Cardno Ecology Lab

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Marine and Freshwater Studies

Marine Fish Stocking in NSW Environmental Impact Statement Vol II

Prepared for: Department of Primary Industries

November 2011

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Marine Fish Stocking Vol II: Online version

Public Consultation Document

Cardno (NSW/ACT) Pty Ltd

ISBN 978 1 74256 222 3

Online Version

Cover Image: Courtesy of DPI.

Document Control

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CHAPTER E THE NSW MARINE FISH STOCKING DRAFT FISHERY MANAGEMENT STRATEGY

E. 1. Introduction

E.1.1 Fish Stocking in NSW

NSW Department of Primary Industries (DPI) and other groups have been stocking native fish and salmonids for over 50 years to boost fish stocks in rivers and in recruitment limited impoundments to enhance recreational fishing opportunities for anglers.

Marine fish stocking is proposed to be delivered by DPI as a specific targeted service, referred to as Harvest Stocking. 'Harvest Stocking', is specifically defined as 'a DPI program of stocking NSW estuaries with native fish recognised as recruitment limited, to enhance both the stock and recreational fishing opportunities'.

This draft Fisheries Management Strategy (FMS), developed as part of the Marine Fish Stocking Environmental Impact Statement (EIS), will manage the activity of stocking native species into estuarine waters by DPI or authorised agents (such as cultural groups), through the Department's Harvest Stocking Program and other applications to stock under section 216 of the *Fisheries Management Act 1994* (FM Act). Together the EIS and draft FMS will provide a framework for the assessment and authorisation of these activities.

Chapters B and C provided a comprehensive description of the proposed activity and included a risk assessment that examined the activity of fish stocking. This chapter, the draft FMS, sets out how the activity is proposed to be managed and conducted to mitigate the risks identified in that assessment process and/or during the development of this draft FMS.

E.1.2 Brief Description of the Activity

DPI proposes to implement Harvest Stocking into selected estuarine waters along the NSW coast to enhance stocks and recreational fishing opportunities.

Harvest Stocking will include up to seven native estuarine species: eastern king prawn, mulloway, blue swimmer crab, giant mud crab, yellowfin bream, dusky flathead and sand whiting, in up to 80 estuaries. DPI will develop a Harvest Stocking Plan each year prior to stocking, and estuaries and species will be selected primarily on a recruitment limited basis.

Over the last ten years there has been a range of stocking activities undertaken by various groups for specific purposes within estuarine waters, such as cultural and conservation groups, and fishing clubs. It is expected that DPI will continue to receive these proposals in the future. Where feasible, these stocking proposals will be incorporated into the DPI Harvest Stocking program. However, if this is not feasible and the proposed stocking is also inconsistent with the FMS, then the stocking proposal would be subject to a separate environmental assessment process consistent with the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The draft FMS does not cover stocking for conservation purposes however it is recognised that these stockings may need to be undertaken as part of future conservation activities (refer to Section E.2.1.3).

Marine fish stocking represents one initiative which is part of a broader DPI program to enhance and improve recreational fishing. Other existing recreational fisheries programs include:

- Deployment of artificial reefs in estuaries and inshore areas
- Habitat Action program
- Fish aggregating devices (FADs)
- Coastal fish habitat protection
- Fishcare Volunteers and Get Hooked…it's fun to fish

These programs complement current DPI fisheries management practices to ensure sustainable fisheries resources and to improve environmental performance of fishing practices.

E.1.3 The Role of the Fisheries Management Strategy

The draft FMS sets out the policies and administrative arrangements to guide the annual stocking events as part of the Harvest Stocking program. It demonstrates a commitment to environmentally responsible stocking in NSW estuarine waters. A policies and procedures manual will be prepared in response to management response 4.1(b) of the draft FMS, to provide an administrative framework for reviewing stocking events.

Pursuant to section 216 of the FM Act, a fish stocking permit is required for the release of live fish into waters. This includes the stocking of fish into the sea, into a river, creek or other naturally flowing stream of water or into a lake but does not apply to the immediate return of fish to waters from which they were taken (catch and release).

This draft FMS outlines the rules, regulations and programs that are designed to manage the activity of marine fish stocking. Impacts by related activities (such as recreational fishing and Aboriginal cultural fishing) or industry sectors (commercial fishing, aquaculture and the aquarium trade) are also considered in the draft FMS, although the rules applying to such sectors are dealt with under separate management or legislative arrangements. In particular, aquaculture has long been synonymous with fish stocking, but the risk assessment in the freshwater fish stocking EIS (2003) highlighted the need to de-couple these two forms of fish production. The same framework will be used for marine fish stocking. Issues related to the aquarium trade are addressed through legislation prohibiting the release of fish into natural waterways without a permit, listing of noxious or pest species, and the concurrent program of establishing a list of species permitted for importation into NSW for use in the aquarium trade.

A key priority for the draft FMS is the introduction of an appropriate management regime to minimise the environmental risks that were identified in Chapter D, which concluded that without sufficient management, many elements of the activity of fish stocking pose some threat to the environment and ecological sustainability, as well as potential social and economic impacts.

Strict hatchery protocols, general administration and information management elements of the activity that would be implemented through the draft FMS will mitigate many of the risks. It will also serve to make administration and compliance less complicated and allow for more targeted monitoring or research related to broodstock and their progeny. Developing and improving research and monitoring of the activity will also reduce much of the uncertainty identified by the risk assessment by assessing the actual rather than potential environmental impacts of fish stocking.

Stocking Review Guidelines (SRGs) have been developed to assess individual fish stocking events (Appendix E.1 & E.2). The guidelines provide a format for rigorous assessment to be undertaken before any stocking can take place by taking into account all matters likely to affect the environment and other relevant FMS issues and the concurrent program of establishing a list of species permitted for importation into NSW.

E.1.4 Overview of the Draft Fisheries Management Strategy

The draft FMS provides a framework for the management of fish stocking activities in estuarine waters in NSW by defining the parameters within which the annual stocking events by DPI (through the Harvest Stocking Program) will be reviewed and approved. The key elements of the draft FMS are described below.

The parameters will be updated as required to be consistent with broader State, National or multi-jurisdictional policies (e.g. National Policy for the Translocation of Live Aquatic Organisms, etc.).

E.1.4.1 Species that can be stocked

The draft FMS details the species that can be stocked in NSW. Any associated conditions of stocking these species, either based on species ranges or other identified risks, are detailed in Tables E.2 and E.3.

Any proposals to stock species into estuarine waters that are not covered by the draft FMS would require a separate environmental assessment process consistent with Divisions 1 and 3 of Part 5 of the EP&A Act.

It should be noted that this draft FMS does not cover the stocking of freshwater fish species. Any proposals to stock fish into waters not provided for by this draft FMS or addressed in the Freshwater FMS will require separate environmental assessment.

E.1.4.2 Waters assessed for stocking

The draft FMS lists a number of waters or sections of waters that have been assessed for stocking, some of these waters are closed to stocking.

E.1.4.2.1 Waters Permanently Closed to Stocking

This is a list of waters (Table E.4) where stocking will not be approved due to those waters comprising pristine or unique aquatic environments (e.g. Ramsar Wetlands). Proposals to stock into these waters will not be approved, even if the proponent supplies a separate environmental assessment on the proposal. The only exception to this is conservation stocking as part of a recovery activity.

E.1.4.2.2 Waters with Restrictions to Stocking

This is a list of waters or sections of waters (see Table E.5) where the stocking of some or all species is restricted following assessment of a range of ecological (e.g. threatened species, marine protected areas (MPAs), habitat condition), economic (e.g. local economic dependencies), social (e.g. history of stocking, alternative opportunities) or policy factors. The draft FMS includes a mechanism to review the list and to list or de-list waters based on changes in the factors over time.

E.1.4.2.3 Waters Suitable for Stocking

One hundred and fifty eight estuaries in NSW were assessed in Chapters B-D as to their suitability for marine fish stocking. Estuaries were assessed according to a range of ecological, social and economic criteria. There were 80 estuaries which were deemed suitable for stocking during the assessment process and these are listed below and in Appendix E.6.

Estuaries deemed suitable for marine stocking

Northern	Central	Southern
Avoca Lake	Allans Creek	Back Lagoon
Bellinger River	Berrara Creek	Barragoot Lake
Boambee Creek	Botany Bay	Bega River
Bonville Creek	Brisbane Water	Bermagui River
Cakora Lagoon	Broken Bay	Bunga Lagoon
Camden Haven River	Burrill Lake	Curalo Lagoon
Clarence River	Cooks River	Cuttagee Lake
Cudgen Creek	Crooked River	Merimbula Lake
Cudgera Creek	Georges River	Murrah Lake
Deep Creek	Hawkesbury River	Nelson Lake
Evans River	Killalea Lagoon	Nullica River
Hastings River	Lake Conjola	Pambula Lake
Hunter River	Lake Illawarra	Towamba River
Jerusalem Creek	Lake Wollumboola	Twofold Bay
Khappinghat Creek	Lane Cove River	Wallagoot Lake
Killick Creek	Meroo Lake	Wapengo Lake
Korogoro Creek	Middle Harbour Creek	Wonboyn River
Lake Innes/Lake Cathie	Minnamurra River	
Lake Macquarie	Narrabeen Lagoon	
Macleay River	Narrawallee Inlet	
Manning River	Parramatta River	

Estuaries deemed suitable for marine stocking		
Northern	**Central**	**Southern**
Mooball Creek	Pittwater	
Nambucca River	Port Hacking	
Oyster Creek	Port Jackson	
Richmond River	Shoalhaven River	
Saltwater Creek (Frederickton)	St Georges Basin	
South West Rocks Creek	Swan Lake	
Terrigal Lagoon	Tabourie Lake	
Tuggerah Lake	Termeil Lake	
Tweed River	Ulladulla	
Wallis Lake	Willinga Lake	
Wamberal Lagoon		

E.1.4.3 Ongoing Review of Stocking Events

Prior to any authorisation, each proposed stocking event will be subject to an explicit review by relevant officers of DPI to ensure that all matters raised within the draft FMS (including those within the local area) have been properly considered and, where relevant, strict conditions are imposed on the stocking event. SRGs for stocking events will guide this process (see Section E.2.6.1.3 and Appendix E.1).

E.1.4.4 Generalised Predatory Impact Model (GPIM)

The GPIM has been developed by Taylor and Suthers (2008) as a decision support tool to assist with the management of fish stocking activities and minimise ecological risk. The GPIM is being used in this draft FMS to determine appropriate stocking rates and to potentially reduce the risk of overstocking (see Appendix E.5). The model has been applied to the seven selected species proposed for stocking in the Harvest Stocking program, and this has been expressed as an estimated stocking rate (maximum number of individuals released per hectare of suitable habitat) and estimated harvest (total tonnes of stocked species to be harvested from the estuary)(Appendix E.5). The limitations of the modelling are acknowledged in Appendix E.5, and the recommended stocking thresholds should be considered as a starting point that will be refined through the research and monitoring proposed in the draft FMS.

The GPIM represents a precautionary approach to minimise potentially negative ecological effects and lower the risk of overstocking by providing an upper threshold for stocking density based on the ecological characteristics of the target estuaries and selected species in conjunction with other policies and protocols that would be in place through the implementation of the draft FMS.

E.1.4.5 Management of Fish Hatcheries

The draft FMS incorporates plans to better manage the production of fish by the one Government and multiple private hatcheries currently licenced for stocking purposes. This includes the development of a quality assurance and accreditation scheme for hatcheries to increase the certainty that fish supplied for stocking have been produced using best practice techniques for broodstock collection and husbandry, management of disease, genetic resource management and stock identification. Policies and guidelines relating to each of these factors will be prepared and will be implemented along with the Hatchery Quality Assurance Scheme (HQAS) which is to be developed to include the seven proposed marine species.

E.1.4.6 Biosecurity

The draft FMS incorporates plans to better manage the production of fish by Government and private hatcheries for Harvest Stocking purposes. This includes the development of biosecurity protocols for fish supplied for stocking. Policies and guidelines relating to biosecurity protocols will be implemented along with the HQAS. **Note:** Biosecurity staff may at any time prohibit a fish stocking event occurring based on biosecurity risks, which have not been addressed in the EIS, import protocols or the HQAS.

E.1.4.7 Information Management

A stocking database has been developed to record all information reported by accredited hatchery operators, from proponents who undertake the stocking activity and from the various research programs that produce information relevant to the review and assessment of individual stocking events. The database, built in a form that can be transposed to Geographic Information System (GIS) software, will allow for spatial management of the activity.

E.1.4.8 Research

A Research Plan has been prepared and is based on the outcomes of the risk assessment of the activity to ensure that the projects being undertaken are focussed on the areas of greatest environmental risk (Table E.7). Research and monitoring related to the survival of stocked fish within the receiving waters is also important to determine whether the stocking events being undertaken are providing good returns for the investment.

E.1.4.9 Compliance and Education

Improved education of stocking proponents and the community about the environmental risks associated with stocking is critical to promote responsible stocking. An education program will highlight the potential damage that can be caused by unauthorised releases. The education program will also include information provided to groups about best practice techniques for transporting and releasing fish at the stocking site.

E.1.4.10 Responsiveness

The controls within the draft FMS, including the detailed policy and guideline documents, are responsive to new information originating from research programs or the information management system. The strategy is also subject to reviews if the performance monitoring (incorporating performance indicators and trigger points) indicates that the management goals are not being met.

E.1.5 The legal and policy regime

A range of legislative and policy instruments apply to or have the potential to influence fish stocking activities in NSW, including:

E.1.5.1 *The Fisheries Management Act 1994* (FM Act)

The FM Act seeks to achieve ecologically sustainable development (ESD) for the fisheries of NSW through the achievement of its stated objectives, which are:

1) To conserve, develop and share the fishery resources of the State for the benefit of present and future generations.

2) In particular, the objects of the Act include:

a) to conserve fish stocks and key fish habitats;

b) to conserve threatened species, populations and ecological communities of fish and marine vegetation;

c) to promote ecological sustainable development, including the conservation of biological diversity;

and, consistently with those objects:

d) to promote viable commercial fishing and aquaculture industries;

e) to promote quality recreational fishing opportunities;

f) to appropriately share fisheries resources between the users of those resources,

g) to provide social and economic benefits for the wider community of NSW;

h) to recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

The activity of marine stocking is consistent with these objectives as outlined in the EIS. Fish stocking is also a designated fishing activity under Schedule 1A of the FM Act.

E.1.5.2 The *Environmental Planning & Assessment Act* (EP&A Act)

Fish stocking is a designated fishing activity under Schedule 1A of the FM Act. As such, DPI developed this draft FMS as a chapter in the EIS for marine fish stocking, consistent with the requirements of the EP&A Act.

The draft FMS includes a strategic framework and approach to the management of marine fish stocking practices. This provides greater control over factors such as translocation, genetic integrity of stocks and disease mitigation, and requires a demonstrated need for any proposed marine stockings to be conducted.

E.1.5.3 Threatened Species Legislation

There are two pieces of State legislation that incorporate provisions for the protection of threatened species, populations or ecological communities. They are the FM Act (Part 7A) and the *Threatened Species Conservation Act 1995* (TSC Act). Aquatic species listed under these Acts could be affected by fish stocking and as such need to be considered during the development and implementation of the FMS for the activity. There is a third piece of legislation addressing threatened species conservation, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), discussed separately below.

In addition to listing species, populations or ecological communities that are presumed extinct, endangered or vulnerable, both of these Acts contain provisions for listing Key Threatening Processes (KTPs). A threatening

process is eligible to be listed as a KTP if, in the opinion of the Scientific Committee (TSC Act) or Fisheries Scientific Committee (FM Act), it:

- adversely affects threatened species, populations or ecological communities, or
- could cause species, populations or ecological communities that are not threatened to become threatened.

A Priority Action Statement (PAS) is a statutory instrument outlining the actions needed to reduce or eliminate the effects of a KTP on the long-term survival of threatened species, populations and ecological communities.

The TSC Act requires the Director General of the Office of Environment and Heritage (OEH) to prepare and adopt a PAS that:

- sets out the recovery and threat abatement strategies to be adopted for each threatened species;
- establishes relative priorities and actions to implement the above strategies;
- establishes performance indicators to report achievements in implementing recovery and threat abatement strategies and their effectiveness;
- contains a status report on each threatened species (where information is available);
- sets out clear timetables for recovery and threat abatement planning and achievement.

OEH has now prepared the PAS which can be found at **www.environment.nsw.gov.au/threatenedspecies**. This website is designed so stakeholders and community members can easily:

- retrieve recovery and threat abatement actions for each threatened species and KTP;
- identify similar recovery and KTP abatement strategies and actions that occur in each broad geographical area (OEH 2011).

E.1.5.4 *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

The Commonwealth EPBC Act commenced in 1999. It is administered by the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) and provides for the protection of certain matters of national environmental significance (NES) from the impact of new activities. Matters of NES relevant to fish stocking activities include: declared World Heritage areas (WHAs), declared Ramsar wetlands, listed threatened species and ecological communities, listed migratory species, Commonwealth marine environment and national heritage places.

In NSW sporadic marine fish stockings have been undertaken for over 10 years and this activity will now be managed under the draft FMS, subject to more stringent environmental controls. Following assessment of the NSW marine fish stocking program, the EIS determined that there was no significant impact on matters of NES (section G.2.1.2.6) and on the basis of this assessment the program has not been referred under Part 7 Section 67 of the EPBC Act as under the current assessment it is a non-controlled action and therefore does not require assessment under that Act (Chapter G, Section G.3.1.2 of the EIS). The draft FMS establishes a comprehensive framework for managing the impacts of stocking on threatened species and environmental heritage.

E.1.5.5 Ecologically Sustainable Development (ESD)

The EIS, and in particular this draft FMS, provide for the management of marine fish stocking consistent with the principles of ESD.

The National Strategy for Ecologically Sustainable Development, endorsed by all Australian jurisdictions at the Council of Australian Governments meeting in 1992, defines the goal of 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.'

According to the NSW *Protection of the Environment Administration Act 1991*, ESD requires the effective integration of economic and environmental considerations in decision-making processes. ESD can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle—namely, 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.

In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment;

(ii) an assessment of the risk-weighted consequences of various options;

(b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations;

(c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration;

(d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement;

(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste; and

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

All fisheries that use ecological risk assessment to assist in formulating their fishery management plans require a qualitative risk assessment method because data deficiency of one or more ecological components is a common feature of almost all fisheries. Therefore, qualitative methods, i.e. those that use attributes or properties of an ecological component rather than exact numerical measurements are needed to assess all major ecological components of data deficient fisheries (Astles *et al*. 2009).

Determining what contributes to an ecological component being at risk is based on two independent aspects – its biological, ecological and/or geological characteristics, and the activities of the fishery that act on that component; the process of conducting the qualitative ecological risk assessment clearly identifies issues that are contributing to the risk and hence indicates the areas that require a management response to mitigate these risks and hence achieve the FMS goals (Astles *et al.* 2009).

E. 2. Designated Stocking Activity

This draft FMS describes the Harvest Stocking program within NSW estuarine waters. The draft FMS also describes cultural and ceremonial fish stockings, in recognition of the spiritual, social and customary significance of fisheries resources stakeholders within the community including to Aboriginal people, in alignment with aims to protect and promote the continuation of Aboriginal cultural fishing (Table E.1). The Harvest Stocking program involves regular reviews of the species to be stocked and stocking areas, and final numbers are dependent upon the extent of recruitment limitation and the annual production of fish from government and private accredited hatcheries.

Table E.1. Overview of the fish stocking programs for approved species under the Fisheries Management Strategy

Component of Designated Stocking Activity	Programs/events that make up the activity
Harvest Stocking	Stocking NSW estuaries with native fish recognised as recruitment limited, to enhance both the stock and recreational fishing opportunities.
Cultural Stocking	Stocking of native species into estuarine waters by cultural groups (including Aboriginal people) as part of recognised cultural or ceremonial events

E.2.1 Policies for Marine Fish Stocking

DPI proposes to undertake selected stocking of estuarine waters of NSW in recruitment limited situations to enhance fish stocks and recreational fishing opportunities and to meet the balance between appropriate environmental management and fishing interests, as outlined in the following sections.

E.2.1.1 Harvest Stocking Policy

1. Only the seven approved native species produced from accredited hatcheries may be stocked into specified estuarine waters in recruitment limited situations of NSW to enhance fish stocks and to provide quality recreational fishing and Aboriginal cultural fishing opportunities.
2. Native species will be stocked for harvesting purposes only: in suitable waters within their specified stocking range as outlined in E.3.2 and Appendix E.3: at or below the recommended stocking rate (Appendix E.6); and in accordance with the genetic protocols outlined in Table E3 and Appendix E3.
3. DPI will produce stocks of native species for stocking at accredited government hatcheries. If a suitable alternative source is available from an accredited NSW hatchery (or interstate hatcheries using production methods of an equivalent standard to the satisfaction of DPI), stock may be obtained from those sources. A combination of those sources may be used to meet stocking requirements.
4. Native species will only be stocked where all of the following conditions apply:
    - pertinent environmental conditions are available for the welfare and optimal survival and health of the stock;
    - the stocked waters offer reasonable access to fishers, and
    - demand for stocking native species in a particular area is evident.
5. Native species will only be stocked where it can be determined to the satisfaction of DPI that either the species or location to be stocked meets one of the following recruitment limiting criteria. Criteria for the determination of a species or sites eligibility in relation to marine stocking:

Recruitment limiting criteria

1. Species based recruitment limitation

- If the NSW exploitation status, as determined by DPI, for the seven species outlined in this FMS is defined as either recruitment overfished or overfished.

2. Location based recruitment limitation

- If the proposed stocking location is acting as a barrier to recruitment. For example, ICOLLs and other physically restricted estuaries may inhibit recruitment of a species to the system.

6. A Harvest Stocking plan will be developed by DPI in consultation with stakeholders, relevant Government agencies and advisory bodies, e.g. the Advisory Council on Recreational Fishing (ACoRF) and the Aboriginal Fishing Advisory Council.
7. Research
   Despite the above provisions, the stocking may take place for targeted research purposes to improve understanding in any of the following key areas;
    - To increase knowledge of a species i.e. the species stock status, through demonstrating recruitment limitation by increasing the number of recruits within the system.
    - To improve our understanding of the impacts of releasing fish into estuarine fisheries and ways to mitigate or minimise these impacts

   It is expected that for a marine fish stocking event to be approved under the research criteria that it would form part of a formal research program.

E.2.1.2 Cultural Stocking Policy

1. Only the seven approved native species produced from accredited hatcheries may be stocked into specified estuarine waters in recruitment limited situations of NSW to maintain or enhance cultural opportunities.
2. DPI may produce the stock of native species for cultural programs from an accredited government hatchery. Where a suitable alternative source of stock is available from an accredited NSW hatchery (or interstate hatcheries using production methods of an equivalent standard to the satisfaction of DPI), stock may be obtained from those sources. A combination of these sources may be used to meet cultural stocking requirements.
3. Cultural stocking will be permitted where:
    - the activity forms part of a recognised cultural activity

- pertinent environmental conditions are available for the welfare and optimal survival and health of the stock.

4. Cultural stockings will be included in the total harvest stocking rates. Once the stocking rate has been reached no further harvest or cultural stockings will be approved under this draft FMS.
5. Native species will be stocked where it can be determined to the satisfaction of DPI that either the species or location to be stocked meets one of the following recruitment limiting criteria. Criteria for the determination of a species or sites eligibility in relation to marine stocking:

Recruitment limiting criteria

1. Species based recruitment limitation
   - If the NSW exploitation status, as determined by DPI, for the seven species outlined in this FMS is defined as either recruitment overfished or overfished.
2. Location based recruitment limitation
   - If the proposed stocking location has a barrier to recruitment. For example the location is an ICOLL or is a similar restricted estuarine waterway, which has inhibited recruitment of a species to the system.

6. Despite any other limiting provision within the draft FMS, additional or other stocking may take place provided an appropriate environmental assessment has been undertaken in accordance with Divisions 1 to 3 of the EP&A Act, and approved by the relevant authority prior to the stocking event. In such events, DPI is likely to assist with both the preparation of guidelines for, and to approve those assessments

E.2.1.3 Other Stockings

This draft FMS only relates to Harvest Stocking for recreational and cultural purposes, however it is recognised that other stockings e.g. conservation stockings, may be needed from time to time. The impact of these activities will be assessed in accordance with Part 5 of the EP&A Act. Those types of stocking activities may be permitted where they can demonstrate they meet the following criteria as well as any requirements under the EP&A Act.

E.2.1.3.1 Conservation Stocking

1. Stocking of native species will be conducted for the purpose of supporting fisheries conservation management objectives at a State, National or International level.
2. DPI may produce the stock of native species for conservation programs from an accredited government hatchery. Where a suitable alternative source of stock is available from an accredited NSW hatchery (or interstate hatcheries using production methods of an equivalent standard to the satisfaction of DPI), stock may be obtained from those sources. A combination of these sources may be used to meet conservation stocking requirements.
3. Conservation stocking will be permitted where:
   - the activity forms part of a threatened species recovery activity; or
   - the activity is a recognised program relating to the conservation of a species.
4. Despite any other limiting provision within the draft FMS, additional or other stocking may take place provided an appropriate environmental assessment has been undertaken in accordance with Divisions 1 to 3 of the EP&A Act, and approved by the relevant authority prior to the stocking event. In such events, DPI is likely to assist with both the preparation of guidelines for, and to approve those assessments.
5. Priority

   The priority arrangements for conservation stocking programs will vary from time to time but will be subject to consultation with the DPI or equivalent relevant authority.

E.2.1.3.2 Stocking of Adult Fish

Large or adult fish will not be stocked on a major scale due to the cost of production and concerns that larger fish can become domesticated and may not survive in the wild. However, the stocking of adult fish may be appropriate in a limited number of circumstances such as to assist with conservation or research programs. Accordingly, adult fish will only be stocked when one or more of the following criteria are met:

- the activity forms part of a conservation stocking activity or a research program that underpins a conservation initiative;
- relates to the return of brood fish to the wild providing genetics, translocation, food safety and health issues are addressed, or
- relates to the release for research purposes

Despite any other limiting provision within the draft FMS, additional or other stocking may take place provided an appropriate environmental assessment, in accordance with Divisions 1 to 3 of the EP&A Act, has been undertaken and duly considered prior to the stocking event. DPI will provide guidelines for these assessments.

'Adult fish' are defined as fish above the size at which 50 % of the stock are mature (i.e. in spawning condition), unless otherwise agreed for individual species by DPI.

E.2.1.3.3 Stocking of Other Native Species of Fish

Stocking of native species not considered within this draft FMS may occur despite any other limiting provision within the draft FMS, provided an appropriate environmental assessment has been undertaken in accordance with Divisions 1 to 3 of the EP&A Act, and approved by the relevant authority prior to the stocking event. In such events, DPI is likely to assist with both the preparation of guidelines for, and to approve those assessments.

E.2.2 Species to be stocked

Waters permitted to be stocked under the draft FMS include estuarine waters of NSW excluding ocean waters. To ensure that environmental impacts of Harvest Stocking are minimised and in some cases avoided altogether, the species and areas to be stocked, and conditions for stocking will be limited to those outlined in Tables E.2 and E.3, respectively.

With the exception of yellowfin bream, all species stocking ranges are identical to their natural ranges within NSW (Table E.2). The stocking range of yellowfin bream has been restricted to those estuaries north of and including the Manning River to avoid the potential for hybridisation with black bream (see Appendix E3 and D4.4).

Table E.2. Species considered in this Fisheries Management Strategy

Species	Stocking Range
Mulloway (*Argyrosomus japonicus*)	Entire length of NSW coastline
Eastern king prawn (*Melicertus plebejus*)	Entire length of NSW coastline
Blue swimmer crabs (*Portunus pelagicus*)	Entire length of NSW coastline
Yellowfin bream (*Acanthopagrus australis*)	From the Queensland (QLD) border south to and including the Manning River
Sand whiting (*Sillago ciliata*)	Entire length of NSW coastline
Dusky flathead (*Platycephalus fuscus*)	Entire length of NSW coastline
Giant mud crabs (*Scylla serrata*)	From the QLD border south to and including Wallaga Lake

Any conditions associated with the stocking of a species are detailed in Table E.3. Stocking will not be permitted unless the conditions have been met.

Table E.3. Species status and conditions

Species	Status and conditions
Eastern king prawn (*Melicertus plebejus)*	Approved subject to genetic regions as detailed in Appendix E 3, prior to stocking, genetic samples are to be collected.
Blue swimmer crab (*Portunus pelagicus)*	Approved subject to genetic regions as detailed in Appendix E.3, prior to stocking, genetic samples are to be collected
Mulloway (*Argyrosomus japonicus)* Yellowfin bream (*Acanthopagrus australis)* Sand whiting (*Sillago ciliata)* Dusky flathead (*Platycephalus fuscus)* Giant mud crab (*Scylla serrata)*	Approved subject to the following conditions: 1) Broodstock must be sourced from the estuary where the proposed stocking is to take place or 2) Broodstock must be sourced from within the same genetic region as the estuary proposed to be stocked. NOTE: stocking using genetic regions allowed for in point 2 will only be approved following completion of a dedicated genetics research program to determine the level of genetic divergence within the NSW population

Any proposal to stock fish species that do not comply with the above specifications in Table E.2 and E.3 will not be permitted to proceed under the draft FMS and would need to be subject to a separate environmental impact assessment process under Divisions 1 to 3 of the EP&A Act or an EIS. In such events, DPI is likely to assist with both the preparation of guidelines for, and to approve those assessments.

Any proposals to stock approved fish species would also be subject to best practice genetic management to ensure that the fish stocked into an estuary are of the same genetic makeup as the resident population within the estuary. Current knowledge about genetic zones in NSW as outlined in Appendix E3 and will also be included in the HQAS. As noted in Table E3, there is currently considerable uncertainty about the population structure for most species along the NSW coast, including those proposed to be stocked as part of this draft FMS. As a precautionary measure and until there is published information available about the population structure for a given species, all finfish and giant mud crabs must be stocked into the estuary from which their parent/broodstock originated. Stockings that do not comply with the best practice genetic management will not be permitted to proceed under the draft FMS.

E.2.3 Waters Permanently Closed to Stocking

Some waters within NSW are unique aquatic environments, where there are minimal anthropogenic influences. Such areas will be permanently closed to stocking to protect existing aquatic biodiversity (irrespective of the potential level of environmental impact). These waters permanently closed to stocking are listed in Table E.4. Apart from proposals to undertake conservation stocking in these areas as part of a recovery activity, no proposals to stock fish in these waters will be considered, even if an associated environmental impact assessment is completed and provided to DPI.

Table E.4. Waters permanently closed to stocking.

Feature	Waterway	Restriction
All waters within or directly adjacent* to declared Wilderness areas and declared World Heritage areas (as at December 2010)	Nadgee River, Nadgee Lake, Merrica River, Limeburners Creek* and Esk River* *These waterways are directly adjacent to declared wilderness areas.	No Stocking within those listed Wilderness areas and World Heritage areas
All waters within declared Ramsar wetlands (as at December 2010)	Myall Lakes, Boolambayte Lake, Bombah Broadwater, Lower Myall River	No stocking within those waters declared as Ramsar wetlands
All waters within the declared sanctuary zones in NSW Marine Park Areas	As described by the Marine park zoning plans.	No Stocking in sanctuary zones within those Marine Park Areas

E.2.4 Waters with Restrictions to Stocking

An outcome of Chapters B-D was that specific waters will be restricted from stocking, primarily in response to the risk assessment undertaken on the proposed activity as well as DPI stocking policies. Table E.5 contains a list of waters where stocking is subject to conditions. Conservation stocking as part of a recovery activity (as detailed in Section E.2.1.3.1) is exempt from these restrictions. Waters may be added to (or removed from) Table E.5 as detailed in Table E.6.

Table E.5. Waters with restrictions to stocking.

Issue	Feature	Restriction
Waters which 'Drain to Dry'	Cockrone Lake, Dee Why Lagoon, Curl Curl Lagoon	These waters are 'drain to dry' ICOLLs and as such are unsuitable for stocking
All waters designated as Commonwealth	No estuarine waters currently listed	No stocking within Commonwealth waters
All waters within the declared general use, habitat protection and special purpose zones in NSW Marine Protected Areas (as at December 2010)	As described by the NSW Marine Park zoning plans	No stocking in general use, habitat protection and special purpose zones in NSW Marine Protected Areas
All waters within Aquatic Reserves (as at December 2010)	Cook Island Aquatic Reserve, Bushrangers Bay Aquatic Reserve, Barrenjoey Head Aquatic Reserve, Boat Harbour Aquatic Reserve, Bronte-Coogee Aquatic Reserve, Cabbage Tree Bay Aquatic Reserve, Cape Banks Aquatic Reserve, Long Reef Aquatic Reserve, Narrabeen Head Aquatic Reserve, North (Sydney) Harbour Aquatic Reserve, Shiprock Aquatic Reserve, Towra Point Aquatic Reserve	No Stocking in Aquatic Reserves
Estuaries less than 10 hectares in area	Broken Head Creek, Darkum Creek, Dalhousie Creek, Middle Lake, Bournda Lagoon, Shadrachs Creek, Boydtown Creek, Fisheries Creek, Table Creek, Black Head Lagoon, Manly Lagoon, Towradgi Creek, Elliot Lake, Shellharbour Creek, Wrights Creek, Werri Lagoon, Wowly Gully, Flat Rock Creek, Nerrindilah	These waters are less than 10 hectares in size and as such have not been previously stocked and are generally considered an unsuitable environment for stocking based on level of habitat and carrying capacities of smaller

Issue	Feature	Restriction
	Creek, Mollymook Creek, Kiola Lagoon, Durras Creek, Maloneys Creek, Bengello Creek	estuaries
All estuarine waters declared as critical habitat	Any waters identified as critical Little Penguin habitat in the Little penguin Recovery Plan. No other estuarine waters currently listed	No Stocking within estuarine waters declared as critical habitat
Shorebird community occurring on the relict tidal delta sands at Taren Point	The Shorebird community occurring on the relict tidal delta sands at Taren Point (as described in the final determination of the Scientific Committee to list the ecological community)	No Stocking within waters declared as part of the Shore Bird Community at Taren Point

Table E.6. Factors for listing (and de-listing) waters with restricted stocking.

Reason for restriction	Potential reasons for listing (and de-listing*)
Protection of listed threatened species, endangered ecological communities and critical habitat of threatened species	If recommended by the Director Aquaculture Conservation and Marine Parks (DPI) or after a declaration of threatened species, population, ecological community or critical habitat by notification in the Government Gazette, it is agreed by the Director, Recreational and Indigenous Fisheries (DPI) that the species, population or community could be detrimentally affected by stocking fish in that area. If recommended by another authorised environmental management agency or after a declaration of threatened species, population, ecological community or critical habitat by notification in the Government Gazette it is agreed by the Director, Recreational and Indigenous Fisheries (DPI) that the species, population or community could be detrimentally affected by stocking fish in that area
Protection of aquatic biodiversity	If, after declaration of a marine protected area and notification in the Government Gazette. or If recommended by the DPI (as approved by the Director, Recreational and Indigenous Fisheries and the Director Aquaculture Conservation and Marine Parks) and/or another authorised environmental management agency and agreed by DPI
Determined as 'unsuitable' by multi-criteria analysis (MCA) or through the stocking review framework	If the area is defined as unsuitable (e.g. temperature ranges, consistently poor returns). If a specific area of concern is identified through a stocking review with respect to an individual stocking event i.e. a culturally sensitive site. If drought or flood affected or affected by toxic agents, noxious aquatic flora or disease.
Places of cultural, historic or Aboriginal significance (must be based on Aboriginal group consultation results)	If such places are identified as requiring special management in consultation with relevant stakeholder groups. If the areas are protected from disturbance under legislation. If otherwise recommended, with sufficient justification, by an authorised agency.

* De-listing generally applies if the reverse situation to a specified trigger occurs.

E.2.5 Waters Suitable for Stocking

One hundred and fifty eight estuaries in NSW were assessed as to their suitability for stocking. Estuaries were assessed according to a range of ecological, social and economic criteria. Estuaries which were deemed suitable for stocking during the MCA process are listed in Appendix E.6.

Chapters B-D also assessed and determined appropriate stocking rates for each species and estuary using the GPIM allocating up to 5 % of available habitat productivity to be utilised by the stocked fish. The results of the model will be used as a guide for fisheries managers so that overstocking and its associated impacts are prevented. The basic concept of the GPIM is outlined in Appendix E.5.

Although the MCA process identified 80 estuaries as suitable locations for marine stocking, DPI will only permit Harvest Stockings to take place if, following assessment, it is determined that the proposed stocking is in a recruitment limited situation.

E.2.6 Review of Proposed Stocking Events

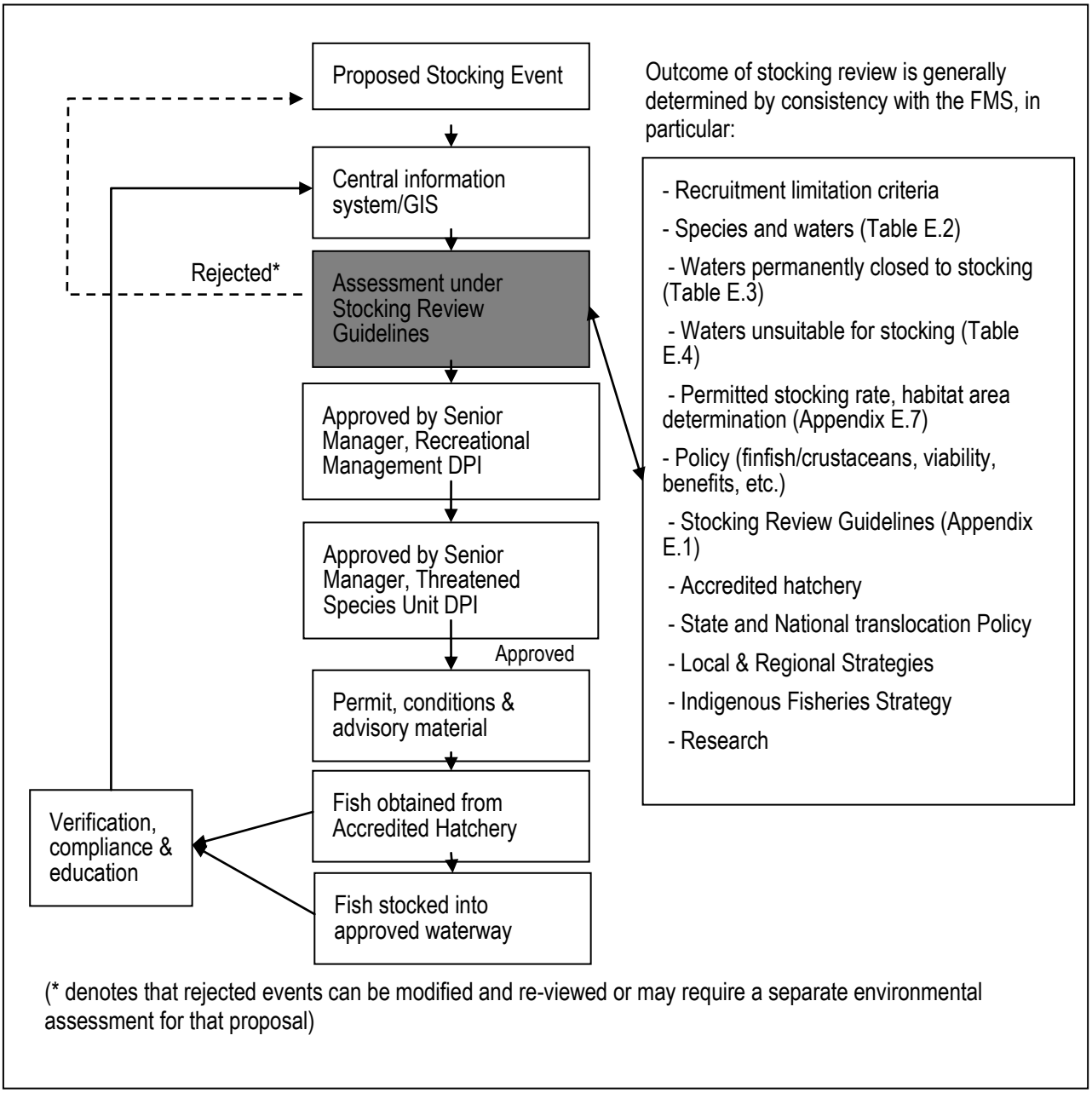
To ensure that individual stocking events are properly reviewed before being carried out, a review framework will be used (Figure E.1). The framework ensures that all potential risks associated with the stocking are mitigated as per the EIS and FMS processes and allows for the identification of constraints early in the planning stage. Events that do not comply with the SRGs (in Appendix E.1 and E.2) and as a result fail to demonstrate compliance with the FMS will not be authorised.

