5	*a) Manage the ocean trawl fishery consistently with other management programs, e.g. marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy*	2A
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW & the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity & the environment*	1B/1C

ii) Establishment of refuge areas for species diversity, assemblages and ecological processes

The establishment of refuge areas is the most effective means of reducing risk to species diversity, assemblages and ecological processes in the information poor environment of the OTF. Two management responses propose establishing closures for different purposes (Table E1.20). Implementing closures specifically to protect a range of marine habitats, including some oceanic waters outside three nautical miles, will have a positive affect on helping to maintain species diversity and assemblages. There are no details given of the criteria or process by which suitable areas will be determined, what activities will be prevented and how they will be monitored. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. It will be important to ensure that the knowledge gained is translated into effective management regimes as soon as possible. However, this makes it difficult to assess how effective the closures will be for reducing risk to species diversity and assemblages. Attention to the size and placement of closures will be critical in ensuring they protect an appropriate range of habitat and species assemblages.

It is acknowledged that the NSW Government's Marine Parks program will contribute to conserving species diversity relevant to the OTF. Three marine parks have been declared on the NSW coast – Solitary Islands, Jervis Bay and Cape Byron. These are designed to incorporate a range of habitats that are representative, adequate and comprehensive of the bioregion in which they exist. Within each park areas are zoned for different purposes, such as habitat protection and general use. In both Jervis Bay and Solitary Islands marine parks all trawling is only permitted in general use zones (note fish trawling is prohibited north of Smoky Cape), which comprise 8 and 34 percent respectively of the total area of the park. Zoning for Cape Byron marine park is currently being developed. Additional marine parks will be established on the NSW coast and the more marine parks the greater their contribution to conserving biodiversity but it depends on where they are sited. It should be noted that these parks extend to 3 nautical miles out to sea from the coast, except Jervis Bay, which extends to less than 1 nautical mile. The operational area of the OTF extends beyond 3 nautical miles north of Barrenjoey Point and, as management response 1.1(b) notes, it is important for there to be closures in these regions also. The Commonwealth Government has the power to introduce marine parks in waters beyond 3 nm, as evidenced by the introduction of the Commonwealth Solitary Islands Marine Reserve, and it has signalled an intent to introduce a national system of marine protected areas as part of the regional marine planning process under the National Oceans Policy (see http://www.affa.gov.au/ministers/macdonald/releases/2004/04006m.html). It would be prudent for the draft FMS to consider the criteria used by the Marine Park Authority in choosing suitable areas for such closures including the proposed 75% of state waters south of Barrenjoey Point (e.g. Avery, 1999).

Table E1.20 Summary of management responses relating to establishment of refuge areas.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Establish refuge areas for species diversity, species assemblages & ecological processes	1	1.1	*b) Implement a series of closures to trawling to protect range of ocean habitats & associated biodiversity, including closure of all reefs and depths > 1100 m*	2A
	2	2.1	*g) Develop strategies to establish refuge areas & spawning closures for species targeted by trawling*	2A
	6	6.5	*a) Manage ocean trawl fishery consistently with other management programs, e.g. marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy*	2A

iii) Ensure management measures are sufficiently precautionary

Because there is so much that is unknown about the species diversity, assemblages and ecological processes in the OTF and the effects of the OTF on these ecological components it is essential that the management measures are sufficiently precautionary (Auster, 2001). For management measures to be sufficiently precautionary requires two important things. First, as smaller proportion of the ecological components as possible should be exposed to the potential impacts of the activities of the OTF. Second, whatever management measures allow ecological components to be exposed to the potential impacts of the fishery should be closely linked to a learning feedback mechanism, i.e. a scientifically rigorous adaptive management framework (Walters, 1986; Underwood, 1990). This would ensure that many information gaps in our understanding of the relationships between habitats, species diversity and assemblages and impacts of fishing would be progressively filled.

The most optimum approach to precautionary management is the establishment of large space/time closures to fishing (Walters, 1998). The draft FMS has made a commitment to establishing a number of different types of closures (MR 1.1(b), 1.2(c), 2.1(f,g), 6.3(b,c)). To achieve long term sustainability in the face of high levels of uncertainty the proposed strategy takes a substantially precautionary approach. It is recognised that such a change in management would have some immediate economic implications for fishers and the associated fishing communities. The alternative of not taking a precautionary approach is that there is a substantial risk that the fishery may become economically unviable in the long term due to continued damage to habitats that support species diversity, assemblages and ecological processes. Furthermore, the economic collapse of a fishery also carries with it environmental damage, which may take decades to recover, and in the case of some habitat forms (see Section E1.6) not recover at all, i.e. irreparable damage. Therefore, not establishing major space/time closures in the short term risks postponing a highly likely economic and ecological decline that has serious long term consequences for more than just the fishing community. The fishing industry, scientists, fisheries managers and the government must all come to terms with this prospect and then work together to find amenable solutions.

b) Evaluation of management responses addressing issues from the risk assessment for ecological processes

The risk assessment in section B2.6 identified risks to ecological processes from three of the main activities of the current fishery, namely harvesting, trawling and discarding. Due to a lack of information on ecological processes in south-east Australian waters, the risk assessment was based largely on overseas studies and expert opinion of the impacts of trawling.

Harvesting was found to present risks to trophodynamic processes, which could result in changes in distribution and abundance of both harvested and non-harvested species. Measures to address this include several management responses under goals 1-3 that aim to reduce the ecological impacts of the fishery. In particular, the promotion of research into ecosystem functioning, reduction of bycatch and prevention of overfishing are management responses that would assist in reducing risks to ecological processes due to harvesting.

Trawling (i.e. physical disturbance of the sea bed) was found to have potential consequences for secondary productivity, and also for altering nutrient dynamics. The most effective measure that would reduce the risk is to introduce closures (MR 1.1(b)). Whilst all reef areas will be closed to trawling, other habitat types, such as some soft sediments will also need protection to help in maintaining secondary productivity. Protecting these habitats should be considered when determining areas to close south of Barrenjoey Point.

Discarding was found to have potential risks to displacement of productivity from demersal fish production to benthic and pelagic scavenger production. Reduction of bycatch may go some way towards reducing this potential risk, however this will depend on the effectiveness of any bycatch reduction measures that are introduced.

The management responses in the draft FMS have been written with the intention of reducing the risk to the ecological processes discussed here, however it is difficult to quantify to what extent the risk is reduced for two reasons. First, there is very little actual information on the impact of the current activity to ecological processes, making it difficult to quantify the extent to which impacts would be reduced under the draft FMS. Second, the draft FMS lacks the necessary detail of how several key responses are to be implemented (e.g. the closures), making assessment of the outcome difficult. It is acknowledged, however, that the draft FMS does propose actions that aim to increase knowledge of the fishery and its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of closures can be worked out. It will be important to ensure that the knowledge gained is translated into effective management regimes in future.

The most effective method of protecting ecological processes on trawl grounds from the effects of trawling is to introduce closures. Ideally, a closure would have clearly stated goals (e.g. larval production of fish species increased by 50% within closed areas), and would take into account biological properties of species (movement, habitat requirements etc.) and use the best available information to ensure success at achieving the goal. In the absence of such information, an adaptive management program would be the best way to proceed, with trial closures based on available information, appropriately rigorous sampling to test their effectiveness and rapid management response to act upon the information gathered.

1.6 Marine Habitats

The goals, objectives and management responses (MR) dealing with issues relating to habitats affected by the OTF are summarised in Tables E1.22-25. There were four major issues arising from the risk assessment of aquatic habitats. If these issues are adequately addressed in the draft FMS, and it is assumed that the management responses will be effective when implemented, then the theoretical risk to aquatic habitats (as defined in the risk context) should be reduced. Each issue will be discussed with respect to how well it has been addressed by the proposed management responses and in terms of the stages in risk reduction outlined in Section E1.1.

a) Overall assessment of reduction of risk to habitats

The strength of the draft FMS is that individual management responses often contribute to multiple management goals. There are a number of management responses (Table E1.21) and also references in the harvest strategy to the establishment of closures which is the most effective way of reducing the risk to marine habitats. However, the effective implementation of the FMS will be dependent on determining the detail for a number of responses (Table E1.21). This is particularly the case in reference to closures, wherein the process by which closures and other measures will be used to achieve their objectives need to be articulated (See Section 2.6(d)). Such a process would include determining a set of criteria for choosing areas to close incorporating input from all stakeholders, stating clear objectives for the closures, and how closures would be evaluated and monitored. For example, the criteria used by the Marine Parks Authority in classifying and selecting habitats needing to be protected provides a useful starting point as a means of formulating criteria for the OTF. In addition, the draft FMS does not address minimising impacts on habitats specific to threatened species under Objective 3.1. However, general habitat protection is provided for in MR 1.1(b) in which all reefs will be closed to trawling and 75% of state waters south of Barrenjoey Point will be closed. In order to conserve threatened species and their populations any habitats important or critical to them need to be protected.

A summary of the management controls proposed and assessment of their potential to reduce risk is given in Table E12.1. Overall, the draft FMS has a minor to moderate influence in reducing the risk to marine habitats associated with the OTF. A significant reduction in risk levels for some habitats is achieved by closing all reefs to trawling and, depending on where they are placed, areas closed south of Barrenjoey Point (MR 1.1(b)).

Table E1.21 Summary of management controls used to reduce risk levels for habitats

	Management control proposed	Potential Risk Reduction	Risk Management Stage	Comment	Reference in FMS
Management Actions	Refuge areas	uncertain	2A	No details given of criteria used to develop refuge areas	MR 2.1(g)
	Habitat protection & restoration areas	Major for reefs; uncertain for other	2A 2B	(a) Few details given of criteria used to select areas for closures other than reefs (b) Proposed closure of all reefs & depths greater than 1100m	MR 1.1(b)
	Gear modification (a) restrict size of bobbins and chains on trawl nets (b) mandatory use of droppers on prawn trawl nets	Nil unknown	2B 2B	Allows possibility for trawling on hard-substrata that will cause irreversible damage Effectiveness for minimising impacts on habitats is unknown	MR 1.3(a)
	Consistent management regimes among jurisdictions (whenever possible)	unknown	2A 2A	(a) Commitment to improve communication but no process outlined (b) Commitment to whole of government approach for management plans, but no process	MR 4.2(c) MR 6.5(a)
Information	Research to fill knowledge gaps	Minor to moderate	1B	Essential information to reduce uncertainty and improve effectiveness of management controls. Many MR's in the draft FMS relate to research issues, however, these should all be regarded as sub-sets of the Research Strategic Plan MR 6.2(a)	MR 6.2(a) see also MR 1.1(a) MR 7.2(a)

Overall risk reduction for habitats	**MINOR to MODERATE (varies among habitats)**

b) Evaluation of management responses addressing issues from the risk assessment for aquatic habitats

i) Fishing practices that cause irreversible damage to habitats

Two habitat types are regarded as being at high risk of irreversible damage from the activities of the OTF. These habitats are: (a) hard-ground substratum having low vertical relief (<2m); (b) the biota associated with hard-ground substratum having low vertical relief (<2m).

A third habitat type, the biota of soft-substratum, was also assessed as being at the highest level of risk from the activities of the OTF. The damage to this habitat type was not regarded as being irreversible, however the very slow dynamics of habitat recovery, particularly for the larger elements of the habitat (see Sainsbury *et al*. 1997), provide a sound justification for the implementation of precautionary management measures.

The draft FMS contains two management responses directed towards reducing the risk to these habitats (Table E1.22).

Table E1.22 Summary of management responses relating to fishing practices that cause irreversible damage to habitats.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Fishing practices that cause irreversible damage to habitats	1	1.3	*a) Require use of trawl gear designs that minimise impacts on habitats and associated biota; in particular:*	2B
			i)Pprohibit use of bobbins on the ground ropes of fish trawl nets north of Seal Rocks; limit maximum size for 'bobbins' on fish trawl nets south of Seal Rocks 100 mm diameter	2B*
			ii) Pending the closure of reef areas, limit the maximum size for bobbins used on fish trawl nets south of Seal Rocks 100 mm diameter	2B*
			iii) Restrict trawl nets to a single ground chain of no greater than 12mm gauge	2B*

* denotes that the management response is inappropriate for reducing risk to some types of habitats. See text for details.

The closure of all reef areas, including low profile reef, to trawling will have a substantial influence in reducing the risk of irreversible damage on these habitats (MR 1.1(b)). This response, therefore, will supersede the response (MR 1.3(a)(ii)) that allows the continued use of bobbins no larger than 100mm diameter on trawl gear.