Reviews of stocking events, supported by the SRGs (Appendix E.1 and E.2), will be carried out by appropriately qualified staff within DPI with the delegated power to approve stocking permits under Section 216 of the FM Act. The outcomes of each review will be counter-signed by appropriately qualified staff to advise on threatened species issues to ensure that threatened species, populations and ecological communities and biodiversity issues are addressed before the stocking event takes place.

E.2.6.1 Review Process

The review process is shown diagrammatically in Figure E.1.

Figure E.1. Diagram of the stocking review process.



E.2.6.1.1 Policy and procedures manual

To ensure consistent application of the review process within DPI, a Fish Stocking Policy and Procedures Manual will be developed (see Management Response 4.1(b)). The manual will describe the relevant policy, procedures, assessment protocols and management arrangements that are to be observed when reviewing a stocking event in NSW. The manual will provide consistency within the organisation and provide transparent review and permit systems to support the strategy.

E.2.6.1.2 Delegation of Power

The Senior Recreational Fisheries Manager and Senior Fisheries Manager (Threatened Species) are the delegated officers to exercise the Minister's authority to issue a stocking permit under Section 216 of the FM Act and pursuant to the FMS.

Reviews of stocking events will be carried out by approved DPI stocking management staff for approval by the delegated officers. The reviews will ensure that all aspects of the review process under the FMS as well as any

issues relating to native title, threatened species, fishing access, habitat, water quality and biological diversity are considered in accordance with the FMS before the stocking event takes place.

E.2.6.1.3 Stocking Review Guidelines

Guidelines have been developed and will be used to assess individual fish stocking events. The guidelines provide a format for rigorous review to be undertaken before any activity can take place by taking into account all matters likely to affect the environment and other relevant FMS issues. The SRGs, incorporated into the Policy and Procedures Manual (see Section E.2.6.1.1), will ensure the consideration of matters such as the source and quality of the stock, translocation and disease risks, local environmental issues and potential conditions that should be applied to the event.

The SRGs will be adaptive to reflect the dynamic nature of the natural environment and may be amended by the Director-General, DPI at any time in light of new information, such as research outcomes or habitat conditions that could influence the decision about whether an individual stocking event should proceed.

The four parts of the guidelines are summarised below and detailed in Appendix E.1:

Part 1. The stocking activity - This part examines the source and quality of the stock, the appropriateness of the intended release site, the permitted stocking rates, the annual stocking cap and general compliance with the FMS.

Part 2. Translocation of live aquatic organisms - This part is based on the National Policy for the Translocation of Live Aquatic Organisms (stocking open waters) and examines the likelihood and consequences of inadvertent translocations of non-target species into the zone through the stocking activity. It identifies translocation risks, highlights mitigating actions that need to be taken to minimise risks and leads to further assessment, where necessary.

Part 3. Local environmental issues - This part considers any potentially significant impacts at a local level that may be caused by the activity. Using the best available information on the zone, the decision-maker can determine whether further assessment or action is required.

Part 4. Review of the stocking proposal and permit arrangements - This part provides a review of the entire proposal to ensure that all matters have been taken into account and that the proposal is permissible under the FMS. It ensures a transparent appraisal of the proposal and outlines the authorisation arrangements, including the application of special conditions where necessary to mitigate unacceptable impacts.

E.2.6.1.4 Application Forms

Forms will be designed for fish stocking events to procure the information required for the review of fish stocking or one-off stocking events in NSW. The forms will be designed to guide the proponents into planning events that comply with the provisions of the FMS.

The information provided in the forms will be considered during the review using the SRGs. Where a stocking event fails to comply with the FMS or has unacceptable environmental impacts, the activity will not proceed.

The forms for fish stocking events will be designed following approval of the draft FMS by the Minister for Primary Industries.

E.2.6.2 Authority to Stock Fish

Stocking permits under Section 216 of the FM Act are required for all stocking events undertaken. The permits authorise the activity and outline the conditions under which the event must be carried out.

A stocking event is deemed authorised if it is undertaken under any DPI fish stocking program and has been favourably reviewed under the FMS to ensure that local environmental issues are properly considered prior to the event. Any measures that are required for individual stocking events in order to manage potential environmental impacts must be complied with before the event progresses.

This draft FMS and the policies and management arrangements contained herein constitute the permit issued by the Minister (by virtue of Section 216 of the FM Act) to undertake stocking for authorised events by DPI staff, volunteers or agents of DPI. The authority is subject to any special conditions determined during the stocking review process.

E.2.7 Management of Hatcheries Producing Fish for Marine Stocking

To ensure the consistent production of quality stock to be used for marine stocking, DPI will develop the current HQAS to include the seven marine species nominated in this draft FMS.

E.2.7.1 Hatchery Quality Assurance Scheme

A first of its kind in Australia, the HQAS currently involves the production of freshwater native fish, namely golden perch, silver perch, Australian bass and Murray cod. Prepared by DPI scientists, hatchery managers and aquaculture managers the HQAS was developed in consultation with private hatchery operators and other relevant agencies. The scheme is designed to guide the production of these key native species in a manner that provides high quality and genetically sound stock. The seven marine species nominated in this draft FMS will be included within the current HQAS, and will consider all aspects of hatchery production through a hazard analysis critical control approach.

The HQAS will apply to any facility producing or growing out fish for stocking (including hatching eggs sourced from another hatchery). Marine hatcheries will be accredited based on their capacity to implement agreed standards under these programs and to maintain minimum requirements in the form of appropriate infrastructure, equipment, breeding techniques and relevant expertise. The department will support new hatcheries with extension advice while ongoing support and compliance checks will also form important components of the system.

During the development stage of the HQAS marine hatcheries may be allowed to stock if they indicate intentions to comply with the HQAS when implemented. This is to provide sufficient time to set up the necessary equipment and procedures. After the implementation, any hatcheries failing to comply with the HQAS will not be permitted to provide fish for stocking. Some of the key initiatives within the HQAS include a N_e of 50 for Harvest Stocking, and the supply of broodstock fin-clips and a sample of fish from larval rearing ponds can be requested by DPI for compliance and monitoring purposes at any stage.

E.2.7.2 Broodstock Collection Policy

The collection of wild fish for use as broodstock is a critically important component of the draft FMS supporting the production of quality fish for stock enhancement and conservation programs. Managed by DPI, a Broodstock Collection Policy has been developed to ensure this component of the activity is managed in accordance with the draft FMS and the principles of Ecologically Sustainable Development.

E.2.8 Research

E.2.8.1 Overview

This Section describes research programs designed to support the draft FMS and provide information that will lead to continuous improvement in the way the stocking activity is undertaken.

E.2.8.2 Research Priorities and Timeframes

The research topics and components supporting the draft FMS (outlined in Table E.7), are categorised into two levels depending on the relevance to the risks identified in the EIS and information required to support the goals and objectives of the draft FMS, as follows:

Level 1 (initial research): Commencement scheduled for within one year of the approval of the draft FMS and reviewed within five years of commencement.

Level 2 (supportive research): Commencement scheduled for within three years of the approval of the draft FMS and reviewed within five years of commencement.

Table E.7. Research Plan (Research Topics and components supporting the draft FMS)

Research Topic	Priority	Order of Components	Short description of research project and expected outcomes
1.1 Genetic distribution of native species and sub-populations	Level 1	1. Eastern king prawn 2. Mulloway 3. Dusky flathead 4. Yellowfin bream 5. Sand whiting 6. Blue swimmer crab 7 Giant mud crab	To research and map the genetic distribution of native species used in the activity with regard to identifying any population substructures within each species. Research outcomes will provide information upon which stocking locations and broodstock collection zones can be determined, thereby minimising negative impacts on genetic resources.
1.2 Impacts of native fish stocking on aquatic biodiversity	Level 1	1. Native species breeding programs 2. Broodstock management	To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of conservation significance and marine protected areas.
		1. Native species breeding programs 2. Broodstock management	To establish a monitoring program to look at impacts of stocking on non-stocked species at fish stocking locations and make recommendations to the FMS for future management arrangements as appropriate.

Research Topic	Priority	Order of Components	Short description of research project and expected outcomes
1.3 Genetic Resource Protocols	Level 1	1. Genetic Protocols	Review current literature and research the most appropriate genetic protocols under NSW conditions with regard to native species breeding programs and broodstock management arrangements.
	Level 1	2. Ryman-Laikre effect and effective population size	Research is needed on all species to determine the potential for a Ryman-Laikre effect. The objective of the research would be to determine the genetic effective population size of the target species population in each estuary where stocking is occurring. Importantly, samples from the target population must be collected prior to stocking commencing.
		3. Introgression	Introgression can be minimised by using pure-bred native individuals from the appropriate population as broodstock. Research is needed on all seven species to find genetic markers that can be applied to potential broodstock to test their ancestry.
1.4 Disease research	Level 1	1. Identify diseases which pose a translocation risk in NSW waters.	To determine the potential aquatic pathogen risks relevant to the target species in NSW waters, in particular where broodstock are to be sourced and where stocking is conducted (including all hatcheries) and subsequent disease mapping within stocking zones to support accurate stocking reviews to minimise translocation risks.

Research Topic	Priority	Order of Components	Short description of research project and expected outcomes
1.5 Disease Resistance	Level 2	1. Identify diseases which pose a genetic resistance risk in hatcheries.	Genetic resistance to disease may develop within hatcheries when disease control procedures are not stringent and when the effective population size of hatchery stock (i.e. brood stock and offspring) is low. Research should identify methods to include (a) use of sensitive disease detection protocols for application to hatchery and field samples, (b) stringent disease control mechanisms within hatcheries and (c) maintenance of high genetic effective population size in all life-stages within hatcheries. Genetically resistant stocked fish will have low levels of infection, thus disease testing procedures need to be particularly sensitive.
2.1 Movement of stocked fish	Level 2	All species	To determine the distance that stocked fish may travel from the point of release. Outcomes will provide data to support accurate reviews of stocking events where threatened species, aquatic biodiversity or ecological communities may be affected.
2.2 Impacts of native fish stocking on threatened species and areas of conservation significance	Level 1	1. Native Species	To determine interactions between stocked native fish species and threatened species and areas of conservation significance. The research outcomes may also support the development of appropriate stocking densities, buffer zones and ongoing reviews of waters listed as closed to stocking.
	Level 2	1. Native Species	To establish a monitoring program to look at incidence of injury/fatality from harmful marine debris and/or hooking and make recommendations to the FMS for future management arrangements as appropriate.
2.3 Food chain interactions	Level 2	1. Native species	To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. The project will also examine sites not stocked to establish relative changes in fish and invertebrate species assemblages. Research outcomes will also support the further development of appropriate stocking densities.

Research Topic	Priority	Order of Components	Short description of research project and expected outcomes
3.1 Cost effective marking techniques	Level 2	1. Native species	To research and implement the most cost effective and reliable marking techniques used to identify stocked individuals for monitoring.
3.2 Optimal stocking practices for NSW waters	Level 2	1. Optimisation of Harvest Stocking techniques	To assess and refine the generalised predatory impact modelling methods for release purposes and specifically to assess measurement approaches, appropriateness of 5 % productivity allocation and the long term monitoring of ecosystem components in both stocked and unstocked (control) systems
	Level 2	2. Optimisation of Harvest Stocking releases	To research the efficiency and effectiveness of current stocking methods for Harvest Stocking programs. Includes appropriate classes of stock, stocking survival/mortality rate, conditioning, timing, release techniques. Information will be used to evaluate success of the activity in achieving the stated goals in the FMS. Outcomes will also guide the development of optimal stocking practices under NSW conditions.

E. 3. Vision and Goals for the Activity

E.3.1 Vision for the Activity

The long-term vision for the activity of marine fish stocking is:

An activity that provides effective enhancement of saltwater fish stocks and recreational and Aboriginal cultural fishing in NSW; that supports conservation outcomes for fish and fish habitat; and that is undertaken within a clear management framework and consistent with the principles of ecologically sustainable development and ecosystem management.

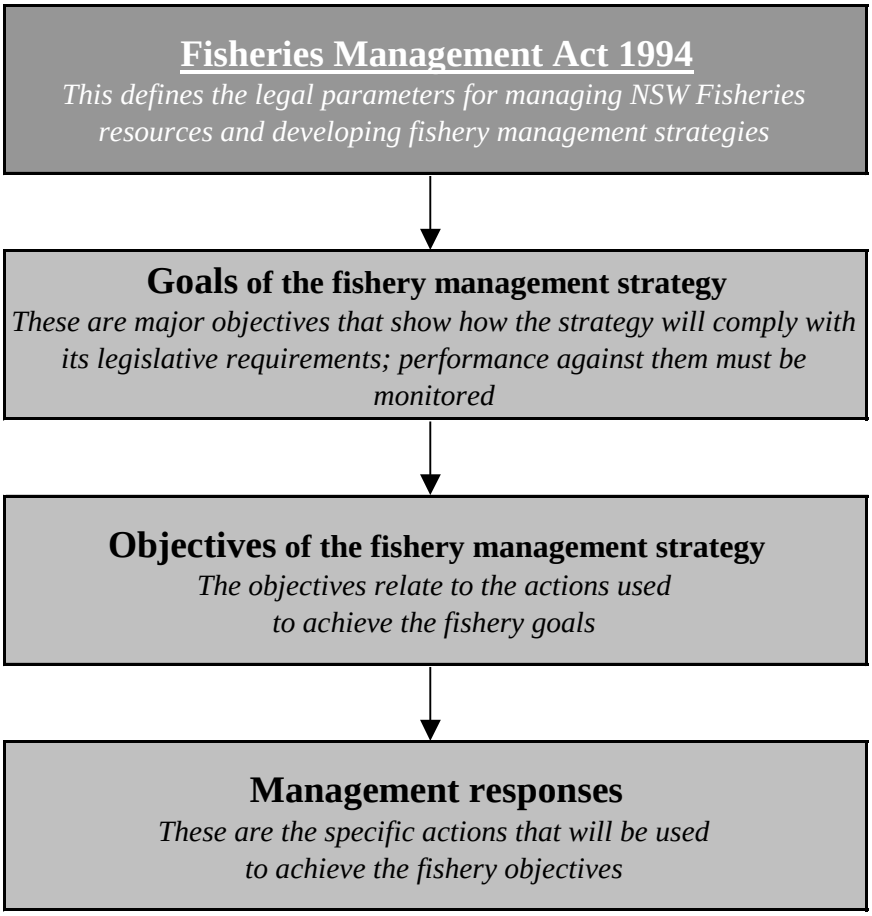
E.3.2 Goals for the Activity

The proposed goals that have been designed to achieve this vision for the activity are as follows:

1. to manage the activity in a manner that minimises impacts on ecological sustainability and aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates.
2. to enhance fishing opportunities through cost-effective stocking programs which complement other existing DPI programs to ensure sustainable fisheries resources and that maximise social, economic, Aboriginal and other cultural benefits, consistent with achieving outcomes aligned with the priorities of the NSW State Plan.
3. to ensure the consistent production and release of appropriate quality stock.
4. to provide efficient administrative services, education and support services, information management and reporting systems.

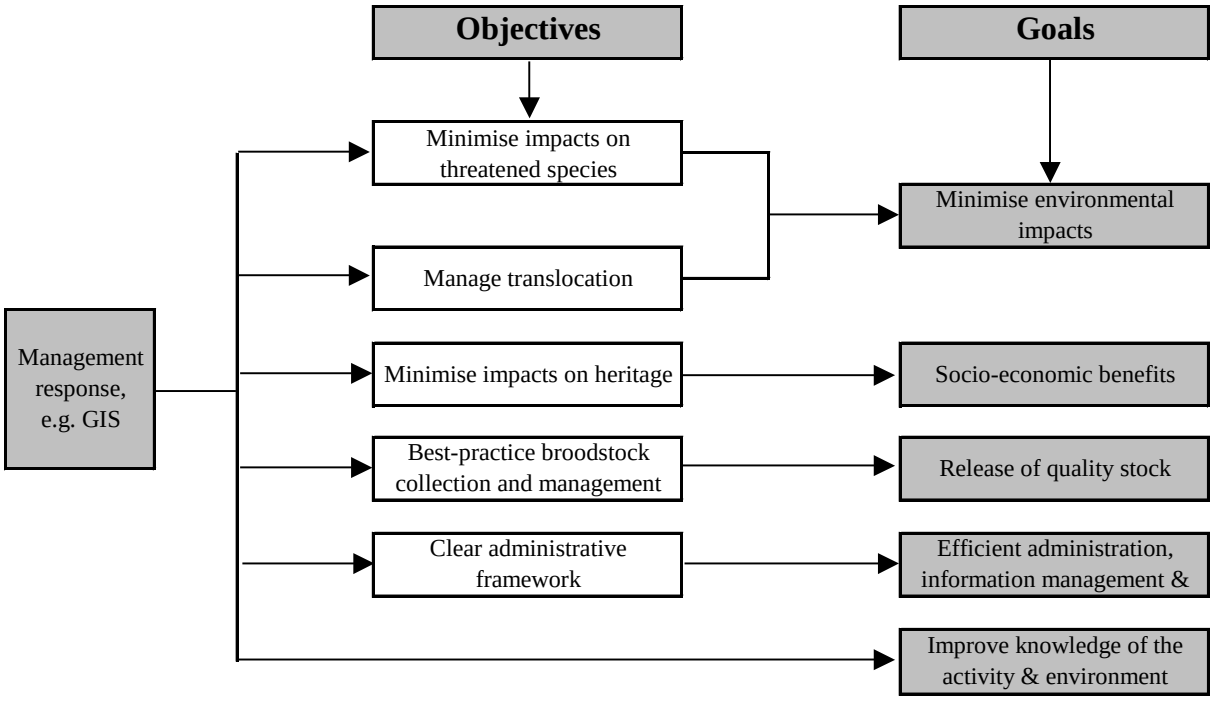
This Section sets out the goals, objectives and management responses for the activity of marine fish stocking established under the FMS.

Figure E.2. A model of the framework for a fisheries management strategy.



The draft FMS contains broad goals, operational objectives and specific management responses (see Figure E.2). The link between the goals, objectives and management responses is not as simple as that portrayed in this figure. The reality is that most management responses assist in achieving more than one goal, and as such cannot be presented in a simplistic issue, goal, objective and response format (see Figure E.3).

Figure E.3. Example of how a single management response from the FMS affects multiple goals and objectives within the activity of marine fish stocking.



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. There are cross-references associated with each management response to the goals that the response assists in achieving (Appendix E.4).

Information relating to the implementation of management responses is provided in a table located in Appendix E.4. The implementation table outlines the scheduled periods within which each management response is 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.

GOAL 1

To manage the activity in a manner that minimises impacts on ecological sustainability and aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates

Objective 1.1 To develop and maintain a framework to guide appropriate assessment of stocking activities

1.1 (a) Use reliable and current information resources to support the stocking review framework

Background: The Stocking Review Guidelines will draw on a set of reliable information sources to assist decision-makers to review stocking events. Information sources used in the review will include the most reliable base-line data available from the Primary Industries Aquatic Ecosystems Unit on estuarine habitat mapping and will also utilise data from the "NSW Atlas of wildlife" information resource (a computer-networked information resource of current natural resource information that draws on a number of data sets including spatial information on threatened species locations, ecological communities and other relevant data supplied by the Australian Museum, the OEH and Royal Botanic Gardens).

1.1 (b) Continually update the list of estuaries where stocking can and cannot occur based on the evaluation of social, economic and ecological factors:

The table of waters suitable and unsuitable for stocking will be reviewed and updated in light of new information or decisions and having regard to a range of ecological (e.g. suitable habitat area, threatened species listings, water condition, frequency and magnitude of stocking), economic (e.g. local economic dependencies) and social (history of stocking, alternative opportunities) factors.

1.1 (c) Map the activity in a Geographic Information System (GIS) to:

- accurately depict the historic stocking activity
- record the ongoing activity to the best available standard
- regularly update the assessment resources
- allow accurate reviews of stocking events in relation to environmental considerations
- plot the presence of disease, pest species, noxious species (including aquatic weeds and algae), and
- contribute to other spatial data sets held by the Government or other authorised agencies as required.

Background: An important component of the FMS is the development of accurate mapping of the activity. The historic and ongoing stocking activity in NSW will be recorded on a series of (GIS-based) maps. This will provide accurate spatial and temporal information in a format that can be considered alongside other similar natural resource data also on GIS platforms. This information will be made accessible to interested stakeholders, recreational fishers and Aboriginal communities.

1.1 (d) Continually update the Stocking Review Guidelines and assessment resources to accurately review potential impacts from the activity

Background: The SRGs established under the FMS are designed to be continually improved and updated. As new information or review procedures are developed they will be readily transposed into the review framework. The document will be assigned version numbers to ensure that only the latest version is in circulation.

This process of modifying the guidelines as new information is developed will equally apply to the other policy and procedures prepared under this draft FMS, such as the Genetic Resource Management Guidelines and guidelines developed under the Hatchery Quality Assurance Scheme.

Objective 1.2 To minimise and/or eliminate any negative impact from the activity on threatened species, populations, ecological communities (including mammals, birds, reptiles, amphibians, fish, invertebrates and vegetation) and critical habitat, and where possible promote their recovery

1.2 (a) Appropriately manage stocking in areas where the activity may adversely affect a threatened species

Background: By drawing on the resources provided by the NSW Atlas of Wildlife and in light of the stocking review framework, any stocking event that has the potential to affect a threatened species will be thoroughly reviewed with a

view to preventing or minimising any potential impacts. The event may be modified, ceased or allowed to proceed subject to stringent conditions in order to mitigate any potential threats.

1.2 (b) To record and monitor sightings and incidences involving threatened and protected species within stocked estuaries.

Background: By drawing on the resources provided by the NSW wildlife atlas, DPI sightings and incidences of threatened species and targeted campaigns in each stocked estuary, these will be linked to the fish stocking database and allow for the monitoring of any potential increases in interaction in order to manage any potential conflicts.

1.2 (c) Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking.

Background: To promote efficiency in stocking rates, empirical methods will be used to determine appropriate stocking densities. In the longer term, it may be possible to further develop and refine stocking density formulae based on fixed factors such as the surface area, shoreline length and water volume of the receiving waterway, and variable factors such as the type and class of stock, existing stock, frequency of past stocking, harvesting pressure and availability of food and habitat values.

1.2 (d) To educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries.

Background: Educational material will continue to be provided through the current methods by DPI. Current methods include signage, pamphlets, media, mail outs, radio as well as a sightings program to allow the angling public to report incidences with threatened species. These sightings may be reported through the internet, phone, email or post. DPI will continually work to improve understanding and awareness in regard to threatened and protected species through all suitable medium with special attention in areas where stocking may take place.

Objective 1.3 To provide reliable genetic resource management in the activity

1.3 (a) Develop and implement genetic resource management guidelines for marine fish stocking in NSW

Background: These guidelines will underpin the critically important use of, and potential effects on, genetic material as it relates to all fish stocking programs in NSW. Designed to be representative of current scientific literature and understanding on the subject, the guidelines will include the DPI policy on the use of aquatic genetic material and will provide precise standards for private hatcheries (stocking) and all NSW Government hatcheries. In essence, the guidelines will address the critically important feature of any ecologically sound stocking management system, namely adherence to genetic, evolutionary, and ecological principles (Miller & Kapuscinski, 2003).

There are four major components of hatchery production and each component represents a genetic risk: (1) Broodstock collection; (2) Breeding Programs; (3) Rearing Progeny; and (4) Stocking Techniques (Miller & Kapuscinski, 2003). How these factors are managed is representative of the level of genetic risks posed under the activity. Each component will be addressed by the guidelines, either outright or in conjunction with the FMS goals and management responses briefly described below.

(1) Broodstock collection: The Broodstock Collection Policy (Management Response 3.3a) will address the point of capture techniques required to mitigate any sampling bias and provide direction on other broodstock collection issues. This will result in high quality broodstock extraction providing a solid basis for good breeding programs.

(2) Breeding programs: The Genetic Resource Management Guidelines (Management Response 1.3a) will address breeding programs through literal standards resulting in an appropriate mix of suitable progeny for harvest and conservation programs by defining the required amount of parent stock and necessary breeding crosses required to establish an effective population size (relevant to the stocking type). For the FMS, the genetic standard for Harvest Stockings will require hatcheries to use an effective population size (N_e) of 50. Principally, the breeding programs established under the guidelines will be designed to minimise or eliminate genetic drift and inbreeding, outbreeding depression and gene pool swamping by considering and mitigating the factors resulting in these problems including population subdivisions and Evolutionarily Significant Units. Knowledge in these areas will be improved by conducting research as outlined in the research plan, in particular the research into distribution of populations (see Section 2.8 - Research Topic 1.1).

(3) Rearing Progeny: This area will be managed under the Hatchery Quality Assurance Scheme (Management Response 3.1a). These systems (each of which draw on the genetic resource management guidelines) will provide direction and guidance on how progeny are to be reared for release into the wild.

(4) Stocking Techniques: Management of this area is improved through the mandatory observance of the Stocking Code of Practice (Management Response 3.4a) that will provide direction for the appropriate release techniques to be used for hatchery progeny under the FMS.

Where the FMS and/or the above requirements generate significant changes to the way the activity is conducted, these will be progressively implemented to minimise any negative impacts on hatcheries.

1.3 (b) Develop and implement species specific stocking guidelines directly relevant to species ranges in NSW

Background: DPI will review species information and where necessary develop detailed and species specific stocking guidelines to improve the management and operation of the stocking program. Appendix E.3 of the FMS outlines some of the specific stocking regions for species. More specific guidelines for species may be established following further research.

Objective 1.4 To implement the FMS in a manner consistent with related Commonwealth and State endorsed programs designed to protect aquatic environments and biodiversity

1.4 (a) Manage the activity having regard to cross-jurisdictional management arrangements

Background: This draft FMS operates alongside other programs relating to the protection and management of aquatic resources. Consultation with other jurisdictions, such as interstate fisheries agencies and other management authorities such as the NSW Marine Parks Authority and the OEH will occur to ensure compatibility between programs and matters of environmental concern. Information relating to cross-jurisdictional management issues will be considered during the stocking review process. Where terrestrial threatened species are of concern the relevant managing agency will be consulted.

1.4 (b) Manage and conduct the activity having regard to other DPI fisheries management arrangements

Background: This draft FMS operates alongside other programs conducted by DPI to improve recreational fishing and ensure fisheries resource sustainability. Consultation with other programs and units within DPI will occur to ensure compatibility between programs and matters of environmental concern. An example of this would be increased advisory campaigns in stocked areas in regard to habitat sensitivities.

Objective 1.5 To appropriately manage the risks associated with translocation of live aquatic organisms during stocking activities

1.5 (a) Manage the activity consistently with State and National policies governing the translocation of live aquatic organisms

Background: Translocation of live aquatic organisms (translocation) has been identified as an area that has the potential to impact on the sustainability of the activity. Translocation issues such as disease transfer and pest/non-target species introductions are immediate threats that are addressed by the FMS. To guide the management of this issue the policies that will be relied upon are the "Introduction and Translocation Policy (1994)" and the "National Policy for the Translocation of Live Aquatic Organisms (1999)" as amended from time to time. These policies will be factored into the stocking review framework and considered in all stocking assessments, while at the same time best practice techniques designed to minimise or eliminate translocations will be incorporated into the Hatchery Quality Assurance Scheme.

In the case of any direct inconsistencies or conflicts between the FMS and the translocation policies, the situation will be reviewed by DPI and the activity or the FMS may be modified as a result.

Objective 1.6 To initiate research relating to the activity

1.6 (a) Facilitate research programs to fill information gaps identified in the risk assessment of the existing activity, as provided for in the Research Plan

Background: This draft FMS will draw on existing research programs that are relevant to the activity while actively developing the most appropriate direction of future research. A Research Plan has been developed and included in the FMS and is based on filling identified information gaps and addressing areas of highest environmental risk as

identified in the EIS. The research proposed in the plan will be considered in order of priority and, subject to available resources, will be carried out according to the timetable set out in the plan (see Section E.2.8).

Objective 1.7 To minimise any competitive advantage of the stocked species over wild conspecifics

1.7 (a) Facilitate stock releases in timing with the selected species lifecycles and natural recruitment patterns

Background: In order to help reduce the impact of releasing juvenile fish, stocking events will be timed as closely as possible to coincide with natural fish spawning events to ensure cohorts of stocked fish are released at the optimal time for survival and that no advantage is created for stocked fish over wild juveniles.

GOAL 2

To enhance fishing opportunities through cost-effective stocking programs which complement other existing DPI programs to ensure sustainable fisheries resources and that maximise social, economic, Aboriginal and other cultural benefits, consistent with achieving outcomes aligned with the priorities of the NSW State Plan

Objective 2.1 To provide quality stock to enhance recreational fisheries

2.1 (a) Commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters

Background: I &I NSW will undertake the release of up to seven marine species in recruitment limited situations consistent with a stocking program plan, which will be developed in consultation with stakeholder groups. The program aims to enhance recreational fisheries and to provide for economic and social benefits arising from them, and will operate within the context of controls on stocking described in the FMS to reduce the environmental risks of stocking fish into estuarine waterways. Stocking activities will need to take account of other measures to restore native fish populations, such as ecosystem restoration and protection.

Objective 2.2 To minimise any negative impacts of the activity on cultural heritage values and provide opportunities for Aboriginal communities to participate in stocking activities and to support cultural fishing practices

2.2 (a) Provide for the stocking of native fish for Aboriginal cultural fishing and moiety purposes as requested in alignment with the FMS

Background: Stocking events of the approved species for Aboriginal cultural fishing and/or moiety purposes will take account of a number of a number of factors, including the findings of research relating to the identification of culturally important species and areas fished by Aboriginal people as well as alternative means of re-establishing native fish populations.

2.2 (b) Ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework

Background: The management regime must be able to respond appropriately to new information about items or locations of cultural significance. For example, stocking waterways near of sites of cultural significance may cause increased disturbance in the area, or, where the local Aboriginal community considers a species of cultural significance, the activity needs to minimise or prevent any impacts on that species, or class of species. Recognition of cultural sites has been incorporated into the SRGs. The OEH is responsible for management of cultural heritage within National Parks and Wildlife Service (NPWS) estate and the protection of all Aboriginal objects on all lands, and their input will help ensure protection of such sites.

2.2 (c) Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked

Background: Stocking has the potential to impact on Aboriginal values and beliefs and as such the relevant Aboriginal groups within the vicinity of any new stocking locations should be consulted prior to the stocking event proceeding.

Objective 2.3 Maximise economic benefits and provide social equity from the activity

2.3 (a) Provide opportunities for religious and ceremonial stocking of approved species and increase awareness of the legislative and policy requirements with the groups involved

Background: Applications are received by DPI to stock approved fish for religious or ceremonial purposes - e.g. Buddhist communities often seek to release a small number of fish into waterways as part of particular religious festivals. In the past DPI has provided such groups with a permit to stock species endemic to the waters proposed to be stocked and observed the stocking event. Provided that the review of these stocking events demonstrates they are appropriate within the context of the FMS, such applications will be supported and advisory material provided to the stockists to educate them about stocking issues.

2.3 (b) Provide opportunities for other stockings of non-approved species and increase awareness of the legislative and policy requirements with the groups involved

Background: Applications are occasionally received by DPI to stock non-approved fish for conservation or research purposes - e.g. Public display aquariums often seek to release a small number of excess fish into waterways. In the past DPI has provided such groups with a permit to stock species endemic to the waters proposed to be stocked and observed the stocking event. Provided that the review of these stocking events has been conducted in accordance with divisions 1 to 3 of the EP&A Act which demonstrates that they are appropriate, such applications will be supported and advisory material provided to the stockists to educate them about stocking issues.

2.3 (c) Monitor the level of socio-economic benefit from fish stocking using surveys undertaken on an episodic basis

Background: Past economic surveys have confirmed the importance of the freshwater fish stocking program in areas such as the Snowy Mountains region. These will be of use to recreational fishers, fisheries managers, Aboriginal communities and the other people in regional communities who are also concerned with maintaining and increasing the value of the enhanced fisheries to the local community.

Further socio-economic surveys will be conducted in stocked areas to measure the benefits of the activity to the economy and societies and/or cultures. This will enable an assessment of the benefits of the activity compared to the expenditure of funds for stocking.

2.3 (d) Monitor the level of fishing effort and changes in effort associated with marine fish stocking

Background: Monitoring of fishing catch and effort both before and after stocking and in adjacent unstocked areas will provide valuable information for assessing the success of the fish stocking program. Previous catch and effort surveys have highlighted the importance of fishing in metropolitan and regional areas. The results of these surveys will be used by fisheries managers, recreational fishers, Aboriginal communities and the other stakeholders involved in monitoring the activity. Catch and effort surveys will be conducted in stocked and unstocked areas to measure the benefits of marine fish stocking.

GOAL 3

To ensure the consistent production and release of appropriate quality stock

Objective 3.1 Ensure stock is of the highest standard in terms of fish health

3.1 (a) Develop and implement quality assurance standards and an accreditation system for hatcheries supplying fish for stocking:

- to ensure consistent production of genetically sound, quality, disease-free stock
- to eliminate non-target species/parasite releases and other translocation risks
- to provide continual improvement in stock production through progressive implementation of best practice techniques
- to ensure new entrants (hatchery permits) are aware of accreditation standards at the application stage, and
- to provide recognition for hatcheries achieving accreditation under the system

Background: Hatcheries are required to comply with the aquaculture permit system established under Part 6 of the FM Act. The conditions placed on hatcheries under this system require compliance with all facets of responsible hatchery management and operation, however, these standards are set for the aquaculture industry only and do not take into account the more robust standards required of hatcheries to produce quality fish for stocking.

All hatcheries (including Government hatcheries) will be required to meet and demonstrate compliance with new quality assurance and accreditation standards that are considered vital to achieving key objectives of the FMS while providing a reliable quality of stock. For instance, hatcheries will be required to comply with the Genetic Resource Management Guidelines as provided for under Management Response 1.3a. By making accreditation mandatory under the HQAS for hatcheries wishing to partake in stocking programs and managing the progressive implementation of the requirements, all hatcheries involved in the activity will need to reach a satisfactory level of accreditation over a three year period.

3.1 (b) Ensure that any fish, fish eggs or larvae procured from interstate hatcheries for import into NSW for the activity of marine fish stocking meets quality assurance standards

Background: Hatcheries can be a vector for disease, release of non-target and pest species (e.g. banded grunter), chemicals and stock of unsuitable genetic background. These are all significant potential impacts that threaten the ecology of the receiving environment. Fish produced for some stocking events in NSW are supplied through hatcheries that operate in other jurisdictions (e.g. QLD). Presently there are no consistent accreditation schemes governing these facilities. The implementation of hatchery standards through accreditation/quality control is the most appropriate way of ensuring consistency in quality assurance. The establishment of a nationally accredited HQAS will eventually address these issues. In the meantime, however, any stock produced by interstate hatcheries for import into NSW will be subject to rigorous review to ensure that standards equivalent to those applied in NSW are met.

3.1 (c) Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of marine fish stocking are mitigated

Background: Hatcheries can be a vector for disease, and the release of disease into waters through fish stocking represents a significant potential impact that could threaten the ecology of the receiving environment.

The implementation of hatchery standards through accreditation/quality control is the most appropriate way of ensuring consistency in quality assurance. All hatcheries (including Government hatcheries) will be required to meet and demonstrate compliance with disease testing regimes developed for hatcheries producing fish for stocking.

Objective 3.2 To promote the use of appropriate technology for genetic resource management in all hatcheries involved in the activity

3.2 (a) Ensure the use of appropriate technology in genetic resource management

Background: The genetic resource management guidelines, as developed under Management Response 1.3a will provide genetic resource management for fish produced for stocking. Appropriate technology to assist broodstock identification includes the use of the Passive Integrated Transponder-tag system (PIT-tags, i.e. microchip identifiers) for stock identification and husbandry, where considered necessary.

DPI will provide leadership and extension services for the implementation of the technology across all hatcheries involved in the activity resulting in the appropriate identification of broodstock used under the HQAS.

Objective 3.3 Implement best practice in broodstock collection and management

3.3 (a) Develop a broodstock collection policy that address collection, husbandry and management arrangements for hatcheries engaged in the activity*:*

Background: Broodstock collection and management is essential to the sustainability of the activity and the aquaculture industry generally. Currently, broodstock collection is authorised by permit issued under Section 37 of the FM Act and managed under the 'Broodstock Collection Policy (1994)' (currently under review). Under the FMS, broodstock collection will attract a greater focus to ensure the level of demand for the resource and ongoing management of broodstock is ecologically sustainable, while ensuring appropriate genetic material is used in stocking programs. Broodstock management will be aligned with genetic resource management arrangements and used to guide the ongoing review of the stocking events. Areas where certain fish populations are of conservation concern or recovering through a recognised management plan will be protected from broodstock collection.

The development of the broodstock collection policy will provide hatcheries involved in fish stocking with vital information regarding critical aspects of broodstock collection operations and further information on maintenance and husbandry and record keeping that are specific to the activity.

3.3 (b) Integrate broodstock collection database

Background: To support the genetic resource management and broodstock management initiatives within the FMS, broodstock collection information will be collated with the aquaculture information system. The purpose of this measure is to ensure that all fish taken from the wild can be monitored by DPI to allow managers to track the numbers of broodstock removed from the natural population. The information will be used in compliance audits to ensure that all hatcheries comply with the broodstock collection policy, especially with regard to recognised genetic zones.

3.3 (c) Continue to provide for the issue of permits under Section 37 of the FM Act for broodstock collection purposes consistent with the vision and goals of the FMS

Background: Permits are used to manage the taking of species by methods or by persons not normally permitted to do so under the Fisheries Management (General) Regulation 2010. The current management of this aspect of the activity includes relevant advisory material to promote best practice techniques and clearly indicate the permit holder's obligations including the specific locations from which the broodstock may be taken. The permits will be subject to conditions to ensure that the broodstock collection techniques are appropriate and that the number of fish collected does not lead to overfishing of the target species.

Objective 3.4 To promote best practice techniques for marine fish stocking

3.4 (a) Develop a stocking Code of Practice that defines and promotes best practice in stocking techniques and release locations, transport medium management, ethical treatment and care of stock, stocking verification procedures, and the assessment of disease and fish health at the point of release.

Background: The provision of a comprehensive Code of Practice to guide the carrying out of the activity at the point of release is seen as an important management tool to ensure a consistently high level of best practice at the stage between fish leaving the hatchery and the eventual point of release. DPI will develop the Code of Practice by drawing on the expertise of hatchery managers and stocking participants.

Once developed, a copy of the Code of Practice will be issued to each stockist before a stocking event can proceed. The Code of Practice will be a comprehensive information resource to guide the activity at point of release.

GOAL 4

To provide efficient administrative services, education and support services, information management and reporting systems

Objective 4.1 To provide a clear and efficient administrative framework for reviewing stocking events

4.1 (a) Develop stocking application forms in plain English

Background: To streamline the process, stocking application forms will be developed in plain English and will procure sufficient information about the event in order to allow a stocking review to be conducted. The forms should not seek information that has already been gathered and reviewed. The forms will be accompanied by relevant advisory material to assist stockists to complete the form and supply the information necessary to undertake the prerequisite review of the stocking event.

4.1 (b) Develop a specific marine stocking policy and procedures manual for DPI staff

Background: To provide a consistent framework for review, management and administration of the activity by DPI, a Policy and Procedures Manual for Marine Fish Stocking will be developed for the relevant DPI staff. The manual will help to collate and preserve corporate memory and promote consistent management of the activity into the future.

Objective 4.2 To maintain and report accurate information relating to the activity

4.2 (a) Maintain records of all stocking events centrally

Background: The review of the freshwater stocking activity in 2005 highlighted that record keeping of stocking activity is fragmented and could be improved by centralising the records. Under the FMS, all records pertaining to stocking events will be held centrally so they can be kept in a consistent format and reported on accurately when required to do so.

For each individual stocking event, records will be kept about the stocking data recorded will include:

1.	site ID	16.	site description
2.	stocking program	17.	closest town to the site
3	date of release	18.	postcode
4.	duration	19.	exact GPS coordinates
5.	stocking event completion date	20.	water type
6.	species	21.	source of funding
7.	size of the released fish	22.	compliance officer district
8.	number	23.	local government area
9.	hatchery of origin	24.	whether or not the fish are marked
10.	stocking group which released them	25.	stocking review guideline number
11.	genetic zone of the fish	26.	permit number
12.	catchment	27.	threatened species incidences
13.	sub catchment	28.	status of the stocking
14.	river system	*29.*	comments in regard to the stocking are recorded (*this may include habitat condition, incidences to other species and stakeholder comments).*
15.	the name of the site		

An appropriate level of monitoring would be maintained during each stocking event so that any incidences to threatened (see MR 1.2(b)) or other species or social conflict that may have arisen as a consequence of the stocking event are recorded. Where incidences have arisen, the potential cause (e.g. accidental release of disease,

increased fishing effort) will be investigated. At the end of the stocking event, record will be made as to the 'success'.

4.2 (b) Periodically report on the activity:

Background: Reporting procedures provide an opportunity to convey information to those engaged in fish stocking as well as those involved in managing the activity including fisheries units, internal and external clients, Ministerial Advisory bodies, the Indigenous Fisheries stakeholders, other natural resource agencies, and angling media. Reporting will take several forms under the FMS including data generated from the performance indicators, results of research, production reporting (aquaculture production), DPI Annual Report, scientific reports, via the Internet, and through submissions to advisory councils and other groups. An efficient way to meet these reporting requirements and avoid duplications is to produce a single report to report on all aspects of the activity.

Information on stocking figures and advances in management will be provided to recreational fishers and Aboriginal stakeholders through appropriate media in a culturally appropriate manner.

Objective 4.3 To improve community understanding and public perception of the activity through an education strategy

4.3 (a) Develop and implement a culturally appropriate educational (communication) plan

Background: To ensure the education component of the FMS is carried out with optimum benefit a culturally appropriate education plan will be developed. It will be designed to develop appropriate educational material in the form of advisory notes, web-based information and specific publications to meet the needs of people involved in the activity or that would like to become involved. In particular, educational and promotional information will be prepared and delivered in a form that considers the expectations of recreational fishers, Aboriginal communities and other people with an interest in fish stocking. The educational material will also include information on responsible fishing practices. Access to information will be improved through the use of the Internet, through all DPI offices, Fishcare Volunteer programs, through NSW 'Natural Resource Service Centres'. Educational material will be provided to all stockists prior to stocking events proceeding and whenever other opportunities arise (such as field days and in the angling media).

Objective 4.4 To develop and deliver an effective compliance program

4.4 (a) Require persons involved in stocking to verify stocking events when complete

Background: It is important to be able to verify that the species and quantity of fish examined under the stocking review framework were actually stocked in the nominated areas. Accurate and timely data is necessary for the ongoing management and reporting of stocking, particularly for disease management and the ability to trace sources of outbreaks. A failure to comply with stocking verification procedures would attract a penalty that is dealt with under the Self Enforcing Infringement Notice System (SEINS) and could result, in extreme cases, in the rejection of future stocking events by that stocking person or group.

E. 4. Performance Monitoring and Review

E.4.1 Performance Monitoring

The complex nature of fish stocking means that many of the management responses 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 this draft FMS against the four goals (i.e. the major objectives). A regular report will, however, be prepared (as outlined later in this Section) detailing the progress made in implementing the management responses.

E.4.1.1 Performance Indicators

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 monitoring programs are detailed later in this Section in Tables E.9 to E.12.

With the implementation of the new research and information management programs for the activity outlined in Goal 1, a broader information base relating to the activity and its impacts will enable more precise performance indicators to be developed over time.

E.4.1.1.1 Data Requirements and Availability

The data requirements and availability for each performance indicator in Tables E.9 to E.12 relate to the collection of information used to measure the performance indicators and the data that are available.

E.4.1.1.2 Robustness

The robustness ratings applied to each performance indicator in Tables E.9 to E.12 have been selected using the definitions established by the Standing Committee on Fisheries and Aquaculture (2000), as outlined in Table E.8:

Table E.8. Robustness ratings applied to each performance indicator.

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

E.4.1.2 Trigger Points

Trigger points specify when a performance indicator has reached a level that suggests there is a problem with the activity and a review is required. Tables E.9 to E.12 establish the performance indicators and trigger points that will be used to measure whether each of the management goals described in Section E.3 of are being attained.

E.4.1.3 Predetermined Review of Performance Indicators and Trigger Points

It is likely that changes to the activities authorised under the FMS will evolve over time. It is also likely 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 current performance indicators. 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 Primary Industries may amend the FMS accordingly.

A review of the appropriateness of all performance indicators and trigger points will occur not more than five years from the commencement of this draft FMS.

E.4.2 Reporting on the Performance of the FMS

There are two types of reports to be prepared under this management strategy. One is a performance report that 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.

E.4.2.1 Performance 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 Primary Industries within two years of the commencement of the FMS, and biennially thereafter. The annual performance review is the formal mechanism for reporting on performance indicators and trigger points, and the report will be made publicly available. This report will also include a review of progress made in implementing each of the management responses.

The vast majority of management responses in the management strategy are linked to specific implementation timeframes. Some of these management actions are subject to specific trigger points that ensure reviews and appropriate remedial actions if the target timeframes are not met. 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 Primary Industries[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 Primary Industries.

E.4.2.2 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. While the biennial performance report will report on whether any trigger points have been exceeded, this does not prevent a review from being conducted at any other time should it become apparent that a performance indicator has breached a trigger point, especially during the annual performance assessment process.

Where the data or information indicates that a trigger point has been breached, details will be provided to the relevant Ministerial advisory bodies and advice sought on the suspected reasons for the breach.

Reviews arising from activities exceeding trigger points should consider (but not be limited to) the following factors:

- changes in the relative production levels or other factors among hatcheries (including those beyond NSW jurisdiction)
- new biological or stock information, and
- changes in the activities or effectiveness of technology producing the species.

A review report is to be provided to the Minister for Primary Industries within six months of the trigger point being breached, and must include the likely reasons for the breach (where known), and any recommendations for remedial actions.

A review report should include whether the suspected reasons for the trigger point being breached are the result of an effect of the activity or an influence external to the activity, or both.

If a review concludes that the reasons for the trigger point being breached are due to the operation of the activity, or if the FMS objectives are compromised if the activity continued to operate unchanged, management action must be taken with the aim to return the performance indicator to an acceptable range within a specified time period. The nature of any remedial action proposed would vary depending on the circumstances that have been identified as responsible for the trigger point being breached.

There may be circumstances where no change to management arrangements or the management strategy is deemed necessary following the review. For example, a review might be triggered because the number of hatcheries producing a species for stocking declines. However, there would be little cause for concern over the performance of the FMS if the decline in production of a species was clearly caused by changing market prices. Price fluctuations can result in hatcheries adjusting their activities.

[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 December 2010, but it is actually completed in January 2011). When this occurs, it is not necessary to proceed with a review.

If a review considers that the management objectives or the performance monitoring provisions are inappropriate and need to be modified, the management strategy itself may be amended by the Minister for Primary Industries. If the reasons are considered to be due to impacts on the resource from factors external to the fishery, these factors should be identified in the review and referred to the relevant managing agency for action.

All review reports will be publicly available.

E.4.2.2.1 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 DPI or the hatchery industry (e.g. environmental conditions, social changes 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.

E.4.3 Contingency Plans for Unpredictable Events

In addition to the circumstances outlined above, the Minister for Primary Industries may order a review and/or make a modification to the activity or to the FMS in circumstances declared by the Minister as requiring contingency action, or upon the recommendation of a Ministerial advisory body on recreational fishing, conservation or Aboriginal issues. In the case of the former, the Minister must consult the relevant advisory body on the proposed modification or review.

These circumstances may include (but are not limited to) food safety events, environmental events, and results of research programs or unpredictable changes in stocking activity over time. Notwithstanding the above, the Minister for Primary Industries may also make amendments to the FMS that the Minister considers to be minor in nature at any time.

E.4.4 Performance Indicators and Trigger Points for the Activity of Marine Fish Stocking

Tables E.9 to E.12 outline the performance indicators and associated trigger points to measure the performance of the FMS in relation to the four goals of the FMS.

Table E.9. Performance indicators and trigger points for Goal 1 of the Fisheries Management Strategy.

[Note: Performance indicators apply to goals and not individual management responses]

GOAL 1: To manage the activity in a manner that minimises impacts on aquatic biodiversity and improves the knowledge of the activity and the ecosystems in which it operates			
Performance indicator (1)	Trigger point	Justification/comments	
Response of the activity to a threatened species recovery plans or threat abatement plans	Threatened species recovery plans or threat abatement plans require a modification to the activity which the Director-General, DPI, considers is not adequately provided for elsewhere in the FMS	There is no single indicator available to monitor the impact of the activity on biodiversity and, as such, surrogate indicators must be used. DPI and other government agencies monitor sightings of threatened species and develop threatened species recovery plans when required to do so	
Data required	Availability/monitoring programs	Robustness	External drivers
Status of implementation of threatened species recovery plans or threat abatement plans	Readily available from DPI and other government agencies (e.g. OEH)	Medium	Nil
Performance indicator (2)	Trigger point	Justification/comments	
Response of the activity to increased incidences with threatened species or key non threatened species or habitat	Threatened species or key non threatened species or habitat incidences within stocked estuaries increases by an amount deemed 'of concern' by the threatened species unit of DPI	Increased incidences on threatened species or key non threatened species or habitat within a stocked estuary may indicate a change in species interactions within that estuary. This may require a modification of the stocking activity.	
Data required	Availability/monitoring programs	Robustness	External drivers
Incidences of threatened species within stocked estuaries	Readily available from DPI and other government agencies (e.g. OEH) and through the fish stocking database	Medium	Nil
Performance indicator (3)	Trigger point	Justification/comments	
Response of the activity to strategies, management plans or legislation (State or national) developed to protect aquatic biodiversity	The Director-General, DPI, considers the FMS does not adequately comply with relevant strategies, management plans or legislation concerning protection of aquatic biodiversity	A number of State and National strategies, management plans and environmental protection laws are in force at present that require compliance by activities (such as fish stocking) that may compromise their effectiveness	
Data required	Availability/monitoring programs	Robustness	External drivers
Status of relevant management plans/strategies (e.g. national/State translocation policies, MPA Zoning plans and other relevant documents)	Readily available from DPI and other government agencies (e.g. OEH)	Medium	Nil

Performance indicator (4)	Trigger point	Justification/comments	
Implementation of research plan in accordance with priorities determined through the environmental assessment process	Research plan not implemented in accordance with priorities identified in the marine fish stocking Environmental Impact Statement	A lack of knowledge about the impact of fish stocking on various environmental factors has resulted in the environmental assessment determining areas of high risk. A research plan developed under the FMS will prioritise research programs based on the areas identified as high risk	
Data required	Availability/monitoring programs	Robustness	External drivers
Research plan available and the research priorities identified	Research plan will be publicly available and progress in implementing the plan will be outlined in the biennial performance report	Medium	Access to government or external funding sources

Table E.10. Performance indicators and trigger points for Goal 2 of the Fisheries Management Strategy.

GOAL 2: To enhance fishing opportunities through cost-effective stocking programs that maximise economic benefits and provide social equity from the activity for recreational fishing and Aboriginal cultural fishing purposes, in alignment with the priorities of the NSW State Plan			
Performance indicator (1)	Trigger point	Justification/comments	
Estimates available to show effectiveness of harvest stocking programs	Estimates not available after four years of approval of the FMS	This relates to the need to have an assessment of the benefits derived from stocking to help guide future stocking events	
Data required	Availability/monitoring programs	Robustness	External drivers
Estimates should be available through research and other programs designed to define and examine the effectiveness of stocking	Results will become available as trials are completed	High	Environmental conditions
Performance indicator (2)	Trigger point	Justification/comments	
Response to Aboriginal or other cultural heritage issues	The Director-General, DPI considers that the FMS does not adequately meet the needs of Aboriginal or other cultural heritage issues	This relates to the need for this FMS to operate in harmony with Aboriginal or other cultural heritage issues	
Data required	Availability/monitoring programs	Robustness	External drivers
Involvement of Aboriginal fishers in stocking activities	Consultation with stakeholders	Medium	Nil

Table E.11. Performance indicators and trigger points for Goal 3 of the Fisheries Management Strategy.

GOAL 3:	***To ensure the consistent production and release of appropriate quality stock***		
Performance indicator (1)	Trigger point	Justification/comments	
Response of the activity to a disease or pest species incursion	The Director-General, DPI certifies that the activity has not responded appropriately to a disease or pest species management program and recommends that the FMS be modified or an incidence of a novel disease of pest within an estuary involved in the fish stocking program	Pests and diseases can pose significant risks to the production of fish and the receiving waters. This indicator ensures that the activity is appropriately responding to pest and disease issues, particularly the translocation of live aquatic organisms and disease control in all hatcheries engaged in the activity	
Data required	Availability/monitoring programs	Robustness	External drivers
Ongoing monitoring of pests and diseases and records of responses to pest or disease incursions	Disease notification procedures (in line with DAFF) and AQUAVETPLAN, including cessation of the stocking program in contact with the notification pending advice from DPI Biosecurity	Medium	Introduction of pests and diseases through other aquatic or land based activities
Performance indicator (2)	Trigger point	Justification/comments	
Reliability of consistent production and appropriate quality fish stocks	More than 10 % of hatcheries fail to meet permit requirements within the HQAS If more than two hatcheries record a “critical defect” in HQAS standards	Hatcheries involved with the program should aim to produce quality fish stocks, compliance with the HQAS aims to ensure this occurs within each stocking year	
Data required	Availability/monitoring programs	Robustness	External drivers
Records of hatchery permits, audits and compliance	Data will be available through the information management system maintained by DPI	Medium	Nil

Table E.12. Performance indicators and trigger points for Goal 4 of the Fisheries Management Strategy.

GOAL 4: To provide efficient administrative services, education and support services, information management and reporting systems, in alignment with the priorities of the NSW State Plan			
Performance indicator (1)	Trigger point	Justification/comments	
Reliability of production reporting by hatcheries engaged in fish stocking	More than 20 % of hatcheries fail to submit production reports by the required time	Hatcheries (Government and Private) must provide prompt reports on the production of stock for fish stocking and other matters such as presence of pests and diseases, mortalities and trends	
Data required	Availability/monitoring programs	Robustness	External drivers
Record of receipt of hatchery production reports compared to due dates	Data will be available through the information management system maintained by DPI	High	Nil
Performance indicator (2)	Trigger point	Justification/comments	
Publication of stocking information in line with education, and research plans	Publications requirements missed or incomplete on two sequential occasions	This relates to the need to accurately report on the components of the FMS to a range of internal and external stakeholders, and ensuring that the FMS is taking account of new and updated information	
Data required	Availability/monitoring programs	Robustness	External drivers
Details of stocking figures, research outputs and compliance outcomes	Data will be available through the information management system maintained by DPI and the annual performance assessments	Medium	Nil
Performance indicator (3)	Trigger point	Justification/comments	
Overall rate of compliance by persons engaged in the activity	Overall rate of compliance with the strategy falls below 80 %	The compliance rate associated with the current operation of the activity is not easily measured. As the compliance strategy for the activity is implemented, the reporting of compliance outcomes is expected to be readily available and accurate	
Data required	Availability/monitoring programs	Robustness	External drivers
Outcomes of compliance operations	Data will be recorded by DPI as part of the compliance plan developed under the FMS	High	Nil

Appendix E.1

Marine Stocking Review Guidelines Reference Form

Part 1: The Stocking Activity

Issue	Response	Significance of potential impacts	Comments – Action required to mitigate impacts (e.g. further assessment required; special conditions; consideration of threatened species)
1.1 Is the species approved for stocking in this zone?	Yes/No	If "No", stocking cannot proceed	Another species or zone must be nominated
1.2 Is the proposed release site approved for stocking in the zone? (see Table E.4 & E.5)	Yes/No	If "No", stocking cannot proceed	Another waterway area must be nominated
1.3 Does the event form part of a DPI stocking program?	Yes/No		
1.4 Is the stock to be sourced from a HQAS accredited hatchery or equivalent?	Yes/No	If "No", stocking cannot proceed	Another source of stock must be nominated
1.5 Is the stock required to be marked with a marking agent or technique (i.e. part of a research or monitoring program)?	Yes/No		
1.6 Will monitoring of the stock be conducted after the release?	Yes/No		
1.7 Is the stocking level below the permitted stocking rate?	Yes/No	If "No" stocking cannot proceed	Another waterway must be nominated, or a change in the stocking level for the identified waterway must be nominated
1.8 Has the stocking cap for the financial year been reached?	Yes/No	If "Yes" stocking cannot proceed	
Comments/Conditions regarding issues raised in Part 1:			

Part 2: Translocation of Live Aquatic Organisms

Issue	Response	Significance of potential impacts	Comments – Action required to mitigate impacts (e.g. further assessment required; special conditions; consideration of threatened species)
2.1 Will the consignments be declared as disease free under the Hatchery Quality Assurance Scheme?	Yes/No	If "No", stocking cannot proceed	Consignments of fish should be sourced from a certified source
2.2 Will the consignment be declared as free of undesirable and non-target species under the Hatchery Quality Assurance Scheme?	Yes/No	If "No", stocking cannot proceed	Another source of stock must be nominated
Comments/Conditions regarding issues raised in Part 2:			

Part 3: Local Environmental Issues

Issue	Response	Significance of potential impacts	Comments – Action required to mitigate impacts (e.g. further assessment required; special conditions; consideration of threatened species)
3.1 Is the nominated site subject to any local management plan or action that would preclude stocking?	Yes/No	If "Yes", stocking cannot proceed	Another waterway area must be nominated
3.2 Are any threatened species (terrestrial or aquatic) Recovery Plans in force in the area?	Yes/No	If "Yes", stocking cannot proceed unless it poses no risk	Another waterway area must be nominated
3.3 Are any endangered or vulnerable species listed under the TSC Act or FM Act known to be present at the release site?	Yes/No	If "Yes", stocking cannot proceed unless it poses no risk	Another waterway and/or species must be nominated for Harvest Stocking
3.4 Is the recovery of a threatened species likely to be adversely impacted by the stocking event?	Yes/No	If "Yes", stocking cannot proceed	Another waterway and/or species must be nominated
3.5 Will the activity negatively impact on adjoining land use?	Yes/No	If "Yes", stocking cannot proceed	Another waterway and/or species must be nominated
3.6 Is a loss of the cultural, recreational or other environmental quality of the locality likely?	Yes/No	If "Yes", stocking cannot proceed unless it poses no risk	Another waterway and/or species must be nominated

3.7 Does the nominated site provide suitable access to anglers?	Yes/No		
3.8 Is the area subject to and compliant with a NPWS Plan of Management	Yes/No		

Comments/Conditions regarding issues raised in Part 3:

Part 4: Review of the Stocking Proposal and Permits

4.1 Taking into account information under Part 1 and Part 2 of this review, is the event consistent with the marine fish stocking FMS?	Yes/No
4.2 Taking into account information under Part 3 of this review and proposed permit conditions, is the event likely to have unacceptable impacts on the local environment given the expected benefits to the angling public?	Yes/No
4.3 Does the event require further review? (e.g. an seven part test for threatened species) (If yes, provide details and course of action in the 'Conditions' box below)	Yes/No
4.4 Having weighed up all the factors, in the delegated officer's opinion should the stocking event proceed?	Yes/No
4.5 Are special conditions required to mitigate any potential negative impacts and ensure the event satisfies the requirements of FMS? (If yes, provide necessary conditions)	Yes/No

Conditions required:

A._____

B._____

C._____

D._____

E._____

F._____

G._____

APPROVAL

Name of delegated Authorising Officer: _____

Position of Authorising Officer: _____

Signature of Authorising Officer: _____

Date: ____ / ____ / ____

Name of delegated Conservation Officer: _____

Position of Conservation Officer: _____

Signature of Conservation Officer: _____

Date: ____ / ____ / ____

If approved, forward papers to Permits Officer

Date received by Permits Officer: ____ / ____ / ____

Appendix E.2

Marine Stocking Review Guidelines Form

Program: _____

Agent: _____

Stocking Summary

No. of stocking Sites: _____

Species:

Dusky Flathead		Eastern King Prawn		Yellowfin Bream	
Sand Whiting		Blue Swimmer Crab		Mulloway	
Giant Mud Crab					

Site Locations: _____

_____

Excel File Reference: _____

Shapefile Reference: _____

Ecological restrictions:

System: _____

Estuary Type: _____

Threatened Species: _____

Size of Stocking Area: _____

Stocking Density: _____

Stocking Review Guideline Number (SRGN): _____

APPROVAL for Review Guideline Number #########

Name of delegated Authorising Officer: _____

Position of Authorising Officer: _____

Signature of Authorising Officer: _____

Date: ____ / ____ / ____

Name of delegated Conservation Officer:_____

Position of Conservation Officer: _____

Signature of Conservation Officer: _____

Date: ____ / ____ / ____

If approved, forward papers to Permits Officer

Date received by Permits Officer: ____ / ____ / ____

If answer is within an * box, stocking must not continue **SRGN ######**

Issue	Yes	No
1.1 Is the species approved for stocking in this zone?		*
1.2 Is the proposed release site approved for stocking in the zone?		*
1.3 Does the event form part of a DPI stocking program?		
1.4 Is the stock to be sourced from a HQAS accredited hatchery or equivalent?		*
1.5 Is the stock required to be marked with a marking agent or technique?		
1.6 Will monitoring of the stock be conducted after the release?		
1.7 Is the stocking level below the permitted stocking rate?		*
1.8 Has the stocking cap for the financial year been reached?	*	
2.1 Will the consignments be declared as disease free under the Hatchery Quality Assurance Scheme?		*
2.2 Will the consignment be declared as free of undesirable and non-target species under the Hatchery Quality Assurance Scheme?		*
3.1 Is the nominated site subject to any local management plan or action that would preclude stocking?	*	
3.2 Are any threatened species (terrestrial or aquatic) recovery plans in force in the area?		
3.3 Are any endangered or vulnerable species listed under the TSC Act or FM Act known to be present at the release site?		
3.4 Is the recovery of a threatened species likely to be adversely impacted by the stocking event?	*	
3.5 Will the activity negatively impact on adjoining land use?	*	
3.6 Is a loss of the cultural, recreational or other environmental quality of the locality likely?	*	
3.7 Does the nominated site provide suitable access to anglers?		*
3.8 Is the area subject to and compliant with a NPWS Plan of Management		*
4.1 Taking into account information under Part 1 and Part 2 of this review, is the event consistent with the marine fish stocking FMS?		
4.2 Taking into account information under Part 3 of this review and proposed permit conditions, is the event likely to have unacceptable impacts on the local environment given the expected benefits to the angling public?		
4.3 Does the event require further review? (e.g. an seven part test for threatened species) If yes, provide details and course of action in the 'Conditions' box below		
4.4 Having weighed up all the factors, in the delegated officer's opinion should the stocking event proceed?		
4.5 Are special conditions required to mitigate any potential negative impacts and ensure the event satisfies the requirements of FMS? If yes, provide necessary conditions		

Conditions required:

_____

_____

Appendix E.3
Stocking Zones

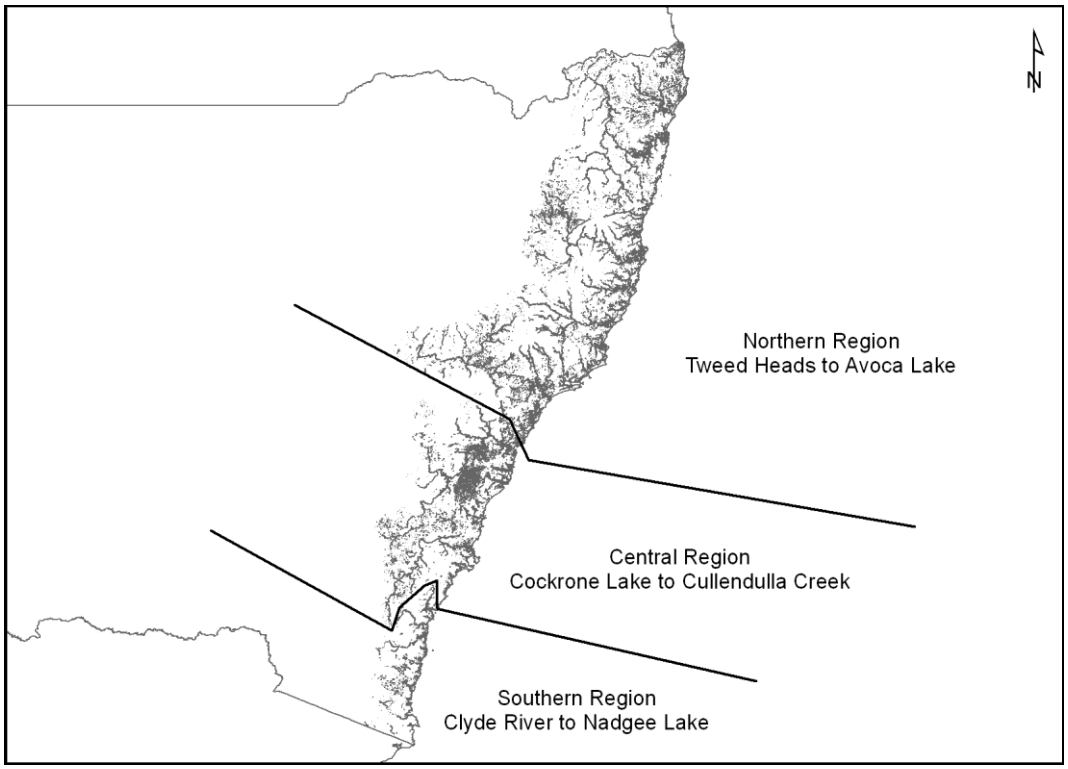
Estuary Regions

For the purposes of geographical equity, the Multi Criteria Assessment (MCA) (refer to Chapter B) was done separately for three regions that contained approximately the same number of estuaries. These were:

- Northern: Tweed River to Avoca Lake (55 estuaries)
- Central: Cockrone Lake to Cullendulla Creek (54 estuaries)
- Southern: Clyde River to Nadgee Lake (46 estuaries)

The locations of the boundaries between these regions are shown in Figure E.4.

Figure E.4. Estuary regions



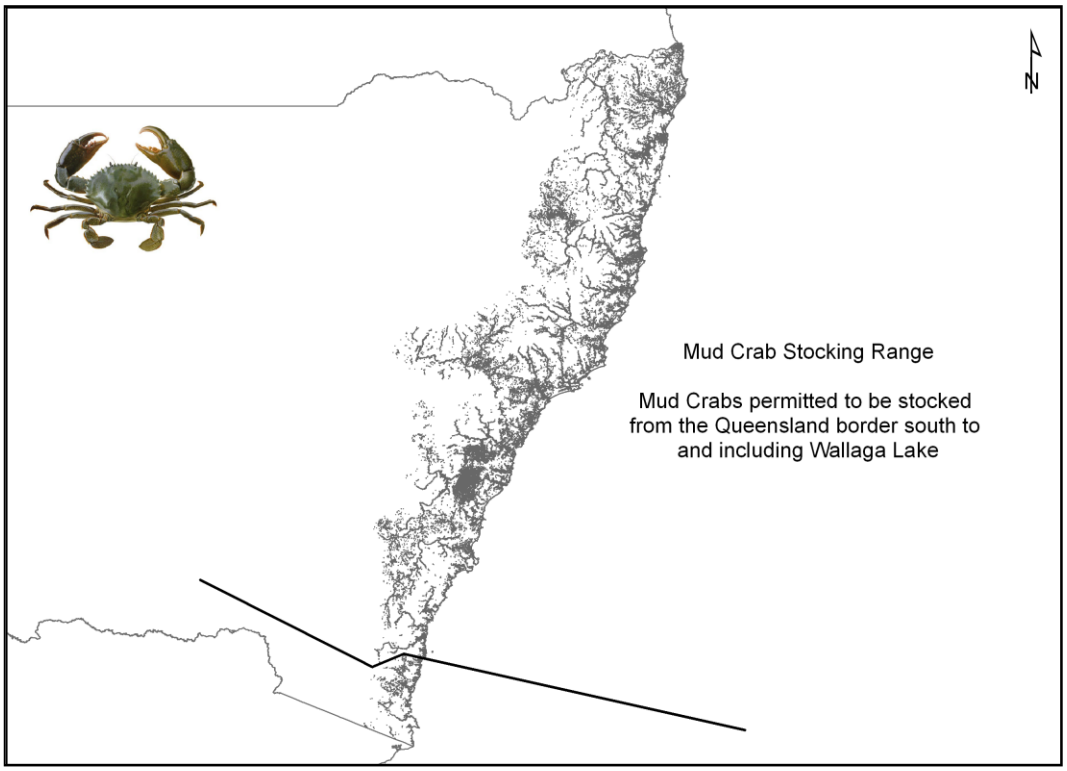
Species Ranges

Introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW has been listed as a key threatening process as it has the potential to cause species, populations or ecological communities that are not threatened to become threatened. As such some restrictions have been placed on giant mud crab and yellowfin bream stocking in NSW waters.

Giant Mud Crabs

Giant mud crabs (*Scylla serrata)* are primarily a northern NSW species although are sometimes found in all estuaries of NSW. As releasing fish outside of their natural range is a KTP under the FM Act, as a precautionary measure a 50 km buffer zone has been implemented beyond the extent of the range of giant mud crabs and as such, the crabs will not be permitted to be stocked south of and including Wallaga Lake (see Figure E.5).

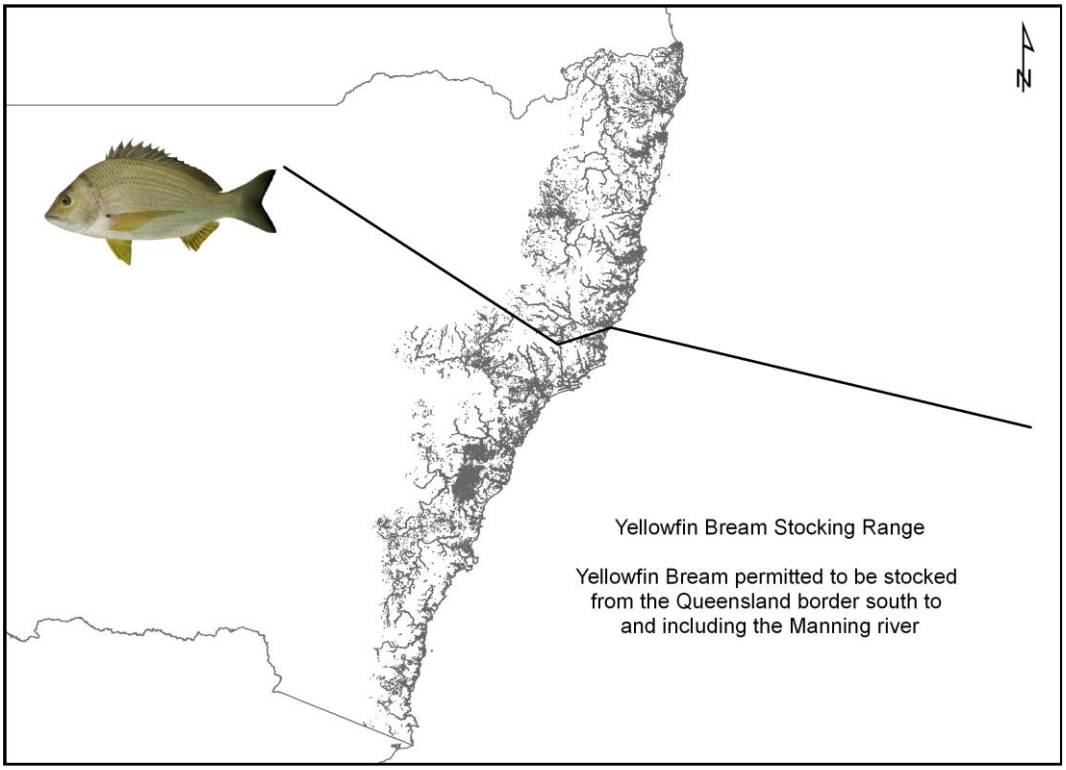
Figure E.5. Range of permitted giant mud crab stocking



Yellowfin bream

Yellowfin bream (*Acanthopagrus australis*) have the ability to hybridise with black bream (*Acanthopagrus butcheri*) and as such, are not permitted under this draft FMS to be stocked within the range of black bream to minimise the risks associated with genetic swamping. As a precautionary measure a 50 km buffer zone has been implemented beyond the extent of the range of black bream. Yellowfin bream are not permitted to be stocked south of and including the Manning River (see Figure E.6).

Figure E.6. Stocking range for yellowfin bream



Broodstock Genetic Regions

The FMS will maintain genetic integrity of natural populations by sourcing broodstock from local fish/invertebrate stock. For five of the species in the proposal, it is unclear whether separate stocks occur in some estuaries or whether stocks range over wider areas or are panmictic in NSW. Until more information on species genetic stock structure is available and under the precautionary principle, broodstock for the program would be sourced from the estuaries into which juveniles would be stocked. These conditions specifically apply to dusky flathead, mulloway, sand whiting, yellowfin bream and giant mud crabs and arise from the lack of genetic information available for each of the species. For the other two species (eastern king prawns and blue swimmer crabs), more information is available that allows conclusions to be made about their stock structure. As such two separate genetic regions have been established for eastern king prawns and blue swimmer crabs see Figures E.7 and E.8.

Eastern King Prawns:

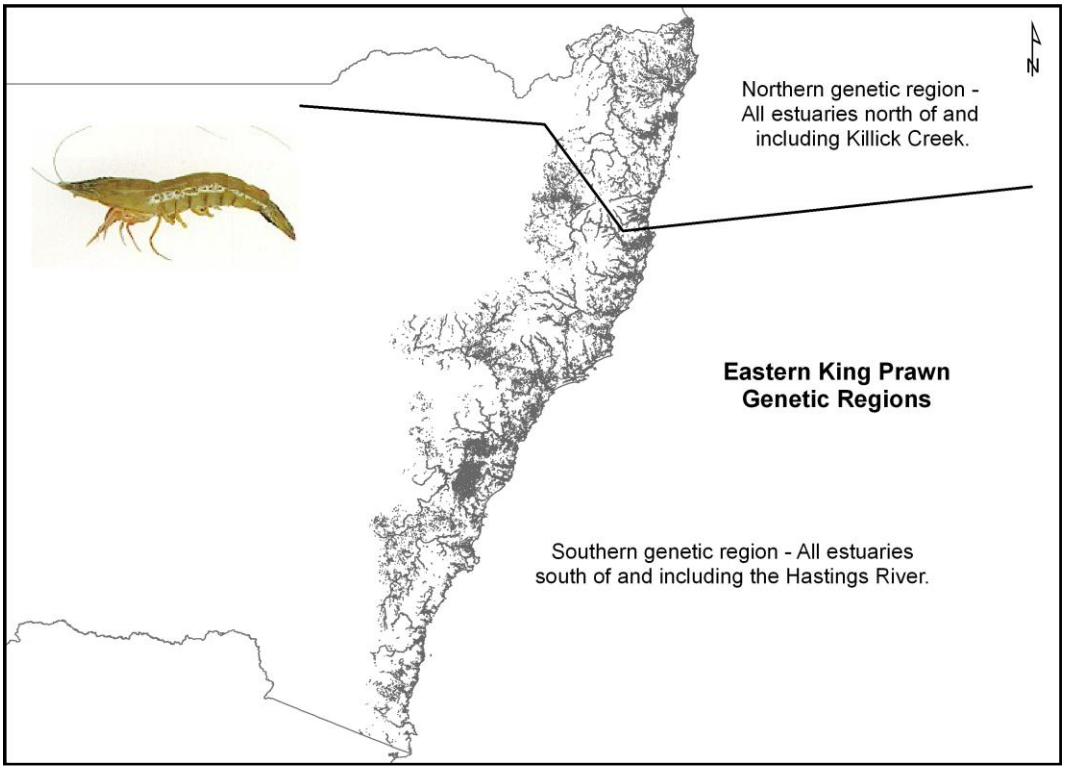
A large spawning stock of eastern king prawns exists off northern NSW and SE QLD that may contribute larvae to estuaries further south. As such, two stocking regions have been established.