Management response 1.3(a)(iii) refers to restrictions on the number of ground chains and the gauge of the chain (12 mm maximum) that may be used on the ground rope of fish and prawn trawl nets. The logic of this management response is sound for soft-substratum habitats and their associated biota. The use of lighter ground gear may reduce fishery related impacts on soft-substrate habitats and their associated biota habitats. However, the effectiveness of 'light chains' for minimising impacts on the biota of soft-substratum habitats is unknown. An assessment of the likely reduction of risk to habitats, attributable to this management response, cannot be made until further information is obtained.

ii) Adequate refuge areas are needed to conserve habitats

The most effective way to conserve habitats in the OTF is to introduce a series of closures. The draft FMS has four management responses that take this approach (Table E1.23). Fundamental to establishing closures to conserve habitat is knowing what habitats exist, their spatial distribution and where trawl fishing occurs in relation to these habitats. Management responses 1.1(a) and 7.2(a) make a commitment to obtaining this essential information. This research should have a high priority given the general knowledge of the vulnerability of oceanic habitats (especially biogenic) and damaging effects of trawling has on these habitats known from studies elsewhere (see Section B2.7, Kaiser and de Groot, 2000, Bax and Williams, 2000).

Obtaining knowledge about the type and spatial extent of marine habitats will take time. Therefore, as a precautionary measure the draft FMS will implement a series of closures to protect a range of habitats (MR 1.1(b)). The proposed closure of reefs is an important concrete step to reducing risk to these habitats with flow on effects to fish productivity and therefore ecological sustainability. Closing depths greater than 1100m will do little to reduce current risks from trawling by the OTF because NSW fishers do not trawl at these depths. However, it will prevent trawling expanding into these depths in the future protecting these deep habitats from potential impacts from the OTF. Closing 75% of state waters south of Barrenjoey Point is a very precautionary approach to habitat conservation but the areas closed must be of a sufficient size to protect continuous types of habitat and include some trawling grounds.

Apart from the reference to closing reefs and depths greater than 1100m, no other details are provided to explain how or where these closures will be established. Studies have shown that marine biota, especially shellfish and finfish, rely on a large range of habitats throughout their life cycle across substantial depth gradients, i.e. from shallow to deep (Love *et al*., 1991; Carr and Reed, 1993; Carr *et al*., 2003). Therefore, effective closures need to encompass a large diversity of habitats to ensure as many requisite habitats over the life of marine biota are included (Carr *et al*., 2003). A possible cost effective way to achieve this for the OTF, with a poor knowledge base about habitats and the desirability of minimising operational complexities and costs, is to establish strip closures at a number of places along the coast, starting at the coastline and extending to the continental slope. Such strip closures would be easy for fishers to comply with and for the department to enforce. Furthermore, monitoring their effectiveness would also be easier. Outcomes of such monitoring can then be fed back into the management regime to improve and refine an integrated system of closures (Sainsbury *et al*., 2000). Until there is more information about how and to what extent the proposed closures will occur it is not possible to fully assess the adequacy of this management response. But it is definitely in the right direction and will contribute to reducing the risks to marine habitats if implemented effectively.

Table E1.23 Summary of management responses relating to adequate refuge areas for conserving habitats.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Adequate refuge areas are needed to conserve habitats	1	1.1	*a) Define & map extent of trawling grounds & determine intensity of trawling on each ground*	1B
			b) Implement a series of closures to trawling to protect a range of ocean habitats and associated biodiversity, including closure of all reefs & depths > 1100 metres	2A/2B
	2	2.1	*g) Develop strategies to establish refuge areas and spawning closures for species targeted by trawling*	2A
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and refuge areas)*	1B

Management response 2.1(g) (Table E1.23) refers to the development of strategies that will be used to establish ‘refuge’ areas and spawning closures for species targeted by trawling. The main focus is to provide these refuge areas for invertebrates and fish targeted by the fishery. However, there needs to be greater recognition of the strong links between habitats and the fish that interact with them in the draft FMS. Essentially, refuges cannot be provided for fish unless careful attention is also paid to protecting their habitats. Whilst the response 2.1(g) has the potential to reduce the risk levels for habitats, the draft FMS does not give details as to how the strategies for establishing refuge areas will be developed nor whether the different requirements of fishes and habitats will be considered in their design. The strategies referred to in the management responses should make use of the abundant literature on marine reserve design and the complex principles that need to be considered it meeting diverse objectives (e.g. see all references in Ecological Applications 13(1) Supplement, 2003; Hooker and Gerber, 2004). This will be especially important when evaluating the combined effects of all closures for the OTF (MR 6.3(c)).

The lack of detailed information about the establishment and design of proposed refuge areas makes it difficult to determine the level of risk reduction for habitats. It is acknowledged that the draft FMS proposes actions that aim to increase knowledge of the fishery and some of its effects (e.g. mapping of trawl grounds), which are necessary before details about the implementation of some closures can be determined. It will be important to ensure that the knowledge gained is translated into effective management regimes as soon as possible. However, until such details are provided this management response can only be assessed as providing minor risk reduction for habitats.

iii) Inconsistent fishery management regimes among jurisdictions – implications for habitats

There were two management responses proposed to address the issue of inconsistent management regimes across jurisdictions (Table E1.24). Man-made boundaries that define the extent of different areas of jurisdiction do not constrain the distribution of geological features or the distribution of biota in the real world. The problems of managing shared fish stocks, which occur across several jurisdictions but are managed differently in each jurisdictional area, have received due attention in the scientific literature (Hilborn and Walters, 1992; Mitchell, 1997; Hoel, 1998). This same concept must also apply to habitats on which populations of fish rely for their survival. Therefore, inconsistency in management approaches must pose similar problems for the ecologically sustainable management of shared fish stocks and the sustainable management of important habitats. The outcome of inconsistent management regimes across adjacent jurisdictions is to increase the risk level for habitats. This occurs because the effectiveness of any management initiative taken in a single jurisdiction is weakened by the lack of consistent or complimentary action in the adjoining areas.

Table E1.24 Summary of management responses relating to inconsistent management regimes among jurisdictions.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Inconsistent fishery management regimes among jurisdictions - implications for habitats	4	4.2	*c) Use cross-fishery & cross-jurisdictional consultation to discuss & manage issues relating to multiple use of specific fishing grounds, collaborative research, fair & equitable access to stocks, complementary management arrangements & other interactions between fishing sectors*	2A
	6	6.3	*b) Modify the arrangements for trawling in the area south of Barrenjoey Pt (within 3 nautical miles) to achieve greater complementarity with Commonwealth fishery, manage fish stocks in State waters on sustainable basis as provided for in Appendix D3.*	2A/2B
		6.5	*a) Manage ocean trawl fishery consistently with other jurisdictional or natural resource management requirements, such as the marine parks program, aquatic biodiversity strategy, threatened species program, Indigenous Fisheries Strategy & other relevant strategies*	2B

Efforts to improve communication and consultation to better coordinate consistent management responses across jurisdictions (MR 4.2(c), 6.5(a)) should lead in the long term to better resource management (fish stocks and habitats) and hence should lead to a reduction in levels of risk. Management response 6.3(b) specifically aims to achieve greater complimentarity between the OTF and the Commonwealth SESSF south of Barrenjoey Point. However, the effectiveness of the management measures outlined in Appendix D3 are likely to be minor and depend upon the resolution of several issues – for full discussion see Section E1.2(b)(vi)). Whilst the draft FMS does not prevent state waters south of Barrenjoey Point from being transferred to Commonwealth jurisdiction in the future the outstanding resolution of issues needed to achieve greater complimentarity means that the reduction in levels of risk for habitats attributable to these management responses is assessed as minor.

iv) Major information gaps

The risk assessment identified four main information gaps. The draft FMS contains many management responses that either directly or indirectly attempt to address these issues (Table E1.25). Essentially, the draft FMS proposes a Research Strategic Plan (see MR 6.2(a)), which should provide the direction and assignment of priorities for research proposals in consultation with the MAC. This Research Strategic Plan should be expected to cover all aspects of research relating to habitats and fishery-related impacts on habitats. Thus, the remaining management responses that are linked to specific information gap issues should be seen as subsets of the Research Strategic Plan.

The management responses in the draft FMS (see Table E1.25) acknowledge the need for research to fill these critical habitat information gaps for the OTF. However, all of the management responses dealing with research issues do not provide detail but are linked to the research plan. A more detailed assessment of proposed research in the draft FMS is given in Section E5.2.

As highlighted in the risk assessment (Section B2.3) increased knowledge of the distribution of habitats, the distribution of fishing effort, and the spatial overlap between habitats and fishing effort are needed to enable reduction in the risk to habitats. Management response 7.2(a) indicates initial work on identifying habitats associated with trawl grounds will be conducted in conjunction with mapping of trawl grounds in management response 1.1(a). This will be a good start but it is important that mapping of marine habitats be undertaken both within and outside of trawled areas under NSW jurisdiction for the OTF, to which management response 7.2(a) is committed.

High priority should be given to undertaking research on the distribution of broad habitat types, particularly those habitats assigned high-risk levels. Unless the distribution of habitats is known it will be impossible to accurately determine the spatial extent or magnitude of fishery-related impacts on habitats nor in determining where reefs are.

Table E1.25 Summary of management responses relating to information gaps.

Risk Assessment Issue	Goal #	Objective #	Abbreviated Management Response	Risk Management Stage
Major information gaps	6	6.2	*a) Develop & implement a Research Strategic Plan for ocean trawl fishery taking account of the priorities for research outlined in harvest strategy*	1B
(a) Identification of fishing grounds and mapping the distribution of fishing effort.	1	1.1	*a) Define & map the extent of 'trawling grounds' & determine intensity of trawling on each ground*	1B
(b) Identification and mapping the distribution of broad habitat types.	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and 'refuge' areas)*	1B
(c) Assessment of the effect size of fishery impacts on habitats.				1B
(d) Lack of biological and ecological knowledge for biogenic habitats.	1	1.1	*d) Promote research & collaborate with research institutions to improve understanding of ecosystem functioning & how it'saffected by trawling*	1B
	7	7.2	*a) Promote & support targeted research projects relevant to:* *ii) the distribution of marine habitats off NSW and the potential impacts of trawling on these habitats* *iii) the impacts of trawling on biodiversity and the environment (including mapping of fishing grounds, the effectiveness of trawl closures and 'refuge' areas)*	1B

2 Biophysical Environment

It is expected that the draft FMS will not result in any major increase in impacts on water quality, noise and light or greenhouse gas emissions (including air quality). The commitment to developing a Code of Conduct (MR 1.2(d)) in which specific reference is made to minimising pollutants and reducing marine debris (MR 1.2(d)(iv, v)) will contribute to reducing impacts to the biophysical environment. The only potential concern may be greater localised turbidity due to increased trawling in soft sediments as a result of restricting fishing to these habitats and closing reefs (Section D3(b) MR 1.1(b)). The draft FMS is committed to mapping habitats in the OTF including soft sediments (MR 1.1(a)) which will be essential in determining to what extent localised turbidity due to trawling may occur. It is suggested that once soft sediment habitats have been described within the OTF area that turbidity levels from trawling be determined and whether any mitigative action is needed. Such a study could be incorporated as part of the proposed research on effects of trawling on ocean ecosystems (Section D4(e)(i)).

3 Economic Issues

This report is a summary of the main report on economic issues undertaken by Dominion Consulting Pty Ltd and presented in full in Volume 4. This report has been compiled by Dominion Consulting Pty Ltd from a limited amount of existing information augmented by new economic and social surveys by Roy Morgan Research, a number of reports prepared by NSW Fisheries and access to ABS data on NSW fishers.

This assessment has been done under the understanding that NSW Fisheries is in the process of finalising the share allocation criteria, and that the criteria for the ocean trawl fishery will differentiate between active and inactive entitlements based on validated catch history.

3.1 Economic Assessment

The Ocean Trawl Fishery Management Strategy (OTFMS) proposed a number of management responses to address the key issues in the fishery. As required by the guidelines, we assessed these responses to "**outline the potential change in economic viability of ocean trawl operators**" (DIPNR, 2003) with a focus on assessing:

- the ability of fishers to pay increased management costs;
- the likely changes in patterns of investment;
- the likely changes in employment;
- the likely changes in economic returns to fishers; and
- the likely changes in overall risks to the economic viability of the fishery.

a) Potential change in economic viability of ocean trawl operators

The category 1 share scheme provides significantly more security of access for fishers than the current *restricted fishery* regime or the previously proposed move to the category 2 scheme. The category 1 right would apply to access only, as the OT fishery does not have catch restraining measures, such as the ITQs in the NSW Abalone and Rock Lobster fisheries.

The FMS indicates an intent to limit the activation of latent effort, but the level of structural adjustment or the means to achieve it are not specified. Limiting the activation of latent fishing capacity can happen through a range of adjustment tools, such as the share allocation criteria and the implementation of the minimum shareholdings limits, higher requirements for new entrants, surrenders, and buybacks – each tool would have different implications for fishers. Attempts to improve profitability in the fishery through reduction of active effort may in fact give an incentive for latent effort to activate. Removal of latent effort would require a 39% reduction in endorsed boats and would reduce the fleet from 410 to 252, a reduction of 158 boats. Given the multi endorsed nature of fishing businesses, improvements in OT fishery profitability may cause fishers with low levels of effort in several fisheries to increase their effort in the OT component of their fishing business. The FMS needs to more clearly propose the steps to contain or remove latent effort, and cater for the potential rise in effort from multi endorsed fishers. Addressing these issues is essential to the maintenance of long term business viability in the OT fishery.

Minimum shareholdings would probably lead to latent entitlement holders and those businesses grossing below $10,000 revenue per year exiting the fishery. Shares will be more readily purchased by remaining businesses in economic surplus. Removing latent effort will only eliminate potential risk to the fishery from effort activation and will not increase economic viability. Increasing total economic returns to fishing businesses depends on the amount of active effort reduced from the fishery.

Vessel capacity restrictions such as horsepower and other unitisations will remain in place. In an input-based control strategy there is always a possibility of substituting controlled inputs by other inputs. Therefore, economic benefits from vessel capacity restrictions will depend on the regulations that maintain total capacity in the fishery.

The FMS proposes a full recovery of management charges within 5 years and assumes the industry will be sufficiently profitable in this adjustment period to meet these charges. Thus the intention to establish “a maximum level of fishing effort within 10 years” may not sufficiently improve profitability in the next five years as costs recovery impacts fishing businesses. Containing total effort may also be made more difficult by rises in fishing effort in response to fishery adjustment initiatives which are not specified in the FMS. A major risk is the inability to contain total effort in the fishery without limits being imposed on individual producers.

Limiting the number of days/nights fished would have a positive impact on controlling total effort in the fishery. Ideally the days and nights should be tradable to realise economic efficiency. Equity would need to be a key consideration when considering the allocation of days/nights in the fishery, for example, having regard to share holdings and past restrictions on vessel capacity.

As management restricts effort in the fishery, the capacity of the resource to yield optimal sized fish becomes more important. Optimising the biological yield will have significant long-term bio-economic implications for resource productivity, stock rebuilding and hence viability of the industry. The economic benefits of optimising biological yield for each species can be modelled by age and price structured bio-economic analysis. This requires research into optimal harvesting, inter-relationships between estuarine and ocean prawn fisheries in particular and on the selectivity of trawl gear for both prawn and finfish production.

Improving post-harvest practices are important to increase economic returns to the fishery. For example, minimizing waste, adding value, developing new products, increasing consumers’ safety and confidence, and ensuring consumers that the product was harvested in a sustainable manner are some of the areas for consideration.

The risk of having insufficient area closures and refuges for fish and prawns is potential stock depletion. In the case of prawn species, ocean trawl fishers and estuary prawn trawl fishers must cooperate with each other as both fisheries depend on the same species. The Prawn Resource Forum deals with issues relating to improved management of species in each estuary by incorporating prawn and species capture outside the estuary and the optimum size and time of harvest (EPT EIS, 2003).

Fishers in the ocean trawl fishery may bear higher operational costs in using BRD, with some potential benefits from improved catch quality, and hence higher prices to fishers, reduced catch sorting time, and potentially satisfying growing consumer preferences for seafood harvested using environmentally sustainable practices. However, there is a possibility of reduction in total catch. The resultant outcome may have a positive or negative impact on total revenue and net income.

The potential economic benefits of rebuilding any overfished species may be significant. But these benefits will largely depend on the rate of recovery and they must be weighed against the short term costs of recovery programs.

The FMS specifies a performance measure to monitor the commercial viability of fisheries at a fishery level. Developing performance measures for monitoring viability at the individual fishing business level is not the recommended way to monitor economic viability / performance in a fishery (ABARE, 2000). There are inherent confidentiality and privacy issues involved in monitoring individual business activities. In addition, monitoring costs may increase depending on the level of monitoring and how it is done.

Assuming that there was a reduction of 158 (latent) fishing business numbers in the fishery, the total charges for an average fishing business are estimated to increase from current $2,035 to $4,620 per annum assuming an increase in management charges due to the new programs in the FMS and adjustment initiatives reducing business numbers in the management cost levy base. Fishers also may face costs associated with structural adjustment, depending on the adjustment tools used and the adjustment timeframe. The cost to industry will depend on the suite of policies adopted to address latent effort and overcapacity. A business remaining in the fishery for the long term would expect to have to pay a portion of the capital value of a business in restructuring costs, depending on the adjustment measures taken. It is important that the development of cost recovery and structural adjustment plans do not lead to an increase effort to the detriment of the fishery.

Fuller incorporation of effective and efficient management requires a framework for improving fishery management services. There should be specification of each of the services to be delivered and clarification of acceptable performance standards within the agreed costs of management.

b) Potential change in overall risks to the economic viability of the fishery

Even if fishing capacity were to be capped at the currently active level, this may not necessarily contain total effort at the current level as vessels may fish more days/nights and/or use more advanced technology to make vessels more efficient (technology creep). Implementing a minimum shareholding limit at a level which removes all latent effort, would eliminate the risk of potential activation of latent effort in the fishery. However active effort levels may rise as fishers may increase effort to meet new payments.

Recovering management costs in 5 years depends on the effectiveness of the policies limiting total effort, so that profitability is maintained in the fishery. Total effort may be controlled by limiting the number of days/nights fished by each fisher. If implemented, fishing days/nights should be transferable and tradable in order to increase efficiency and the value of the shares.

Under the FMS, the costs of management and restructuring will increase, but the ability of fishers to pay for this increased cost will only increase with further reductions in total active fishing effort. Risks from insecure access rights can be reduced under Category 1 share management which increases access security, but does not automatically improve business viability, which is dependent on containing effort levels. Many fishers will see the security of category 1 shares as a form of superannuation. This will hopefully give fishers the incentive to increase the value of the shares through limitation of effort. Failure to do this may see a share values reduce with economic and social implications for fishers.

The monitoring of economic performance should be a priority area for future research.

3.2 Conclusions

In summary, the FMS reflects the current move to category 1 share management, which will provide a significantly more secure right, and incentive, for fishers. The FMS signals the intent to limit latent effort, but the level of structural adjustment or the means to achieve it are not specified. Fishing businesses remaining in the fishery in the long term will likely incur costs in reducing fishing capacity, depending on the adjustment tools used, the extent of restructuring and the pace of adjustment. Limitation of total effort could be an issue as fishers face increased management charges with an incentive to increase their effort, although this may be offset if individual returns improve as a result of restructuring.

A regime with a more specific limited number of days/nights per fisher may be inevitable in the 5 year view, to support a structural adjustment plan and to augment category 1 share management Other available management strategies that provide fishers with more incentives, in addition to moving towards category 1 share management, warrant further investigation. For example, implementing more advanced input and output control management systems should be evaluated during the next 5 years, taking account of the outcomes of adjustments in fishing effort and improvements in gear.

Fishing capacity and fishing effort levels must be addressed if a viable fishery is to be achieved long term. It is important that the FMS provide for a high level of industry involvement in decision making with regard to structural adjustment and that the decisions to improve long term viability are implemented.

4 Social Issues

This report is a summary of the main report on social issues undertaken by Dominion Consulting Pty Ltd and presented in full in Volume 4. This report has been compiled by Dominion Consulting Pty Ltd from a limited amount of existing information augmented by new economic and social surveys by Roy Morgan Research, a number of reports prepared by NSW Fisheries and access to ABS data on NSW fishers.

This assessment has been done under the understanding that NSW Fisheries is in the process of finalising the share allocation criteria, and that the criteria for the ocean trawl fishery will differentiate between active and inactive entitlements based on validated catch history.

4.1 Social assessment

The Ocean Trawl Fishery Management Strategy (OTFMS) proposed a number of management responses to address the key social issues in the fishery. The potential social impacts of implementing the draft OTFMS are assessed against the following criteria:

- likely changes in social impacts on fishers, their families or any local communities;
- whether the level of job satisfaction among commercial fishers is likely to change;
- likely employment fate of any fishers exiting the industry; and
- whether the risk of social impacts are changed.

The major social changes in the FMS involve the potential displacement of fishers, due to the removal of overcapacity in the fishery. The actual impacts will be dependent on the extent of restructuring, its timing and the way in which it is achieved, as well as how these factors interact with fishers retirement. For example a scenario of adjustment in the ocean trawl fishery in the economic issues section indicates that 104 of 311 OPT and 54 of 99 OFT fishing businesses maybe removed in the 2003-2008 period. Such a change would probably impact part-time and older fishers, and latent endorsement holders, or fishing businesses grossing less than $10,000 per year. Displacing latent effort may potentially impact 39% of total dependents of ocean trawl fishers, approximately 144 dependents.

On implementation of the OT FMS different areas along the coasts will be impacted. For the OPT fishers in Tweed, Richmond, Clarence, Coffs Harbour and Hastings, and OFT fishers in Hastings, Hunter, Port Stephens, Sydney North, Batemans Bay and Far South Coast, are probably most vulnerable to changes from the socio-economic impacts under the strategy.

The social impact of the FMS could also be noticeable in ocean trawl fishing communities, given the lack of alternative employment for many aged fishers. However, it could potentially enable elderly fishers to retire with a payment from the sale of shares. Opportunities for greater value adding may also arise. Importantly, the FMS creates the platform to move the fishery to a sustainable and viable basis in the longer term, in consultation with industry providing that the risks identified to viability are addressed. Further research should prioritise understanding of fishing communities, to reduce the cumulative impacts from successive management strategies.

As a result of implementing the OTFMS, we envisage the following changes in overall social risks in the fishery:

- the move to the category 1 share scheme will significantly improve access security over the current situation;

- fishing will be seen more as a commercial activity than a way of life, which may have negative impact on some fishers whose main objective is not maximising economic returns from the fishery;
- the need to create alternative employment opportunities for outgoing fishers will increase and may increase unemployment in rural areas and place an extra burden on alternative fisheries and on the social security system;
- there may be some rise in conflict as allocation of access rights and compliance issues are introduced. They are comparatively well addressed in the FMS though there is a risk of new conflicts over the allocation of access rights, sharing responsibilities, authority and accountability of policy decision-making and management, and funding future research programs; and
- monitoring social aspects in the fishery is likely to increase because of increased emphasis on socio-economic research.

Conclusions

In summary, the move to the category 1 share scheme provides significantly greater security and certainty for fishers, their families and local communities. However, the FMS may have significant social impacts on some parts of the ocean trawl fishing community in rural NSW as reducing overcapacity inevitably displaces a number of people associated with the fishery. Fishers with ownership in a licence will be able to sell their shares, if they wish to leave the fishery or reduce their fishing operations. Crew members will be displaced with a resultant loss of income.

Outgoing fishers may face difficulties in finding alternative employment or business opportunities, though some fishers are latent in the OT fishery as they fish elsewhere and others may retire. The nature of the fishery will change. Fishers who remain in the fishery will see fishing more as a commercial activity than a lifestyle, being able to develop long-term business plans and increase their economic returns.

4.2 Health and safety

The draft FMS will not result in any change to the health and safety risks of OTF. The only potential area of concern is banning the use of spikes (MR 1.2(c)(iii)). Fishers use these on a variety of animals including those that are more dangerous to handle, such as stingrays. However, it is proposed that use of spikes will be restricted to a specific list of species, generated by fishers in the OTF. Along with developing improved handling practices (MR 1.2(d)(ii)) this will mitigate any problems associated with safety in handling animals on deck.

5 Assessment of Performance Reporting, Monitoring and Research

5.1 Assessment of Performance Reporting and Monitoring

The performance monitoring and reporting in the draft FMS is intended to serve two functions. First, they are to monitor the performance of the draft FMS in achieving its seven broad goals (DIPNR guidelines D4, 2003). Thus the performance indicators and trigger points were set at the goal level not individual management responses. Second, the performance monitoring and reporting are to monitor the impacts, as identified in the risk assessment stage, of the fishery on the environment (DIPNR guidelines E5(a), 2003). Therefore, the assessment of the performance monitoring will be based on these two aspects – management and environmental.