1. Southern stocking region - broodstock for any stockings in this region must be collected from offshore waters in northern NSW. The southern stocking region covers all estuaries south of and including the Hastings River to the Victorian border.

2. Northern stocking region - As the potential exists for local spawning and recruitment to northern NSW estuaries, broodstock for stocking in the northern stocking region must be sourced from the estuary that is to be stocked. The northern stocking region covers all estuaries north of and including Killick Creek to the QLD border.

These requirements will be maintained in the FMS until genetic studies provide further information about local recruitment to these estuaries.

Figure E.7. Genetic regions for eastern king prawns



Blue Swimmer Crabs:

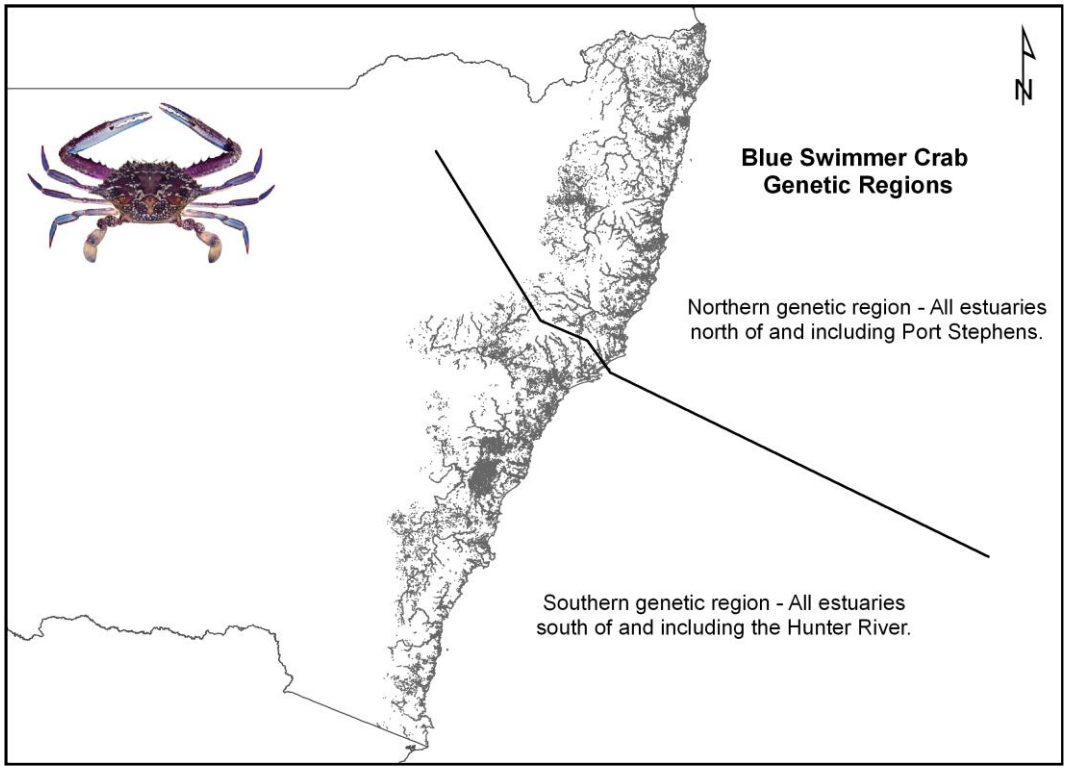
Populations of blue swimmer crabs in NSW occurring north of Port Stephens are regarded as a single stock, however, little is known about the stock structure south of this. As such, two stocking regions have been established.

1. Northern stocking region - broodstock for any stockings in this region must be collected from within this region. The northern stocking region covers all estuaries north of and including Port Stephens to the QLD border.

2. Southern stocking region - as little information was available about the genetics of natural populations of blue swimmer crabs occurring south of Port Stephens, a southern stocking region has also been established. Broodstock for the marine stocking program in this region must be sourced from the estuary that is to be stocked. The southern stocking region covers all estuaries south of and including the Hunter River to the Victorian border.

This requirement will be maintained in the FMS until genetic studies provide further information.

Figure E.8. Genetic regions for blue swimmer crabs



Appendix E.4

Implementation of Management Responses

The following tables outline the time periods within which each management response is to be implemented. The table also provides information relating to the head of power for implementation and who has the lead responsibility for carrying out the action(s). A general description of the terms used in the table with respect to timeframes is given in Table E.13 below:

Table E.13. Implementation time periods.

Term	Description
Immediate	Upon the date of approval of the strategy
Short term	Within one year of the date of approval of the strategy
Medium term	Within three years of the date of approval of the strategy
Long term	In excess of three years of the date of approval of the strategy
As required	Whenever the circumstances warrant action
Ongoing	Continuing into the future

Where an implementation date (e.g. a particular month) has been included for a management response instead of the terms above, the date represents a specific target time within which the management response is to be implemented.

Goal 1. To manage the activity in a manner that minimises impacts on aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates						
OBJECTIVES	**MANAGEMENT RESPONSES**	**CONTRIBUTE TO GOALS**	**TIMEFRAME**	**RESPONSIBILITY**	**AUTHORITY**	**PAGE**
1.1 To develop and maintain a framework to guide appropriate review of stocking activities	**a)** Use reliable and current information resources to support the stocking review framework	2,3,4	Ongoing	DPI	Policy	32
	b) Continually update the list of estuaries where stocking can and cannot occur based on the evaluation of social, economic and ecological factors	2,3,4	As required	DPI		32
	c) Map the activity in a Geographic Information System (GIS)	2,3,4	Ongoing	DPI	-	32
	d) Continually update the Stocking Review Guidelines and assessment resources to accurately review potential impacts from the activity	2,3,4	As required	DPI		33
1.2 To minimise and/or eliminate any negative impact from the activity on threatened species, populations, ecological communities (including mammals, birds, reptiles, amphibians, fish, invertebrates and vegetation) and critical habitat, and where possible promote their recovery	**a)** Appropriately manage stocking in areas where the activity may adversely affect a threatened species	2,3	Ongoing	DPI	Policy	33
	b) To record and monitor sightings and incidences involving threatened and protected species within stocked estuaries.	2,3	Ongoing	DPI		33
	c) Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking.	2,3,4	Long term	DPI		33
	d) To educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries	2,3	Ongoing	DPI	-	33
1.3 To provide reliable genetic resource management in the activity	**a)** Develop and implement genetic resource management guidelines for marine fish stocking in NSW	2,3,4	Short term	DPI Fish hatcheries	Policy	34
	b) Develop and implement species specific stocking guidelines directly relevant to species ranges in NSW	2,3,4	Short Term	DPI	-	34
1.4 To implement the FMS in a manner consistent with related Commonwealth	**a)** Manage the activity having regard to cross-jurisdictional management arrangements	2,4	Ongoing	DPI	-	35

Goal 1. To manage the activity in a manner that minimises impacts on aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates						
OBJECTIVES	**MANAGEMENT RESPONSES**	**CONTRIBUTE TO GOALS**	**TIMEFRAME**	**RESPONSIBILITY**	**AUTHORITY**	**PAGE**
and State endorsed programs designed to protect aquatic environments and biodiversity	**b)** Manage and conduct the activity having regard to other DPI fisheries management arrangements	2,4	Ongoing	DPI		35
1.5 To appropriately manage the risks associated with translocation of live aquatic organisms during stocking activities	**a)** Manage the activity consistently with State and National policies governing the translocation of live aquatic organisms	2,3,4	Ongoing	DPI	Policy	35
1.6 To initiate research relating to the activity	**a)** Facilitate research programs to fill information gaps identified in the risk assessment of the existing activity, as provided for in the Research Plan	2,3,4	As Required	DPI	-	35
1.7 To minimise any competitive advantage of the stocked species over wild conspecifics.	**a)** Facilitate stock releases in timing with the selected species lifecycles and recruitment patterns	2,3,4	Ongoing	DPI		35

Goal 2. To enhance fishing opportunities through cost-effective stocking programs that maximise social and economic benefits and provide equity from the activity for recreational fishing and Aboriginal cultural fishing purposes, in alignment of with the priorities of the NSW State Plan						
OBJECTIVES	**MANAGEMENT RESPONSES**	**CONTRIBUTE TO GOALS**	**TIMEFRAME**	**RESPONSIBILITY**	**AUTHORITY**	**PAGE**
2.1 To provide quality stock to enhance recreational fisheries	a) Commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters	1,3,4	Ongoing	DPI	-	37
2.2 To minimise any negative impacts of the activity on cultural heritage values and provide opportunities for Aboriginal communities to participate in stocking activities and to support cultural fishing practices	a) Provide for the stocking of native fish for Aboriginal cultural fishing and moiety purposes as requested in alignment with the FMS	1,4	Ongoing	DPI, stockists	Policy	37
	b) Ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework	1,4	Ongoing	DPI	Policy	37
	c) Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked	1,4	Ongoing	DPI	Policy	38
2.3 Maximise economic benefits and provide social equity from the activity	a) Provide opportunities for religious and ceremonial stocking and increase awareness of the legislative and policy requirements with the groups involved	1,3,4	Ongoing	DPI	Policy	38
	b) Provide opportunities for other stockings of non-approved species and increase awareness of the legislative and policy requirements with the groups involved	1,3,4	As required	DPI		38
	c) Monitor the level of socio-economic benefit from fish stocking using surveys undertaken on an episodic basis	4	As required	DPI		38
	d) Monitor the level of fishing effort and changes in effort associated with fish stocking	4	As required	DPI		38

Goal 3. To ensure the consistent production and release of appropriate quality stock						
OBJECTIVES	**MANAGEMENT RESPONSES**	**CONTRIBUTE TO GOALS**	**TIMEFRAME**	**RESPONSIBILITY**	**AUTHORITY**	**PAGE**
3.1 Ensure stock is of the highest standard in terms of fish health	**a)** Develop and implement quality assurance standards and an accreditation system for hatcheries supplying fish for stocking	1,2,4	Medium term	DPI	Regulatory	39
	b) Ensure that any fish, fish eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets quality assurance standards	1,2,4	Ongoing	DPI	Regulatory	39
	c) Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated	1,4	Ongoing	DPI		40
3.2 To promote the use of appropriate technology for genetic resource management in all hatcheries involved in the activity	**a)** Ensure the use of appropriate technology in genetic resource management	1,4	Short term	DPI	-	40
3.3 Implement best practice in broodstock collection and management	**a)** Develop a broodstock policy and guidelines that address collection, husbandry and management arrangements for hatcheries engaged in the activity	1,4	Medium term	DPI	Policy	40
	b) Integrate broodstock collection database	1,4	Short term	DPI	-	41
	c) Continue to provide for the issue of permits under Section 37 of the *Fisheries Management Act 1994* for broodstock collection purposes consistent with the vision and goals of the FMS	1,4	Ongoing	DPI	Regulatory	41
3.4 To promote best practice techniques for fish stocking	**a)** Develop a stocking Code of Practice that defines and promotes best practice in stocking techniques, transport medium management, ethical treatment and care of stock, stocking verification procedures, and the assessment of disease and fish health at the point of release	1,4	Short term	DPI	Various	41

Goal 4. To provide efficient administrative services, education and support services, information management and reporting systems, in alignment with the priorities of the NSW State Plan						
OBJECTIVES	**MANAGEMENT RESPONSES**	**CONTRIBUTE TO GOALS**	**TIMEFRAME**	**RESPONSIBILITY**	**AUTHORITY**	**PAGE**
4.1 To provide a clear administrative framework for reviewing stocking events	**a)** Develop stocking application forms in plain English	1,3	Short term	DPI	-	42
	b) Develop a specific marine stocking policy and procedures manual for DPI staff	1,2	Short term	DPI	Policy	42
4.2 To maintain and report accurate information relating to the activity	**a)** Maintain records of all stocking events centrally	1,2,3	Short term – ongoing	DPI	-	42
	b) Periodically report on the activity	1,2,3	Short term – ongoing	DPI		42
4.3 To improve community understanding and public perception of the activity through an education strategy	**a)** Develop and implement a culturally appropriate educational (communication) plan	1,2,3	Medium term	DPI	Policy	42
4.4 To develop and deliver an effective compliance program	**a)** Require persons involved in stocking to verify stocking events when complete	1,2,3	Short term - ongoing	DPI	Regulatory	43

Appendix E.5

Generalised Predatory Impact Model

Introduction

Stocking at appropriate levels, particularly in recruitment limited estuaries, may potentially enhance local fish stocks and increase productivity. However, overstocking of predatory fish, or crustaceans, and/or stocking into estuaries that are not recruitment-limited can have a number of potentially negative impacts on components of the receiving ecosystem and there are risks that should be avoided (see Chapter D, Section D.4). Ideally prior to stocking, the carrying capacity of each estuary needs to be known, and whether the addition of stocked fish or crustaceans would exceed this. In reality, this is very difficult to measure, especially in dynamic estuarine systems where production and recruitment are highly variable. Detailed species and habitat specific models have been developed in some cases to quantify these dynamics, and inform stocking decisions (e.g. Salvanes *et al*. 1995; Svåsand *et al.* 2000). Fisheries managers can minimise the potential for overstocking by estimating appropriate stocking density through the appraisal of ecological characteristics of the target estuaries and selected species. Taylor and Suthers (2008) have outlined and tested a Generalised Predatory Impact Model (GPIM) to determine appropriate stocking densities for mulloway in the Georges River, NSW. The model was a first step in stocking pilot studies, which used potential trophic impacts and ecosystem productivity to inform stocking density estimation, and potentially reduce the risk of overstocking and adverse ecosystem consequences. In recent years, the model has been further developed as a decision support tool to assess the relative impacts of different stocking scenarios (Taylor *et al*. 2008), such as comparisons of the outcomes of stocking at different release sizes, stocking different species, and stocking different systems. The GPIM uses growth and population parameters such as maximum length and weight, the von Bertelanffy growth coefficient and habitat specific parameters such as temperature and forage production capacity these parameters are explained in detail for each of the selected species in Table E.18.

The GPIM has been applied to the seven selected species proposed for stocking in the marine fish stocking program to obtain estimated stocking rates (maximum number of individuals released per hectare of suitable habitat) and estimated harvest (total tonnes of stocked species to be harvested from the estuary). The GPIM represents a precautionary approach to minimise potentially negative ecological effects and lower the risk of overstocking, in conjunction with other policies and protocols that would be in place through the implementation of the draft FMS, by providing an upper threshold for stocking density based on the ecological characteristics of the target estuaries and selected species.

Model Overview

The GPIM has been adapted for the current study to provide the following estimates:

1. An estimate of the maximum stocking rate (i.e. maximum number of each of the selected species that may be stocked) per hectare of suitable habitat, for a given level of productivity;

2. Estimated harvest rates (in kilos) for species stocked at the maximum stocking rate determined in 1.

These estimates have been calculated for each of the species of fish proposed to be used in the stocking program and for the two species of crabs for three different sizes at stocking (Table E.14).

Table E.14: Size classes for which the Generalised Predatory Impact Model has been calculated.

Size Classes	Species	Key Juvenile Habitat
3.4 mm	Eastern king prawn	Seagrass, unvegetated soft sediment
10 mm, 25 mm, 50 mm	Giant mud crab	Seagrass, mangrove
10 mm, 25 mm, 50 mm	Blue swimmer crab	Seagrass, unvegetated soft sediment
25 mm, 50 mm, 75 mm	Yellowfin bream	Seagrass, mangrove
25 mm, 50 mm, 75 mm	Dusky flathead	Seagrass, mangrove
25 mm, 50 mm, 75 mm	Sand whiting	Seagrass, mangrove, unvegetated soft sediment
50 mm, 75 mm, 100 mm	Mulloway	Deep holes (>5 m depth)

Simplified steps in the model are outlined in Figure E.9.

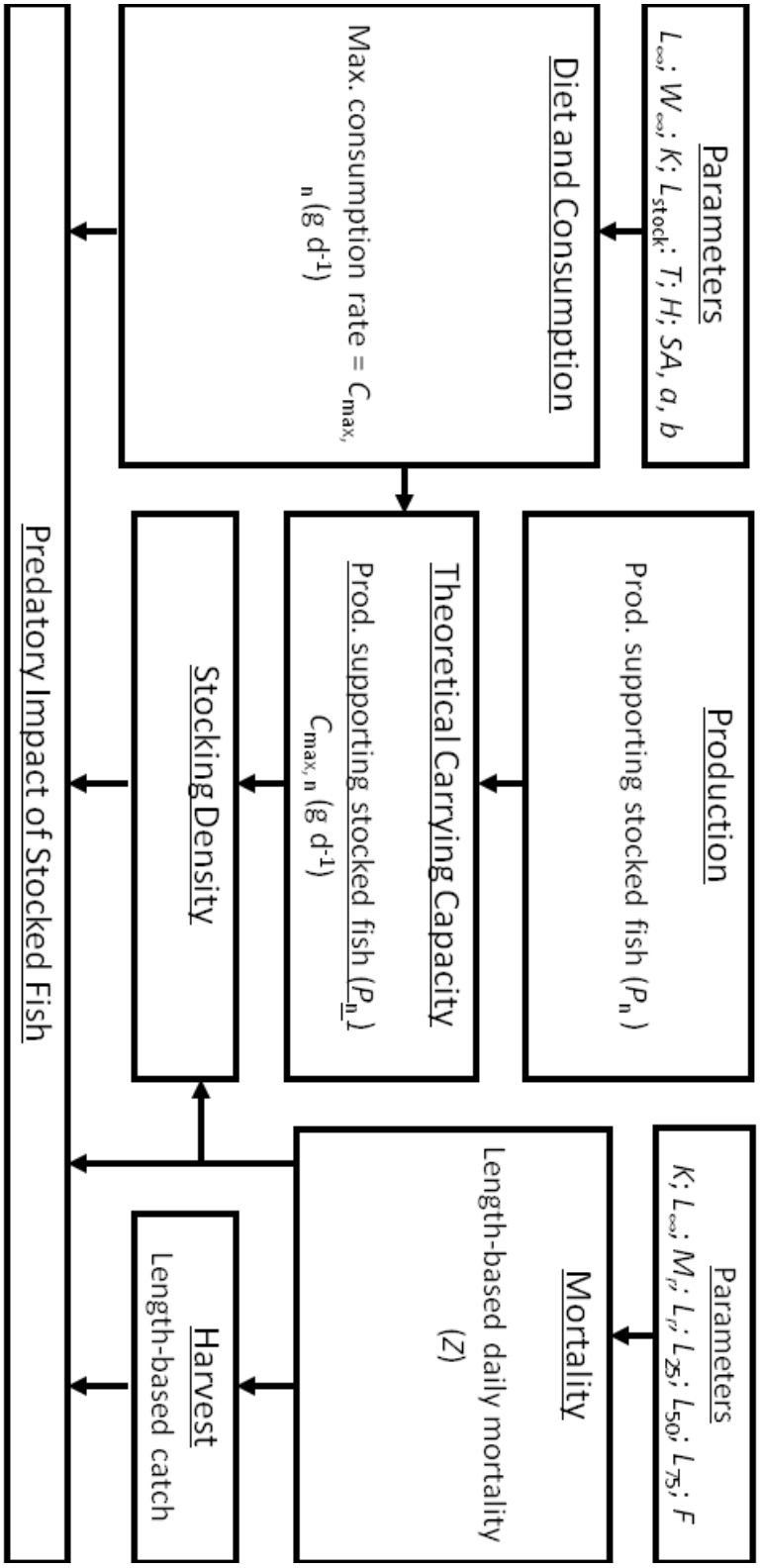


Figure E.9: Simplified approach to the predatory impact model adapted from Taylor and Suthers (2008). The model principally relies on input parameters which should be available for the species through the scientific literature, and can employ generalised descriptors of productivity for initial simulations.

The smallest stocking size for each species was chosen in consultation with hatchery operators. These sizes are considered to represent those at which juveniles can be produced cost-effectively but also when they would be robust enough to cope with handling and transport and are ready for grow-out in the wild. For many of the fish, the smallest stocking sizes correspond to the size at which small juveniles *in situ* become recognisable from post-larvae (SPCC 1981b). Stocking rates are also given for two larger stocking sizes for all species (apart from prawns) so that fisheries managers have options to stock at these sizes if these fish or crustaceans are available or if research shows that there would be better returns from stocking juveniles at these sizes. Stocking rates are given for only one size of eastern king prawns (3.4 mm post-larvae) as hatcheries commonly produce post-larvae at this size for sale to prawn farms. This size represents a practical size for stocking prawns.

In order to calculate stocking rate and harvest, primary productivity and energy flow between trophic levels was estimated to determine the potential carrying capacity of estuaries. Carrying capacity was calculated by dividing the maximum rate of consumption on each individual trophic level or prey species in the portion of productivity at that trophic level which was assigned to support the stocked population. As carrying capacity is calculated at the size corresponding to this maximum rate of consumption, length-based mortality relationships (Lorenzen 2000) were used to back calculate from this size to the specified size at release (Table E.14) to give the supported stocking or release density. These values represent the corresponding carrying capacity at the release size and a value is provided for each prey type or trophic level specified (usually between two and four trophic levels). The model selects the lowest of these values as the stocking density, which ensures that the predatory impact never exceeds the portion of productivity at that trophic level specified to the model. GPIM then calculates the consumption/trophic impacts for the released population, the growth of the released population, the natural mortality of the released population and the harvest of the released population using standard population and fishery models (Baranov 1918, Ricker1975).

Estimation of Productivity

The main downstream input for the model is an estimate of primary productivity within the estuary to be stocked, which is constrained by the area of structural/physical habitat within the estuary that would be utilised. Key juvenile habitat for each of the species to be stocked is given in Table E.14 (see also Chapter C, Section C.8). Very few empirical measurements are available for NSW estuaries and productivity is temporally and spatially variable especially across seasons, so the CSIRO Simple Estuarine Response Model (SERM) (Baird *et al*. 2001) was used to provide integrated estimates of benthic and pelagic primary productivity from biomechanical and mechanistic descriptors of key ecological processes in estuaries. SERM accounts for processes such as nutrient uptake and light capture of planktonic and benthic autotrophs and encounter rates of planktonic predators and prey (Baird *et al*. 2003).

Generalised and categorical parameter inputs that can be easily determined are used for each estuary. The SERM interface provides a productivity estimate, which is converted to a productivity estimate for prey species which are important throughout the model period. This value is further adjusted by the area of key habitat which the stocked species uses (Matsukawa 2006) and the portion of productivity assigned to support the released population.

SERM estimates of primary productivity were obtained for every estuary where stocking may potentially occur (i.e. according to the results of the MCA and are explained in Appendix 6 of the EIS.

To limit the number of simulations to be undertaken, estuaries were grouped using the SERM into coastal lagoons and riverine estuaries and two levels of productivity were assigned to each group:

- Coastal lagoon - Low productivity (<1 g m^{-2} d^{-1})
- Coastal lagoon - High productivity (≥1 g m^{-2} d^{-1})
- Riverine estuary - Low Productivity (<1 g m^{-2} d^{-1})
- Riverine estuary - High Productivity (≥1 g m^{-2} d^{-1})

SERM estimates of primary productivity were averaged for all estuaries assigned to each category and a separate model run undertaken for each category.

Estimation of Consumption

GPIM calculates consumption for fish using a generalised estimator of consumption derived from a dataset of relative consumption estimates for 108 species (Palomares and Pauly 1998). The core consumption estimates are primarily based on temperature, swimming activity and growth rate of the fish, the latter being apportioned using morphometric measurements of tail shape (Pauly 1989) as a function of fish size (to reflect ontogenetic changes in swimming activity). Consumption rates are thus calculated as a function of size using this approach and apportioned according

to the trophic level of different dietary items specified to the model. For most species, dietary information was incorporated as 2-3 trophic groups expressed as a function of size. These relationships were estimated from records of dietary composition found in grey and scientific literature and FishBase (Froese and Pauly 2003). The generalised estimator of consumption described above is only appropriate for fish, so a variation was incorporated into GPIM to allow the estimation of consumption for invertebrate species. This variation determined daily ration as a function of the daily growth increment, using food conversion efficiency information available from published aquaculture literature. This provided a proxy for the rates of consumption required to support the growth rates estimated for each species.

Model Simulations

Model outputs were generated by varying key model parameters by ±10 %, and using a repeated random sampling (Monte-Carlo) routine, selecting random combinations of these varied parameter values for each simulation. This was undertaken to incorporate uncertainty in the model, given that estimates for many parameters may not be known with a high degree of accuracy. Monte-Carlo simulations were performed with a random selection of a varied or unvaried values for each parameter, producing a completely random combination of parameter values for each model run. Monte-Carlo simulations were allowed to run until the variance in stocking density estimates stabilized, which was normally within 50,000 simulations. The resultant model outputs were displayed as probability density distributions and the value bin with the greatest probability chosen to represent the maximum stocking density, and expected harvest. The final output provides probability distributions for key management indicators, which give the range and probability of the various key outputs relevant to managers.

Limitations of the Model

Confidence in the model simulations conducted here is limited by availability of data to calculate key model parameters for the species in the regions specified in this document. This is exacerbated by the lack of empirical data to determine trophic relationships and the lack of quantitative data on fine-scale habitat use for most of the species. Consequently, various parameters have been estimated based on available information (including unpublished and anecdotal sources) and species knowledge (Table E.18). Simulations have only been applied and tested through research stockings of mulloway to date. Further model simulations should be performed once more accurate data is obtained e.g. through monitoring, further pilot stockings and investigation of the specific elements which affect stocking in individual estuaries. The draft FMS has provisions for this through research topic 3.2.

Standard population and fishery models used to calculate consumption/trophic impact are based on wild fisheries data and may differ slightly for hatchery reared fish.

Results

Results are presented as estimated ‘stocking rates’ i.e. number of fish/crustaceans that can be stocked (per hectare) and ‘total harvest’, or yield (kg) for each species, at minimum legal length per estuary. Results have been divided up and are presented by region (Northern, Central and Southern) and by species.

Stocking Rates

Modelling indicated that stocking rates for riverine estuaries or coastal lagoons with high productivity are near double those with low productivity (Table E.15). Estimated maximum stocking rates are for individual estuaries are given in Appendix E.6, Table E.20.

Table E.15: Stocking rates (per ha^{-1} of key habitat) for each species for each estuary type.

Species	Size Class	Estuary Type			
		Coastal Lagoon		**Riverine Estuary**	
		Low Productivity	**High Productivity**	**Low Productivity**	**High Productivity**
Eastern king prawn	3.4 mm	1203	1782	1069	2053
Giant mud crab	10 mm	83	122	74	141
	25 mm	60	87	52	99
	50 mm	43	65	39	75
Blue Swimmer crab	10 mm	213	317	189	366
	25 mm	100	149	89	170
	50 mm	54	80	48	92
Yellowfin bream	25 mm	274	407	244	464
	50 mm	210	309	185	357
	75 mm	176	263	157	300
Dusky flathead	25 mm	307	457	272	517
	50 mm	253	373	225	432
	75 mm	222	328	200	381
Sand whiting	25 mm	631	944	562	1075
	50 mm	459	675	404	776
	75 mm	369	541	329	629
Mulloway	50 mm	140	208	123	238
	75 mm	106	155	94	180
	100 mm	83	123	74	141

Stocking rates are not provided for some species in some estuaries. No stocking rates are given for giant mud crabs in the southern region as this is beyond the usual range of this species and for yellowfin bream south of the Manning River to prevent the risk of hybridisation with black bream. Stocking rates are given for sand whiting and blue swimmer crabs in all of the 80 estuaries. These species have the least specific juvenile habitat requirements and their key juvenile habitats can be found in all the estuaries (Table E.14). Juvenile mulloway have the most specific habitat requirement i.e. deep holes. Deep holes (> 5 m depth) only occur in 33 estuaries, and in only two estuaries in the southern region (Merimbula Lake and Twofold Bay).

Stocking rates vary greatly among stocking sizes and among species. For each species, not unexpectedly, the appropriate stocking rates for larger sizes are much less than for the smaller sizes. Under the GPIM, the difference in numbers largely reflects the difference in mortality associated with size.

Of the seven species in the proposal, modelling indicates the greatest stocking rates would be for post-larval eastern king prawns (Table E.15). This is a function of the stocking size, habitat availability and trophic status of prawns (3.4

mm) which is much smaller/lower than for any of the other species. The trophic impact of each post-larval prawn would be much less than for a larger fish or crustacean.

Of the fish, modelling indicates that more sand whiting can be stocked per hectare than for other species of an equivalent size indicating low consumption/trophic impact for this species. Mulloway has the greatest trophic impact for a given size, therefore fewer individuals can be stocked. More blue swimmer crabs can be stocked per area of habitat than equivalent sized mud crabs (Table E.15).

Harvest Rates

The predicted harvest from a given stocking event for an estuary is dependent on the productivity of the estuary, fishing mortality and predator and prey abundance but more particularly on the amount of juvenile habitat in that estuary. Some estuaries have much more juvenile habitat than others. Notwithstanding this, the greatest predicted harvests occur in the larger estuaries. The majority of these consist of the large, riverine estuaries (e.g. Clarence River, Hawkesbury River) but there are also many large lagoons where predicted harvests are also great (e.g. Lake Macquarie, Tuggerah Lake).

Predicted harvests are, in general, much greater for those species which have less specific juvenile habitat requirements (i.e. sand whiting and blue swimmer crabs) as there is more available habitat into which these species can be stocked. Notably, the predicted harvest for any species does not vary substantially among the stocking size of the fingerlings or crablets being stocked (Table E.16), although as discussed earlier, the number of each size class stocked will vary.

Table E.16: Predicted harvest (kg) per ha^{-1} for each species in each estuary type as determined from outputs from the Generalised Predatory Impact Model.

Species	Size Class	Estuary Type			
		Riverine Estuary		**Coastal Lagoon**	
		Low Productivity	**High Productivity**	**Low Productivity**	**High Productivity**
Eastern King Prawn	3.4 mm	6.1	11.9	7.0	10.4
Giant mud Crab	10 mm	9.9	18.8	11.1	16.3
	25 mm	9.8	18.8	11.2	16.4
	50 mm	9.9	18.8	11.0	16.4
Blue Swimmer Crab	10 mm	11.7	22.5	13.2	19.5
	25 mm	11.7	22.4	13.1	19.4
	50 mm	11.7	22.4	13.2	19.6
Yellowfin Bream	25 mm	34.5	65.9	38.6	57.3
	50 mm	34.3	65.7	38.6	57.1
	75 mm	34.4	65.6	38.7	57.4
Dusky Flathead	25 mm	36.0	69.0	40.6	60.1
	50 mm	36.1	69.0	40.5	59.9
	75 mm	36.1	68.5	40.2	59.6
Sand Whiting	25 mm	10.9	20.8	12.3	18.2
	50 mm	10.9	20.8	12.3	18.2

Species	Size Class	Estuary Type			
		Riverine Estuary		**Coastal Lagoon**	
		Low Productivity	**High Productivity**	**Low Productivity**	**High Productivity**
	75 mm	10.9	20.8	12.2	18.1
Mulloway	50 mm	15.6	30.0	17.7	26.2
	75 mm	15.8	30.3	17.7	26.7
	100 mm	15.8	30.1	17.7	26.4

Integration of the GPIM and the FMS

The GPIM will be a guide for fisheries managers so that overstocking and its associated impacts are prevented. Stocking rates are given as the maximum number of fish that may be stocked per hectare over the duration of a stocking event. As a precautionary measure, estimates for the number of fish to be stocked were allocated a maximum of 5 % of the total productivity within an estuary, which is considered to have minimal impact on the receiving ecosystem but that yields a worthwhile return in terms of predicted harvest and catch rates (see discussion of alternatives in Chapter F, Section F.5.4).

A single stocking event is defined as 'single or multiple releases of a species in a particular estuary and includes the time it takes for all released post-larvae or juveniles to reach a harvestable size' (Table E.17).

Table E.17. Durations of a 'stocking event' for each species proposed for stocking.

Species	Minimum Harvestable Size (mm)	Ave. Age at Minimum Harvestable Size	Approximate Duration of Stocking 'Event' ^
Yellowfin bream	250 TL	3 yrs*	min 4 years
Mulloway	450 TL	2 yrs (Silberschneider and Gray 2005)*	min 3 years
Dusky flathead	360 TL	1.5 yrs (m) 1.0 yrs (f) (Gray and Barnes 2007)*	min 2 years
Sand whiting	270 TL	2 yrs, 5 months*	min 3 years
Eastern king prawn	N/A	N/A (but are known to reach adulthood and remain in estuaries for up to a year)	min 1 year
Giant mud crab	85 CL	Approx. 5-6 months	min 1 year
Blue swimmer crab	60 CL	10 months (Johnson 2007)*	min 1 year

(*) indicates references for growth curve tables within Rowling *et al.* 2010. (TL)=Total Length, (CL) =Carapace Length. (FL)=Fork Length, (m) =male, (f) =female

^. The period would need to be extended in the event that an ICOLL closed after an initial stocking event or was closed at the time of stocking.

Stocking events can be achieved through a single release or several releases. This is because constraints in hatchery production may limit the numbers of juveniles that can be supplied at any one time and therefore a stocking

event may need to be staggered over a number of years. If several releases are undertaken as part of a stocking event, the stocking event duration will commence from the date of the final release.

Stockings of multiple species will be permitted to occur only if the combined stockings do not exceed the 5 % of allocated estuarine productivity. For example a stocking event could take place where 2.5 % of the estuary's productivity is allocated to mulloway and 2.5 % is allocated to yellowfin bream. Stocking event durations for combined stockings must also be maintained (i.e. four years in this example as yellowfin bream has the longer stocking event duration).

The formula used when generating the number of individuals to be released into any estuary is as follows:

Suitable habitat within estuary (ha)	x	Individuals per hectare (Table E.15)	=	Permitted stocking rate per stocking event

Duration of stocking events for each species are outlined in Table E.17.

Suitable habitat for each species has been defined during the EIS process (Chapter C, Section C.8). In large estuaries (e.g. the Hawkesbury estuary), areas of habitat within a reasonable distance from the stocking site have been used in the determination.

It is also recognised that hatcheries may produce batches of juvenile fish or crustaceans that do not consistently correspond with one of the sizes for which stocking rates are modelled. In practice, fisheries (and hatchery) managers should match the average size of juveniles in a batch to the nearest stocking size for which an appropriate stocking rate has been given.

Model details and parameters

The GPIM has been adapted for the current study to provide the estimates as detailed in Appendix E.6. The details of the model, equation and parameters are described in detail in the following Section.

Initially, biometric relationships were established following standard length-age and weight-age relationships including $L_t = L_\infty (1-e^{-K(t-t_0)})$ and $W_t = aL_t^b$ where L_t and W_t reflected fish length (cm) and weight (g) at time t respectively, K was the von Bertelanffy growth coefficient, L_∞ is the asymptotic length (cm), t_0 was the theoretical age at which L=0 and a and b are the constants for the length-weight relationship. Length and weight were defined for each individual daily time step over the model period (4.5 y, except for eastern king prawns for which the model period was 2 y), and corresponding matrices of length, weight, and time (expressed a daily time steps) used as required in the equations below. For crabs, L_t and L_∞ reflected carapace width rather than fish length, and for prawns L_t reflected carapace length. Separate length and weight relationships were developed from quantitative data measured from pilot prawn stockings in Wallagoot Lake for eastern king prawns, which better reflects the growth of stocked prawns in shallow, closed estuaries (Ochwada-Doyle, 2010). Prawn weight (g) was expressed as a quadratic function of time-since-stocking (S_t, d) according to $W_t = 5.3exp^{-a}. S_t + 11.5exp^{-4} \cdot S_t^2 + 2.3exp^{-6} \cdot S_t^a - 0.25$ for the first 330 days after release, and then held constant after that point. For eastern king prawns, carapace length (L_t, mm) was determined as a function of weight according to $L_t = 1.3 \cdot W_t + 3.4$.

For finfish, the model requires empirical measurements of the caudal aspect ratio across the model period. Aspect ratio was calculated as a function of caudal fin height (h) and surface area (SA) for each length increment according to (Pauly, 1989) $A_L = \frac{h_L^2}{SA_L}$. Consumption-per-unit-biomass can change with length due to greater foraging efficiency, different foraging strategy, or greater allometric energetic efficiency. The caudal aspect ratio A generalises the bioenergetic considerations in Palomares and Pauly (1998) Q/B model, and including it in the model as a function of length rather than as a static value may help account for the mouse-to-elephant scaling of metabolism and other associated factors (such as changes in swimming activity). Consumption of an individual fish was calculated as a function of time (C_t) and corresponding body mass (W_t) using a generalised predictor of consumption per unit biomass (Palomares and Pauly, 1998), and expressed as daily consumption (g d^{-1}) over the model period $C_t = W_t \cdot 10^{(7.964 - 0.204 \log W_\infty - 1.965T' + 0.083A_L + 0.532h + 0.398d)} / 365$ where T` was calculated as a function of water temperature ($T$) $T` = 1000 \cdot (T + 273.15)^{-1}$, W_∞ was the asymptotic weight, and h and d are logical values; h = 1 and d = 0 if the species is a herbivore, h = 0 and d = 1 if the species is a detritivore, and h = 0 and d = 0 if the species is a carnivore. As the model was developed principally for use with finfish, adaptation was

required to run the model with invertebrates. Invertebrates do not have a caudal fin, and thus the above equation cannot be used. As data on food conversion and growth efficiency were lacking for the invertebrate species, a growth efficiency of 0.1 was chosen (indicating 10 g of food are required for every 1 g of mass gain). This value was applied to determine the consumption for each time step (C_t) by multiplying the mass increase for each time step by 10. This value was chosen as, in the absence of any other data, it represents the most frequent efficiency observed in marine systems (Pauly and Christensen, 1995) and represented a conservative estimate for crabs (Wolff and Cerda, 1992).