Two basic questions were used to assess the performance monitoring and reporting

a) Does it adequately measure and report the performance of the draft FMS against its goals ?

b) Does it adequately monitor the potential impacts of the fishery ?

a) Performance Monitoring and Reporting

The performance monitoring and review in the draft FMS consists of the following components:

i) Performance indicators and trigger points

ii) Monitoring and information collection

iii) Reporting and review

These were assessed in terms of how adequately they measure and report on the performance of the draft FMS against its goals using a series of questions illustrated in Figure E5.1.

i) Measuring and Reporting

The following criteria were used to assess the adequacy of the performance indicators (PI) and trigger points (TP) for monitoring the draft FMS against its goals. They were adapted from those developed by Rochet and Trenkel (2003):

a) Relevance – is the PI connected either directly or indirectly with the expected outcome of the goal ? (Poor – little or no direct or indirect connection to goal outcomes; Moderate – mainly indirect connection to goal outcomes; Good – directly connected to goal outcomes)

b) Expected effect of management – How does the PI change under the application of the management controls ? There are three possible categories of change:

   i) unpredictable
   ii) change in direction, either up or down with respect to a reference direction
   iii) change in value with respect to a reference point such as a known value defined as a limit.

c) Measurable – are TP measurable and detectable ?

d) Interpretable – can the changes in the TP be interpreted unambiguously as a result of management action and not other influences ? Is there a clear reference point or baseline on which to make an interpretation ?

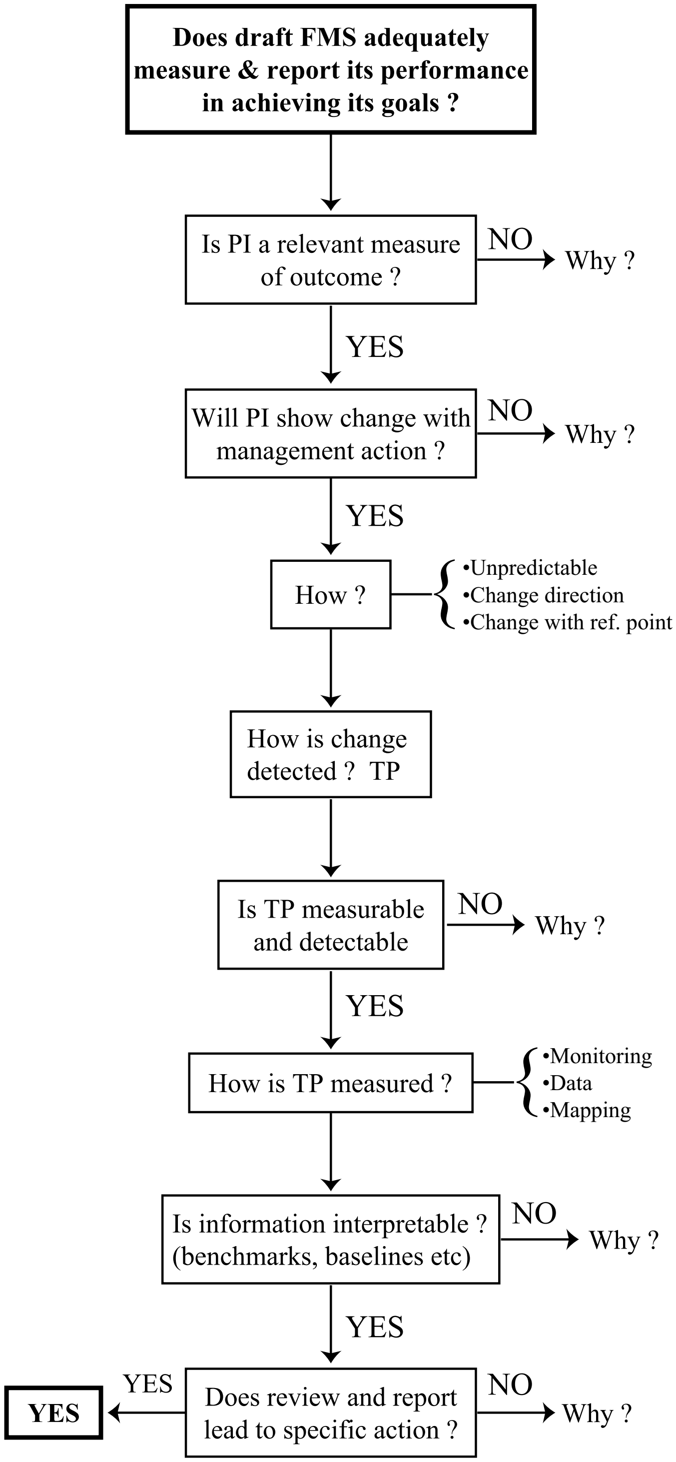

Figure E5.1 Diagram showing logical steps used to assess the adequacy of the performance monitoring and reporting in the draft FMS of the OTF.

Note: PI – performance indicator, TP – trigger point

Tables E5.1 and 2 summarise how each PI and TP meet these criteria. A little under fifty percent were directly connected to the goal outcomes covering mainly goals 1, 3 and 7. Therefore the performance of the FMS against these goals is being measured relatively well, but could be improved in a number areas. Those PI that were moderately relevant (43.75%) were for areas where there are currently no standard types of indicators and further work is flagged to improve them. For example, in Goal 4 PI 1 is the proportion of primary species etc taken by each sector (including recreational and indigenous). By defining what is meant by "appropriate share" in the goal a more relevant PI can be developed. Goal 1 PI 4 was moderately relevant because it is a less effective measure of the performance of Goal 1 as a measure of actual area closed. Ideally, the total area closed should also be included with the number of areas closed to trawling. Research has shown that it is the size of closed areas and not just the number of closed areas that is important in conserving biological diversity (Shanks *et. al*., 2003). Two PI had a poor relevance to the goals because they did not measure the outcome of the goal (Table E5.2). Goal 2 PI 2 measures changes in targeting between sectors of the OTF rather than changes in sustainability in the stocks. However, tracking changes in targeting is related as it may signal secondary species becoming primary species. In Goal 6 PI 2 the number of meetings of the management advisory committee for the OTF, whilst a statutory requirement, does not track the outcome of the goal, i.e. effective and efficient management.

The majority of PI (75%) had the ability to detect change under the effect of the management controls. However, 25% were uncertain as to how they would change (Table E5.1). The uncertainty is due to how relevant the PI is to the goal. For example, Goal 5 PI 1 the median fishery-wide gross return of ocean trawl fisheries may vary for many reasons other than due to the FMS (Table E5.2).

The majority of the TP were both measurable (93.8%) and interpretable (68.8%). This gives the performance monitoring program substantial rigour in monitoring the performance of the FMS. However, 18.8% had uncertain interpretation (Table E5.1). The uncertainty of interpretation centres around there being no established reference point with which the TP can be compared. For example, for Goal 1 reference levels of species diversity/richness have not yet been established for the habitats and fishing grounds of the OTF. Nor do we have any estimate about the level of natural variability in species richness in the oceanic environment off the NSW coast. Consequently, TP 1 and 2 for Goal 1 will not be clearly interpretable until some species richness references can be established (Underwood and Chapman, 2003b). This will need to form part of the monitoring process itself as well as the specific research project on developing a biodiversity index relevant to the fishery.

Table E5.1 Percentage of performance indicators (PI) and trigger points (TP) that meet the criteria for adequacy in tracking the performance of the goals.

NA – not applicable; Good – directly connected to goal outcomes; Moderate – mainly indirect connection to goal outcomes; Poor – little or no direct or indirect connection to goal outcomes

Perfomance Indicators

	Categories		
Criteria	**Good**	**Moderate**	**Poor**
Relevant	43.75	43.75	12.5
	Yes	**No**	**Uncertain**
Expected effect	75	0	25

Trigger Points

	Categories			
Criteria	**Yes**	**No**	**Uncertain**	**NA**
Measurable	93.8	0.0	0.0	6.3
Interpretable	68.8	6.3	18.8	6.3

Table E5.2 Summary of assessment of PI and TP against criteria for adequacy.

R - relevance, E - expected effect under management control, M - measurable, I - interpretable, N/A - not applicable

Goal No.	PI No.	Performance Indicator		Trigger Point		Comments
		Brief Description	Assessment	Brief Description	Assessment	
1	1	Species composition of catch	***R:*** Good ***E:*** Yes, unpredictable	Large area species richness shows a significant shift	***M:*** Yes ***I:*** Uncertain	Significant shift will need to be defined; effectiveness of TP dependent on etablishing a baseline
	2	Proportion & species composition discarded	***R:*** Good ***E:*** Yes, unpredictable	Species richness & quantity doesn't decrease	***M:*** Yes ***I:*** Uncertain	The type of species richness index used for this TP should be established before sampling takes place; as for previous TP a baseline will be essential
	3	Response to marine pest incursions	***R:*** Moderate ***E:*** Yes	Guidelines from Marine Pest and Disease Management program not adhered to	***M:*** Yes ***I:*** Yes	Communication links among Marine Pest and Disease Management program, relevant fishery managers & industry will need to be established and/or maintained
	4	Areas of ocean waters closed to trawling & habitat types included	***R:*** Moderate ***E:*** Yes, increase	Areas closed to trawling doesn't increase & % with adequate habitat type descriptions not increased within 5 years	***M:*** Yes ***I:*** Yes	Area closed should also be measured; on-going measurement of changes in large area species richness should also be done inside & outside closures to determine whether biodiversity is changing as a result of the management action
2	1	Exploitation status of primary & key secondary species	***R:*** Good ***E:*** Yes, Direction up/down	No. primary or key secondary species "overfished" > 0	***M:*** Yes ***I:*** Yes	This will require stock assessments to be done of all species in these two groups and will take time, but are important for the achievement of the goal; see Table D5 & Section D4(b)(vii) for list of species
	2	Ratio - Total Annual landings Secondary species : Total annual landings of primary, key secondary	***R:*** Poor ***E:*** Uncertain	Contribution of secondary species > 5%	***M:*** Yes ***I:*** Yes	Doesn't measure sustainability levels; change in targetting may result in secondary species becoming key secondary & therefore requires revision of primary & key secondary list
3	1	Number & degree of interaction with threatened species	***R:*** Good ***E:*** Yes, should have low negative impacts	Proportion of negative interactions doesn't decrease	***M:*** Yes ***I:*** Yes	Degree of interaction will need to be defined before observer programme commences & then tested on first observer study

Table E5.2 cont'd

R - relevance, E - expected effect under management control, M - measurable, I - interpretable, N/A - not applicable

Goal No.	PI No.	Performance Indicator		Trigger Point		Comments
		Brief Description	Assessment	Brief Description	Assessment	
4	1	Proportion of primary, key secondary & secondary species taken by each fishery (including commercial, recreational & indigenous)	***R:*** Moderate ***E:*** Uncertain	Proportion in any sector increase or decrease by 10% between 2 consecutive years	***M:*** Yes ***I:*** Yes	No defiition of what is an "appropriate share" therefore percentage of change is arbitary & must be reviewed when more information is obtained; Data from recreational & indigenous sectors may not be comparable
5	1	Median fishery-wide gross return of ocean trawl fishers derived from commercial fishing in NSW	***R:*** Moderate ***E:*** Uncertain	Median fishery-wide gross return has not increased by at least 20% four years after the commencement of the FMS	***M:*** Yes ***I:*** Uncertain	No defiition of what is a "viable commercial fishery" therefore percentage of change is arbitary & must be reviewed to determine a more accurate measure and trigger level
	2	Average market value traded shares	***R:*** Moderate ***E:*** uncertain	To be determined	***M:*** N/A ***I:*** N/A	PI should be revised after the share management plan for the fishery has been established & share trading has commenced
6	1	Percentage of inspections resulting in minor & major offences	***R:*** Moderate ***E:*** Yes	Percentage of detections: < 20% minor < 10% major	***M:*** Yes ***I:*** Yes	TP should be reviewed after the first year, may need to be smaller. Reasons for rate of non-compliance, especially for major offences, will need to be investigated to improve efficiency & effectiveness (e.g see Honneland, 2000).
	2	Number of Ocean Trawl MAC meetings held each year	***R:*** Poor ***E:*** Yes	< 2 meetings per year	***M:*** Yes ***I:*** No	Does not measure outcome of goal
	3	Reviews & outcomes of strategic plans for research & compliance	***R:*** Moderate ***E:*** Yes	Plans expire without being reviewed or outcomes of reviews are not acted on	***M:*** Yes ***I:*** Yes	Criteria for reviews must be specified & an accountability mechanism for implementing the review outcomes be established or clarified
7	1	Scientific observer program operated in accordance with specifications developed to meet requirements of relevant MR	***R:*** Good ***E:*** Yes	Observer program does not meet specifications	***M:*** Yes ***I:*** Yes	Effectiveness of PI depends on the rigor of the specifications; different specifications may be needed for different types of observer programs
	2	Number of active research projects with flow-on benefits to OTF & fill information gaps from EIS	***R:*** Good ***E:*** Yes	No. research projects relevant to information gaps < 2 any one year.	***M:*** Yes ***I:*** Yes	List of information gaps should be held by internal fisheries approval processes to ensure proposed projects are relevant
	3	Accuracy of catch return (or daily logboook) data	***R:*** Good ***E:*** Yes	Percentage species records with poor reporting does not decline significantly	***M:*** Yes ***I:*** Yes, if % defined	"Accuracy" needs to be defined & percentage determined

ii) Monitoring and information collection

Data and other information required for the PI and TP will be obtained using a range of monitoring programs and sources (Table E5.3). Much of the information will come from improved catch and effort reporting system for the fishery.