The model required empirical determination of the proportion of major prey items in the diet, and variation with length or age; these values were determined from published studies or estimated where no data was available. Values were expressed as trophic groups rather than as individual species, and reflected ontogenetic dietary changes in the proportion of these trophic groups in the diet throughout the model period. This assumed a non-selective diet but provided values which could be linked with instantaneous estimates of production for specific trophic levels. For mulloway, these relationships followed those described in Taylor and Suthers (2008). For other species, these relationships were estimated based on expert knowledge of the project team, for each species, on the basis of any available data, and described for *n* trophic groups which were important throughout the species life history. These relationships were used to partition the consumption rate across important trophic groups using the equation $C_{t,n} = C_t \cdot D_{t,n}$, where $C_{t,n}$ was the consumption at time *t* of trophic group *n*, and $D_{t,n}$ was the proportion of trophic group *n* in the diet at time *t*. Maxima that occur in the consumption for *n* trophic levels were evaluated by the model and passed through the model as the maximum instantaneous consumption on each trophic group, and the factor determining the maximum capacity of the receiving system to support a particular size of stocked fish ($C_{n,\max}$, Taylor and Suthers 2008).

Production (P_n) was calculated for each prey group *n* at the corresponding trophic level for each trophic group using the equation (Pauly and Christensen, 1995) $P_n = Pa_n\left(A \cdot P_1 \cdot 9.1 \cdot 0.15^{TL_n - 1}\right)$

where Pa_n was the proportion of production at trophic level *n* that was assigned to support stocked fish, P_1 was the primary productivity of the area to be stocked (g C m^{-2} d^{-1}) estimated by the SERM, TL_n was the estimated trophic level of prey group *n*, and *A* was the standardised area of habitat for this series of simulations (1 hectare, 10,000 m^2). Model simulations can be adapted for individual systems be multiplying *A* by the area of key habitat which the target species will exploit in the stocked estuary, which should consider both foraging arena habitat as per Walters and Martell (2004). The parameter Pa_n was a subjective assignment by management of the maximum acceptable trophic impact that is exerted by stocked fish at the specific trophic level. The capacity of the stocked habitat to support stocked fish at the corresponding age and size at which $C_{n,\max}$ values occur was calculated using $CC_n = \frac{P_n}{C_{n,\max}}$.

Natural mortality expressed as a function of time-after-release (M_t, y) using (Lorenzen, 2000) using the equation $M_t = 1 - \left(\frac{L_{stock}}{L_{stock} + L_\infty (e^{K \cdot t} - 1)}\right)^{\frac{M_r \cdot L_r}{L_\infty \cdot K}}$, where L_{stock} is the length at stocking, M_r is the instantaneous mortality rate at length L_r, and the other parameters are as defined above. A length-based estimator for natural mortality of released penaeid prawns was proposed by Loneragan *et al.* (2003), and was applied in the eastern king prawn model in this series of simulations; $M_t = \alpha e^{-\beta \cdot L_t}$., where α and β are constants defined by Loneragan *et al.* (2003) as 0.06 and 0.14 respectively. Fishing mortality was expressed as a function of length (F_L), as product of *F* and a length-based logistic selectivity curve (Wileman *et al*. 1996), $F_L = F \cdot \frac{e^{(a+b \cdot L)}}{1+e^{(a+b \cdot L)}}$ where *L* is length (cm), and *a* and *b* are calculated based on length at 25 % retention (L_{25}), 50 % retention (L_{50}), and 75 % retention (L_{75}) and the selection range of the gear according to $a = -L_{50} \cdot b$ and $b = \frac{2.197}{L_{75} - L_{25}}$. Instantaneous total daily mortality (Z_t) was calculated by expressing both M_t and F_t as daily rates of mortality, and summing these for

each daily time step. Daily total mortality rates were used to convert estimates of the capacity of the receiving habitat to support stocked fish (CC_n) to an equivalent capacity at the size at stocking (Taylor and Suthers, 2008).

The number of fish remaining at each time step after stocking was calculated as $N_t = N_0 \cdot e^{-Z_t \cdot t}$, and cumulative biomass harvested as a function of time-since-stocking (H_t) was calculated for the duration of the model period using a modification of the Baranov catch equation $H_t = \sum_{k=}^{t_{\max}} \frac{F_t}{Z_t} \cdot N_t \cdot (1 - e^{-Z_t}) \cdot W_t$ .Table E.18 shows the model parameters used, and highlights that for many of the models, no data was available and the parameter used simply reflects an estimate by the project team. In addition, some model parameters were obtained for different geographic areas and may represent a marked departure from the area to be stocked. Due to the nature of these estimates, the uncertainty around the model parameter used was not known, so the model was provided with three values for most parameters (reflected in Table E.18 as a range). These values represented the best guess parameter values obtained from FishBase, stock assessments, the literature, or expert opinion and values representing ±10 % of these values. Monte-Carlo simulations were performed with a random selection of varied or unvaried values for each parameter, producing a completely random combination of parameter values for each model run. Monte-Carlo simulations were allowed to run until the variance in stocking density estimates stabilized, which was normally within 50,000 simulations. The resultant model outputs were displayed as probability density distributions and the value bin with the greatest probability chosen to represent the maximum stocking density and expected harvest.

A Summary of calculations and equations used in the model are given in Table E.19.

Table E.18: Estimates of key parameters used in the Generalised Predatory Impact Model for selected fish and invertebrate species and source of previous data used to inform the parameter range

Parameter Estimates	Mulloway	Yellowfin bream	Dusky flathead	Sand whiting	Eastern king prawns	Mud crab	Blue swimmer crab
K	0.18-0.22♦	0.46-0.57♥,+	0.08-0.09•	0.61-0.75♣	0.11-0.14◊	0.74-0.9+,▽	U.P.ƒ
L_∞ (cm)	120-146♦	37-46♥,+	116-141•	33-40♣	-↜	16.9-20.6+,▽	U.P.ƒ
W_∞ (kg)	18.5-22.6♦	1.1-1.3◊	15.5-19.0◊	0.5-0.6♣	-↜	-↜	-↜
a	0.01679♦	0.0248	0.002475•	0.0056~	-↜	0.00034+,↝	U.P.ƒ
b	2.869♦	3	3.248•	3.19~	-↜	2.84011+,↝	U.P.ƒ
F	0.45-0.55♦	0.31-0.39◊	0.27-0.33◊	0.09-0.11◊	0.45-0.55◊	0.31-0.38+,↝	U.P.ƒ
M_r	0.21-0.26♦	0.32-0.40~	0.36-0.44~	0.48-0.58~	-↜	0.36-0.44◊	U.P.ƒ
L_r (cm)	51-63◊	18-22◊	18-22◊	18-22◊	-↜	9-11◊	U.P.ƒ
L_{25} (cm)	46◊	20♠	28♠	21♠	2.5◊	7.4◊	6.5◊
L_{50} (cm)	47◊	24♠	32♠	23♠	3.0◊	8.9◊	7.5◊
L_{75} (cm)	48◊	27♠	36♠	25♠	3.5◊	13.4◊	9◊
T (°C)	16-19◊	16-19◊	16-19◊	16-19◊	16-19◊	16-19◊	16-19◊

♦(Silberschneider and Gray, 2005); ♣(Froese and Pauly, 2003); ♥(Pollock, 1982); ♠(Steffe *et al.* 2005 a & b); •(Gray and Barnes, 2007) ◊(expert opinion of the project team) +(source was from a different geographic area), ~(Scandol and Forrest, 2001) ▽(Ward *et al.* 2007) ƒ(These parameters were informed from the findings of a current ongoing study by the NSW Department of Primary Industries on the growth, mortality and exploitation of *Portunus pelagicus* in Wallis Lake. thus, these data are unpublished and cannot be presented. Please contact Dr C. Gray, (DPI) for further information on the study) ↝(Personal Communication, Dr Ian W. Brown, QLD Department of Employment, Economic Development and Innovation) ↜(Parameter not required for this model, see model description).

Table E.19: Key equations included in the Generalised Predatory Impact Model to quantify growth, mortality, consumption of the selected species to be stocked, production in the stocked ecosystem and potential harvest of the stocked species at the end of the stocking event.

	Key Equations	Key Parameters
Growth	$L_t = L_\infty\left(1-e^{-K(t-t_0)}\right)$ $W_t = aL_t^{\,b}$	L_∞: Asymptotic length (cm) W_∞: Asymptotic weight (g) K: Growth coefficient
Mortality	$M_t = 1-\left(\frac{L_{stock}}{L_{stock}+L_\infty(e^{K\cdot t}-1)}\right)^{\frac{M_r\cdot L_r}{L_\infty\cdot K}}$ $F_L = F\cdot\frac{e^{(a+b\cdot L_t)}}{1+e^{(a+b\cdot L_t)}}$[1], $a=-L_{50}\cdot b$, $b=\frac{2.197}{L_{75}-L_{25}}$	M_r: Natural mortality at reference point L_r: Length at reference point (cm) F: Fishing mortality L_{stock}: Length at stocking (cm) L_t: Length at t (cm)
Production	$P_n = Pa_n\left(A\cdot P_1\cdot E^{TL_n-1}\right)$	A: Area of habitat (m^2) Pa_n: Proportion of production of diet group n assigned to support stocked fish P_1: Primary productivity of the area to be stocked (gC m^{-2} d^{-1}) E: Trophic transfer efficiency TL_n: Trophic level of diet group n
Consumption	$A_L = \frac{h_L^{\,2}}{SA_L}$ ♦ $C_t = \frac{10^{(7.964-0.204\log W_\infty-1.965T'+0.083A_t+0.532h+0.398d)}}{W_t\cdot 365}$ $T` = 1000\cdot(T+273.15)^{-1}$	h_L: Height of caudal fin at L SA_L: Surface area of caudal fin at L h and d: See Palomares and Pauly (1998) T: Temperature (oC)
Catch	$H_t = \sum_{k=L_{stock}}^{t_{max}}\frac{F_t}{Z_t}\cdot N_t\cdot(1-e^{-Z_t})\cdot W_t$	F_t: Fishing mortality N_t: Number surviving at t Z_t: Mortality at t

♦ Converted within the GPIM model to a function of time-since-stocking

Appendix E.6

Estuaries Suitable for Stocking and Stocking Rates

Table E.20: Appropriate stocking rates (per ha) for each species in each estuary as determined from outputs from the Generalised Predatory Impact Model.

NB. Stocking rates are not given for species in estuaries where suitable juvenile habitat is not available, where there are genetic concerns associated with stocked yellowfin bream interbreeding with black bream, or where there would potentially be adverse interactions with threatened species.

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Northern																				
Tweed River*	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Cudgen Creek	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Cudgera Creek	Riv Low	244	185	157				272	225	200	562	404	329		74	52	39	189	89	48
Mooball Creek	Riv High	464	357	300				517	433	381	1075	776	630	2053	141	99	75	366	170	92
Richmond River*	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Evans River	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Jerusalem Creek	Co Lg High										944	675	541	1782				317	149	80

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Clarence River*[E]	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Cakora Lagoon	Co Lg High	407	309	263				457	373	328	944	675	541	1782	122	87	65	317	149	80
Boambee Creek	Riv High	464	357	300				517	433	381	1075	776	630	2053	141	99	75	366	170	92
Bonville Creek	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Bellinger River*	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Oyster Creek	Co Lg High	407	309	263				457	373	328	944	675	541	1782				317	149	80
Deep Creek*	Riv High	464	357	300				517	433	381	1075	776	630	2053	141	99	75	366	170	92
Nambucca River	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Macleay River	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
South West Rocks Creek	Riv High	464	357	300				517	433	381	1075	776	630	2053	141	99	75	366	170	92
Saltwater Creek (Frederickton)	Riv High										1075	776	630	2053				366	170	92

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Korogoro Creek	Riv High	464	357	300				517	433	381	1075	776	630	2053	141	99	75	366	170	92
Killick Creek	Co Lg High	407	309	263				457	373	328	944	675	541	1782	122	87	65	317	149	80
Hastings River*[L]	Riv High	464	357	300	239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Lake Innes/Lake Cathie	Co Lg Low										631	459	369	1203				213	100	54
Camden Haven River*	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Manning River*	Riv Low	244	185	157	123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Khappinghat Creek	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Wallis Lake	Co Lg Low				141	106	83	307	253	222	631	459	369	1203	83	60	43	213	100	54
Hunter River	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Lake Macquarie*	Co Lg High				209	155	123	457	373	328	944	675	541	1782	122	87	65	317	149	80
Tuggerah Lake	Co Lg Low				141	106	83				631	459	369	1203				213	100	54
Wamberal	Co Lg Low							307	253	222	631	459	369	1203	83	60	43	213	100	54

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Lagoon																				
Terrigal Lagoon	Co Lg Low							307	253	222	631	459	369	1203	83	60	43	213	100	54
Avoca Lake	Co Lg Low										631	459	369	1203				213	100	54
Central																				
Brisbane Water	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Broken Bay	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Hawkesbury River	Riv Low				123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Pittwater	Co Lg High				209	155	123	457	373	328	944	675	541	1782	122	87	65	317	149	80
Narrabeen Lagoon	Co Lg Low				141	106	83	307	253	222	631	459	369	1203	83	60	43	213	100	54
Middle Harbour Creek	Riv Low							272	225	200	562	404	329	1069	74	52	39	189	89	48
Port Jackson	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Lane Cove River	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Parramatta	Riv Low				123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
River																				
Cooks River	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Botany Bay*	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Georges River	Riv Low				123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Port Hacking	Riv Low				123	94	74	272	225	200	562	404	329	1069	74	52	39	189	89	48
Allans Creek	Riv Low							272	225	200	562	404	329	1069	74	52	39	189	89	48
Lake Illawarra	Co Lg Low							307	253	222	631	459	369	1203	83	60	43	213	100	54
Killalea Lagoon	Co Lg High										944	675	541	1782				317	149	80
Minnamurra River	Riv Low							272	225	200	562	404	329	1069	74	52	39	189	89	48
Crooked River	Riv High							517	433	381	1075	776	630	2053	141	99	75	366	170	92
Shoalhaven River	Riv High				239	180	141	517	433	381	1075	776	630	2053	141	99	75	366	170	92
Lake Wollumboola	Co Lg High							457	373	328	944	675	541	1782	122	87	65	317	149	80
St Georges Basin*	Co Lg High				209	155	123	457	373	328	944	675	541	1782	122	87	65	317	149	80

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Swan Lake	Co Lg High							457	373	328	944	675	541	1782	122	87	65	317	149	80
Berrara Creek	Riv Low							272	225	200	562	404	329	1069	74	52	39	189	89	48
Lake Conjola*	Co Lg Low				141	106	83	307	253	222	631	459	369	1203	83	60	43	213	100	54
Narrawallee Inlet*	Co Lg High							457	373	328	944	675	541	1782	122	87	65	317	149	80
Ulladulla	Riv Low				123	94	74				562	404	329	1069				189	89	48
Burrill Lake*	Co Lg High							457	373	328	944	675	541	1782	122	87	65	317	149	80
Tabourie Lake*	Co Lg High										944	675	541	1782				317	149	80
Termeil Lake	Riv Low							272	225	200	562	404	329	1069	74	52	39	189	89	48
Meroo Lake*	Co Lg Low							307	253	222	631	459	369	1203	83	60	43	213	100	54
Willinga Lake	Riv High							1317	1098	972	1075	776	630	2053	141	99	75	366	170	92
Southern																				
Bermagui River*	Co Lg Low							307	253	222	631	459	369	1203				213	100	54
Barragoot Lake	Co Lg High							457	373	328	944	675	541	1782				317	149	80

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Cuttagee Lake	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Murrah Lake	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Bunga	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Wapengo Lake	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Nelson Lake*	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Bega River*	Riv High							1317	1098	972	1075	776	630	2053				366	170	92
Wallagoot Lake	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Back Lagoon*	Co Lg High							457	373	328	944	675	541	1782				317	149	80
Merimbula Lake	Co Lg High				209	155	123	457	373	328	944	675	541	1782				317	149	80
Pambula Lake	Riv Low							272	225	200	562	404	329	1069				189	89	48
Curalo Lagoon	Riv Low							272	225	200	562	404	329	1069				189	89	48
Twofold Bay	Co Lg Low				141	106	83	307	253	222	631	459	369	1203				213	100	54
Nullica River*	Riv Low							272	225	200	562	404	329	1069				189	89	48

Estuary	Type	Yellowfin Bream			Mulloway			Dusky Flathead			Sand Whiting			Eastern King Prawn	Giant mud Crab			Blue Swimmer Crab		
		Stocking Size (mm)																		
		25	50	75	50	75	100	25	50	75	25	50	75	3.4	10	25	50	10	25	50
Towamba River*	Riv Low							272	225	200	562	404	329	1069				189	89	48
Wonboyn River*	Riv High							517	433	381	1075	776	630	2053				366	170	92

(*) = Recreational Fishing Haven

[E] = Excluding the Esk River (within a Wilderness area)

[L] = Excluding Limeburners Creek (within a Wilderness area)

Riv High (Riverine estuary with high productivity)

Riv Low (Riverine estuary with low productivity),

Co Lg High (Coastal lagoon with high productivity)

Co Lg Low (Coastal lagoon with low productivity)

Chapter F
Consideration of Alternatives

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CHAPTER F CONSIDERATION OF ALTERNATIVES

F.1 Introduction

The draft Fisheries Management Strategy (FMS) presented in Chapter E provides a suite of management responses supporting a broader strategic framework. The vision, goals and objectives of the strategy are designed to ensure that marine fish stocking can be conducted in an ecologically sustainable manner while remaining flexible enough to adapt to other management actions concurrently addressing environmental risks.

Lorenzen (2008) outlines a framework for the integrated analysis of stock enhancement within a fisheries management context, taking into account biological and human components. A logical outcome is that investment in stock enhancement should not be made unless it adds value to other forms of management. As part of the framework, assessing the benefits of releases in relation to alternative options is recommended.

During the development of the draft FMS, numerous alternatives were considered for addressing the risks identified in Chapter D. These ranged from consideration of alternative broad-scale approaches to alternatives for specific management responses. This Chapter considers the following management responses:

- the no stocking alternative;
- alternative means of enhancing stocks and fisheries;
- alternative species, locations, stocking rates and stocking practices;
- alternative performance indicators and monitoring; and
- alternative arrangements for cost recovery or funding sources for operations and monitoring.

F.2 The No Stocking Alternative

F.2.1 Socio-Economics

As marine fish stocking is not an existing activity, the socio-economic advantages and disadvantages of not stocking are not obvious and rely on predictions. Although it was not possible to establish the precise monetary benefits from the marine stocking proposal (due to data limitations), the feasibility study indicated that stocking was feasible in all regions and for all species (Specialist Report B).

Under the no stocking alternative the New South Wales (NSW) government would save approximately $300,000 per annum (i.e. annual budget proposed for the first three years of marine stocking). However, given there would be potentially socio-economic benefits to regional economies, no stocking would be an extreme adoption of the precautionary principle.

The potential for flow-on effects to regional economies from stocking can be seen from the freshwater stocking program, where significant benefits are realised, particularly in the Snowy Mountains where a site-specific study has estimated salmonid fishing to be worth approximately $46 M per annum to the local economy (Dominion 2001). As the marine stocking proposal is likely to be feasible, flow-on effects to regional economies and employment are also likely.

As marine stocking is part of DPI comprehensive package to increase the utility and benefits of fishing (NSW Government 2010a) the no stocking alternative has potential to affect well-established and highly valuable fisheries and may also lead to associated losses and reduced employment in related industries. Recent data suggests that estuarine recreational fishing expenditure is worth at least $340 M per annum to the State economy and the sales of estuarine commercially caught fish are worth at least $24 M (NSW Government 2010a). Furthermore, a total of $12.4 million was raised in NSW through recreational fishing licence sales in 2010/11.

There is also the social benefit to local communities through involvement in stocking activities and the perception of improving fishing or the conservation status of estuaries. This would not occur under the no stocking alternative.

F.2.2 Management and Research

No stocking is generally considered an extreme response to some of the concerns and uncertainties surrounding the activity. It would be unlikely to prevent stocking from happening as an illegal, unmanaged activity, and would probably result in it occurring on a smaller scale whereby potentially genetically inferior (or diseased) stock, and possibly non-endemic species are released. This is one of the many problems that the draft FMS would address by allowing marine stocking to proceed but mitigating risks associated with the activity and proposing research to resolve many of the uncertainties such as gaps related to genetics, disease management and the impacts of marine

stocking. In recent times, trial stockings have been done to investigate ways to optimise marine fish stocking. Stocking research also has significant other benefits, including enhancement of knowledge about the species to be stocked and estuarine ecosystems and education of scientists which can lead to transfer of skills and knowledge to other areas of ecology and fisheries biology. Partnerships between the Government and the recreational fishing sector have been developed only relatively recently and the no stocking alternative could be considered a retrogressive action.

F.2.3 Recreational, Commercial and Aboriginal Harvest

Given the population of people in NSW is projected to increase in the future, there is likely to be a corresponding increase in recreational fishing effort. The population in NSW is predicted to increase by 33 % by 2036. Some areas, such as Sydney and the South Eastern, Richmond-Tweed and the Illawarra coastal regions are projected to experience growth rates above those of the State as a whole (NSW Department of Planning 2008).

Increased fishing effort will present a challenge to managers of estuarine fisheries placing the balance of commercial and recreational fishing interests under increasing pressure. Species selected for marine stocking are fully fished, except for mulloway which is classified as overfished, eastern king prawns which are growth overfished and mud crabs which are undefined (Chapter C, Section C.8.2). Increased fishing effort could lead to reduced catches among fishers as the finite catch is redistributed among more users. This would reduce the quality of recreational (and Aboriginal cultural) fishing and the viability of commercial fishing. In a worst case scenario, increased fishing effort could lead to overfishing of some species. Although stocking is not the only alternative to enhancing populations of fish (see below) it has the potential to be an important tool (combined with other fisheries management measures) for enhancing the quality of estuarine fishing in NSW and may potentially increase the resilience of fish stocks.

F.3 Alternative Methods of Enhancement

Managers of commercial and recreational fisheries worldwide will be challenged in the future to find ways to increase fisheries production to help meet the projected demand for fish and shellfish (Blankenship and Leber 1995). Three principal tactics are available to fishery managers: regulating fishing effort and outputs; restoring degraded habitats; and increasing recruitment through propagation and release (marine harvest stocking). The first two methods have traditionally formed the basis for government approaches to managing fisheries. Lorenzen *et al*. (2010) suggest stock enhancements expand the tactical management toolbox and provide opportunities for trading off different management interventions. Stock enhancement has rarely been used to manage fisheries in the past because of the lack of a strong foundation of scientific information evaluating its effectiveness.

F.3.1 Management of Bag and Size Limits, Restricting Fishing Effort

Alterations of size-limit, catch and effort are the main regulatory tools traditionally used by fisheries managers to maintain sustainable fishery resources. Altering the size-limit can be a strategy for increasing protection to the spawning biomass of a stock or, in a more sophisticated case, to increase the yield per- recruit (Hilborn and Walters 1992).

Very few studies have made direct comparisons of the benefits of stocking versus the benefits of adjustments to size-limits. Rogers *et al*. (2010) simulated size-dependent harvest restrictions and stock enhancement contributions to explore trade-offs between increasing minimum size-limits and stock enhancement for improving population sustainability and fishery metrics (e.g. catch) of Murray cod (*Maccullochella peelii peelii*). They found increased size-limits increased angler catches in fished populations. They also found, however, that less fish in total would be caught and point to other studies (Coggins *et al.* 2007) that indicate increased size-limits can fail to improve fishery sustainability if discard mortality is high. Rogers *et al*. (2010) predicted that stocking would significantly increase total recruitment, population sustainability, and fishery metrics only in systems where natural reproduction had been greatly reduced, fishing mortality was high, or both (this could apply to some estuaries in NSW, particularly intermittently closed and open lakes and lagoons (ICOLLs)). They also point out that this may not apply if stocking attracted fishing effort as this would erode the benefits of stocking. In NSW, the size-limits for many harvested estuarine fish are greater than the size at which fish first begin reproduction (Rowling *et al.* 2010) but not for dusky flathead (Barnes and Gray 2008) or mulloway (Silberschneider *et al*. 2008) where the size-limit is less than the size at maturity. Other factors such as survival of released fish and interactions with fishing gear also influence setting of size limits. Size based prawn counts are also undertaken for prawns in commercial fisheries. Although the benefits of altering size-limits on a State-wide (TAC Committee 2010) or more local basis (Worthington *et al*. 1995) have been

investigated for other coastal species they have not been evaluated for the species in this proposal. However, if indeed there were increased catches of these species from increasing the size-limit (protection of part of the spawning biomass and possibly increased yield per recruit) it is unknown what discard mortality would be.

Rogers *et al*. (2010) propose an adaptive experimental approach to test predictions of stocking versus size-limit increases. However, as whole estuaries would need to be allocated to a treatment and each treatment replicated, such an experiment would not be practicable in NSW due to the scale of the experiment required, enforcement of treatments and inherent natural variability among estuaries that may complicate experimental results.

Control of catch and effort is a regulatory strategy that has potential to increase long-term yields from fisheries but each year such strategies require a well-informed decision making process so that catches can be adjusted in response to new stock estimates (e.g. the fishery for abalone and rock lobster in NSW). Regulatory strategies may often combine control of catch and effort with size-limits.

Regulatory strategies controlling catch and effort are difficult to implement in fisheries where there are commercial and recreational components (such as the fisheries for many estuarine species in NSW) because of the difficulties in controlling recreational fishing effort. Although recreational bag limits do control catch for many estuarine species to some extent in NSW, there is currently limited opportunity to cap recreational fishing effort. In NSW the commercial fishing industry operates under stringent controls regarding fishing times, seasonal closures and gear restrictions, including regulations on the size and engine capacity of boats and the length and mesh size of nets. Spatial fishing closures are also used to prohibit the use of commercial gear, for example at the mouths of estuaries important for spawning migrations e.g. at the mouth of the Richmond River near Ballina, which is an important area for the migration of juvenile prawns between the estuary and the sea. Recreational fishers are also very highly regulated to use very limited amounts and types of gear in NSW, a range of fishing closures also apply. .Regulatory strategies and regular review of these strategies aim to ensure that fishing is carried out in a sustainable manner but unlike marine stocking they do not necessarily 'enhance' fishing opportunity.

F.3.2 Habitat Restoration or Creation

There is some conjecture that the use of hatchery production technology has been applied without due regard to environmental sustainability and that release of cultured juveniles is diverting money away from the real solution (Blankenship and Leber 1995). Stocking is often considered as 'over-used' and applied like a universal remedy for enhancing fisheries rather than addressing underlying environmental problems which, if fixed, may lead to similar or better results than stocking. Many of the key species targeted by recreational fishers in NSW spend most of their life in estuaries, mainly as juveniles, where they receive food and protection from predation. However, since European settlement, NSW has lost over 60 % of all its coastal wetlands, 97 % of assessed river length in NSW has been modified in some way and seagrass meadows have been greatly reduced in area (West 1983). Fish passage and nutrient passage in many rivers and creeks has been blocked by floodgates, weirs, causeways and impoundments and there is greater pollution. The links between habitat and fisheries production are well established. These impacts would have most likely reduced production of recreational and commercial fish species.

Hence, restoration of habitat is in theory an attractive option for enhancing fish stocks. Restoration of habitats as a means of enhancement is generally appropriate where habitats that support fish have been damaged by pollution, urbanisation, industrialisation or agriculture and other impacts. These potentially may have taken a severe toll on fish stocks that then may be compounded by recreational fishing pressure. Habitat rehabilitation is a fishery-independent mechanism that can realistically increase the abundance of key target recreational species. While there are many successful programs underway to rehabilitate fish habitats as listed below, in comparison to the scale of the loss and degradation the programs are quite small.

One of the main constraints of restoration programs are that some habitats have been so badly degraded that long term recovery actions are needed to reach a point where productivity increases significantly. Alteration to size-limits or catch and effort can also take time for benefits to become apparent. The NSW Government is actively involved in restoring degraded habitats using targeted programs, often in partnership with other government and community organisations including recreational fishers, as a means of improving productivity and conservation outcomes for native fish including:

- delivering improvement to fish passage at over 200 sites providing access to more than 2,000 km of riverine habitat;
- returning in excess of 5,000 large woody habitats (or snags) to NSW rivers; and
- modifying the operation of almost 100 tidal floodgates.

The current development of the NSW Habitat Action Plan by DPI is a first step in delivering a coordinated response targeting habitats that are critical to fisheries production. It will identify specific habitats that are limiting the production of commercial and recreationally important species and provide recommendations for their rehabilitation. The development and implementation of the Plan presents a major opportunity for an improved recreational fishing sector within NSW.

In some cases, although there are enough spawning adults, some areas of good habitat will still fail to produce many fish even when fishing is well-regulated. This can occur, for example, because larvae or juveniles are swept away by currents before they settle in nursery habitats in estuaries, physical barriers to estuaries (e.g. a sand berm) or changes to natural flow regimes (which act as a cue for spawning in certain species). In NSW, many of the ICOLLs are likely to show such 'recruitment limitation' because of the sand berms which can create an obstruction to recruitment of post-larvae/juveniles into the estuary. In this case, there will be few fish to harvest once juveniles grow up regardless of any amount of restoration. It is this situation where many consider hatchery-based propagation to be the most appropriate tool for enhancement (Bartley and Bell 2008).

Estuarine artificial reefs which are currently being deployed by DPI are another means by which recreational fishing opportunities can be enhanced. In this case suitable habitat is enhanced rather than restored. These devices made from aggregations of concrete balls have potential to create new habitat and provide for additional fishing locations. DPI has assessed the effectiveness of constructing artificial reefs in NSW estuaries to enhance recreational fishing opportunities. A precautionary approach was adopted, with a small number of artificial reefs constructed in three RFHs, including Lake Macquarie, Botany Bay and St Georges Basin, between 2005 and 2007. The reefs were constructed of 'Reef Balls' which are specially designed concrete modules developed in the United States which promote marine growth and provide fish with a complex artificial habitat. Three years of detailed scientific monitoring of the reefs showed that the artificial reefs were effective at providing new reef habitat for a diverse assemblage of fish species and had limited impact on existing habitats. The results also showed rapid recruitment of a number of highly sought-after sport fish to the artificial reefs. Following the success of the pilot reefs project, the program was expanded into other estuaries including Lake Conjola, where 400 Reef Balls were deployed representing a reef volume of 160 m^3 distributed over an area of 2100 m^2; and, Merimbula Lake, where a further 400 Reef Balls, representing a reef volume of 160 m^3 covering approximately 3500 m^2. The Botany Bay and St Georges Basin reefs were also expanded in 2011. Despite being able to create changes in fish assemblages around the artificial reef sites, this form of enhancement is limited in the scale at which it can be applied.

F.3.3 Marine Protected Areas (MPAs)

MPAs provide various levels of protection to marine habitats and ecosystems. In Australia, MPAs may include large closures that eliminate specific types of fishing gear (e.g. trawling) and/or smaller areas designed to protect important fisheries habitat (Ward and Hegerl 2003). The highest level of protection is generally 'no-take' MPAs where the intention is to fully protect species and their associated habitats. MPAs have primarily been used as a tool to conserve biodiversity with fisheries enhancement as a possible additional benefit (Buxton *et al*. 2006). MPAs are a tool to specify the location of fishing but do not affect the incentive to fish or level of overfishing at a broader scale (Hanne *et al*. 2000) and such area closures are just one of many fisheries management tools discussed in this Section. The benefits of MPAs to the conservation of biological diversity are well documented. Analysis comparing reserves in temperate reserves in Australia, Canada and New Zealand shows increases in mean biomass of 975 % (Lester *et al.* 2009). Edgar *et al*. (2009) also found that of 14 MPAs analysed in Australia, total fish biomass and density of large fish increased significantly based on the age of sanctuary zones relative to fished zones. Reef sites protected for up to 20 years averaged twice the total fish biomass present relative to nearby fished zones, with no indication the trend has yet stabilized. Direct effects on target species, usually high order predators, can be rapid (NSW Government 2010). However, indirect effects on food webs and habitats can take a decade or longer to observe. The response of systems is also dependent on the level and intensity of fishing that previously occurred, the extent of habitat that fish are associated with and overall productivity. Lightly fished sites change more slowly than productive, heavily fished sites (NSW Government 2010). Networks of MPAs also have potential to deliver benefits greater than the sum of their individual parts (Gaines *et al*.2010). Spatial management of fisheries has a long tradition (e.g. protection of spawning grounds) and there are a number of fisheries that benefit from spatial closures. In addition they are useful where other forms of fisheries management are unavailable or poorly applied (Buxton *et al*. 2006). For fisheries that target highly mobile single species with little or no by-catch or habitat impact, marine reserves are less likely to provide benefits beyond that of conventional fishery management tools. MPAs do, however, have potential advantages for fisheries that target multi-species, more sedentary stocks, or for which broader ecological impacts of fishing are an issue (Hilborn *et al*. 2004). It is suggested that their successful use

requires a site specific understanding of the spatial structure of the impacted fisheries, ecosystems and human communities and as for other management tools, their use requires careful planning and evaluation.

Although it is debated as to whether hatchery-based propagation is the ultimate means of enhancement, it is probable, that if done properly, it would increase the resilience of fully fished stocks. Notwithstanding this, it may be appropriate to integrate hatchery-based propagation with other management measures. For example, Hamasaki and Kitada (2006, cited in Bartley and Bell 2008) and Kitada and Kishino (2006, cited in Bartley and Bell 2008) attribute the failure of many of the stock enhancement efforts for shrimp and finfish in Japan to insufficient nursery habitat resulting from coastal pollution. The NSW Government plays a key role in the protection of aquatic biodiversity and fish habitat. Legislative controls are in place to enable assessment of any works that harm marine vegetation; involve dredging or reclamation; obstruct fish passage; construct or modify barriers to fish passage; harm spawning areas for certain fish; use explosive substances in waters; or involve aquaculture developments. The marine fish stocking FMS is committed to complementing habitat rehabilitation and protection programs and other initiatives into the future to aid in increasing productivity of fish stocks in NSW through increased fisher education and research.

The approach taken in the proposal is to integrate marine stocking into the management of estuarine fisheries in NSW along with other traditional measures already being used. The alternatives are to use either traditional measures, habitat restoration/creation or stocking on their own. Discussions above indicate that more can be gained in an integrated approach. This is consistent with an emerging broader view of the role of stocking in fishery systems (Lorenzen 2008, Lorenzen *et al*. 2010). For some fisheries in some countries (e.g. Japan and New Zealand) traditional measures and stocking are already being integrated into fisheries management frameworks.

F.4 Structure of the Fisheries Management Strategy

F.4.1 Comparison with Other States

To our knowledge there are no policy and legislative documents in Australian States and Territories specifically covering stock enhancement of marine organisms as it is proposed here. Like NSW, however, policy is being developed in some States where marine fisheries enhancement is receiving increasing interest. In Western Australia (WA), for example, research stockings have been conducted (Section C.3.2) but there is currently no legislative requirement to be licensed by, or seek the approval for, the release of fish into the marine environment, unless the species to be released is not endemic to the area. If the species is not endemic, then the proponent must apply for permission from the WA Department of Fisheries to translocate the species. With increasing interest in marine stocking it is understood that the WA Department of Fisheries will move to introduce powers under the *WA Fish Resources Management Act 1994* to allow the Department to regulate the release of fish into marine and freshwater environments for the purpose of stock enhancement. These changes will require legislative amendment. Should legislation be amended in WA to require licensing, it is envisaged applications for stock enhancement would be taken through a consultation and assessment process to ensure accountability of the proponent and full consultation with user and interest groups.

In NSW, fish stocking is a 'designated fishing activity' under Schedule 1A Section 216 of the *Fisheries Management Act 1994* (FM Act). Under Section 115O of the *Environmental Planning and Assessment Act 1979* (EP&A Act), a designated fishing activity must be the subject of an Environmental Impact Statement (EIS). The draft FMS provides the framework under which the activity is proposed to be managed and the basis for the environmental assessment and under the legislation there is no alternative to this process.

The comparison of management of stock enhancement in NSW to other States is important as it shows that under the FMS, NSW would have a system of management that is highly developed and the most sophisticated in Australia. A lesser level of sophistication, as currently occurs in other States, would be an unacceptable alternative for NSW not only because of the high risk to the environment that unregulated marine stocking could have but also because of legislative requirements.

F.4.2 Alternative Frameworks

The overall intention of the draft FMS is to be able to provide a framework to manage unforeseen risks that may arise during the marine fish stocking program. Clearly, some risks are more likely to occur and have greater consequences than others. Thus, the draft FMS must also be able to identify priorities to address identified risks and present a schedule of how, when and at what cost those priorities can be addressed.

The structure of the draft FMS for marine stocking follows other FMSs already prepared for fisheries in NSW, particularly the draft FMS prepared for freshwater stocking. It comprises three tiers: Goals, Objectives and Management Responses. These are supported by requirements for performance reporting and monitoring (including definitions of performance indicators and trigger points) and by a plan of ongoing research and a hatchery quality assurance scheme (HQAS). The structure of the draft FMS has two important components. First, it encapsulates methods of operation, possible risks associated with these methods and appropriate responses if risks eventuate. Second, it provides for a wide range of alternatives that can be initiated where appropriate, with both stakeholder and independent scientific input.

The draft FMS (and associated HQAS), is built upon the existing operation of the freshwater stocking program and marine stocking research and stakeholders are confident that it is workable and addresses risks identified at this time. It would be subject to review and can be adapted to respond to a range of threats that may arise in the short and long-term.

The remainder of this Section considers alternatives to the way the marine stocking program is proposed to operate, in terms of stocking and harvesting rates, performance indicators and monitoring, cost recovery and sources of funding.

F.5 Key Alternative Management Approaches

F.5.1 Stocking Other Species

As discussed in Section B.3, selection of the most suitable species of finfish and/or invertebrates for inclusion in the marine stocking program involved consideration of a number of factors. Species were assessed against the following selection criteria:

- Whether the species are estuarine residents and have a widespread distribution in NSW. Being non-migratory for at least part of their life-cycle was considered favourable as it would prevent high rates of dispersal or dilution of stocked juveniles, thereby giving fishers the greatest chance to catch the stocked fish. An extensive species range within NSW would increase the locations suitable for stocking the species within NSW estuarine waters and reduce the chance of non-natural introductions of stocked fish.
- Evidence of fast growth to their minimum legal size. Fast growth was considered appropriate so the benefits of stocking could be quickly realised.
- Popularity with recreational fishers. Species popular with recreational anglers represented a direct link to enhancing recreational fishing.
- Available aquaculture technology on a commercial scale (i.e. whether aquaculture technology and licensing required for production of fingerlings for fish stocking programs was available or could be made available).

Table F.1 shows the initial list of species that were investigated for their potential for inclusion in the marine fish stocking program and whether they met the selection criteria.

Of the 25 species considered for marine stocking, 10 met the general selection criteria but three of these were not considered further in the EIS for the following reasons.

Some of the species are very similar to each other. School prawns are very similar to eastern king prawns in many ways. They live in similar habitats, have similar growth rates and are regularly caught coincidentally by prawners., Although school prawns are targeted specifically in some North coast estuaries by recreational anglers the majority of recreational prawn catch (97 %) is eastern king prawns (Henry and Lyle 2003). Given that there would be little advantage to stocking both species and stocking trials for eastern king prawns in ICOLLS have been shown to be successful through pilot research stockings (Section C.8.5.5), school prawns have not been considered any further at this stage.

Due to their similarity, only one whiting species was assessed in the EIS. Sand whiting were considered more preferable than trumpeter whiting (*Sillago maculata*) because they grow to a much larger size.

Black bream also met most of the general selection criteria for consideration for marine fish stocking. However, recent research has shown that there are few pure-bred black bream in NSW with the majority being hybrids that have resulted from cross-breeding with yellowfin bream (Section C.8.1). An abundance of hybrids would make it difficult to source pure strain broodstock, hence black bream have not been considered further.

This left seven species for consideration in the EIS. This number would give the marine stocking program the variety and flexibility that may be needed if problems become apparent for some species. It is noteworthy that the implementation of the marine fish stocking FMS would not inhibit the ability for other species to be stocked in the future. Other species not considered within the program may be considered in the future, subject to further environmental assessment under the EP&A Act but the need to do this would largely depend on advances in aquaculture technology, future research, changes in demand, fishery objectives and temporal trends in fish population dynamics. The selected species are considered to be economically viable for a marine stocking program based on the assessment carried out in Specialist Report B.

Table F.1: Species considered for marine stocking.

Shading indicates the seven species selected for the marine fish stocking proposal. [1] Information supplied by DPI Aquaculture Section, [2] Information derived from eastern States aquaculture output reports, [3] Information derived from aquaculture literature, [4] Information supplied by hatchery operators, [5] Scandol *et al*. (2008) or Froese and Pauly (2003), [6] Henry and Lyle (2003).

	Hatchery Information				Life history information		Desirability	
Species	Licensed hatchery(s) in NSW [1]	Commercially available [2]	Rearing technology available [2, 3]	Cost per fingerling [2,4]	Estuarine resident	Growth rate [5]	Commercially harvested	Recreational importance [6]
Black Drummer *Girella elevata*	No	No	No	N/A	Reef, near mouths	Unknown	No	Higher than 25th, Not commonly targeted in estuaries
Samson Fish *Seriola hippos*	No	No	No	N/A	No	Probably fast	Rarely	Higher than 25th, Not commonly targeted in estuaries
Australian Salmon *Arripis trutta*	No	No	No	N/A	No	Fast	Yes	Ranked 8th, Not commonly targeted in estuaries
Morwongs Cheilodactylidae	No	No	No	N/A	Reef, near mouths	Medium	Yes	Ranked 12th, Not commonly targeted in estuaries
Tailor *Pomatomus saltatrix*	No	No	No	N/A	No	Fast	Yes	Ranked 7th
Luderick *Girella tricuspidata*	Yes	No	No	N/A	Yes	Medium	Yes	Ranked 5th
Amberjack *Seriola dumerili*	No	No	Yes	N/A	No	Probably fast	Rarely	Higher than 25th, Not commonly targeted in estuaries
Cobia *Rachycentron canadum*	Yes	Yes	Yes	$1.00 to $2.50	No	Fast	Rarely	Higher than 25th, Not commonly targeted in estuaries

	Hatchery Information				Life history information		Desirability	
Species	Licensed hatchery(s) in NSW [1]	Commercially available [2]	Rearing technology available [2, 3]	Cost per fingerling [2,4]	Estuarine resident	Growth rate [5]	Commercially harvested	Recreational importance [6]
Yellowtail Kingfish *Seriola lolandii*	Yes	Yes	Yes	$1.05	No	Fast	Yes	Ranked 9th
Snapper *Pagrus auratus*	Yes	Yes	Yes	$1.05	Juvenile only	Medium	Yes	Ranked 13th
Dolphinfish *Mahi mahi*	Yes	No	Yes	N/A	No	Probably fast	Yes	Higher than 25th, Not commonly targeted in estuaries
Abalone *Haliotis rubra*	Yes	No	Yes	N/A	Reef, near mouths	Slow	Yes	Higher than 25th, Not commonly targeted in estuaries
Yellowfin Bream *Acanthopagrus australis*	Yes	Yes	Yes	$0.85 to $1.00	Yes	Medium	Yes	Ranked 3rd
Sand Whiting *Sillago ciliata*	Yes	Yes	Yes	$0.30 to $1.00	Yes	Medium	Yes	Ranked 4th
Trumpeter Whiting *Sillago maculata*	Yes	Yes	Yes	$0.30 to $1.00	Yes	Medium	Yes	Ranked 4th
Blue Swimmer Crab *Portunus pelagicus*	Yes	Yes	Yes	$0.20 to $0.50	Yes	Fast	Yes	Ranked 10th
School Prawns *Metapenaeus macleayi*	Yes	Yes	Yes	$0.017	Yes	Fast	Yes	Ranked 15th
Silver Trevally *Pseudocaranx dentex*	Yes	No	Yes	N/A	No	Medium	Yes	Ranked 17th
Giant Mud Crab *Scylla serrata*	Yes	Yes	Yes	$0.20 to $0.50	Yes	Fast	Yes	Ranked 22nd
Estuary Perch *Macquaria colonorum*	Yes	Yes	Yes	$0.85 to $1.00	Yes	Medium	No	Higher than 25th

	Hatchery Information				Life history information		Desirability	
Species	Licensed hatchery(s) in NSW [1]	Commercially available [2]	Rearing technology available [2, 3]	Cost per fingerling [2,4]	Estuarine resident	Growth rate [5]	Commercially harvested	Recreational importance [6]
Mangrove Jack *Lutjanus argentimaculatus*	Yes	Yes	Yes	$6.00	Yes	Medium	No	Higher than 25th
Eastern King Prawns *Melicertus plebejus*	Yes	Yes	Yes	$0.017	Juvenile only	Fast	Yes	Ranked 15th
Dusky Flathead *Platycephalus fuscus*	Yes	Yes	Yes	$0.30 to $1.00	Yes	Medium	Yes	Ranked 1st
Black Bream *Acanthopagrus butcheri*	Yes	Yes	Yes	$0.85 to $1.00	Yes	Medium	Yes	Ranked 3rd
Mulloway *Argyrosomus japonicus*	Yes	Yes	Yes	$0.80 to $1.05	Yes	Fast	Yes	Ranked 6th

F.5.2 Stocking Forage Species

The production of forage species along with the target species was considered as an alternative to the proposed activity. Forage species could potentially be stocked into an estuary so as to provide a source of food for other stocked fish and offer a ready source of protein and an alternative food source to naturally available species or juvenile stocked species. Stocking forage fish could feasibly improve growth rates of target recreational and commercial species and offer a level of protection to immature stock and endemic species.

The use of this alternative was not considered appropriate at this time due to a number of factors, including: insufficient technology to produce stocks of forage fish; potential environmental impacts; appropriate species selection; and the added cost of conducting such a program preclude serious consideration of that alternative at this time. Community consultation suggested stocking prawns together with mulloway would appear to make sense (Section D.2.2), however, prawns form only part of the diet of mulloway and the proportions of prawns in their diet varies as the fish grow (Section C.8.2). Mulloway are likely to be dependent on various other sources of food occurring naturally in estuaries. The stocking rates being proposed take into account the natural supply of food and sustainable use of these resources. It is also likely that it would not be possible to cost-effectively increase the productivity of estuaries at the scale required to effectively improve the success of stocking.

F.5.3 Stocking Other Estuaries

There are potentially 158 estuaries in NSW that could be stocked. Choosing the most suitable estuaries for stock enhancement requires consideration of many factors. Certain characteristics make some estuaries more favourable than others. Among the characteristics that make an estuary favourable are whether there is appropriate adult habitat available and whether populations in particular estuaries are recruitment limited. It is generally considered that there must be adequate resources to support an increased supply of individuals (Bartley and Bell 2008). Characteristics of estuaries that maximise the social and economic benefits of stock enhancement are also generally considered favourable. It is logical that the greatest socio-economic benefits from stock enhancement would occur if the benefits were spread among the community, hence estuaries that already have, or have great potential for, a large amount of fishers would be preferable. An example of an unfavourable characteristic is pollution as this would

possibly effect the survival of stocked fish or could lead to contamination. Pollution can occur from industrial, urban or agricultural runoff.

As some estuaries may possess both favourable and unfavourable characteristics the choice of suitable estuaries for stock enhancement is not straightforward. The approach in the EIS was to use a multi-criteria assessment approach where estuaries were ranked against each other based on their total score as compiled from a sum of ten criteria. Using this process, estuaries in each of three stocking regions were ranked to indicate those with the greatest potential for successful marine stocking. Further details and methods used in the multi-criteria analysis (MCA) can be found in Section B.5.

The results of the MCA (Section B.5) depend upon the weightings given to each of the criteria used to score each estuary and different weightings would deliver an alternative 'preferred' set of estuaries for each region. Our weightings of criteria were based on a weight of evidence approach that included consultation with stakeholders. This allowed us to determine whether a factor was favourable or not. A greater range in the weightings is a possible alternative that could deliver an alternative set of 'preferred' estuaries. More detailed knowledge of the importance of particular factors would be required to have the confidence to alter a weighting. Current weightings are considered appropriate based on our current knowledge and feedback from community consultation.

F.5.4 Alternative Stocking Rates and Harvest

It is generally considered that there must be adequate resources in the receiving environment if stock enhancement is to increase the supply of individuals (Bartley and Bell 2008). In NSW, it is likely that surplus resources would be available in recruitment limited estuaries. Notwithstanding this, overstocking of estuaries above carrying capacity is possible even in recruitment limited estuaries.

To reduce the potential for overstocking and the associated risks to wild stocks, Taylor and Suthers' (2008) Generalised Predatory Impact Model (GPIM) combines the food resource needs of stocked species with estuarine productivity and habitat availability to predict an appropriate stocking density. For each estuary, the model allocates only a very small proportion of productivity (food resources) to the stocked fish, thereby reducing the potential for competition with wild fish. A full description of the process for determining appropriate stocking densities (and harvest weights) is presented in Chapter E, Appendix E.5.

The stocking rates (and harvest) depend on the level of allocation of estuarine food resources to stocked fish in the Predatory Impact Model. Taylor and Suthers (2008) used a level of 10 % in determining an optimal stocking rate for mulloway in the Georges River but discussed alternative levels. They considered greater allocation (e.g. 15 %) would probably lead to displacement of competitors and/or conspecifics. Hence, although a greater level of allocation is likely to result in greater yield, it could potentially cause negative impacts to the ecology of estuaries. Conversely, they considered that harvest would potentially become trivial at some level.

The proposal is to allocate 5 % of the predicted productivity of estuaries to stocked fish. Given that there is a degree of uncertainty in the GPIM, 5 % of an estuary's productivity is considered to be the most balanced and precautionary option. A key objective of the draft FMS (Objective 1.2 (d)) is to apply empirical methods to determine optimum stocking density rates and also to undertake further research into food chain interactions between stocked fish and the environment (Research Topic 2.3). As new data becomes available, this would be used to further refine the allocation of food resources for future stockings so that the balance between yield and displacement of competitors and/or conspecifics is optimised.

F.5.5 Alternative Stocking Practices

F.5.5.1 Size at Release

The size at release of fish is one of the most important questions governing the economics of stocking programs and the potential effects releases may have on natural systems. This relates to the time fish must spend in hatcheries, their competence to survive when placed in unprotected natural systems, and their potential negative impacts on the environment. The approach taken in this EIS to resolving the issue of the most appropriate sizes for stocking is to provide stocking rates for three sizes (ranging from the very smallest possible size to larger juveniles) of six of the seven species and one size of eastern king prawn. In the long-term, this approach would not only optimise the use of hatchery infrastructures and other logistic resources for maximum benefits, but it can provide evidence of successes or failures and give valuable guidance to future activities.

The alternative is to stock all species in a single size-class, either as very small juveniles or large juveniles. There are arguments for and against releasing smaller or larger fish but few studies evaluate each in terms of cost-effectiveness and environmental impact.

The work by Russell *et al.* (2004) with barramundi in North Queensland (QLD) points towards the release of larger fish (300 mm long) as a preferred option. Releases at this size were considered cost-effective even when the high costs of rearing the fish in nursery systems was taken into account. Several other recent studies in Australia have also shown good recaptures of larger rather than smaller fingerlings and recommended stocking the largest fish that programs could afford (Hutchison *et al*. 2006). At the other extreme, Palmer *et al*. (2007) has suggested the release of smaller barramundi (metamorphosed fry at 8 - 10 mm long) as these can be produced in large numbers without the need for nursery systems. Support for this size at release for barramundi is indicated by long-term observations from recreational and commercial fishers of catches in the Mary River system in Southern QLD (Palmer 2005).

Economic arguments for stocking suggest choosing a size that maximises the greatest return from the costs of production. Cost-benefit models generally do not take into account depreciation costs on nursery systems, the risks of stock losses when holding fish for a long period or the potential scale that marine stocking could rise to, should it become a standard fisheries management tool over the next several decades. The extra costs of larger fish are often based only on the commercial prices of the various species and their ease of production. Different logistical considerations and cost structures would apply at different scales of production, and lower survival with lower costs may in fact be optimal in the long-term. These considerations apply to both crustaceans and fish. For example, the high cost of rearing advanced stage, juvenile tiger prawns in nursery systems, rather than post-larval prawns (as used in the prawn farming environment and for stocking trials of eastern king prawns in NSW – see Section C.3.3), has placed the Western Australian program in a position where its economic viability is in question (reported by Loneragan *et al*. 2004).

Ecological arguments favour the stocking of the smallest fish possible. The extra time that fish spend growing to larger sizes in aquaculture nursery systems represents additional risks of disease infection and or amplification prior to release (Section C.4.1.5). Furthermore, fish that are grown in biosecure aquaculture systems are afforded artificial protection from disease. Having potentially been treated with therapeutic chemicals to overcome disease problems in a hatchery could potentially reduce the fitness of wild stocks if a lower level of resistance to disease was passed on. Allowing natural selection of disease-resistant fish at the earliest possible stage in their life cycle could be considered a responsible approach to disease-related genetic management.

This size-at-release question will remain one of the primary research questions into the future of the marine stocking program as DPI seek to identify the most cost-effective and environmentally sustainable ways to enhance wild fish populations with hatchery-produced juveniles. Survival which can very effectively be addressed by the empirical release/recapture experiments that accompany responsible approaches (see Blankenship and Leber 1995) should be accompanied by potential issues of diluting disease resistance and genetic diversity in wild fish. At the time of preparation of this EIS, such studies are nearing completion in the Blackwood River in WA, where the long-term (6 - 7 year) effects of stocking different sized fingerlings (30 mm and 60 mm) has been under review since the projects inception (pers. com. G. Jenkins October 2009).

The approach taken in this EIS to resolving the issue of the most appropriate sizes for stocking is to provide stocking rates for three sizes (ranging from the very smallest possible size to larger juveniles) of six of the seven species and one size of eastern king prawn. In the long-term, this approach would not only optimise the use of hatchery infrastructures and other logistic resources for maximum benefits, but it can provide evidence of successes or failures and give valuable guidance to future activities.

The alternative is to stock all species in a single size-class, either as very small juveniles or large juveniles.

F.5.5.2 Monitoring Techniques

In order to monitor the survival, movements and recapture rates of stocked fish it is essential that suitable tagging techniques are employed. There are a number of alternative tagging techniques including implanted coded wire tags (CWTs), visible implant elastomer (VIE) tags, marking of otoliths with various chemicals such as oxytetracycline (OTC), scale pattern analysis (Taylor and Piola 2008), passive integrated transponders (PIT) tags and genetic markers. Each of the techniques and tag types has advantages and disadvantages and are more useful than others for particular needs. Some tags for example, can be repeatedly sampled without harm to the individual but are expensive (e.g. PIT tags). Others such as CWTs are comparatively less expensive, but require excision from the individuals to read the details of the tag. Genetic and chemical markers have limited constraints for the number, size,

or species of release, and may be particularly applicable to various batch-marking needs when there is no need to identify fish at an individual level. Under Research Topic 3.1 of the draft FMS, the most cost-effective and reliable marking techniques used to identify stocked individuals would be determined.

F.5.5.3 Other Considerations

Under the draft FMS Research Plan (Research Topic 3.2), other alternative stocking techniques relating to conditioning, timing and release techniques would be investigated to ensure the most efficient and effective methods are employed. Information would be used to evaluate the success of the activity in achieving goals of the draft FMS and guide the development of optimal stocking practice in NSW conditions.

F.5.6 Alternative Stakeholder Involvement and Community Consultation

Bell *et al*. (2008), note that the technical ability to engage in stock enhancement is only one of the components that would determine whether programs prove useful to fisheries managers. Estuarine fisheries in NSW are complex and there are many stakeholder groups. To be effective, releases need to contribute to the biological, economic, social and institutional management objectives of fisheries. Further, with many stakeholders having an interest in estuaries in NSW, stakeholder involvement in the marine enhancement program is important to avoid the potential for any negative social impacts to one or more groups.

The alternatives for making stakeholder involvement effective are for the different stakeholder groups to consult between each other on an individual basis or to communicate together through an advisory committee such as the Advisory Committee for Recreational Fishing (ACoRF). ACoRF is a statutory body and represents an efficient and effective means by which communication and consultation could occur. Recreational and Aboriginal fishers and conservationists (i.e. the Nature Conservation Council of NSW) have representation on ACoRF but commercial fishers are not represented.

The proposal in the draft FMS is to initiate a public consultation period each year with the list of potential sites for marine stocking in the upcoming season. This would then allow stakeholders from the recreational, Aboriginal, and commercial and aquaculture sectors to have an input into the stocking program. This is the current mechanism used for the NSW freshwater impoundments stocking program and is found to be largely successful. This is consistent with the best practice approach advocated by Lorenzen (2008) in which there would be an integrated approach to marine stocking programs with equal involvement by stakeholders, scientists and managers and proposes that it is ultimately the actions of stakeholders that must and will drive stock enhancement projects. A multi-disciplinary team of scientists, analysts and managers would need to guide stakeholders but it is the stakeholders that should make the decisions.

An alternative to these arrangements would be to establish a marine stocking reference group whose main purpose is to develop stocking priorities across the State. A reference group could be established with representatives of DPI (management, hatcheries, and research), native fish stockists, conservationists, Aboriginal groups, water resource representatives or other. Such a group would meet initially and then periodically throughout the year to assess representations for stock allocations aimed at satisfying demand through appropriate grading or other assessment criteria. This alternative was not selected over the preferred arrangement as proposed in the draft FMS as it was considered that by expanding the consultation process in the first instance, the same outcomes could be achieved but with significantly lower management costs.

F.5.7 Alternative Performance Indicators

Performance reporting in the draft FMS relies on a series of performance indicators and trigger points related to activity goals, which if exceeded, cause the goal or the FMS to be reviewed and adjusted where necessary. This sets out a system of desired outcomes that can be achieved within a reasonable level of probability before trigger points are exceeded and is designed to ensure the overall objectives of the draft FMS are achieved within expected and reasonable variables.

An alternative performance reporting and monitoring regime could be used whereby specific outcomes are set out as tangible achievements within the management framework. Outcomes could include stock production targets (quotas), and recapture targets (returns to fishers), as the primary reportable objectives for performance and monitoring.

To embrace such a production and return-based system would not take into account the potential environmental and social impacts of the activity and would be more suited to an aquaculture venture on private land. Collection of accurate information about returns would be also be very expensive and would not be practicable for every stocking. As such, these alternatives were not adopted in the draft FMS.

F.5.8 Alternative Arrangements for Cost Recovery or Funding Sources

F.5.8.1 Alternative Arrangements for Cost Recovery

Initially, cost recovery would be administered through DPI using funding from the Recreational Saltwater Fishing Trust for management costs. The cost of management is likely to be derived from the cost of producing and releasing fingerlings and the allocation and apportionment of indirect overhead costs.

If the program is to operate on cost recovery, one alternative is for one or more groups of stakeholders to examine the option of collecting levies through a group entity. The entity can then negotiate with government and hatcheries for increased stocking events possibly under an alternative budget. Under this alternative there could be a shift in the benefits of stocking away from the whole community to the smaller groups collecting levies as presumably stockings would be done in areas that maximised benefits to these groups. Such an alternative would be evaluated during the life of the FMS if required.

F.5.8.2 Sources for Research Programs

There are a number of sources of funding for implementing proposed research programs

- NSW Department of Primary Industries. DPI fully-fund or contributes to many research programs associated with the conservation of fish stocks and fish habitat. Currently, however, stock enhancement from hatchery-based releases would be less of a priority than other programs.
- Fisheries Research and Development Corporation (FRDC). The FRDC is a national body that funds fisheries research and development. The FRDC obtains money by levying commercial fishers all over Australia which is in turn matched by government funding. The money is used to fund research and development needs in fisheries, including stocking. Funding from FRDC is very competitive.
- Universities. Universities have some potential for contributing to research needs in fisheries. They also, however, depend on government funding bodies to support their research and must apply for funding on a competitive basis.
- NSW Recreational Saltwater Fishing Trust. The NSW Government's Recreational Saltwater Fishing Trust is funded from revenue generated from the recreational fishing licence fee. Funds have been allocated from the Trust for the preparation of the EIS and the implementation of stocking operations. The Recreational Saltwater Fishing Trust also funds research that aims to improve recreational fishing. All proposals are evaluated to ensure benefits to recreational fishing.
- Stakeholders. Commercial fishers, Aboriginal groups or other recreational fishing groups are stakeholders that may offer financial support for research and monitoring to evaluate the benefits of marine stocking to their groups. There may be opportunities for joint funding partnerships with these groups, although is noteworthy that recreational fishing groups fund many components of the inland stocking program.

It is not possible to rely completely on any one of the above sources to fund research and development programs for stock enhancement. As such, the approach taken in the draft FMS, as has been the approach used for many of the designated fisheries, is to continue to explore ways of obtaining funding from a number of sources.

F.6 Conclusions

The comparisons shown in this Section reveal that although feasible alternatives are available for the management of marine fish stocking in NSW, a cautious and pro-active suite of management actions are put in place by the draft FMS. These cater for contingencies in a manner far more effectively than the alternatives. This is achieved with the well-being of those involved in the activity in mind, both socially and financially, while potential impacts on the environment are also adequately managed.

1. The no stocking alternative is likely to result in:

    - Discontinued research that would otherwise contribute to improved knowledge and understanding of fisheries ecology and biology;

- Continued pressure on fully fished resources;
- Loss of opportunity for local economies.

Justification for implementing a marine fish stocking program in NSW is given in Section H.

2. Alternative methods of enhancement such as fisheries regulation and long-term habitat restoration or creation programs are currently being implemented by DPI and are essential tools for the long-term sustainability of fisheries resources. Carrying out marine fish stocking in parallel with these existing management methods is considered a preferable option.

3. The draft FMS (and associated HQAS) provides a flexible approach to the operation and management of marine fish stocking and would be subject to review to accommodate alternative management strategies in line with changing conditions and as new information may become available in future.

4. The FMS provides for the incorporation of new and alternative species into the marine stocking program as new aquaculture advances, future research and changes in demand allow.

5. The draft FMS and MCA provide a list of 80 alternative estuaries that could be potentially considered for stocking. These estuaries would potentially provide access to recreational and commercial fishers in regional and city areas along the NSW coastline.

6. Stocking rates and projected harvest rates are modelled in the GPIM and based on allocating approximately 5 % of estuarine food and habitat resources which is theoretically considered an appropriate balance between sustainable ecological impacts and a worthwhile return (in terms of harvest).

7. Stocking rates for most species are given for three size-classes. This is considered to be best practice and the most cost-effective approach, given the available information at present. The alternative of stocking a preferred size-class would be considered pending the results of research and monitoring (including post-stocking mortality) specifically carried out as part of the FMS.
8. Research would be undertaken to determine the most cost-effective and reliable marking techniques used to identify stocked individuals.

9. Other alternative stocking techniques relating to conditioning, timing and release techniques would be investigated under the FMS Research Plan to ensure optimal stocking practices are employed.

10. Stakeholder involvement would be done through a public consultation period each year, which would include consultation with recreational, commercial and Aboriginal fishers and conservationists.

11. Performance indicators relating to the goals and objectives of the draft FMS are cost effective and practical. Other alternative performance indicators that focus simply on a production and return-based system are inappropriate for this program.

12. Cost recovery and funding for research would initially be administered through DPI with funding to be sought from the Recreational Saltwater Fishing Trust and other sources and partnerships.

Chapter G
Assessment of Impacts of Implementing the Draft FMS

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CHAPTER G ASSESSMENT OF IMPACTS OF IMPLEMENTING THE DRAFT FMS

G.1 Introduction

The draft Fisheries Management Strategy (FMS) (Chapter E) sets out the policies and administrative arrangements to guide stocking events as part of the proposed marine stocking program and ensure they are implemented in an environmentally sustainable manner. The draft FMS has been developed to manage the key areas of risk as identified in Chapter D. This Chapter of the Environmental Impact Statement (EIS) (Chapter G) outlines the mitigative/management measures required to remove or minimise identified risks to an acceptable level and indicates how this would be achieved through implementation of the draft FMS. The residual risk (with the draft FMS in place), is then determined for each of the issues identified in Sections G.3.1 (Biophysical Impacts), G.3.2 – (Social Impacts) and G.3.3 – (Other, Physico-Chemical Impacts). The economic feasibility of a marine stocking program in NSW has also been assessed (Specialist Report B) and the results summarised in Section G.4.

Each sub-section lists the risk level before implementation of the draft FMS for each key issue identified in the risk analysis in Chapter D. A table at the end of the sub-section indicates the residual risk level after mitigative measures in the draft FMS are implemented. Implementation of the draft FMS does not necessarily reduce the residual risk level in all circumstances, but strategies may still be identified that would help maintain or control the level of risk.

Risks identified as 'low' in Chapter D (Identification of Risks) are not considered further and are therefore not addressed in this Chapter of the assessment. The exception, is where there is mitigation already outlined in the draft FMS for other high to moderate risks, that may also be applied to low risk issues to ensure and maintain the low risk level. This may or may not result in a further reduction of likelihood or consequence.

Often mitigation or management strategies implemented to address one particular issue would have multiple benefits for other areas of risk. Specific goals, objectives, management responses and research topics within the draft FMS are identified as relevant. Two tables (G.37 and G.38) are given at the end of this chapter which summarise all the risks/issues identified in Chapter D before and after implementation of the draft FMS and lists all mitigation/management measures and relevant research/monitoring priorities that the NSW Department of Primary Industries (DPI) are committed to implement through the draft FMS.

G.2 Mitigation and Impacts of Implementing the Draft Fisheries Management Strategy

The following Sections outline the mitigation and management measures required to address the risks/issues identified in Chapter D and indicates how these measures would be implemented through the draft FMS and the residual risk level with mitigation.

G.2.1 Biophysical Impacts

G.2.1.1 Ecology

G.2.1.1.1 Impacts on Conspecifics

Key issues identified in Chapter D.4.1.2.1:

- Decrease in abundance of wild conspecifics (e.g. through overstocking/ increased fishing effort) - high risk;
- Alteration of population size structure (conspecifics) - high risk;
- Alteration of the natural species distribution - moderate risk.

A key strategy to mitigating potential consequences on wild conspecifics is to determine the capacity of the receiving estuary to accommodate the addition of stocked fish or crustaceans (i.e. to ensure that that the estuary is not overstocked). In reality, this is difficult to measure, especially in dynamic estuarine systems where production and recruitment are highly variable. Taylor and Suthers (2008) have outlined and tested a Generalised Predatory Impact Model (GPIM) to determine appropriate stocking densities for mulloway in the Georges River, NSW. The model was a first step in stocking pilot studies, which used potential trophic impacts and ecosystem productivity to inform stocking density estimation and potentially reduce the risk of overstocking and adverse ecosystem impacts. In recent years, the model has been further developed as a decision support tool to assess the relative impacts of different stocking scenarios (Taylor and Suthers 2008), such as comparisons of the outcomes of stocking at different release sizes, stocking different species, and stocking different systems.

The GPIM has been applied to the species and estuaries proposed for marine stocking and uses growth and population parameters (outlined in Chapter E, Appendix E.5) to estimate maximum stocking rates and potential harvest rates. Stocking rates are expressed as the 'maximum number of individuals released per hectare of suitable habitat' and harvest as 'total tonnes of stocked species to be harvested from the estuary.'

The draft FMS recognises that there are limitations to the data used to calculate key model parameters for the selected species and estuaries proposed for marine stocking. Consequently, the recommended stocking thresholds would therefore be considered as a conservative reference point that would be refined through the research and monitoring proposed in the draft FMS. (Objective 1.2 d) of the draft FMS is to apply empirical methods to determine optimum stocking rates and also to undertake further research into food chain interactions between stocked fish and the environment (Research Topic 2.3). As new data becomes available, this could potentially contribute to further validating and refining the modelling (as per Research Topic 3.2 (1)).

The modelled maximum stocking rates (and harvest) calculated depends heavily on the level of allocation of estuarine food resources to stocked fish in the GPIM. The proposal is to allocate 5 % of the predicted productivity of estuaries to stocked fish, which is the preferred approach in providing a balance between yield and minimal ecological impact (discussed in Chapter F.5.4). Given that only 5 % of the estimated productivity of estuaries is to be allocated to stocked fish and that uncertainties in the modelling are to be addressed in the proposed research program, these stocking rates are considered to represent a precautionary approach that would be very unlikely to result in the disruption of the ecological balance of an estuary as outlined in Research Topic 3.2 (1). Information on trophic interactions from future research would also be used to validate the preferred (5 %) level of resource allocation.

Although there is unlikely to be a regional/state-wide increase in fishing effort it is possible that there may be an increase of fishing effort at the local (estuary) scale due to a redistribution of effort. In order to address this uncertainty, the level of fishing effort and changes in effort associated with stocking would be monitored as per Objective 2.3 (d). Catch and effort surveys would commence in regional areas and procedures for the monitoring of catch and effort would be developed upon completion of the stocking plan.

The potential risk of stocking altering the population size structure of conspecifics would be minimised by timing stocking events in relation to the natural life cycles and recruitment patterns of each particular species i.e. stocking would take place during known recruitment periods.

To ensure that species are stocked within their natural geographic range, stocking would not occur within a minimum of a 50 km buffer from the limits of the distribution (refer to Appendix E.3 of Chapter E). DPI would also review information on the species selected for stocking included genetic stock structure and where needed, species specific stocking guidelines would be developed as per Management Objective 1.3 (b) and Research Topic 1.1.

To remove the potential for smaller scale non-endemic introductions, species would not be stocked in estuaries where the amount of juvenile or adult habitat is limited. This would be ensured by stocking into estuaries with high suitability rankings as per the MCA. The Hatchery Quality Assurance Scheme (HQAS) would be modified to include appropriate stocking regions for each of the marine species.

By ensuring that maximum stocking rates (determined through the application of the GPIM) are not exceeded, the risk of a decrease in the abundance of wild conspecifics (through overstocking/increased fishing effort) would be reduced from 'high' to 'low'. This is because both the likelihood and consequence of overstocking/increased fishing effort would be reduced.

The risks of alteration of size structure would be reduced from 'high' to 'low' as both the consequence and likelihood would be reduced by ensuring appropriate stocking rates and timing stocking events with natural recruitment rates.

The risks of natural species distribution being altered would be reduced from 'moderate' to 'low' as species would only be stocked into their natural geographic range as a requirement of the draft FMS, including a buffer zone to prevent potential overlap. A summary of the issues, management strategy and relevant Sections of the draft FMS is provided in Table G.1 below.

Table G.1: Summary of measures to reduce impacts on conspecifics.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Decrease in abundance of wild conspecifics (e.g. through overstocking or increased fishing effort).	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). Monitoring of fishing catch and effort DPI would carry out routine inspections to ensure compliance with existing fishing regulations. Research and monitoring for potential impacts on wild conspecifics.	Appendix E.6 of the FMS: outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.6 (a): To initiate research relating to the activity. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking. Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the native populations within stocking areas. Research Topic 3.2 (1) (Priority Level 1): Optimisation of harvest stocking techniques.	Low
Alteration of population size structure (conspecifics).	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). DPI would carry out routine inspections to ensure compliance with existing fisheries regulations. Research and monitoring for potential impacts on wild conspecifics. Stocking would be timed in relation to natural life cycles and species recruitment patterns.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.6 (a): To initiate research relating to the activity. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques (This would ensure preferred timing and release locations). Research Topic 1.2 (Priority level 1): To research impacts of stocking	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		activities on the native populations within stocking areas.	
Alteration of the natural species distribution.	Species would be stocked only in estuaries occurring within their natural geographic range.	Appendix E.3 of the FMS outlines the approved stocking regions for each species permitted for stocking. Objective 1.3 (b): Develop and implement species specific stocking guidelines directly relevant to species ranges in NSW. Research Topic 1.1 (Priority level 1): To investigate genetic distribution of native species and sub populations.	Low

G.2.1.1.2 Impacts on Competitors (Inter-Specific Competition)

Key issues identified in Chapter D.4.1.2.2:

- Alteration of the distribution, abundance or structure of populations e.g. through inter-specific competition and/overstocking/increased fishing effort - high risk.

As for the previous Section, determining the capacity of the receiving estuary to accommodate stocked fish/crustaceans is a key priority so that the consequences of stocking would not disrupt the ecological balance of an estuary. The maximum stocking rates as estimated by the GPIM (Chapter E, Appendix E.6) would not be exceeded. The stocking thresholds would be refined through the research and monitoring proposed in the draft FMS. (Objective 1.2 d) of the draft FMS is to apply empirical methods to determine optimum stocking rates and also to undertake further research into food chain interactions between stocked fish and the environment (Research Topic 2.3). As new data becomes available, this would be used to further validate and refine the GPIM and help to develop and apply a standard formula for use in the future (as per Research Topic 3.2 (1)).

As for the previous Section, other strategies are proposed to reduce potential impacts to competitors. The level of fishing effort and changes in local effort associated with stocking would be monitored as per Objective 2.3 (d). Catch and effort surveys would commence in regional areas and procedures for the monitoring of catch and effort would be developed upon completion of the stocking plan. This would help determine whether fishing effort substantially increases in stocked areas, such that there might be an impact on inter-specific competition.

Objective 1.7(a) is to minimise any competitive advantage of the stocked species over wild conspecifics by facilitating stock releases in timing with the selected species lifecycles and recruitment patterns. Under Research Topic 1.2 (to research impacts of stocking activities on the biodiversity of native populations within stocking areas), a monitoring program would also be established to investigate incidences of interaction between non-stocked species and recreational fishers at marine fish stocking locations. This information would be used to make future management recommendations and refine the FMS when it is reviewed.

Compliance with existing catch and bag limits and size restrictions would also minimise the likelihood of over-harvesting of other competitor species. The marine stocking Research Plan outlined in Chapter E (Table E.7) would evaluate the specific effects on competitors and competitive interactions as per Research Topic 1.2.

A controlled approach to stocking with research to monitor the potential impacts to competitors and a process for adapting stocking rates accordingly would reduce the potential for impacts on competitors to 'unlikely'. The consequences would also be reduced from 'moderate' to 'minor' (localised impact within estuary, recovery between 1-3 years) through the application of conservative stocking rates as determined by the GPIM coupled with research and monitoring and so the residual risk level is 'low'(Table G.2).

Table G.2: Summary of measures to reduce impacts on competitors (inter-specific competition).

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Alteration of the distribution, abundance or structure of populations (e.g. through inter-specific competition and/overstocking/increased fishing effort).	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). DPI would carry out routine inspections to ensure compliance with existing fisheries regulations. Research and monitoring.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.7 (a): Facilitate stock releases in timing with the selected species lifecycles and recruitment patterns. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the biodiversity of native populations within stocking areas. Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking	Low

G.2.1.1.3 Impacts on Other Trophic Levels

Key issues identified in Chapter D, Section D.4.1.2.3:

- Alteration of the distribution, abundance or structure of populations - high risk.

Determining the capacity of the receiving estuary to accommodate stocked fish/crustaceans through the GPIM would reduce the risk of overstocking and the potential for undesirable density dependent interactions and consequential impacts at other trophic levels.

Compliance with existing catch and bag limits and size restrictions would also minimise the likelihood of over-harvesting of other competitor species/trophic levels. Catch and effort surveys would commence in regional areas and procedures for the monitoring of catch and effort would be developed upon completion of the stocking plan. This would help determine whether fishing effort substantially increases in stocked areas, such that there might be an impact at other trophic levels.

The FMS would include a controlled approach to stocking with research to specifically monitor the potential impacts at other trophic levels (Research Topic 2.3) and a process for adapting stocking rates accordingly would reduce the potential for impacts on other species by reducing the likelihood of negative impacts occurring to 'unlikely'. The consequences would also be reduced to 'minor' (localised impact within estuary, recovery between 1-3 years) through use of conservative stocking rates as determined by the GPIM and so the overall risk severity becomes 'low' (Table G.3).

Table G.3: Summary of measures to reduce impacts on other trophic levels.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Alteration of the distribution, abundance or structure of populations.	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). DPI would carry out routine inspections to ensure compliance with existing fisheries regulations. Research and monitoring.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking. Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the biodiversity of native populations within stocking areas. Research Topic 2.3 (Priority level 2): To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. Research outcomes would help support the GPIM.	Low

G.2.1.1.4 Impacts on Estuarine Habitat

Key issues identified in Chapter D, Section D.4.1.2.4:

- Direct effects (e.g. overgrazing of seagrass by stocked crustaceans) - high risk;
- Indirect effects (e.g. trampling, littering, habitat disturbance) – high risk.

Direct impacts from herbivory of stocked species on important estuarine habitats i.e. seagrass would be addressed by stocking at appropriate densities according to the GPIM. By stocking at appropriate rates which are calculated according to the amount of primary juvenile habitat, significant impacts would not be expected. As new empirical data is obtained throughout the stocking program, this would be incorporated into the GPIM to improve the confidence in its application. This application and continual improvement of the GPIM specifically reduces the potential for direct effects on the estuarine habitat.

Stocking releases would ideally take place within a 'preferred habitat' to maximise survival. For example, Taylor *et al*. (2006b) suggest that mulloway should be released into deep hole habitat (e.g. by boat). However, where possible releases should take place where there are hard stand access points/boat ramps, or ideally by boat to minimise indirect disturbance to foreshore or intertidal habitat.

Marine stocking would not be carried out in conjunction with specific habitat restoration programs, however, it is an objective of the draft FMS that the marine stocking program is implemented in a manner that would complement existing State and Commonwealth endorsed programs designed to protect aquatic environments and biodiversity (Objective 1.4 a, b). Marine stocking locations would also be the focus of advisory campaigns to promote awareness of habitat sensitivities.