Table E5.3 Sources of information used to monitor PI.

Source	Number of PI using this source
Compliance	1
Observer study	4
Catch data/returns/effort	6
Mapping	1
Other reports	10*
Stock assessments	1

* 5 are external reports

There are 10 PI and TP that require information from reports produced within NSW Fisheries or agencies external to NSW Fisheries. A vast amount of data and information will be needed in order to adequately monitor the performance of the OTF against its goals. Furthermore, given the implementation of FMS's are a relatively new process (for the department) careful attention will be required as the FMS is implemented as to how the results of reports will be coordinated to ensure the appropriate information is passed on to the right group of people for appropriate analysis, interpretation and action.

iii) Reporting and review

Reporting and reviewing is a crucial step in monitoring the performance of the fishery because it provides a path for feedback into the process and opportunities for learning how to improve the management and science of the OTF. Two types of reporting are proposed in the draft FMS – performance assessment and trigger point review. In the former both the performance indicators and implementation of each management response will be included and reviewed annually and reported biannually. The latter reports on any performance indicator that has been triggered encompassing the likely causes for the breach and recommendations for remedial action required, within a specified timeframe. It will be important that there is some mechanism to ensure the recommendations for remedial action from both these types of report are acted on in an appropriate and timely manner. The response taken on any recommended remedial action in the previous year should be included as part of the annual review.

The review and reporting process of the draft FMS will be complex and therefore it will be essential there are clear paths of information transfer and analysis. The draft strategy describes the high level process for the reports, including submissions to the Minister for Fisheries, the relevant MACs and advisory councils and the public. The operational aspects of the reporting and review process, including how information will be disseminated to the relevant scientists and managers within or outside of NSW Fisheries, for their input, will need to be developed as part of the implementation of the FMS.

Many performance monitoring programs in other parts of the world have specific remedial actions already set if a trigger point is breached (e.g. Gray and Jensen, 1993; Caddy and Mahon, 1995; Caddy, 2002) so that management can take action immediately there is a signal something is wrong. These types of programs usually occur in fisheries with well developed stock assessment data and analysis where specific management responses can be identified and are specifically linked to the PI, which is not the case in this and other commercial fisheries of NSW. However, the performance indicators and trigger points in the draft FMS of the OTF are all at a very preliminary level and until these are refined (via research, monitoring, review, and feedback) remedial actions can't be specified in advance. But it would be highly desirable in the longer term that as the performance indicators and trigger points are improved the review process be adjusted to incorporate pre-determined management action (in consultation with stakeholders, scientists and management) if an indicator is triggered (where a limited number of factors could have triggered it). This would have the advantage of allowing an immediate response to a problem rather than waiting for a lengthy and costly consultative process. Of course it would be essential that the outcomes of such management actions be monitored and reported.

iv) Conclusion

The answer to the question posed at the beginning – "Does the performance monitoring and reporting process in the draft FMS adequately measure its performance in attaining the goals?" - is mostly yes. However, many of the PI and TP are initial suggestions until further work is done to develop the PI and TP further or determine new ones that are more appropriate. It is essential that this further work and development is done.

b) Environmental Impact Monitoring

As discussed at length in Chapter B2 and E5.1 there are numerous ecological impacts that the OTF can have on the marine environment. Monitoring impacts in the sea is very complex. One of the major difficulties is knowing what to monitor, at what spatial and temporal scales and how to measure them (Fairweather, 1991; Underwood, 1995). For some primary species we have a reasonable understanding of what to measure in order to monitor the impact of growth and recruitment overfishing, such as length and sex composition in catches of a species. But for many other impacts it is not clear what to measure, nor how, because the ecological processes that may be affected by the OTF are complex, have multiple interactions and can involve populations and assemblages of species across a large range of spatial and temporal scales (see discussion in Section B2.6(c)(i)). Furthermore, natural variability in marine systems is often large. Therefore, detecting that an impact has occurred requires the ability to distinguish between changes in whatever is being measured (e.g. length of adult fish) from this natural background variability (Fairweather, 1991; Underwood, 1995). There is a substantial body of ecological research that provides many insights into how to detect impacts. (e.g. Fairweather, 1989, Schmitt and Osenberg, 1996, Underwood, 1996). Clearly, the OTF should make use of this research in applying it to understanding the ecological impacts in the oceanic environment off NSW.

Therefore, monitoring for the impacts of the OTF on the marine environment is not a simple case of regularly measuring a set number of entities and watching for when they exceed certain critical levels. Rather, it will require a more diverse approach via research programs designed to increase our understanding of the oceanic environment and how fishing impacts may be occurring in them, that help determine what aspects could be monitored for detecting impacts from fishing. How much of this increased understanding can be done through the ~~draft~~ FMS itself will be limited by its scope and will therefore require collaboration with other research projects within and outside NSW Fisheries.

DIPNR guidelines (2003) for EIS requires that performance reporting and monitoring be assessed in terms of their effectiveness in providing information for monitoring impacts of the proposed FMS of the OTF on the environment. The effectiveness of the information to monitor impacts was assessed using the following questions:

i) For the impacts of overfishing, habitat destruction, changes in biodiversity and threatened species what entities should be measured to monitor them ?

ii) Is the information provided by the performance indicators and relevant management responses adequate to monitor the impacts ?

iii) For other ecological impacts what information is needed to investigate how these impacts manifest themselves in the oceanic environment of NSW and the adequacy of proposed research programs to provide this information ?

iv) How is the information reported and acted upon ?

i) Measures of impacts in the OTF

There were five major ecological impacts of the OTF identified in the risk assessment of Chapter B2. These were:

i. Overfishing (recruitment and growth)

ii. Damage to habitats

iii. Changes to biodiversity

iv. Impeding recovery of threatened species, populations and communities

v. Disruption of ecological processes (which encompasses several processes such as recruitment, dispersal, predator-prey interactions etc)

There were no direct measures for impact (v). Given the lack of knowledge about the ecological processes in the oceanic environment it is difficult to measure disruption to ecological processes directly. However, these types of impacts can have profound long-term effects of the sustainability of a fishery (e.g. Fogarty and Murawski, 1998) and should be taken into account. In reality disruption to ecological processes is the result of the cumulative effects of the other major impacts that have been identified. Therefore, until our knowledge base about the ecology of the oceanic environment improves emphasis must be placed on ensuring that the measures of the other impacts is adequate and analysed as a whole and cumulatively as well as singularly. Murawskl (2000) proposed a helpful way this could be done that should be used as a starting point for the OTF.

Table E5.4 lists the main entities to be measured for each impact i.-iv. This list is not exhaustive for all impacts. It then summarises the information provided by the performance indicators (PI) and management responses (MR) that relate to these entities.

ii) Adequacy of information provided to monitor impacts

Assessment of the adequacy of the information was based on how well the PI corresponded to the entities needing to be measured for each impact i.-iv. (Table E5.4). Overfishing impacts are relatively well monitored via the appropriate PI and MR. Impacts on threatened species, populations and communities are also adequately monitored via information collected through the proposed self reporting and observer program. The remaining potential impacts, however, are only partially monitored by some of the PI and MR (Table E5.4).

The level of detail provided by the PI and MR varies greatly among impacts. Management responses 2.1(a)-(d) provide substantial detail to monitor the impact of overfishing on primary, key secondary and secondary species. The combination of the information from these MR means that detecting this impact is monitored relatively well for these species provided that suitable reference points for what constitutes overfishing for each species can be specified. Whether detection of this impact occurs within a reasonable timeframe is unknown. Information from these MR will contribute to determining the exploitation status of primary and key secondary species, which is one of the PI for Goal 1.

Two potential impacts identified by the risk assessment have entities for which there is no or only partial information provided by either the PI or MR – damage to habitats and changes in biodiversity. The condition of habitats within and outside trawling areas is not measured by a PI and management response 1.1(a) only provides information about the intensity of trawling within trawl grounds (Table E5.4). For the time being this information can be used to infer levels of damage on habitats. However, once habitats are mapped and a possible vessel monitoring system is in place more effective monitoring of impacts on habitats within trawl grounds should occur.

Numbers of species within trawl grounds will be measured by PI 1 from Goal 1 but not outside of trawl grounds (Table E5.4). Unless the number of species in non-trawl grounds with similar habitats is also measured, it will be very difficult to interpret changes over time and space to species diversity within trawl grounds. Whilst there are no measures of species diversity within particular habitats species composition of discarded catches is an important first step toward monitoring impacts on biodiversity. Much more work in this area is needed to interpret the changes in the measures of biodiversity proposed in the draft FMS.

Table E5.4 List of ecological impacts of the OTF, the entities measured to monitor them and adequacy of the information provided by the PI and MR.

Y – yes, N- no, A – Adequate, P – primary species, K2 – key secondary species, S – secondary species

Potential Ecological Impacts	What needs to be measured to monitor impacts ?	Goal #	PI #	Information provided by PI	A	MR #	Information provided by MR	A
Growth & recruitment overfishing	Size structure of P, K2, S; Landings, temporal variability, exploitation status	2	1	Determining exploitation status will require knowing landings & temporal variability	Y	2.1a	Quantity, length, age, sex composition of landings of P & K2 spp.; Indicates whether there are significant changes in reported landings over time	Y
						2.1b	Age/size at maturity, fecundity, age & sex structure of stocks of P & K2 spp.; Contributes to determining exploitation status of spp.	Y
						2.1c	Landings of P, K2 & S spp.; Indicates any increases in landings over time; Contributes to determining exploitation status of spp.	Y
						2.1d		Y
						2.1j	For sharks & rays - size at maturity, brood size, sex composition of catches; Contributes to determining exploitation status of spp.	Y
	Bycatch/discards	1	2	Measures changes in proportion discarded	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
						1.2e	Area & times of high discards	Y
						2.1j	For sharks & rays - size at maturity, brood size, sex composition of catches; Contributes to determining exploitation status of spp.	Y
	Intensity of trawling over areas			*Not provided*		1.1a	Determine intensity of trawling	Y
Overall Adequacy of Monitoring	Adequate - all enitites being measured by either PI or MR							

Table E5.4 cont'd

Y – yes, N- no, A – Adequate, P – primary species, K2 – key secondary species, S – secondary species

Potential Ecological Impacts	What needs to be measured to monitor impacts ?	Goal #	PI #	Information provided by PI	A	MR #	Information provided by MR	A
Damage/destruction of habitats	Areas & habitats where trawling occurs	1	4	How much of ocean waters are protected from trawling	Y	1.1a	Identifies trawl grounds, identifies habitats within trawl grounds	Y
	Condition of habitats within and outside trawling areas			*Not provided*		1.1a	Level of fishing intensity in trawl grounds; Indicates increases in intensity	Part
Overall Adequacy of Monitoring	Partial - only one entity being measured by both PI & MR; insufficient information provided to determine state of habitats							
Decrease or change in biodiversity	Number of species within and outside trawl grounds	1	1	Within trawl grounds: Number of species in total catch	Part		*Not provided*	
	Species discarded	1	1	Species composition of entire catch	Y	1.2e	Area & times of excessive non-retained bycatch	Part
			2	Species composition of discarded catch	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
	Number of species in each habitat			*Not provided*			*Not provided*	
Overall Adequacy of Monitoring	Partial - one entity measured by both PI & MR; insufficient information provided to monitor & interpret changes to species richness							
Impede recovery and conservation of threatened species	Rate & outcomes of interactions with threatened species, populations & communities	3	1	Measures the rate & degree of interaction of the OTF with threatened species	Y	1.2a	Observer programme to monitor levels of discards, species & length composition	Y
Overall Adequacy of Monitoring	Adequate - enitity measured by PI & MR							

iii) Investigation of other ecological impacts and adequacy of research to provide information

The most fundamental information needed to monitor other major ecological impacts is the description and analysis of patterns of abundance and distribution of various ecological entities, such as non-commercial species of fish, invertebrates and habitat associations, at a variety of spatial and temporal scales (Fairweather, 1989; Underwood, 2000). Unless we understand these ecological entities monitoring the impacts of fishing on these aspects will not be possible. Table E5.5 lists some of these entities and summarises the proposed research programs that may address them. The greatest opportunity presented by the draft FMS to investigate these impacts of fishing is through research on the effectiveness of closures. The research program of the draft FMS has been assessed in detail in Section E5.2. Generally, the research associated with these potential impacts has been given a low commitment compared to stock assessments. Relevant information about these impacts will be best obtained via properly designed large scale experiments using the closures to describe, analyse and interpret patterns in aspects of habitat associations, biodiversity changes and some specific ecological processes. These research projects need to be given higher priority if information to assist in understanding these ecological impacts of fishing is to be obtained.

Table E5.5 Ecological impacts of the OTF and their aspects requiring further investigation.

Ecological Impact	Some Aspects requiring investigation	Proposed Research in draft FMS
Habitat degradation of primary & key secondary species	Patterns of association between species and habitat types, at different spatial & temporal scales	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts
Changes to biodiversity	Patterns of distribution & abundance of species over a braod range of habitats, spatial and temporal scales	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts
Disruption of ecological processes	Choosing a key process, such as recruitment, patterns of dispersal, settlement & movement of species	*D4(e)(i) Fifth research area* - effects of trawling on ocean ecosystems & effectiveness of trawl closures in addressing impacts

iv) Reporting on impact monitoring

Measuring and monitoring the appropriate entities is only part of the process of providing effective information for monitoring impacts. What is monitored must also be reported in a coherent and on-going manner. Much of the reporting of the impact monitoring of the OTF will be done via the annual report on the progress of implementing the management responses and performance monitoring, particularly for the primary, key secondary and secondary species. However, there are some impacts which are not specifically covered by the reporting framework of the draft FMS. For example, the draft FMS is committed to mapping ocean habitats within and outside trawl grounds, but there is no clear process for how the condition of the these habitats might be reported on in an on-going manner. One aspect of the process would require re-mapping or some from of field survey of the condition of the habitats in both trawled and non-trawl areas. On-going reporting would be particularly important where areas have been closed to trawling. Both the fishing industry and the community would benefit from knowing how habitats are recovering (or not).

Because the information to monitor the various major impacts of the OTF is dispersed throughout the MR of the draft FMS and distributed according to goals rather than impacts, it would be easy for this information to become disjunct. This is especially the case for impacts other than overfishing. Therefore, it is recommended that a specific list be kept of the entities being measured for each impact and as part of the annual report on implementing the MR that the results of the impact monitoring be given. This will enable a clearer picture of how impacts of the OTF, especially those other than overfishing, are being managed.

v) Conclusion

The information provided by the draft FMS is reasonably adequate in monitoring most of the impacts of the fishery. There are a number of areas where a greater commitment to gathering relevant information about the patterns and nature of ecological impacts is required. It also needs to be acknowledged that monitoring impacts in the ocean environment is very complex and requires a more comprehensive approach than simply monitoring a few entities. Finding cost effective ways to do this presents a challenge.

5.2 Assessment of Research Plan

a) Method of assessment

DIPNR guidelines (2003) for EIS requires that proposed research be assessed in terms of its effectiveness in identifying and prioritising research that fills information gaps for sustainable management of the fishery. The key element in the assessment is “effectiveness”. Two criteria were used in assessing whether the proposed research will be effective.

a) Does it address information gaps identified in the risk assessment or arising from the draft FMS itself ?

b) Is the research sufficiently targeted to answer the questions raised by the knowledge gap ?

Information gaps that were not addressed by the draft FMS are discussed separately.

b) Assessment of Proposed Research

i) Stock assessments of primary species

Twelve primary species were identified as requiring stock assessments. They were ranked according to either their economic importance, large proportion of landings, decline in landings, previous history of growth overfishing or time since previous stock assessment. Of the first five species two had moderately high levels of risk (eastern king prawn and school prawn) and one a high risk level (fiddler shark). The latter has the least amount of information currently available for stock assessment. However, collection of basic biological data for all major elasmobranchs is part of a specific management response in the draft FMS (MR 2.1(k)). Silver trevally, which was given a moderately high level of risk was ranked twelfth in the order of priority for stock assessments largely because a preliminary assessment had been done in 2000 (Rowling and Raines, 2000). The remaining species had either low or intermediate levels of risk. Therefore, the proposed priority for stock assessments on primary species appears to be appropriate. The class of assessment (according to Scandol, 2003a) to achieve for each of these 12 species was not specified therefore it is difficult to determine the adequacy of the proposed assessments in providing information for the sustainable management of the fishery. But as a minimum the assessments should be aimed at a class 3 which requires information on basic biology, such as life history and growth, and mortality of the species.

The proposed stock assessments will adequately cover the information gaps for the primary species with respect to their basic biology and stock information, provided the latter is at a minimum of a class 3 (Scandol, 2003a). The ecology of the species is not addressed by the research on stock assessments (Table E5.6).

Table E5.6 Summary of adequacy of proposed stock assessments in meeting identified knowledge gaps for primary species.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Stock assessment of Primary species
Fish stocks (Primary, Key Secondary & Secondary species)	Stock and community structure, and spatial and temporal complexity of fish stocks	B2.3c)	adequate
	Knowledge on the ecology and basic biology of primary and key secondary	B2.6d)	adequate for basic biology, inadequate for ecology

ii) Quantification and reduction of bycatch

Three specific areas of research are proposed for the quantification and reduction of bycatch – development of more effective BRD, effectiveness of BRD under commercial conditions and quantification of the spatial and temporal distribution of bycatch in fish trawls. Research on more effective BRD is continuing in NSW Fisheries and as these become available they will be introduced into the fishery (although proposed measures in Appendices D3 and D5 suggest otherwise). The effectiveness of all BRD currently used in the fishery and any new ones will be monitored. Although not specifically mentioned this will be particularly important for any new gear introduced for the purpose of targeting school whiting (see MR 5.1(c) and Appendices D3 and D5). The quantification of the spatial and temporal variability of the abundance and distribution of bycatch will be a very important step forward in determining effective ways of reducing bycatch in fish trawls which cannot use BRD like prawn trawl nets. The proposed research does not specifically mention quantifying species composition nor whether it will focus on unwanted commercial or non-commercial species or both. This information is important to achieve ecological sustainability and reduce risks.

The proposed research on bycatch will adequately fill knowledge gaps (Table E5.7) in this area provided attention is given to quantifying bycatch from both prawn and fish trawls for both unwanted commercial and non-commercial species.

Table E5.7 Summary of adequacy of proposed quantification and reduction of bycatch in meeting identified information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Quantification & reduction of bycatch
Discards of undersized commercial & non-commercial species	Information on the quantity, composition, frequency and temporal and spatial variability of discarding of unmarketable commercial species & non-commercial	B2.3c) B2.4c)	Unmarketable commercial species not specified, only for fish trawl, adequate if both commerncial and non-commercial are done for fish and prawn trawl
	Motives for discarding of commercial species	B2.3b)	not addressed
Bycatch reduction devices (BRD)	Effectiveness of BRD in reducing unwanted catch of commercial species	B2.3c) B2.4c)	adequate, but unwanted commercial species not specified
	Range of BRD actually used by fishers	B2.3c) B2.4c)	adequate
	Fate and survival of escapees from BRD include the composition, size range, condition, quantity and proportion of each species escaping compared to that caught and the level of behavioural impairment.	B2.3c) B2.4c)	not addressed (This is a difficult area to research)

iii) Impact of trawling of key secondary species

There are two major areas of research proposed to assess the impact of trawling on key secondary species – rudimentary stock assessment information and collection of basic catch data for groups of multiple species, specifically some teleost species and sharks. Key secondary species should be ranked in accordance with their risk levels (see Table B2.18) so that high priority is placed on those at greatest risk.

Data will be collected for groups that contain multiple species. There are three teleost species groups in the key secondary group – leatherjackets, sole and flounder. The latter two have low levels of risk and leatherjackets are at moderately high risk. Consequently, data to identify species and quantify the mix of species in landings should be focused on leatherjackets in the first instance for teleosts. Identification of sharks will be given a high priority as well as collecting more detailed biological data of the landings of sharks such as sex ratios, size at maturity, fecundity and size composition of catches. Given that sharks are the most vulnerable of the key secondary species the proposed research will be extremely important in ensuring the fishery is managed in a sustainable manner.

The proposed research on the impacts of trawling on key secondary species is focused on gathering very basic biological data such as species identification and size composition. These data will be a substantial improvement to the level of information that is currently available for these species. However, as for primary species, there is no indication that research will be done to collect data for these species to fill information gaps on their ecology (Table E5.8). The importance of this knowledge will be discussed further under Section E5.2 (c) below.

Table E5.8 Summary of adequacy of proposed impact of trawling on key secondary species in meeting identified information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2	Impact of trawling on key secondary species, elasmobranchs
Fish stocks (Primary, Key Secondary & Secondary species)	Knowledge on the ecology and basic biology of primary and key secondary	B2.6d)	Adequate for some basic biology of species, but inadequate for ecological knowledge

iv) Economic research

See Dominion consultant report in Volume 4 of this EIS

v) Impact of trawling on ocean ecosystems and effectiveness of trawl closures in addressing impacts

There are four direct areas and one indirect area of research proposed to examine the impact of trawling on ocean ecosystems. The four direct areas are:

i) Mapping of trawl grounds

ii) Information on habitat types within and nearby trawl grounds

iii) Frequency of trawling on all trawl grounds

iv) Evaluation of effectiveness of closures

There is a strong commitment in the proposed research for the first three areas. Mapping trawl grounds, habitat types and quantifying the frequency of trawling on these grounds will fill very important information gaps in managing the fishery sustainably. Whilst it is acknowledged that such an undertaking will take time and substantial resources these areas of research should be given a high priority in implementing the FMS.

There is less commitment to doing the fourth area of direct research – evaluation of the effectiveness of closures in addressing impacts. The use of different types of closures occurs a number of times in the draft FMS (see Table E5.9). This is entirely appropriate and necessary in a fishery where there is a high degree of uncertainty on the extent of the impacts of trawling on the ecosystem in NSW oceanic waters. Given closures are an important management tool of the draft FMS, it is essential to determine whether the closures are effective in achieving their stated goals (Hilborn *et al*., 2004). Yet the proposed FMS only indicates that research "could be" done in this area, thereby leaving uncertainty about the level of commitment. Whilst it is acknowledged that undertaking such research is long term and requires substantial resources, the consequences of not doing this research will be far more costly to managing the fishery in an ecologically sustainable manner into the future.

There are three important consequences if this research is not done. First, it will result in ambiguity in the interpretation of reported landed catch trends (e.g. are the trends a result of closures or some other phenomenon ?). Such ambiguity will only serve to increase uncertainty when it could have been decreased with the appropriate research. Second, it will result in lack of clarity in demonstrating to commercial fishers (who are most impacted by the closures) the benefits of different types of closures. Lack of clarity could lead to scepticism and reduced cooperation from fishers when further management action is required to be taken on an issue. Third, lack of information on the effectiveness of closures will inhibit fishery management from knowing how to improve and build on the draft FMS in the future. The approach of putting management actions in place and not evaluating their effectiveness is becoming a thing of the past in fisheries management (e.g. McAllister and Peterman, 1992; Underwood, 1995; McAllister *et al.*, 1999; Smith, *et al.*, 1999; Sainsbury *et al.*, 2000; Punt *et al.*, 2001). It would therefore be prudent for the department to make a strong commitment to undertake research on the effectiveness of closures in addressing impacts.

Table E5.9 Summary of proposed closures for the OTF.

K2 – key secondary, S – secondary, T – temporary, P – permanent.

MR	Permanent or temporary	Type	Main Purpose
1.1b)	P	Close all reefs	Protect stocks, habitat & biodiversity
	P	Close depths > 1100m	Protect habitat & biodiversity
	P	Habitat types outside 3nm	Protect habitat & biodiversity
1.1c)	P	Close north Smoky Cape to fish trawlers	Minimise overlap of fishing sectors
1.2 e)	T	Close around river entrances during high discharge	Protect juvenile fish & prawns, estuarine species, biodiversity
2.1 f)	P/T	Juvenile king prawn closures	Protect small and & juvenile prawns
2.1 g)	P	Refuge areas for P & K2	Protect primary, K2 & S species biomass
	T or P	Spawning areas	Protect primary, K2 & S species spawning sites, larvae, eggs
4.3 a)	P	Close depths between 150-200 fathoms to prawn trawlers	Minimise overlap of fishing sectors
6.3 b)	P	Close 75% state waters inside 3nm south Barrenjoey, except whiting areas	Protect habitat & biodiversity

The draft FMS would be greatly strengthened if it included a dedicated set of research projects using rigorous scientific methods (Walters, 1986; Underwood, 1990, 1992; McAllister and Peterman, 1992) to test predefined hypotheses about the effectiveness of the different types of closures in protecting oceanic habitats, biodiversity and biomass of primary and key secondary species. As a minimum, the research plan should consider how the results of research from the Marine Parks Authority on the effectiveness of the marine parks could be used to evaluate and test closures made for the OTF.