A controlled approach to stocking as is proposed through the draft FMS with research to monitor the potential impacts to habitat and a process for adapting stocking rates accordingly would reduce the likelihood for direct impacts on habitat to 'unlikely'. The likelihood of indirect events remains uncertain and would remain as 'possible'. The consequence for both direct and indirect effects would also be reduced to 'minor' (localised impact within estuary, recovery measurable within 1-3 years) through the application of conservative stocking rates as determined by the GPIM because the scale of impacts would be relatively small under a controlled program and any cumulative impacts can be avoided. Hence, the overall risk severity becomes 'low' for direct impacts and 'moderate' for indirect impacts. (Table G.4).

Table G.4*:* Summary of measures to reduce impacts on estuarine habitat.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Direct effects	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). Research and monitoring.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the biodiversity of native populations within stocking areas.	Low
Indirect effects	Ensure stocking releases take place at suitable access points or by boat. Research and monitoring. Increased advisory campaigns to promote awareness of habitat sensitivities.	Objective 1.4 (a, b): To implement the FMS in a manner consistent with Commonwealth and State endorsed programs designed to protect aquatic biodiversity. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques (This would ensure preferred release locations). Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the biodiversity of native populations within stocking areas.	Moderate

G.2.1.1.5 Impacts on Adjacent Coastal Waters

Key issues identified in Chapter D, Section D.4.1.2.5:

- Potential ecological impacts beyond the estuary e.g. trophic effects and competitive interactions - low risk.

Although the overall risk of ecological impacts beyond the stocked estuary are low as identified in Chapter D, the application of the GPIM (to prevent the risk of overstocking) and dissemination of information attained from research and monitoring carried out as part of the FMS specifically through Research Topic 2.1, would help to further mitigate these potential risks. Research Topic 2.1 of the draft FMS specifically aims to determine the distances travelled by stocked species and may help provide more accurate information on impacts beyond the stocked estuary (Table G.5).

Table G.5: Summary of measures to reduce impacts on adjacent coastal waters

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Potential ecological impacts beyond the estuary e.g. trophic effects and competitive interactions.	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). Research and monitoring.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Research Topic 2.3 (Priority level 2): To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. Research outcomes would help support the GPIM. Research Topic 2.1 (Priority Level 1) Investigate distance stock travel from point of release.	Low

G.2.1.2 Threatened Species

Threatened and protected species, populations and ecological communities listed under the relevant State and Commonwealth legislation that could potentially occur within NSW estuaries are listed in Chapter C, Section C.9.1. Key issues associated with the proposal as having potential to affect threatened species are identified in Chapter D, Section D.4.4.2. The following sections focus on how the draft FMS mitigates risks to threatened species with respect to the key issues. For brevity, generalised statements are used for species that utilise similar habitats except where it is apparent that a particular species would be more vulnerable than others. The conclusions from State and Commonwealth 'Assessments of Significance' applied to particular species, groups of species, populations or ecological communities are included in this Section (complete assessments in Appendices 2 and 3), as they are taken into account in deciding whether there are likely to be significant effects on threatened species or their habitats.

G.2.1.2.1 Key Threatening Processes (KTPs)

Key issues identified in Chapter D, Section D.4.2.2.1:

- *Hook and line fishing in areas important for the survival of threatened fish species* (FM Act) - high risk;
- *Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* (EPBC Act) - high risk;
- *Entanglement or ingestion of anthropogenic debris in marine and estuarine environments* (TSC Act) - high risk.

There is potential for a localised increase in fishing effort with the implementation of marine stocking, which may exacerbate the above KTPs. Although it is uncertain whether local increases to fishing effort would occur with the proposal, the draft FMS, however, acknowledges that they may occur. To minimise risks of KTPs, stocking would not take place in declared critical habitats. Changes to fishing effort associated with stocking at the local scale can only be determined with monitoring and review over the course of a stocking event. Under Research Topic 2.2 (impacts of native fish stocking on threatened species and areas of conservation significance) the draft FMS also proposes a monitoring program to investigate the incidence of injury/fatality from harmful marine debris and/or hooking. Risks to threatened species would be evaluated in accordance with stocking events and the outcomes of the monitoring reviewed against key performance indicators (Chapter E, Table E.9). Fishing effort and changes in local effort associated with stocking would also be monitored as per Objective 2.3 (d). Education on general responsible fishing, threatened species and methods to report sightings or incidents would be included as part of a strategy to minimise any negative impact of the activity on threatened or protected species (Objective 1.2 d).

If a significant impact on a threatened species is detected or if new information on a threatened species becomes available, then the stocking program would be adapted accordingly. For example, this could involve de-listing of estuaries where adverse interactions with a threatened species became apparent or reducing stocking rates.

Providing that the above measures are in place then the likelihood of stocking exacerbating any of the relevant KTPs would be reduced from 'possible' to 'unlikely' and the residual risk is 'moderate' (Table G.6).

Table G.6: Summary of measures to reduce impacts of Key Threatening Processes.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Hook and line fishing in areas important for the survival of threatened fish species	Stocking would not take place into declared critical habitat of a threatened species of fish. Monitor incidence of injury/fatality from harmful marine debris and/or hooking and manage as appropriate. Monitoring of fishing catch and effort. Education on threatened species and responsible fishing.	Table E.5 waters with restrictions to stocking. Objective 1.2 (a): To appropriately manage stocking in areas where the activity may adversely affect a threatened species. Any stocking event that has the potential to affect a threatened species would be thoroughly reviewed to prevent or minimise any potential impact. Objective 1.2 (b): to record and monitor sightings and incidences involving threatened and protected species within stocked estuaries. Objective 1.2 (d): to educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries. Research Topic 2.2 (Priority level 2) Impacts of native fish stocking on threatened species and areas of conservation significance. Including monitoring the incidence of injury/fatality of hooking/harmful marine debris. Research Topic 2.3 (d): Monitor the	Moderate
Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris			Moderate
Entanglement or ingestion of anthropogenic debris in marine and estuarine environments			Moderate

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		level of fishing effort and changes in effort associated with stocking.	

G.2.1.2.2 Trophic Impacts

Key issues identified in Chapter D, Section D.4.2.2.2:

- Alteration of distribution, abundance and structure of populations - high risk.

NSW estuaries are host to a large number of bird, fish and invertebrate species. Most of these have potential to be affected by trophic interactions arising from stocking but the species most likely to be affected are benthic omnivores/scavengers and also some wader birds as these would be competing directly with juvenile stocked fish and crustaceans for food.

To address the issue, the approach taken to minimising the potential for trophic impacts is to limit stockings so that stocked fish or crustaceans only use a small proportion of the total food resources within an estuary. The numbers of individuals stocked in any one estuary would not exceed the stocking rates as estimated by the GPIM (Chapter E, Appendix E.6) and as such, stocking would be unlikely to result in the disruption of the ecological balance of an estuary. The stocking rates are also based on the allocation of 5 % of the total resources within an estuary (discussed in Chapter F, Section F.5.4), which, based on previous trial stockings is considered to be precautionary.

Given the conservative numbers of stocked fish within any one estuary, impacts on threatened and protected species that are benthic omnivores/scavengers consumers would therefore be unlikely. There would be little risk to higher order consumers as stocking is more likely to provide more food to these trophic groups.

The draft FMS acknowledges limitations to the modelling that has been used to estimate the carrying capacity of estuaries and stocking rates. The stocking rates would, however, be refined through the research and monitoring proposed in the draft FMS. (Objective 1.2 d) of the draft FMS is to apply empirical methods to determine optimum stocking rates and also to undertake further research into food chain interactions between stocked fish and the environment (Research Topic 2.3). As new data becomes available, this would be used to further validate and refine the GPIM and help to develop and apply an established formula for use in the long-term (as per Objective 1.2c and Research Topic 3.2 (1)).

Providing that the above measures are in place then the likelihood of stocking causing adverse trophic impacts on threatened and protected species would be reduced to 'unlikely' and the consequence to 'minor' (localised impact within an estuary with recovery measurable within 1-3 years) through the application of conservative stocking rates as determined by the GPIM. The residual risk would be reduced to 'low' (Table G.7).

Table G.7: Summary of measures to reduce potential trophic impacts on threatened and protected species.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Alteration of distribution, abundance and structure of populations.	Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence of estimates). Monitoring and research to determine potential trophic impacts through food chain interactions. Monitoring of fishing catch and effort.	Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		estuarine waters. Research Topic 2.3 (Priority level 2): To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. Research outcomes would help support the GPIM. Research Topic 2.3 (d): Monitor the level of fishing effort and changes in effort associated with stocking.	

G.2.1.2.3 The Potential for a Concentration/Increase in Recreational Boating Activity

Key issues identified in Chapter D, Section D.4.2.2.3:

- Acoustic disturbance (marine mammals) - moderate risk;
- Boat strike (marine mammals and loggerhead turtles) - low risk.

There are existing restrictions on the distances of approach and interaction with marine mammals, which is regulated under the NSW National Parks and Wildlife Regulation (2009), and administered by the OEH. This would minimise the potential risk of acoustic disturbance or boat strike to these animals. In Queensland (QLD), loggerhead turtles and dugongs are known to be susceptible to boat strike and there is no reason to believe that they would not also be susceptible in NSW. The draft FMS acknowledges the risk of boat strike could be increased with an increase to boating activity and includes objectives to appropriately manage stocking in areas where the activity may adversely affect a threatened species (Objective 1.2 a) and to record and monitor marine mammal sightings or any incidence of boat strike within stocked estuaries in a central stocking database (Objective 1.2 b).

Education on general responsible fishing, threatened species and methods to report sightings or incidents would be included as part of a strategy to minimise any negative impact of the activity on threatened or protected species (Objective 1.2 d). DPI would provide educational material to stakeholders and there are currently mechanisms in place to allow the angling public to report incidences and sightings of threatened and protected species. DPI would continue to improve understanding and awareness relating to threatened species in areas where stocking may take place.

Fishing effort and changes in local effort associated with stocking would be monitored as per Objective 2.3 (d).

Research Topic 2.2 also aims to investigate impacts of marine stocking on threatened species and areas of conservation significance. The draft FMS would be reviewed and updated in light of further information or new species listings.

The mitigative measures outlined would reduce the likelihood of boat strike to ‘rare’ and the residual risk to ‘low’ (Table G.8). Measures to manage the potential for impacts to water quality and noise associated with a potential increased in boating activity are described in Section G.2.3.

Table G.8: Summary of measures used to reduce potential risks of increased boating activity on threatened species.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Acoustic disturbance (marine mammals)	Education on threatened species and responsible fishing. Monitoring of fishing catch and effort.	Objective 1.2 (a): To appropriately manage stocking in areas where the activity may adversely affect a threatened species. Any stocking event that has the potential to affect a threatened species would be thoroughly reviewed to prevent or minimise any potential impact. Objective 1.2 (b): to record and monitor sightings and incidences involving threatened and protected species within stocked estuaries. Objective 1.2 (d): to educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries. Research Topic 2.2 (Priority level 1): Impacts of native fish stocking on threatened species and areas of conservation significance. Research Topic 2.3 (d): Monitor the level of fishing effort and changes in effort associated with stocking.	Low
Boat strike (marine mammals and loggerhead turtles)			Low

G.2.1.2.4 Incidental Capture

Key issues identified in Chapter D, Section D.4.2.2.3:

- Injury/mortality - high risk.

Incidental capture is unlikely to have a significant impact such that it could affect viable populations of threatened or protected species. However, localised increases in fishing effort could result in an increase (beyond current levels) in the incidental capture of some species leading to hooking injury and/or death. Although stocking would not take place in declared critical habitat (Chapter E, Table E.5), critical habitat has not been identified for many of the threatened species vulnerable to incidental hooking.

DPI would continue to educate fishers operating in estuaries to help minimise the risk of impacts (Objective 1.2 d). The education program would include provision of information in the identification of threatened and protected species and best practice in the release of incidentally caught fish.

In addition, the draft FMS acknowledges the potential for marine stocking to cause local increases in fishing effort and proposes a monitoring program where fishing effort and the associated risks to threatened species would be evaluated in accordance with stocking events (Objective 1.2 b and Objective 2.3 d). The outcomes of the monitoring would provide key performance indicators of stocking that will relate measurement of fishing effort to threats or harm to threatened species. If a significant impact on a threatened species is detected or if new information on a threatened species becomes available (e.g. through review of the NSW Wildlife Atlas), then the stocking program would be adapted accordingly as per Objective 1.1 (a). For example, this could involve de-listing of estuaries where adverse interactions with a threatened species became apparent or reducing stocking rates. It should also be ensured that existing mechanisms used by DPI for reporting sightings and/or incidence of incidental capture (e.g. online forms) are linked to a stocking database and utilised to help inform monitoring work. These measures would

reduce the likelihood of mortality of threatened species resulting from incidental capture associated with increased fishing activity to 'unlikely'. Providing that the measures outlined in the draft FMS are in place then the likelihood of stocking causing the incidental capture of threatened species would be reduced to 'unlikely' and the consequence to 'moderate', hence the residual risk would be reduced to 'moderate' (Table G.9).

Table G.9: Summary of measures used to reduce the potential risk of incidental capture on threatened species.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Injury/mortality.	Stocking would not take place into declared critical habitat of a threatened species of fish. Monitor incidence of incidental capture of a threatened species. Use of existing DPI mechanisms in place to report incidental catch or sightings of threatened or protected species. Education on threatened species and responsible fishing. Monitoring of fishing catch and effort.	Table E.5 Waters with restrictions to stocking. Objective 1.2 (a): To appropriately manage stocking in areas where the activity may adversely affect a threatened species. Any stocking event that has the potential to affect a threatened species would be thoroughly reviewed to prevent or minimise any potential impact. Objective 1.2 (b): to record and monitor sightings and incidences involving threatened and protected species within stocked estuaries. Objective 1.2 (d): Objective 1.2 (d): to educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries. Research Topic 2.2 (Priority Level 1): To determine interactions between stocked fish and threatened species and areas of conservation significance. Research Topic 2.3 (d): Monitor the level of fishing effort and changes in effort associated with stocking.	Moderate

G.2.1.2.5 Damage to Habitat

Key issues identified in Chapter D, SectionD.4.2.2.4:

- Trampling/ habitat disturbance – high risk.

The draft FMS recognises the fragility of estuarine habitat and also those specific areas of habitat within estuaries have been identified as important to the survival of threatened species. Habitat disturbance specifically through human disturbance at roost and feeding sites has been identified as a specific threat to the endangered *Shorebird community occurring on the relict tidal delta sands at Taren Point*. Disturbance to this endangered ecological community could increase beyond current levels if stocking were to increase fishing effort in the Georges River. As a precautionary approach, the draft FMS has closed endangered ecological community at Taren Point to stocking to mitigate the potential risks to this particular endangered ecological community.

Posidonia australis meadows at Port Hacking, Botany Bay, Port Jackson, Pittwater, Brisbane Waters and Lake Macquarie are endangered populations with potential to be affected by the proposal because of its potential to cause local increases in fishing effort and associated trampling. Other areas of *Posidonia* and other types of seagrass

which are important habitat to some threatened species would also be vulnerable to an increased risk of trampling if fishing effort were to increase.

If the risk of trampling were to increase, it is considered, however, that impacts would be confined to the very near shore of estuaries and hence would have little potential to affect the persistence of meadows of seagrass at any location.

As described in Section G.2.1.1.4 stocking releases would ideally take place where there are hard stand access points/boat ramps, or by boat to minimise habitat disturbance to banks and foreshores.

Notwithstanding this, the draft FMS proposes monitoring and a research plan where fishing effort and the associated risks to threatened species (and their habitat) are evaluated in accordance with stocking events (Objective 1.2 b and Objective 2.3 d). Providing that the measures outlined in the draft FMS are in place, the likelihood of trampling/habitat disturbance occurring as a result of marine stocking would remain as 'possible' and the consequences lowered to 'minor', hence the residual risk level would be 'moderate' (Table G.10).

Table G.10: Summary of measures to minimise potential risks on habitat important to threatened and protected species.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Trampling/ habitat disturbance.	Stocking would not take place at Taren Point (Botany Bay) where there is an endangered ecological community of shorebirds. Releases would take place from suitable access points or by boat. Monitoring of fishing catch and effort.	Table E.4 (Waters permanently closed to stocking): Objective 1.2 (a): To appropriately manage stocking in areas where the activity may adversely affect a threatened species. Any stocking event that has the potential to affect a threatened species would be thoroughly reviewed to prevent or minimise any potential impact. Research Topic 1.2 (Priority Level 1): To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of conservation significance and MPAs. Research Topic 2.3 (d): Monitor the level of fishing effort and changes in effort associated with stocking.	Moderate

G.2.1.2.6 Summary of Impacts to Threatened Species

Threatened or protected species, populations or endangered ecological communities that are most likely to be affected by marine fish stocking are those that would compete directly with stocked fish or crustaceans for the same food or habitat or those that would be affected by activities (i.e. disturbance or incidental capture) associated with potential localised increases to fishing effort. This includes almost all of the listed threatened or protected species, populations or endangered ecological communities that occur in estuaries because of the changing dietary and habitat needs of stocked fish or crustaceans that occur ontogenically and because activities associated with potential localised increases to fishing effort could affect all estuarine habitats.

To mitigate risk to threatened or protected species, populations or endangered ecological communities, the draft FMS gives careful consideration to stocking rates so that stocking events would not disrupt the ecological balance of an estuary and research is proposed to learn from stockings so that stocking rates can be refined as necessary. In addition, the draft FMS recognises the implications of the uncertainly associated with the potential for localised increases to fishing effort by proposing close monitoring for potential changes to fishing effort and incidents to threatened species so that unsatisfactory linkages between the two can be recognised where they have occurred

and the program modified accordingly. As such, it is concluded that the proposed harvest stocking program is not considered to have a significant impact on any threatened species, population or endangered ecological community (including those which are matters of National Environmental Significance), therefore a Species Impact Statement or a referral under the EPBC Act is not considered to be required.

G.2.1.3 Areas of Conservation Significance

G.2.1.3.1 Marine Park/Ramsar

Key issues identified in Chapter D, Section D.4.3.2.1:

- Potential impacts on Ramsar wetlands – low risk;
- Potential impacts on the conservation value of Marine Parks – low risk.

As estuaries occurring within Ramsar wetlands and/or Marine Parks would not be stocked (as determine in the MCA, Chapter B) and the risks to these area was identified in Chapter D as 'low', no direct mitigative action is considered necessary. Under the draft FMS, these waters are closed to marine stocking. It is concluded that the proposed harvest stocking program is not considered to have a significant impact on any wetland of international importance (listed under the Ramsar convention), therefore a referral under the EPBC Act is not considered to be required.

Although the harvest stocking program would aim to have minimal impact on MPAs and stocking would not take place within MPAs, there is potential to add value to MPAs through the marine stocking program i.e. by facilitating and assisting in stocking for conservation purposes. The impacts of conservation stockings however, would be assessed separately under Part 5 of the EP&A Act.

The draft FMS also addresses a number of other issues that have a 'low' risk of affecting these areas (i.e. disease, ecological interactions, habitat degradation). Therefore, the likelihood of indirect impacts to these areas would be further reduced to 'rare', although the residual risk level remains as 'low' (Table G.11).

Table G.11: Summary of measures to minimise potential risks on Marine Park/Ramsar.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Potential impacts on Ramsar wetlands	Ramsar wetlands would be completely closed to marine fish stocking.	Table E.4: waters permanently closed to stocking. Table E.5: waters with restrictions to stocking.	Low
Potential impacts on the conservation value of Marine Parks	Marine Parks would be completely closed to marine fish stocking.	Table E.4: waters permanently closed to stocking. Table E.5: waters with restrictions to stocking.	Low

G.2.1.3.2 Aquatic Reserves

Key issues identified in Chapter D, Section D.4.3.2.2:

- Potential impacts on the conservation value of Aquatic Reserves – high risk.

Potential impacts on Aquatic Reserves would be mitigated by not stocking into those areas and designating them as 'waters with restrictions to stocking' (Chapter E, Table E.5). This is most relevant to Towra Point (Botany Bay), Ship Rock (Port Hacking) and North Harbour (Port Jackson) Aquatic Reserves as they occur within estuarine waterways, whereas all other Aquatic Reserves in NSW are located in coastal waters outside estuary mouths. Note that stocking would still be permitted in other parts of these estuaries.

Research would be undertaken to monitor the movements of stocked fish (Research Topic 2.1) which would help determine the potential for interactions with areas of conservation significance. Under Research Topic 2.2 interactions between stocked fish, threatened species and areas of conservation significance would also be investigated.

Provided this is done, in combination with other mitigative and management strategies to minimise biological impacts as discussed in this Chapter (ecological, threatened species, genetics and disease risks), the likelihood of impacts to

Aquatic Reserves would be reduced from 'possible' to 'unlikely' and the consequences reduced from 'moderate' to 'minor', hence the residual risk level would be 'low' (Table G.12).

Table G.12: Summary of measures to reduce risks to Aquatic Reserves.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Potential impacts on the conservation value of Aquatic Reserves.	Estuaries that have Aquatic Reserves would not be excluded from stocking, but stocking would not take place within Aquatic Reserves.	Table E.5: waters with restrictions to stocking. Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements. Research Topic 2.1 (Priority Level 1): To determine the distance that stock may travel from the point of release. Research Topic 2.2 (Priority Level 1): To determine interactions between stocked native fish and threatened species and areas of conservation significance.	Low

G.2.1.3.3 Critical Habitat, Nature Reserves, National Parks

Key issues identified in Chapter D, Section D.4.3.2.3:

- Potential impacts on the conservation value of National Parks with marine extensions and Nature Reserves - low risk;
- Potential impacts on the conservation value of Critical Habitats – low risk.

As identified in Chapter D, areas of declared Critical Habitat, or marine extensions of National Parks or Nature Reserves do not currently exist within estuaries listed as suitable for marine stocking and hence, the draft FMS does not currently list these areas as closed to stocking. Given the substantial distance of these areas from estuaries suitable for stocking, the risks to these areas were considered to be 'low'. If, however, for future management needs, these areas are declared within estuaries which are stocked, then they may be designated as 'waters with restrictions to stocking' so that stocking could not take place within them. The draft FMS contains a provision within Table E.6 for the listing of these areas as waters closed to stocking should the need arise.

It should also be noted that the draft FMS addresses a number of other issues that have a 'low' risk of indirectly affecting these areas (i.e. disease, ecological interactions, habitat degradation), therefore, the likelihood of indirect impacts to these areas would be further reduced from 'unlikely' to 'rare', although the residual risk level remains as 'low'(Table G.13).

Table G.13: Summary of measures to reduce risks to Critical Habitat, Nature Reserves, National Parks.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Potential impacts on the conservation value of Nature Reserves and National Parks with Marine extensions.	Stocking would not take place within marine extensions of Nature Reserves or National Parks.	Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements. Research Topic 1.2 (Priority Level 1): To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		conservation significance and MPAs. Research Topic 2.1 (Priority Level 1): To determine the distance that stock may travel from the point of release. Research Topic 2.2 (Priority Level 1): To determine interactions between stocked native fish and threatened species and areas of conservation significance. Table E.6: Factors for listing and de-listing waters with restricted stocking.	
Potential impacts to Critical Habitat	Stocking would not take place within declared Critical Habitats.	Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements. Research Topic 1.2 (Priority Level 1): To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of conservation significance and MPAs. Research Topic 2.1 (Priority Level 1): To determine the distance that stock may travel from the point of release. Research Topic 2.2 (Priority Level 1): To determine interactions between stocked native fish and threatened species and areas of conservation significance. Tables E.5: waters with restrictions to stocking. Table E.6: Factors for listing and de-listing waters with restricted stocking.	Low

G.2.1.4 Population Genetics

G.2.1.4.1 Direct Impacts

Key issues identified in Chapter D, Section D.4.4.2.1:

- Ryman-Laikre effect - high to moderate risk;
- Introgression - high to moderate risk.

The existing HQAS mitigates direct genetic effects by ensuring that high genetic effective population size is maintained for stock reared in the hatchery. The current Hatchery Quality Assurance Program (HQAP) indicates an effective population size (N_e), which is calculated from the number of broodstock used to produce fingerlings, should be at least 50 per generation. An effective population size of 50 can be achieved by using at least 5 different pairs of broodstock each year to produce each batch of fingerlings for stocking in a location over a 5-year period (Rowland and Tully 2004).

It is, however, of key importance that the existing HQAS protocol is developed to accommodate marine species proposed for stocking. In its current form, much of Parts 1, 2 and 4 of the HQAS are already generalised and applicable to marine stocking. Apart from including reference to marine stocking as well as freshwater stocking these

sections require no modification. Many of the Standards (Part 3) referred to in HQAS are also generalised. However, the following sections of Part 3 would be modified as detailed below.

Part 3.2. Broodstock genetic regions

This section would be modified to include the broodstock collection regions for the marine species to be stocked under the proposal. As outlined in Chapter E, Section E.5.2 and Appendix E.3 for five of the species selected for stocking (yellowfin bream, mulloway, dusky flathead, sand whiting and giant mud crabs), it is unclear whether separate stocks occur in some estuaries or whether stocks are panmictic in NSW. Until further information is known about their genetic population structure and in applying the precautionary approach, broodstock for yellowfin bream, mulloway, dusky flathead, sand whiting and giant mud crabs, would be collected from the same estuaries in which stocking is to be done. If future, peer-reviewed studies on the genetic stock structure of these species in NSW does not reject the hypothesis of panmixia, then the constraint on using locally collected broodstock could be revised.

More information is known about the stock structure of eastern king prawns and the blue swimmer crabs (discussed in Sections C.8.5.1 and C.8.7.1) and the broodstock collection zones would be less constrained for these species. For eastern king prawns, two stocking regions would be established:

1. Southern stocking region - broodstock for any stockings in this region must be collected from offshore waters in northern NSW. The southern stocking region covers all estuaries south of and including the Hastings River to the Victorian border.

2. Northern stocking region - As the potential exists for local spawning and recruitment to northern NSW estuaries, broodstock for stocking in the northern stocking region must be sourced from the estuary that is to be stocked. The northern stocking region covers all estuaries north of and including Killick Creek to the QLD border.

Populations of blue swimmer crabs in NSW occurring north of Port Stephens are regarded as a single stock, however, little is known about the stock structure south of this. As such, two stockings regions would be established:

1. Northern stocking region - broodstock for any stockings in this region must be collected from within this region. The northern stocking region covers all estuaries north of and including Port Stephens to the QLD border.

2. Southern stocking region - As little information was available about the genetics of natural populations of blue swimmer crabs occurring south of Port Stephens; a southern stocking region has also been established. Broodstock for the marine stocking program in this region must be sourced from the estuary that is to be stocked. The southern stocking region covers all estuaries south of and including the Hunter River to the Victorian border.

These requirements would be maintained in the FMS until genetic studies provide further information about local recruitment to these estuaries. Species specific stocking guidelines directly relevant to species ranges in NSW would also be developed and implemented under the draft FMS (Objective 1.3 b).

Part 3.11. Broodstock and breeding - S26. Tagging

This standard needs to be modified so that 'the hatchery must have a satisfactory system to individually identify species proposed for marine stocking'.

Part 3.11. Broodstock and breeding - S27. Separation

This standard needs to be modified so that 'the hatchery must have sufficient ponds or tanks to separate yellowfin bream, mulloway, dusky flathead, sand whiting and giant mud crabs from different broodstock genetic regions. Different species from different broodstock genetic regions must be kept separate during concurrent production runs'.

Modification of the HQAS standards to include best practice procedures for collection of broodstock and producing progeny would help to ensure that the genetic diversity and genetic effective population size of target populations is maintained. Hatcheries in NSW that produce fingerlings, post-larval prawns or crablets for stocking must be suitably accredited under the HQAS. Note that the proposed harvest stocking program would not be used to produce non-breeding (e.g. triploid) animals.

Research and monitoring plans are proposed in the draft FMS for reducing the potential for direct genetic effects. Research and monitoring would be carried out in representative estuaries to determine baseline genetic effective population size of wild fish populations in estuaries to be stocked. The genetic effective population size (N_e) of cohorts of stocked fish needs to be determined and compared to the effective population of the receiving population

(as per Research Topic 1.3 (2)). If the effective size of the receiving population drops below 100, stocking should be halted or a revised genetic rescue stocking strategy implemented to restore the lost N_e.

Provided these measures are carried out, the likelihood of Ryman-Laikre would be reduced from 'possible' to 'unlikely' (i.e. could occur as a result of the project but is not expected) for all species except the eastern king prawn for which the overall risk level would remain at 'moderate'. This is because the life cycle of the eastern king prawn is such that adults and juveniles move to waters off northern NSW and QLD to spawn (Montgomery 1990, Montgomery *et al.* 2007). Therefore interbreeding between stocked individuals and wild conspecifics would be 'rare' as a substantial proportion of prawns stocked into estuaries are likely to be caught before making a northern spawning migration and hence direct genetic effects (caused as a result of interbreeding) are less likely than for other species that spawn nearshore or in the entrance to estuaries where they were stocked. As the likelihood is already 'rare' and the consequences would still be moderate if effects did occur, the residual risk cannot be further reduced, but is accepted.

The risk of introgression would be reduced from 'high' to 'moderate' for all species (except eastern king prawn) by reducing the likelihood of occurrence. The likelihood of introgression occurring for eastern king prawn remains at 'rare' and cannot be reduced further, for the same reasons explained above.

Measures to manage and mitigate potential direct genetic effects and the relevant parts of the draft FMS are summarised in Table G.14 below.

Table G.14: Summary of measures to reduce risk of direct genetic effects (Ryman-Laikre effect and introgression).

Key Issues	Management Strategy	Relevant Section of the FMS	Residual Risk
Ryman-Laikre effect. Introgression.	HQAS would be developed to include the selected marine species. Fish/crustaceans would only be stocked by HQAS accredited hatcheries or equivalent recognised standard. ▪ Hatchery management procedures outlined in the HQAS would be implemented to maintain high genetic effective population size e.g. an Ne of 50 broodstock per generation ▪ Broodstock used for stocking would be from the same genetic stock as that in the estuary to be stocked (except for eastern king prawn and blue swimmer crab which have specific requirements). Research and Monitoring ▪ Research on the genetic stock structure of yellowfin bream, mulloway, dusky flathead, whiting, mud crab, blue swimmer crab and eastern king prawn should be carried out to reduce broodstock collection constraints. Research and monitoring to assess changes in genetic diversity (e.g. every 5 years).	Appendix E.3 (Section E.5.2) Broodstock collection regions. Objective 1.3 (a): To develop and implement genetic resource management guidelines for marine fish stocking in NSW. Objective 3.1 (a): To develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 1.3 (b): To develop and implement species specific stocking guidelines directly relevant to species ranges in NSW. Objective 3.2 (a): Ensure the use of appropriate technology in genetic resource management Objective 3.3 (a, b, c): To implement best practice in broodstock collection and management. Research Topic 1.1 (Priority Level 1): To research and map the genetic distribution of native species used in the activity. Research Topic 1.3 (1)(Priority level 1): Review current literature and research the most appropriate genetic protocols under NSW conditions with regard to native species breeding programs and broodstock management arrangements.	Moderate

Key Issues	Management Strategy	Relevant Section of the FMS	Residual Risk
		Research Topic 1.3 (2) (Priority level 1): determine the genetic effective population size of the target species population in each estuary where stocking is occurring. As part of this exercise, samples must be collected from target estuaries and species before stocking commences in order to establish pre-stocking benchmark conditions. Research Topic 1.3 (3) (Priority level 1): research into the most appropriate genetic markers that can be applied to potential broodstock to test their ancestry. Interbreeding between native and stocked individuals would lead to offspring of mixed ancestry.	

G.2.1.4.2 Indirect Impacts

Key issues identified in Chapter D, Section D.4.4.2.2:

- Wastage of gametes - extreme to low risk;
- Naturalisation leading to fragmentation – moderate to low risk;
- Overfishing of mixed stock fisheries leading to a reduction in genetic diversity – moderate to low risk.

For all proposed species HQAS standards for broodstock management and production of progeny (as discussed in the previous Section) would help ensure that viable offspring would be produced and risks of wastage of gametes remains at 'low'.

For yellowfin bream further mitigative action also needs to take place to prevent potentially extreme impacts of gametic wastage on black bream populations, as such stocking of yellowfin bream would not be conducted in areas where yellowfin bream and black bream populations coexist (i.e. south of the Manning River). This includes a buffer zone of approximately 50 km between the first suitable yellowfin bream stocking site and the northern extent of the known black bream distribution. This would control the possible flow of stocked yellowfin bream southwards into black bream populations. The risk of wastage of gametes occurring would therefore be reduced from 'extreme' to 'low' (for yellowfin bream).

The risk of naturalisation and subsequent fragmentation occurring for all proposed species is minimised through the application HQAS standards for broodstock management and production of progeny (as discussed in the previous Section) which would help to ensure that offspring produced would be of the same genetic makeup as the estuary being stocked. The risk level remains at low for those species that can disperse along the coast in their adult stages (i.e. yellowfin bream, mulloway, dusky flathead, sand whiting, and eastern king prawns) and that are assumed to disperse within estuaries. These populations are more likely to become sympatric (i.e. co-occurring) with stocked fish and crustaceans rather than isolated by groups of them that had become naturalised. Risks of naturalisation leading to fragmentation of wild populations is more of an issue for giant mud crabs and blue swimmer crabs which may not disperse at a later stage in their life cycle. This risk would be minimised by not exceeding maximum stocking rates, as estimated by the GPIM so that the potential for overstocking and competition between conspecifics and stocked fish would be minimal. Stockings would also be variable in space and time and several release sites should be identified per estuary with stocked individuals released randomly among these sites. This would minimise the possibility of natural populations within an estuary being isolated from one another by the presence of large numbers of stocked crabs. Thus, the overall risk would be reduced from 'moderate' to 'low' as both the likelihood and consequences would be reduced.

Existing fishing regulations on gear type and restrictions on bag and size limits for the stocked species are considered adequate measures to minimise potential impacts of overfishing from a potential localised increase in

fishing effort associated with stocking. However, appropriate monitoring (e.g. of catch rates for commercial and recreationally important species and fishing effort) would also be implemented as part of the research and monitoring plan to measure whether stocking significantly increases fishing effort to a level that may result in overfishing. This would reduce the likelihood of overfishing leading to a reduction in genetic diversity in all species to 'rare' and reduce the consequence to 'minor'; hence the residual risk level would be 'low' for all species. Further research into the population structure of species for which there is uncertainty is also a priority and would help address this issue by identifying species which form a panmictic east coast population (Research Topic 1.1).

Measures to manage and mitigate potential indirect genetic effects are summarised in Table G.15 below.

Table G.15: Summary of measures to reduce risks of indirect genetic effects.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Wastage of gametes. Naturalisation leading to fragmentation. Overfishing of mixed stock fisheries leading to a reduction in genetic diversity.	Yellowfin bream should not be stocked south of the Manning River (including a 50 km buffer zone). All other HQAS measures to preserve genetic integrity as outlined in Section G.2.1.4. Variation of stockings in space and time. Maximum stocking rates would not be exceeded to minimise risk of overstocking or swamping, (new data would be incorporated into the GPIM to improve confidence in estimates). Appropriate monitoring (e.g. of catch rates and fishing effort) carried out as part of the monitoring and research plan. DPI would carry out routine inspections to ensure compliance with existing fisheries regulations. HQAS would be developed to include the selected marine species. Fish/crustaceans would only be stocked by HQAS accredited hatcheries or equivalent recognised standard. ▪ Hatchery management procedures outlined in the HQAS would be implemented to maintain high genetic effective population size e.g. an Ne of 50 broodstock per generation ▪ Broodstock used for stocking would be from the same genetic stock as that in the estuary to be stocked (except for eastern king prawn and blue swimmer crab which have specific requirements).	Appendix E.3 of the FMS outlines the approved stocking regions for each species permitted for stocking. Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 2.3 (d): Monitor the level of fishing effort and changes in effort associated with fish stocking. Objective 4.2 (a, b): Maintain and report on accurate information relating to the activity. Research Topic 1.1: To research and map the genetic population structures of mulloway, giant mud crab, yellowfin bream and sand whiting. Appendix E.3 (Section E.5.2) Broodstock collection regions. Objective 1.3 (a): To develop and implement genetic resource management guidelines for marine fish stocking in NSW. Objective 3.1 (a): To develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 1.3 (b): To develop and implement species specific stocking guidelines directly relevant to species ranges in NSW.	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		Objective 3.2 (a): Ensure the use of appropriate technology in genetic resource management. Objective 3.3 (a, b, c): To implement best practice in broodstock collection and management. Research Topic 1.1 (Priority Level 1): To research and map the genetic distribution of native species used in the activity. Research Topic 1.3 (1)(Priority level 1): Review current literature and research the most appropriate genetic protocols under NSW conditions with regard to native species breeding programs and broodstock management arrangements.	

G.2.1.5 Disease, Parasites and Pests

G.2.1.5.1 Infection of Hatchery-Reared Fish and Crustaceans with Exotic Disease/Parasite Causing Contamination of Farm and Adjacent Waterways

Key issues identified in Chapter D, Section D.4.5.2.1:

- Infection of hatchery-reared fish with exotic disease/parasite causing contamination of farm and adjacent waterways – high risk;
- Infection of hatchery-reared crustaceans with exotic disease/parasite causing contamination of farm and adjacent waterways – high risk.

Preventing the occurrence of diseases exotic to NSW in hatcheries and adjacent waterways is largely reliant upon National and State importation and screening polices. Australia is isolated from other major land masses which have afforded a high level of prevention and biosecurity controls against exotic diseases and parasites. Regular import risk analyses and reviews of quarantine arrangements in Australia and State-based translocation policies for cultured organisms aim to maintain the low prevalence of animal disease (Biosecurity Australia 2010). In the event that an exotic disease was identified within an aquaculture facility, the risk of transfer into the environment can be appropriately controlled through quarantine procedures including containment of the farmed species and appropriate treatment and disposal of any transport medium and discharge (MCFFA 1999). The existing freshwater HQAS would be modified to include marine species proposed for stocking. This is considered to be the key to disease prevention and management, which includes quarantine procedures, surveillance and monitoring within hatchery facilities and disease zoning policies. This would also involve a system whereby relevant biosecurity authorities would immediately be notified of any disease thought not to occur in Australia or in NSW.

Although these mitigative measures are considered to be highly effective, the risk severity remains 'moderate' (Table G.16). This is because while the likelihood of occurrence would be 'rare' due to the implementation of the HQAS, the consequences of viral infection would not change (i.e. the virulence of the virus or other disease causing organism would be unlikely to be affected). So although, the residual risk is 'moderate', there are no mitigative measures that can be applied to further reduce the consequence. Provided mitigation is in place to reduce the likelihood, the risk of infection and potential for transfer into natural waterways is considered to be acceptable.