The indirect area of research proposed in the research plan relates to determining indicators for biodiversity. Instead of a direct research project it is suggested that a combination of other studies by both NSW Fisheries and other organisations could form the basis for appropriate indicators. However, the plan is unclear how the various initiatives referred to could contribute to determining biodiversity indicators. Whilst it is acknowledged that this area of research is very difficult and potentially expensive the research plan does not make a strong commitment to pursuing means of how biodiversity indicators could be identified. It does note that NSW Fisheries currently has a joint research project with the University of British Columbia (Canada) that will develop an ecosystem based model for fishery management in NSW. Whilst it is hoped this will provide a better understanding of the ecosystem of the OTF it is not clear to what extent it may contribute to developing appropriate biodiversity indicators.

Overall the research proposed on the impact of trawling on ocean ecosystems is effective in filling information gaps for three areas – location of trawl grounds, location and types of habitats and frequency of trawling. But it is inadequate for determining the effectiveness of closures in addressing impacts of trawling and determining indicators for biodiversity, although the difficulties in doing so are acknowledged (Table E5.10).

Table E5.10 Summary of adequacy of proposed research on the impact of trawling on ocean ecosystems and effectiveness of closures in meeting identified information gaps.

Area	Information Gaps from Risk Assessment and draft FMS	Reference in Chapter B2	Effects of trawling on ocean ecosystems
Trawl grownds and fishing intensity	Mapping location & extent of fishing grounds	B2.3c)	adequate
	Frequency the grounds are fished by how many fishers	B2.3c)	adequate
	Spatial distribution of fishing effort	B2.7d)	adequate
Habitats	Knowledge about the identification and spatial distribution of important habitat types	B2.7d)	adequate
	Habitat mapping is needed at various spatial scales.	B2.7d)	Not specifically mentioned
	An assessment of impact effect size on habitat	B2.7d)	not addressed
	Taxonomic status of biota that live on geological habitats and that provide additional biogenic habitat structure	B2.7d)	not addressed
	Understanding of the biology and ecology of the biota that creates biogenic habitats	B2.7d)	not addressed
Non commercial species (including discards)	Information about the ecological processes that are associated with the non-commercial assemblages interacting with the OTF	B2.6d)	not addressed
	Understanding the larval supply and recruitment dynamics of sessile invertebrates that may provide habitat for exploitable species	B2.6d)	not addressed
Species Assemblages	Spatial and temporal distribution and abundance of macroalgae, benthic motile invertebrates and species diversity in the fishing grounds and adjacent areas of the OTF, mapping of habitats	B2.6d)	inadequate
Shifts in trophic interactions	Predator-prey relationships, foodweb dynamics among commercial and non-commercial species including invertebrates	B2.6d)	inadequate

vi) Impact of fishing on threatened species

Three things are proposed to investigate the impact of trawling on threatened species. First, accuracy of information on interactions between threatened species by OTF trawlers will be improved via observer studies and self reporting. Second, recovery plans on threatened species will be used to guide specific research on relevant issues and third, the outcomes of a current research project on broad scale interactions with commercial fishing in NSW will also be used to target research. Overall, these strategies will be effective in filling information gaps about the level of interaction between the OTF and threatened species provided any relevant issues identified by other studies are acted on (Table E5.11).

Table E5.11 Summary of adequacy of proposed research on interactions with threatened species in meeting identified knowledge gaps.

Area	Information Gaps from Risk Assessment or arising from the draft FMS	Reference in Chapter B2	Interactions with threatened species
Interactions with threatened species	Report on fishery interactions with threatened species, including bycatch, provisioning and disturbance	B2.5c)	Adequate
Food provisioning from discards	Information to quantify the importance of trawl discards in the diets of threatened species	B2.5c)	Not addressed, possibly via threatened species recovery plans

c) Information Gaps Not Addressed and the Consequences

Table E5.12 summarises the information gaps that were identified by the risk assessment but have not been addressed by the research plan. The shaded boxes highlight the most important information gaps needing attention and these centre on understanding ecological processes relevant to ocean ecosystems in which the OTF operates.

The probable reason for these areas not being addressed in the research plan is the great difficultly in doing such research both from a logistical and resource perspective and because stock assessment research is considered more directly relevant to managing the fishery sustainably. However, there is increasing recognition in fisheries research that understanding the ecological processes that shape fish communities is as equally important in making predictions about future trends as traditional stock assessment information (Pitcher, 2001; Pauly and Christensen, 2002; Reynolds *et al*, 2002; Holland, 2003). Furthermore, for some commercial species it may in fact be more beneficial to understand some key aspects of their ecology rather than their stock size and dynamics alone.

For example, two genera (*Lethrinus* and *Lutjanus*) that were trawled on the north west shelf in WA declined in abundance over a period of 15 years (Sainsbury, 1988). The reason for their decline was later discovered to be due to their habitat association with sponges and other biogenic fauna, which was gradually almost completely eroded by the physical disturbance of frequent and intense trawling. As a result the fish community changed in composition to poorer value fish species (Sainsbury *et al*., 1997). Had the habitat associations of these two species and the impact of trawling on those habitats been known earlier, then the management arrangements for the fishery could have been designed to minimise the impacts and therefore manage it in an ecologically sustainable manner. Two points are worth noting about this example. First, no amount of stock assessment information alone would have revealed the cause of the decline in these fish species. Second, a well designed ecological study on the species examining their habitat associations could have been conducted in 2-3 years and would not require relying on analysis of long sets of catch history data that may have had numerous inconsistencies and problems. Therefore, in this particular case putting resources into an ecological study would have been more economical, easier and produced outcomes more relevant to managing the fishery with lower uncertainty than stock assessment studies alone.

Table E5.12 Summary of information gaps not addressed by the proposed research plan for the OTF. Shaded boxes are most important information gaps.

Area	Information Gaps from Risk Assessment	Reference in Chapter B2
Fish stocks (Primary, Key Secondary & Secondary species)	Knowledge of the ecological processes that are important for the ecological sustainability of primary and key secondary species	B2.6d)
	Knowledge of habitat associations, trophic interactions, intra- and inter-specific competition, distribution and movement	
	Estimate of the spatial and temporal magnitude and variability of fishing pressure being exerted on the key species	
Biological & ecological processes	Ecological processes that interact between primary and key secondary species and other aspects of ecosystems including biodiversity and species assemblages	B2.6d)
	Interactions among fish species and non-target species Interactions of fish with the environment and habitats	
Habitats	Understanding of the biology and ecology of the biota that creates biogenic habitats	B2.7d)
	Understanding the larval supply and recruitment dynamics of sessile invertebrates that may provide habitat for exploitable species	B2.6d)
	An assessment of impact effect size on habitat	B2.7d)
	Taxonomic status of biota that live on geological habitats and that provide additional biogenic habitat structure	B2.7d)
Species Assemblages	Spatial and temporal distribution and abundance of macroalgae, benthic motile invertebrates and species diversity in the fishing grounds and adjacent areas of the OTF	B2.6d)
	Information about the ecological processes that are associated with the non-commercial assemblages interacting with the OTF	
Food provisioning from discards	Assess whether there are any scavenger species that have become dependent or partially dependent on discards as a source of food, particularly during their breeding seasons	B2.4c)
	Information to quantify the importance of trawl discards in the diets of threatened species	B2.5c)
Discards of undersize commercial species	Motives for discarding of commercial species; fate and survival	B2.4c)
Bycatch reduction devices (BRD)	Fate and survival of escapees from BRD include the composition, size range, condition, quantity and proportion of each species escaping compared to that caught and the level of behavioural impairment.	B2.3c) B2.4c)

It is acknowledged that resources are very limited and industry and NSW Fisheries need to be prudent in where these resources are channelled to lower uncertainty and enable more fishery management to be ecologically sustainable. Therefore, it is strongly recommended that serious consideration be given to whether research into some aspects of the ecology of the fish communities of the OTF would be more cost efficient for, or at least add significantly to, its ability to manage the fishery than traditional stock assessment approaches.

The following series of questions could be used to help determine priorities for ecological research:

a) Which ecological process(es) is at highest risk from the major activities (i.e. trawling, harvesting, discarding) of the OTF ?

b) What is already known (even at a very broad level) about the interaction between this process and species at high and moderately high risk ?

AND/OR

Are there any patterns in the reported catch data or other observations that suggest an interaction between this process and these species ?

c) Based on this information what is likely to be the relative importance of this ecological process to the ecological sustainability of these species ?

In other words there needs to be an integration of the outcomes of the risk assessment on the primary and key secondary species with that on the ecological processes, to discern any patterns that may give direction to the most fruitful area of ecological research for the species or fish community.

d) Observer Studies used in the Research Plan

Observer studies are referred to in the research plan as one of the important means by which some of the various research areas will be investigated. There are seven management responses that mention observer studies (Table E5.13) covering six major research areas. Whilst observer studies are appropriate and the most effective means of doing the nominated research, not all the areas of research will be able to be done simultaneously by one observer program. Some of the areas require a different set of tasks to record the information. For example, data collection on abundance and composition of bycatch will be time consuming and may not be able to be done simultaneously with collecting biological data of sharks. Therefore, to maintain the effectiveness of the observer program it will be essential to not overload observers on board vessels with too many tasks with multiple purposes. Either a number of observers per boat or an appropriate separation of tasks for different trips will be required. It should be recognised that the observer work is at two scales. One scale is routine and regular, randomly applied across the fishery. The other requires a more dedicated series of studies for collecting more specific information, such as on elasmobranchs.

Table E5.13 Summary of observer studies in the draft FMS and their main areas of research.

Main Research Areas	MR#	Observer Study
Bycatch	1.2 (a)	Document the degree of interaction with non-retained species
	1.2 (b)	Data will be collected on the levels of use of the approved BRDs and the resulting reductions in bycatch
Bycatch in whiting gear	5.1 (c)	Accurately assess the level of incidental catch taken when using new whiting gear.
BRD	1.2 (a) (b)	Observations on BRD use and effectiveness Analysis of the effectiveness of each of the BRDs approved for use in commercial trawling
Gear selectivity	1.2 (a)	Observations on gear selectivity for retained species
Recovery programmes	2.2 (a)	Assess the effectiveness of the recovery program in preventing the capture and marketing of large numbers of small trevally, including the recording of any discarding of trevally smaller than the new minimum legal length.
Threatened species	1.2 (a) & 3.1 (a)	Observations on any interactions with threatened or protected species.
Shark data	2.1 (j)	Collect additional biological information, including size at maturity and fecundity/brood size data, for the important elasmobranch species taken by the fishery.
	2.1 (j)	Improve the identification of captured sharks and thereby increasing the accuracy of reported catch data, and undertaking targeted research on shark species.
Identification of species	7.3 (b)	Provide first hand information on local names for fish and any patterns in the use of those names

CHAPTER F JUSTIFICATION FOR THE PROPOSED COMMERCIAL FISHING ACTIVITY

1. The need for the Ocean Trawl Fishery

This section examines the need for undertaking the fishing activity proposed in the draft Fishery Management Strategy (FMS) and the consequences of not undertaking the activity. The OTF exists because it satisfies a number of significant community needs, each of which is discussed separately below.

Should the OTF not continue, some of the resources used by the fishery would become available to other users, or would contribute to ecological processes and diversity. However, many of the primary and key secondary species taken by the OTF can not be taken in significant quantities by other fishing methods, and it is unlikely that increased catches by other resource harvesters would offset the loss of product if the OTF ceased to operate. The employment and economic contributions of the OTF to the coastal economy of NSW are also quite significant, and would not be easily replaced should the fishery cease to operate.

a) Supply of seafood to the community

The OTF provides, on average, about 4,500 t of fresh seafood annually, most of which is consumed locally within NSW, although small quantities of certain species are exported. Demersal trawl nets represent the most efficient fishing method for capturing commercial quantities of many of the important species taken by the fishery (e.g. all prawn and bug species, school whiting, flathead and flounder species, john dory, redfish and bottom dwelling sharks and rays). Without the OTF the availability of these species to NSW consumers would be very significantly reduced, as other fisheries or fishing methods would be unable to land sufficient quantities (or similar quality) of product to meet market demand. In the case of both school and eastern king prawns, the OTF consistently lands larger prawns than are generally available from the Estuary Prawn Trawl or Estuary General fisheries, and the ocean caught product commands a much higher market price (and results in better yield, both biologically and economically, from the stock).

A recent survey (Ruello and Associates, 2000) identified the increasing importance of fresh local seafood to both consumers and businesses, and retailers continue to promote the local product (e.g. recent promotion of silver warehou *Seriolella punctata* by Sydney Fish Market). A viable OTF will continue to satisfy the high community demand for local, fresh seafood.

b) Employment considerations

The OTF provides considerable employment opportunities in many coastal centres in NSW, with around 803 to 1314 people being employed either directly or indirectly by fishing businesses endorsed to operate in the fishery. In many instances these jobs are created in rural areas where unemployment rates are generally high. The presence of ocean trawlers in a port also encourages the development of considerable infrastructure for the supply of fuel, ice, netting materials, electronic aids and vessel maintenance, and for the unloading, handling and marketing of product. Studies of employment flow-on effects indicate that for each job created in the OTF, approximately 0.6 jobs are created in the broader community, so the OTF contributes directly to the employment of a further 482 to 788 people in NSW. Even with the necessary controls proposed to be implemented by the draft FMS, the OTF will still support a significant number of jobs in the broader community.

c) Economic considerations

The OTF generates direct revenue for product of about $36 million annually, which is around 45% of the total value of commercial fisheries (excluding abalone) in NSW. The economic flow-on effects from seafood caught by ocean trawlers in NSW are estimated to be 1.5 to 1.6 times the base revenue, so the OTF probably contributes about $50 to $55 million in economic activity to the coastal economy in NSW annually. A significant proportion of the catch is sold in local and regional outlets, as well as the traditional markets in Sydney, Brisbane, Melbourne and Canberra, so the fishery could be considered to be a significant component of the regional fishing industry economy.

2. Justification of Measures in Terms of ESD Principles

The OTF is primarily a single method fishery managed by input controls, including restricted entry, limits on vessel and trawl gear size, and some closures to trawling. Trawl nets catch a large number of species, and for some species minimum size limits or trip limits apply. There is considerable interaction with adjoining jurisdictions in the management of the OTF, and a number of ocean trawl fishers are also endorsed for operating in these adjoining jurisdictions. The benefits and need to maintain a viable commercial OTF are outlined above.

The impact of the OTF on the marine environment has been assessed in the EIS by an initial analysis of the risks associated with the existing management regime. The risks associated with the fishery are partitioned into components related to the impacts of trawling on retained species, incidental catches, threatened and protected species, habitat damage and other associated activities. These risks have been fully reviewed and discussed in Part II of Chapter B and Chapter E of this EIS.

The draft FMS, as outlined in Chapter D of the EIS, proposes goals, objectives and management responses for the fishery, having regard to the risks identified in the existing management regime (i.e. Part II of Chapter B). The preferred suite of rules (including management responses) in the draft FMS, provides for appropriate access to the resources and incorporates the tools necessary to achieve resource sustainability.

The draft FMS provides a broad framework for managing the OTF that describes a range of programs to be implemented; some of which are immediate actions, others are longer term programs with a development stage and need to undertake further stakeholder consultation built in. For these longer term programs, while the draft FMS outlines the proposals in broad terms, it often omits fine detail and the environmental assessment has consequently concluded only a negligible or minor reduction in risk in some areas. In order to ensure that the fishery operates in an ecologically sustainable manner into the future and that the risks are meaningfully reduced, it will be important to ensure that the strategies and plans that are subsequently developed under the FMS are implemented so as to fulfil the goals and objectives for the fishery. With this qualification, it can be stated that the draft FMS addresses the principles of ESD in the following ways:

a) Precautionary principle

The precautionary principle is defined in the May 1992 Intergovernmental Agreement on the Environment as:

"*Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation*"

The introduction of the precautionary principle has, as described by Deville and Harding (1997), shifted the 'onus of proof' regarding impacts away from regulatory bodies and more towards those whose actions may cause damage. Those undertaking the activity are required to provide a convincing argument that their actions will not have serious or irreversible impacts on the environment, which exceed the long-term benefits of the actions (Deville and Harding, 1997).

As recognised in the assessment guidelines under which this EIS was prepared, scientific research into the size and characteristics of shellfish and finfish stocks is inherently complex and costly. Shellfish and finfish populations and the aquatic environment inhabited by them are extremely dynamic. This means that the level of scientific uncertainty associated with shellfish and finfish stocks, and aquatic communities in general, is very high. This is especially so for the many species taken in the trawl fishery that are of low commercial value or occur only infrequently in catches. This situation is by no means unique to NSW or indeed Australian fisheries.

Historically, management of the ocean trawl fisheries has been issue-driven, resulting in management that could be described as somewhat fragmented and un-coordinated. Measures proposed in the draft FMS take a more precautionary approach by, on the basis of a risk based assessment, continuing the existing controls on fishing, and by proposing new initiatives to deal at the "whole-of-fishery" level with the uncertainty surrounding the impact of trawling on ocean habitats and the effects of trawling on marine species. Appropriate actions within the draft FMS that are positive precautionary steps aiming to minimise the impacts (known and presumed) of trawling on the ocean environment include:

- a commitment to conduct research into gear selectivity along with interim proposals to improve the selectivity of trawl nets
- encouraging further research into bycatch reduction, and setting research priorities to fill the information gaps identified in this EIS
- increasing the area closed to trawling
- extending the vessel capacity controls across the entire fishery
- setting programs to set long term fishing effort targets
- implementing an onboard observer program
- improving the strength of the compliance regime through a penalty points scheme, involving endorsement suspension and share forfeiture
- improving the collection of social and economic information on the fishery, and
- developing a code of conduct.

The performance monitoring system established by the proposed FMS also provides a necessary safeguard in case there are changes in either the operation of the fishery or stock levels, which could compromise the long-term sustainability of the fishery.

b) Intragenerational equity

Intragenerational equity relates to distributing the costs and benefits of pursuing ESD strategies as evenly as practicable within each generation (i.e. within the OTF but also between the fishery and other parts of the community).

A large number of species caught in ocean trawl nets are taken in other commercial fisheries and also by recreational and Indigenous fishers, sometimes as primary target species. In some cases it is the juvenile or very small fish that are caught by the trawl fishery, of species where the adults or larger fish are taken by other fisheries, however in many cases the trawl fishery takes the same size classes of fish taken by other fishers. In addition to the question of resource allocation, there are issues relating to habitat degradation and the allocation and management of often conflicting user activities (i.e. commercial fishing, charter boat/recreational fishing, boating, swimming etc.).

The proposed FMS contains proposals to assess the size of the total catch of each species by all sectors, so that the distribution of the resource is known, and performance measures are to be put in place to monitor and manage the distribution of catches of the retained species between sectors. The measures proposed in the draft FMS distribute, as far as practicable, a fair and equitable sharing of the fisheries resource amongst fishers and the community. The operation of the fishery provides fresh local seafood to satisfy an ever-increasing consumer demand for seafood, particularly the relatively high value species, such as eastern king prawns and Balmain bugs. Under the FMS, stock assessments incorporating data from all significant user groups will be developed for each of the primary and key secondary species. For important species groups (e.g. eastern king and school prawns) sharing arrangements can be made between sector groups and the FMS will provide the means to adjust the ocean trawl component of the allocation over time.

The cross jurisdictional liaison, mapping of trawling grounds, and the development of a code of conduct proposed in the proposed FMS all promote equity of access to the physical environment used by ocean trawl fishers and others in the community.

c) Intergenerational equity

Intergenerational equity relates to the present generation ensuring that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

Intergenerational equity in the context of the OTF is a fundamental, if complex, concept. It consists of ensuring the fishery operates in a manner that minimises the impact of trawl fishing on habitat, bycatch and threatened species, populations and ecological communities, as well as maintaining primary, key secondary and other secondary stocks at sustainable levels.

A long-term approach is necessary to ensure the sustainability of the OTF, and the resources on which it depends. Overfished stocks may take a long time to recover when a long-lived species is involved, and benefits of management actions might not accrue for a considerable period after the 'costs' of rehabilitation have been incurred. Conversely, impacts of fishing on newly exploited stocks generally do not become evident until the stock suffers a distinct decline, which is frequently due to the cumulative effects of fishing over a considerable period.

The irreversible effect of the OTF on some ocean habitats is a significant issue in intergenerational equity. The lack of information on the distribution of the different ocean habitat types off NSW, and historical changes to these habitats, makes an assessment of any long-term habitat changes very difficult.

Fishing closures, including marine parks and aquatic reserves, are used to conserve the resources and protect areas of ecological significance. Future generations will benefit from the data collected through the monitoring programs and future research proposed by the draft FMS. There will also be substantial benefits to future generations from the recent and continued declaration of a comprehensive, adequate and representative system of marine protected areas (such as marine parks, aquatic reserves and intertidal protected areas) that includes a full range of marine biodiversity at ecosystem, habitat and species levels (Marine Parks Authority, 2000).

The draft FMS contains seven broad goals that, if realised, will provide future generations with the same or improved opportunities to benefit from the valuable natural resources which the current generation enjoys. Some management measures proposed within the draft FMS to achieve these goals, and hence intergenerational equity, include:

- Improvement in the accuracy of information on activities and catches of the fishery, and development of stock assessments for all primary and key secondary species
- Specification of trawl gears that, over time, reduce the impact on habitats, minimise the catch of incidental species, and have optimal selectivity for the primary species
- Increased use of fishing closures for multiple purposes (biodiversity conservation; protection of nursery areas, juvenile and spawning fish; conflict resolution)
- Continued use and review of the compliance strategic plan including advisory and education programs to deter illegal activity and educate the broader community
- Implementation of an endorsement suspension and share forfeiture scheme to ensure a consistent and complimentary approach to compliance across all fisheries
- Development of a comprehensive performance monitoring and review program, the results of which will be publicly available.

d) Conservation of biodiversity and ecological integrity

This principle incorporates the notion that conservation of biological diversity and ecological integrity should be a fundamental consideration in resource decision making. The draft FMS strongly adopts this principle, with one of the seven major goals being "to manage the OTF in a manner that promotes the conservation of biological diversity in the marine environment". There are four objectives beneath that goal which specifically aim to address the following issues:

- Reducing the likelihood of the fishery affecting populations of species and ecological communities in a manner that threatens ecosystem integrity
- Mitigating the impact of the fishery on non-retained species
- Mitigating the impact of the fishery on ocean habitats and their associated biota
- Preventing the introduction and translocation of marine pests and diseases by ocean trawl fishing activities.

In order to achieve this goal and its objectives, there are 11 management responses in the draft FMS that directly address biodiversity and ecological integrity issues, including mapping trawl grounds and managing the intensity of fishing on each ground, using fishing closures to protect areas of key habitat (including all reef areas), implementing an observer program to collect information on the quantity and composition of bycatch and other key information, using best practice techniques for handling non-retained animals, introducing a code of conduct for the fishery, and supporting monitoring and research on ecosystem functioning.

The draft FMS also contains proposals which attempt to monitor the impact of the fishery on biodiversity, such as recording interactions with threatened or protected species, monitoring bycatch levels and the performance of Bycatch Reduction Devices, and providing mechanisms for taking action if the performance of the fishery relative to the goals of the strategy changes to a significant degree.

In conclusion, the draft FMS contains a comprehensive and appropriate package of measures for ensuring that the impacts of the OTF on biodiversity are properly managed.

e) Improved valuation, pricing and incentive mechanisms

This principle relates to the use of schemes like user pays and incentive structures to promote efficiency in achieving environmental goals. With the exception of the fish trawl sector south of Barrenjoey Point, the OTF, along with most other marine commercial fisheries in NSW, is moving towards a category 1 share management fishery regime. This management framework provides for the issue of shares in perpetuity to eligible fishers and provides for the existence of a market-based trading scheme. The share management scheme for the OTF will provide greater incentives for stewardship and long term sustainability of the resource because the value of shares when traded is likely to be linked to investor's views about the health of the fishery and the anticipated returns on investment.

The share management scheme should also provide greater flexibility for shareholders in the fishery to be able to trade shares with each other. This will enable fishers to change the structure of their fishing businesses more efficiently. It will enable fishers to sell shares in those fisheries (or parts of fisheries) that they do not rely on, and to purchase shares in the fisheries (or parts of fisheries) that are important to their fishing businesses.

The share management scheme incorporates the notion of a user pays system as there is a an annual rental charge payable by each shareholder additional to the normal licensing and management fees, and the current Government policy is to phase in full cost recovery to the fishery between the years 2005 and 2008.

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