Table G.16: Summary of measures to reduce risks of infection of hatchery-reared fish and crustaceans with exotic disease/parasite causing contamination of farm and adjacent waterways.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Infection of hatchery-reared fish with exotic disease/parasite causing contamination of farm and adjacent waterways. Infection of hatchery-reared crustaceans with exotic disease/parasite causing contamination of farm and adjacent waterways.	Fish/crustaceans would only be stocked from HQAS accredited hatcheries or hatcheries receiving a similar level of assessment and accreditation in other States. This specifically includes: ▪ implementing stringent farm containment and disinfection plans; ▪ disease zoning policies; and Immediate notification of health authorities if there is potential disease risk.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.1 (c): Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated.	Moderate

G.2.1.5.2 Infection of Hatchery-Reared Fish and Crustaceans with Endemic Disease/Parasite Causing Contamination of Farm and Adjacent Waterways

Key issues identified in Chapter D, Section D.4.5.2.2:

- Infection of hatchery-reared fish with endemic disease/parasite causing contamination of farm and adjacent waterways – moderate risk;
- Infection of hatchery-reared crustaceans with endemic disease/parasite causing contamination of farm and adjacent waterways – moderate risk.

The draft FMS through the implementation of the HQAS, which will be developed to include the selected marine species, proposes the implementation of biosecurity protocols such as water filtration, sterilisation procedures and disease and health management standards/protocols which would minimise the influx of endemic diseases into farming facilities. Infection of broodstock in hatcheries with endemic diseases can be minimised through screening of broodstock and seedstock (histology and PCR testing) and by minimising stressful environments during the culture period. In addition, knowledge of the pest and disease status of the source area (through HQAS broodstock quarantine procedures) prior to stocking would provide early indications of potential parasite and disease problems that may occur as a consequence of collecting broodstock. Regular surveillance and monitoring of collected wild individuals would be carried out to assist in providing knowledge of the pest and disease status of the source area prior to stocking and would provide early indications of potential parasite and disease problems that may occur as a consequence of collecting broodstock.

With the therapeutic treatment of broodstock and juveniles in hatcheries and with the implementation of containment and disinfection procedures proposed as part of the HQAS, the likelihood of infection in hatcheries or contamination of adjacent waterways would be reduced to 'rare'. Hence, the residual risk level for this category would be 'low' (Table G.17).

Table G.17: Summary of measures to reduce risks of infection of hatchery-reared fish and crustaceans with endemic disease/parasite causing contamination of farm and adjacent waterways.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Infection of hatchery-reared fish with endemic disease/parasite causing contamination of farm and adjacent waterways. Infection of hatchery-reared crustaceans with endemic disease/parasite causing contamination of farm and adjacent waterways.	Fish/crustaceans would only be stocked by HQAS accredited hatcheries. This specifically includes: ▪ implementing stringent farm containment and disinfection plans; ▪ disease zoning policies; and ▪ Immediate notification of health authorities if there is potential disease risk. Broodstock would be screened to be clinically healthy and treated for external parasites as part of HQAS quarantine procedures any diseases identified would assist with the knowledge of the disease status of the broodstock source area and further species specific risk assessments would be carried out if required.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.1 (c): Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated. Research Topic 1.4 (Priority level 1): Identify diseases which pose a translocation risk in NSW waters.	Low

G.2.1.5.3 Translocation of Exotic Fish and Crustacean Disease/Parasite from Hatcheries into Wild Populations

Key issues identified in Chapter D, Section D.4.5.2.3:

- Translocation of exotic fish disease/parasite from hatcheries into wild populations – high risk;
- Translocation of exotic crustacean disease/parasite from hatcheries into wild populations – high risk.

The draft FMS through the implementation of the HQAS, which will be developed to include the selected marine species, proposes multi-faceted testing, screening and management procedures as standards for marine stocking. These measures are expected to dramatically reduce the risk of releasing stock that are contaminated with exotic disease, so that the likelihood of the risk occurring is lowered to 'rare'. This reduction in likelihood will lower the overall risk level from 'high' to 'moderate'. Although the likelihood of occurrence is 'rare', the consequences of viral infection would not change (i.e. the virulence of the virus or other disease causing organism would be unlikely to be affected). So although, the risk remains 'moderate', there are no mitigative measures that can be applied to further reduce the risk which, with the controls in place, is considered to be acceptable (Table G.18).

Table G.18*:* Summary of measures to reduce the risk of translocation of exotic fish and crustacean disease/parasite from hatcheries into wild populations.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Translocation of exotic fish disease/parasite from hatcheries into wild populations. Translocation of exotic crustacean disease/parasite from hatcheries into wild populations.	Fish/crustaceans would only be stocked by HQAS accredited hatcheries.	Objective 1.5 (a): To manage the activity consistently with State and National policies governing the translocation of live aquatic organisms. Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries	Moderate

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
		supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.1 (c): Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated. Research Topic 1.4: Identify diseases which pose a translocation risk in NSW waters.	

G.2.1.5.4 Translocation of Endemic Fish and Crustacean Disease/Parasite from Hatcheries into Wild Populations

Key issues identified in Chapter D, Section D.4.5.2.4:

- Translocation of endemic fish disease/parasite from hatcheries into wild populations – moderate risk;
- Translocation of endemic crustacean disease/parasite from hatcheries into wild populations – moderate risk.

The draft FMS through the implementation of the HQAS, which will be developed to include the selected marine species, proposes multi-faceted testing, screening and management procedures as standards for marine stocking. Disease causing pathogens, parasites and pests potentially affecting, or known to affect the species proposed for marine stocking are listed in Chapter C, Section C.4.1.5. Advocating the precautionary approach, absence of documented evidence for vulnerability to particular diseases/parasites should not, however, eliminate them from pre-screening procedures. This is because knowledge is still lacking regarding the proposed species host specificities and in regards to the disease status of all NSW estuaries proposed for stocking. For fish, the list of more serious bacterial and parasitic disease-causing organisms provided in Table C.2 (after Colorini 1998) and various viral and fungal diseases also identified in Chapter C, Section.4.1.5.1 would form the basis of further risk assessments and screening procedures.

Regular surveillance and monitoring of wild individuals would also assist in providing knowledge of the pest and disease status of the source area prior to stocking and would provide early indications of potential parasite and disease problems that may occur as a consequence of collecting broodstock. This is expected to reduce the likelihood releasing stock that are contaminated with endemic disease, to such an extent that it could only happen in 'rare' circumstances.

Furthermore, research to identify diseases which pose a translocation risk in NSW waters has been identified as a priority of the draft FMS (Research Topic 1.4). These mitigative measures as proposed by the draft FMS would reduce the overall risk level from 'moderate' to 'low' (Table G.19).

Table G.19*:* Summary of measures to reduce the risk of translocation of endemic fish and crustacean disease/parasite from hatcheries into wild populations.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Translocation of endemic fish disease/parasite from hatcheries into wild populations. Translocation of endemic crustacean disease/parasite from hatcheries into wild	Fish/crustaceans would only be stocked by HQAS accredited hatcheries. Broodstock would be screened to be clinically healthy and treated for external parasites as part of	Objective 1.5 (a): To manage the activity consistently with State and National policies governing the translocation of live aquatic organisms Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
populations.	HQAS quarantine procedures any diseases identified would assist with the knowledge of the disease status of the broodstock source area and further species specific risk assessments would be carried out if required.	supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.1 (c): Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated. Research Topic 1.4: Identify diseases which pose a translocation risk in NSW waters.	

G.2.1.5.5 Translocation of Non-Target Species

Key issues identified in Chapter D, Section D.4.5.2.6:

- Translocation of non-target species – high risk.

Broodstock would only be collected from within the population targeted for stocking and would not occur outside the natural geographic range of the target species. This would prevent the risk of associated genetic and/or ecological effects on the receiving populations and their environment. The potential risk of non-target species being accidentally released and translocated into waterways would be mitigated through the implementation of the HQAS, which will be developed to include the selected marine species, and will include procedures to ensure that all fish and crustaceans (adults, juveniles and fingerlings) are appropriately contained, separated as appropriate and can be suitably identified. For example, HQAS accredited hatcheries must have sufficient ponds or tanks to achieve adequate separation of broodstock and species from different genetic regions. Prior to dispatch quality checks would be carried out to ensure that non-target species or moribund fish are not dispatched along with a consignment. Fish would not be stocked outside their natural geographic range and as a precaution there would be a 50 km buffer zone beyond this where fish would not be stocked.

In the event of an unforseen emergency DPI would work with the Biosecurity Branch to appropriately control and rectify the situation as most appropriate for the species in question and nature of the receiving waterway. The proposed mitigative measures would reduce the likelihood of the risk occurring from 'possible' to 'unlikely'. Contingency measures (as deemed appropriate by the DPI Biosecurity Unit) would further reduce the potential consequences of an incursion but limiting the extent of the impact, hence, the residual risk level would be 'low' (Table G.20).

Table G.20*:* Summary of measures to reduce the risk of translocation of non-target species

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Translocation of non-target species.	Fish/Crustaceans would only be stocked by HQAS accredited hatcheries. Fish/crustaceans would not be stocked outside their natural geographic range. As a contingency the DPI Biosecurity Branch would be enlisted to control any unpredicted pest incursions.	Objective 1.5 (a): To manage the activity consistently with State and National policies governing the translocation of live aquatic organisms Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking.	Low

G.2.1.5.6 Translocation of Other Pest Organisms

Key issues identified in Chapter D, Section D.4.5.2.5:

- Translocation of other pest organisms - moderate risk.

The draft FMS through the implementation of the HQAS, which will be developed to include the selected marine species, would ensure that appropriate containment and quarantine systems and a contingency plan are in place to minimise the risk of translocation into natural waterways. Transport media would be treated (if necessary) and disposed of as appropriate. Any transport equipment such as cages, buckets and nets would be washed and cleaned after each use. Prior to dispatch quality checks would be carried out to ensure that pest organisms such as noxious algae or invertebrates are not dispatched along with a consignment.

Under the draft FMS, stocking review guidelines (Appendix E.1, Part 2 of the draft FMS), would provide a framework for the identification of translocation risks and implementation of any mitigative actions required prior to approval of any stocking event.

HQAS accredited hatcheries would also have contingencies in place to deal with translocation issues such as back-up power supply capabilities, back-up sterilization capabilities, on-site storage of waste water, water treatment facilities, emergency stock disposal procedures and pest incursion notification arrangements. In the event of an unforseen emergency, DPI (Fisheries) would work with the DPI Biosecurity Branch to appropriately control and rectify the situation as most appropriate for the species in question and nature of the receiving waterway. The proposed mitigative measures would reduce the likelihood of the risk occurring from 'unlikely' to 'rare'. Contingency measures would also further reduce the potential consequences of an incursion by limiting the extent of the impact, hence, the residual risk level would be 'low' (Table G.21).

Table G.21: Summary of measures to reduce the risk of translocation of other pest organisms.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Translocation of other pest organisms.	Fish/crustaceans would only be stocked by HQAS accredited hatcheries. As a contingency the DPI Biosecurity Branch would be enlisted to control any unpredicted pest incursions.	Objective 1.5 (a): To manage the activity consistently with State and National policies governing the translocation of live aquatic organisms Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking.	Low

G.2.1.5.7 Release of Stock (Fish and Crustaceans) Selected for Reduced Disease/Parasite Susceptibility Causing Undesirable Modification of Wild Genotypes

Key issues identified in Chapter D, Section D.4.5.2.5:

- Release of stock selected for reduced disease/parasite susceptibility causing undesirable modification of wild genotypes – high risk.

The existing HQAS, which is to be modified as required by the draft FMS, would reduce the risks for releasing undesirable modifications to wild genotypes by ensuring that high genetic effective population size is maintained for stock reared in the hatchery. The mitigation of this risk is based around ensuring that adequate numbers of broodstock acquired from appropriate collection zones are used to produce the stock. The HQAS has a specific focus of the adequacy of gene pools in released stock and it is proposed that a review of this aspect of the scheme would be undertaken to make it applicable for marine species. This could be expected to reduce the likelihood of the modification of wild genotypes to 'rare' and reduce the overall risks of this from 'high' to 'moderate' (Table G.22).

Table G.22: Summary of measures to minimise the release of hatchery-produced fish and crustaceans selected for reduced disease/parasite susceptibility causing undesirable modification of wild genotypes.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Release of stock selected for reduced disease/parasite susceptibility causing undesirable modification of wild genotypes.	Ensure adequate number of broodstock through hatcheries compliant with the HQAS.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.3 (a): Implement best practice in broodstock collection and management. Research Topic 1.5: Identify diseases which pose a genetic resistance risk in hatcheries.	Moderate

G.2.1.5.8 Hatchery Culture System Failure

Key issues identified in Chapter D, Section D.4.5.2.6:

- Hatchery/farm culture system failure causing poor on-farm stock health and culminating in stock which have difficulty withstanding stresses associated with harvest, transport and/or handling procedures – moderate risk.

Health problems and significant losses within the hatchery would be avoided or reduced through use of best practice, experienced operators, regular maintenance procedures and backup systems such as power generators and secondary aeration systems. In some situations, however, the fate of stock can be out of the control of the operator due to uncontrollable factors (e.g. environmental catastrophes) or unknown sub-lethal factors (e.g. dietary imbalances).

In all of these situations, adequate health and condition testing of the stock prior to harvest and transport can greatly reduce the potential for problems emerging at the release site. The prior experience of the operator, with the species in question will also greatly affect the levels of success. Ensuring that stocks are reared in hatcheries that are compliant with the HQAS standards, which will be developed to include the selected marine species, would address this issue. A code of practice would also be developed which defines and promotes best practice in stocking techniques, including procedures for disease and health assessment.

As such, appropriate management can reduce the likelihood of risks of poor on-farm health of progeny to 'unlikely', hence the residual risk is 'low' (Table G.23).

Table G.23: Summary of measures to minimise risk of hatchery culture system failure.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Hatchery/farm culture system failure causing poor on-farm stock health and culminating in stock which have difficulty withstanding stresses associated with harvest, transport and/or handling procedures.	Ensure adequate health and conditioning by using stock reared in hatcheries that comply with the HQAS.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques, transport medium management, ethical treatment and care of stock, stocking verification procedures and the assessment of disease and fish health prior to commencement of program.	Low

G.2.1.5.9 Transport System Failure Causing Poor Progeny Health Prior to Release

Key issues identified in Chapter D, Section.4.5.2.7:

- Transport system failure causing poor stock health prior to release – moderate risk.

The risk of transport system failure causing poor stock health prior to release would be addressed through the implementation of standard procedures to monitor and control conditions during transport as outlined in the HQAS, which will be developed to include the selected marine species.

This includes completion of a Hatchery Dispatch and Health Statement for each consignment and quarantine of the consignment for a minimum of 24 hours prior to stocking. HQAS protocol would include the monitoring of temperature, dissolved oxygen, pH, turbidity and gas flow and ensuring appropriate densities of fingerlings in the transportation tanks. Before bulk handling and transport, the fingerlings would be visually inspected. A random sample of fingerlings would then be removed from the transport tank and placed into a small tank containing water from the stocking site for close inspection. In doing this they would be treated in a similar way to how the bulk stock would be released at the stocking site. Obvious signs of problems may include loss of equilibrium, limited response to physical and visual stimuli and in the worst case, widespread mortalities. If the majority of fingerlings do not achieve a critical level of apparent health they would not be released, as there may be an underlying health and/or disease issue that, until that point, have gone undetected.

According to DPI 'Safe transport of fish and stocking code of practice (2007)' fish survive transport better if they are, undamaged, disease free and well-conditioned and although this code of practice was developed for freshwater stocking, many of the procedures would be similar for marine fish and implemented as during transport i.e.:

- The time in transit would be as short as possible;
- Temperatures would be kept stable and suitable for the specific species;
- Fish would be handled/disturbed as little as possible and have adequate shading;
- Transportation tanks would be uncrowded and well insulated with good oxygen supply,
- Optimum transport conditions would be known for the species in question.

The current code of practice would be modified to include marine species. As such, appropriate management would reduce the likelihood of risks of transport system failures to 'unlikely' and the residual risk level would be 'low' (Table G.24).

Table G.24: Summary of measures to minimise risk of transport system failure causing poor progeny health prior to release.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Transport system failure causing poor stock health prior to release.	Conduct practically achievable (visual) health assessments immediately prior to release and retain fish (do not release) if significant health issues are apparent. Develop a code of practice for the safe transport and release of marine fish.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques, transport medium management, ethical treatment and care of stock, stocking verification procedures and the assessment of disease and fish health prior to commencement of program.	Low

G.2.1.5.10 Release System Failure Causing Poor Progeny Health and/or Mortalities at the Release Site

Key issues identified in Chapter D, Section D.4.5.2.8:

- Release system failure causing poor stock health and/or mortalities at the release site – moderate risk.

Depending on the site, floating net pens and devices designed to afford some immediate protection from predation while stocked fish adjust to their new environment may be used where appropriate. Any fish that die post-release would then be contained and recovered to avoid contamination. This approach has been used in both fresh and brackish water fish stocking programs in QLD (Hutchison *et al.* 2006; Butcher *et al.* 2000) and would also facilitate valuable short-term survival estimates for use in the assessment of stocking successes. Where the use of netted release points is unfeasible, the foreshore in the downstream and downwind areas of the release sites would be inspected to detect any dead fish that could have been washed ashore. Any fish that are recovered from the release site would later be inspected in the laboratory to determine the cause of death before they are suitably disposed of. By following appropriate post-stocking surveillance and recovery activities the various contamination risks associated with the unavoidable occurrence of mortalities at the stocking site can be reduced from 'moderate' to 'low' (Table G.25).

Table G.25: Summary of measures to minimise the risk of release system failure causing poor health/mortality.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Release system failure causing poor stock health and/or mortalities at the release site.	Post-stocking surveillance. Recover and dispose of any dead/contaminated fish appropriately. Develop a code of practice for appropriate release of stock.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.4 (a): Develop a code of practice prior to the commencement of the program that defines and promotes best practice in stocking techniques, transport medium management, ethical treatment and care of stock, stocking verification procedures and the assessment of disease and fish health. (This would ensure preferred timing and release locations).	Low

G.2.2 Social Impacts

G.2.2.1 Aboriginal Social Issues

G.2.2.1.1 Impact of Marine Stocking on Areas of Aboriginal Cultural Heritage

Key issues identified in Chapter D, Section D.5.1.2.1:

- Impingement on areas of Aboriginal cultural importance (sites, places and objects) – moderate risk.

DPI would implement a number of measures to ensure that Aboriginal sites are not damaged during marine stocking activities. DPI would utilise existing ramps and jetties when collecting broodstock or releasing fingerlings into waterways where appropriate. This minimises the risk that vehicles or boats involved in stocking activities would impact on Aboriginal Sites or Places.

The draft FMS proposes to consult with representatives of the local Aboriginal community groups at each new estuary that would be stocked, prior to any stocking activity (management objective 2.2 (c)). This is similar to the consultation processes already in place for consulting with Aboriginal stakeholders prior to stocking into new freshwater stocking sites.

Groups would be asked for advice about any place that should be avoided during marine stocking activities. Aboriginal communities may prefer that marine stocking does not take place within or in the immediate vicinity of estuarine waters which are associated with particular fish totems (such as the bream increase site reported from the Clarence River) or a valued Aboriginal Place which is located in an estuary proposed for stocking. Where this may be the case, DPI would work with the Aboriginal stakeholders to avoid any impact on the value of that place. This may mean stocking a different part of the estuary. None of the Aboriginal stakeholder groups who have responded in writing and taken part in discussions about marine fish stocking so far have suggested that any places should be excluded from stocking because of cultural stories about them. Provided that the management strategies outlined above are put in place relevant to the objectives of the draft FMS, the likelihood of marine stocking impinging on areas of Aboriginal cultural importance would be reduced and the overall risk level would remain as 'moderate' (Table G.26) as the level of consequence cannot be reduced any further in this case. This is considered to be acceptable.

Table G.26: Summary of measures to reduce impacts on areas of Aboriginal cultural importance.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Places listed on the National Heritage List for their Aboriginal values.	No mitigation required.	Objective 2.2 (c): Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked.	Low
Aboriginal objects and sites protected under the *National Parks and Wildlife Act 1974* (NPW Act).	DPI would consult with representatives of the local Aboriginal community groups at new estuaries that may be stocked.	Objective 2.2 (b): to ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework. Objective 2.2 (c): Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked.	Moderate
Aboriginal Places (as gazetted under Section 84 of the NPW Act).	DPI would consult with representatives of the local Aboriginal community groups at new estuaries that may be stocked. DPI would not conduct stocking inside estuarine Aboriginal Places without the approval of the relevant local Aboriginal stakeholder groups and the Office of Environment and Heritage (OEH). Stocking would not be conducted in areas where the local Aboriginal community expresses a specific cultural concern about the detrimental impact of fish stocking on the spiritual or other cultural values of a place.	Objective 2.2 (b): to ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework. Objective 2.2 (c): Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked.	Moderate

G.2.2.1.2 Aboriginal Stakeholder and Community Involvement

Key issues identified in Chapter D, Section D.5.1.2.2:

- Lack of involvement of Aboriginal stakeholders in fishery management and stocking activities – low risk.

It has been highlighted that a failure to involve Aboriginal and community stakeholder groups can impede relationship building between DPI and Aboriginal communities, affect the efficient delivery of marine stocking activities and may result in a poor relationship. DPI through the implementation of the draft FMS would consult with local Aboriginal stakeholders in the assessment of any new sites to be stocked. DPI is also proposing to periodically report on the

outcome of stocking events, so that regional communities are aware of the results in terms of stocks, catch effort and/or other measures. As part of this process, DPI would seek feedback from Aboriginal stakeholders about their observations of fishing effort in stocked estuaries. Opportunities for Aboriginal stakeholders to participate in monitoring of fish stocks and estuary health, in partnership with NSW ALC and other natural resource management organisations such as the OEH and CMAs would also be investigated and continuously developed over the duration of the stocking program.

With these measures in place, the likelihood of there being a lack of Aboriginal stakeholder involvement would be reduced from 'unlikely' to 'rare', hence the residual risk level would remain as 'low' (Table G.27).

Table G.27: Summary of measures to address the issue of insufficient community involvement.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Lack of involvement of Aboriginal stakeholders in fishery management and stocking activities.	Consultation with local Aboriginal stakeholders prior to stocking of any new sites. Investigate opportunities for Aboriginal stakeholders and the local community to be involved in planning, implementation and monitoring. Ensure local communities and stakeholders are informed of relevant outcomes of stocking activities.	Objective 2.2: To minimise any negative impacts of the activity on cultural heritage values and provide opportunities for Aboriginal communities to participate in stocking activities and to support cultural fishing practices". Objective 2.2 (c): Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked. Objective 4.3(a): Develop and implement a culturally appropriate educational (communication) plan. Objective 4.2 (b): Periodically report on the activity.	Low

G.2.2.1.3 Marine Stocking as a Valuable Part of Looking After Sea Country

Key issues identified in Chapter D, Section D.5.1.2.3:

- Marine stocking is not seen as, adequate or good value or, a sustainable approach to looking after sea country – moderate risk.

As Specialist Report A highlights, 'Aboriginal groups value healthy functioning ecological systems where wild biodiversity and productivity for a healthy diet in the community, allow people to practice and teach traditional cultural knowledge, and support family and social obligations'. By supporting a healthy functioning ecosystem, the proposed activities would provide good value to Aboriginal communities and therefore provide increased value to sea country. The ability to create value for sea country through stocking activities, as highlighted by the draft FMS, requires the involvement of local Aboriginal groups in planning, management and monitoring of activities, as highlighted in Table G.28.

Specialist Report A also highlighted a concern of Aboriginal groups with regard to stocking; this being the contribution of habitat destruction through removal of estuary litter, land clearing and agricultural activities which leads to degradation of local ecosystems. DPI are currently running a number of habitat restoration and protection programs aimed at ensuring the long-term sustainability of fisheries resources and the health of aquatic ecosystems which would complement the marine fish stocking program. These include the Aquatic Habitat Protection Program and the Aquatic Habitat Rehabilitation Program, including the Habitat Action Program. A key objective of the draft FMS is to manage the activity of marine stocking in a way which is consistent with other State and Commonwealth endorsed programs, this includes programs designed to preserve aquatic biodiversity (Management Objective 1.4 (a) & 1.4 (b).

The MCA has been developed to identify estuaries that are suitable for stocking. A key component of the MCA is to favour estuaries which are healthier to ensure resources for stocking are used more efficiently. Marine stocking would initially be implemented on a small scale, given the requirements of the draft FMS, and distributed over the

three stocking regions (Northern, Central and Southern). As Specialist Report A has highlighted, Aboriginal groups consulted were weary of the potential for marine stocking activities to be detrimental to local estuary health and biodiversity, highlighting the need for the project to be small scale in its initial period to mitigate against the potential for any unwanted impacts due to an increase in certain fish species.

Success of the stocking programs would be monitored using various stock assessment approaches, aligned with estuary health indicators and community feedback, thus providing a link to ecosystem health targets as outlined in the draft FMS. Risk should continue to decrease over time, as partnerships between natural resource management organisations, Aboriginal stakeholders and DPI strengthen and the full implications of marine stocking activities become clear to local Aboriginal groups.

Table G.28: Summary of measures to address issues related to the protection of sea country.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Marine stocking not seen as adequate or good value or a sustainable approach to looking after sea country.	DPI would continue to run long-term habitat restoration and protection programs that would complement fish stocking. Stockings would be monitored to ensure success in line with appropriate management objectives.	Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements (including programs designed to protect aquatic environments and biodiversity).	Moderate

G.2.2.1.4 Access to Stocked Fish

Key issues identified in Chapter D, Section D.5.1.2.4:

- Competition from other fishing sectors reduces Aboriginal access to stocked fish for a healthy diet – moderate risk.

In order to ensure equity of access to stocked fish resources between recreational, Aboriginal cultural and commercial fishers, estuaries which are both closed (i.e. RFHs) and open to commercial fishing would be stocked. Careful monitoring would also help to clarify the extent of benefit that can be achieved for Aboriginal fishers (as per Objective 2.3 c). It is noted that commercial fisheries have already been subject to environmental assessment and are tightly regulated under their relevant FMS's; therefore temporary closures as discussed at community stakeholder meetings would not be considered an appropriate measure to address resource allocation issues.

Stocking both RFH and non-RFH estuaries is considered to reduce the risk that competition from the commercial fishing sector would have on Aboriginal fishers access to stocked fish (and consequently access to a healthy source of food) from moderate to low (Table G.29). Stocking does not, however, specifically aim to improve the diet of Aboriginal people; rather it is a consequential benefit of marine stocking.

Table G.29: Summary of measures to address the issue of Aboriginal access to stocked fish.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Competition from other fishing sectors reduces Aboriginal access to stocked fish for a healthy diet.	DPI would ensure that there is a balance between the number of RFHs and non-RFHs that are stocked. Representative stocked estuaries would be monitored and outcomes of stocking reported. DPI would maintain sound records of the effects of fish stocking and ensuring local communities and	Objective 2.3 (c): Monitor the level of socio-economic benefit for fish stocking using surveys undertaken on an episodic basis. Objective 4.2 (a): To maintain all records of stocking events centrally. Objective 4.2 (b): Periodically report on the activity. Objective 4.3 (a): Develop and	Low

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
	stakeholders are informed of relevant outcomes of stocking activities.	implement a culturally appropriate educational (communication) plan. Research Topic 3.2 (2): Optimisation of harvest stocking releases.	

G.2.2.2 Non-Aboriginal Cultural Values

G.2.2.2.1 Consistency with Objectives of the State-wide Template Local Environment Plan (LEP) Zone for Waterways or Other State-wide Requirements for the Coastal Zone

Key issues identified in Chapter D, Section D.5.2.2.2:

- Marine stocking not consistent with objectives of State-wide template LEP zone for waterways or other State-wide requirements for the coastal zone – moderate risk.

Relevant LEPs would be reviewed for listings of heritage places or objects that could be impinged upon prior to stocking activity as outlined in the draft FMS Stocking Review Guidelines (Chapter E, Appendix E.1). Should any significant places or objects be identified (or any other inconsistencies with an LEP) then stocking activities would be reconsidered or altered in consultation with the relevant local authority, so that potential impacts may be mitigated. Any risks to non-Aboriginal cultural values or inconsistency with relevant LEPs would be reduced from 'moderate' to 'low' (Table G.30). Local management plans would be checked under Part 3 of the FMS 'Marine Stocking Review Guidelines'. Stockings would also be carried out consistent with other cross-jurisdictional management arrangements as per Objective 1.4 (a) and (b) of the draft FMS.

Table G.30: Summary of measures to ensure consistency with the State-wide Local Environment Plan template or other State-wide requirements for the coastal zone.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Marine stocking not consistent with objectives of State-wide template LEP zone for waterways or other State-wide requirements for the coastal zone.	Review relevant LEPs prior to stocking for listings of heritage places or objects.	Appendix E.1 (Marine Stocking Review Guidelines), Part 3 (Local Environmental Issues), Issue 3.1 of the FMS requires that stocking must be consistent with local management plans. Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements (including programs designed to protect aquatic environments and biodiversity).	Low

G.2.2.2.2 Resource Sharing

Key issues identified in Chapter D, Section D.5.2.2.4:

- Resource sharing (e.g. conflict among fishing sectors) – low risk.

The risk of conflict among different fishing sectors is considered low risk as there has been little evidence of it occurring in the freshwater fish stocking program and the recent Mulloway and Eastern King Prawn research stocking programs. There are, however, measures within the draft FMS that would mitigate this risk. Stocking into both RFHs and estuaries open to commercial fishing would minimise the risk of conflict between recreational and commercial fishing groups, although some conflict is still possible. Failing to stock estuaries accessible to both

commercial and recreational fishing would in itself create conflict over resources. The draft FMS would ensure that mechanisms are in place for all fishing groups to have the opportunities to report any incidences or concerns regarding conflict and resource sharing and further management measures implemented as necessary. This would be done through communications with community representatives and the local fisheries office. Any reported incidences would be maintained on the central stocking database which would be developed under Objective 4.2 (a) of the draft FMS. For each individual stocking event and where any incidences have occurred, the potential cause of the incident would be investigated. With these measures in place, the overall risk level would remain as 'low' (Table G.31) which is acceptable.

Table G.31: Summary of measures to address resource sharing issues.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Resource sharing (e.g. conflict among fishing sectors).	Consultation was undertaken as part of the EIS process and MCA to identify estuaries where stocking could have a detrimental impact on social values Ensure that there is a balance between the number of RFHs and non RFHs that are stocked. Ensure provision of mechanisms to report concerns and conflict through an administrative framework.	Objective 2.3 (c): Monitor the level of socio-economic benefit for fish stocking using surveys undertaken on an episodic basis. Objective 4.2 (a): To maintain all records of stocking events centrally. Objective 4.2 (b): Periodically report on the activity.	Low

G.2.2.2.3 Aquaculture Industry

Key issues identified in Chapter D, Section D.5.2.2.6:

- Impacts on oyster leases – high risk;
- Impacts on other aquaculture – low risk.

The draft FMS has outlined potential conflicts that may arise between oyster leases and marine stocking activities. The oyster industry is extensive in NSW with over 77 estuaries containing leases; therefore it is not feasible to avoid stocking activities in every estuary containing an oyster lease. Further to this, it is not feasible to prevent fish from moving into areas of oyster leases, as fish are free to move within estuaries. The draft FMS has outlined consultative processes to be undertaken in order to work with oyster lease stakeholders to determine the level of stocking to take place with respect to type of farm, size and the personal view of individual farmers.

DPI would facilitate monitoring and consultation with representatives of the oyster industry and lease holders in stocked estuaries to identify any potential impacts. In the case that an impact was detected then appropriate mitigative action would be taken and the stocking policy reviewed. Research would also be carried out to determine the distance that stock may travel from the point of release which would help in monitoring the dispersal and potential wider reaching effects within and beyond the stocked estuary. Provided these measures are implemented as described, the level of risk would be reduced from 'high' to 'moderate' (Table G.32).

Approved aquaculture in NSW includes finfish in Port Stephens and Botany Bay, and mussels Twofold Bay. Fingerlings that do enter the sea pens of cultured fish are likely to be consumed by these fish, but as the fish are contained potential trophic impacts beyond the cages would not be expected and hence, the risk level is 'low'.

Table G.32: Summary of measures to reduce the risks of impacts to the aquaculture industry.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Impacts on oyster leases.	Stocking would be avoided in parts of estuaries where oyster leases occur. DPI would undertake further consultation with oyster farmers and	Research Topic 2.1 (Priority Level 1) Investigate distance stock travel from point of release.	Moderate

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
	industry representatives and monitor for any impacts. Further research to investigate stock movements.		
Impacts on other aquaculture.	Further research to investigate stock movements.	Research Topic 2.1 (Priority Level 1) Investigate distance stock travel from point of release.	Low

G.2.2.2.4 Community Support, Participation and Fishing Effort

Key issues identified in Chapter D, Section D.5.2.2.7:

- Perceived negative environmental impact of marine stocking- moderate risk;
- Lack of community support – low risk;
- Increase/concentration of fishing participation/effort – moderate risk.

Community stakeholders have been consulted in regard to the proposed stocking activity through meetings in the north, central and south coast regions of NSW. In addition, it is important that stakeholders local to stocked estuaries are kept informed of when and where stockings are taking place and that results of any monitoring and research are freely accessible. Under the draft FMS awareness and support relating to stocking activity would be provided to the local community and stakeholders via an educational (communication) plan. Educational and promotional material in the form of pamphlets, via the internet and specific publications would be prepared and delivered to meet the needs of the community. Access to information would also be provided through DPI Offices, Fishcare Volunteer programs and through NSW Natural Resource Service Centres. Educational material would also be provided prior to stocking events in the media and by the stockists. Under Objective 4.2 (b) of the draft FMS, Reporting on stocking activities would take several forms, including data from performance indicators, aquaculture production reporting, scientific reports, the internet and submissions to advisory councils and other groups. Information would be provided to stakeholders and the community through the appropriate media.

With the proposed measures to improve community awareness and education the residual risk from a lack of community support and negative perceptions of stocking is 'low' (Table G.33).

There is uncertainty as to the scale and extent that fishing effort might be affected by the proposed marine stocking program. Based on existing information, it is considered most likely that there could be an increase of fishing effort at the local scale (due to a redistribution of effort), but no overall increase in fishing effort/participation at a regional/State-wide scale. Any increase in local fishing effort is not considered likely to be substantial. As identified in Chapter D, Section D.5.2.2.8, local increases in fishing effort could result in greater pressure on wild fish stocks and has implications for increased incidental capture, habitat degradation and population genetics. Measures to address these potential impacts on the biological environment are identified in Section G.2.1. In terms of social impacts, more people participating in recreational fishing could result in increased traffic/crowding at boat ramps within or near to stocked estuaries. Whether this might result in traffic congestion would depend on the existing infrastructure at the stocked estuary. Stocking would, however, only take place in areas which are appropriately zoned according to the relevant LEP and are therefore activities that are consistent with the types of land/waterway use in the area. Individual LEPs would be reviewed for the relevant estuaries and stocking would only take place where the activity is approved and consistent with LEPs. The same would be the case should stocking affect the visual amenity of an area. Furthermore, the level of fishing effort and changes in effort associated with stocking in regional areas would be monitored under Objective 2.3 (d) of the draft FMS. This would also contribute to measuring the socio-economic benefits of stocking. Procedures for monitoring would be established following the development of the stocking plan.

Table G.33: Summary of measures to mitigate/manage risks relating to community support, participation and fishing effort

Key Issues	Management Strategy	Relevant Section of the FMS	Residual Risk
Lack of Community support. Perceived negative environmental impact	Community consultation meetings were carried out as part of the EIS process (Chapter D, Section D.2). Further community consultation and education during the stocking process to ensure awareness and support.	Objective 4.2 (b): Periodically report on the activity. Objective 4.3 (a): To improve community understanding and public perception of the activity through an education strategy.	Low
Increase/concentration of fishing participation/effort	Review relevant LEPs prior to stocking to ensure the activity is consistent with LEP zoning. Monitoring of fishing effort	Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking.	Moderate

G.2.3 Other Impacts (Physico-Chemical)

G.2.3.1 Water Quality

Key issues identified in Chapter D, Section D.6.1.2.1:

- Reduction in water quality from increased boating (large, well flushed, open estuary) – low risk;
- Reduction in water quality from increased boating (small, poorly flushed, semi-enclosed water body) – moderate risk;
- Reduction in water quality from aquaculture operations – low risk.

Under the *Protection of the Environment Operations Act 1997* (POEO Act), it is an offence to pollute any waters in NSW unless permitted under an environment protection licence issued by the Environment Protection Authority (EPA). NSW Maritime and also DPI also raise awareness of recreational fishers to best practice in relation to boating and water quality via boating handbooks, the NSW Saltwater Fishing Guide and online media (e.g. NSW Maritime 2010a, I&I NSW 2011). In addition to these existing controls, under the draft FMS there would be mechanisms in place to report any concerns with regard to water quality through maintaining a central database of stocking records (Objective 4.2 a). Incidents reported in relation to stocking events would be reviewed and action taken as necessary.

Given existing controls on water quality, the risk of a reduction in water quality through increased boating (as a result of stocking) remains at 'low' to 'moderate' as there are no mitigative or management measures within the scope of the proposal that could further reduce this risk. As such this level of risk is accepted.

As outlined in Chapter D, Section.6.1.2 aquaculture farms that are permitted to discharge water to natural waterbodies must manage this water to ensure it complies with the conditions of the aquaculture permit, development consent (if required) and any licence issued by the OEH under the (POEO Act). Any accidental release of untreated water would be reported to the OEH or the appropriate regulatory authority/council. These existing controls and licences to manage and mitigate potential risks associated with the discharge of water from aquaculture facilities are considered sufficient to address this issue and the residual risk level is 'low'. Measures to manage and mitigate potential water quality issues are summarised in Table G.34 below.

Table G.34: Summary of measures to address water quality issues.

Key Issues	Management Strategy	Relevant Section of the FMS	Residual Risk
Reduction in water quality from increased boating (large, well flushed, open estuary).	DPI would ensure there are mechanisms in place to report water quality concerns for further investigation where necessary. Promote existing best practice boating	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 4.2 (a): To maintain all	Low
Reduction in water quality from increased boating (small, poorly flushed, semi-enclosed water			Moderate

Key Issues	Management Strategy	Relevant Section of the FMS	Residual Risk
body).	guidelines.	records of stocking events centrally.	
Reduction in water quality from aquaculture operations.	Ensure that juvenile fish/crustaceans for stocking are reared in hatcheries that comply with the HQAS. Reporting of unauthorised release of untreated water into natural waterways.	Section 1.5.5 of the FMS provides for the management of marine fish stocking consistent with principles of Ecologically Sustainable Development (ESD).	Low

G.2.3.2 Air Quality

Key issues identified in Chapter D, Section.6.1.2.3:

- Impact on air quality (e.g. from car/ boat emissions and aquaculture facilities) – low risk.

As discussed in Chapter D, Section D.6.1.2.3 risks to environmental air quality from a potential increase in car/boat emissions is considered to be 'low' as the potential increase in travel/emissions would be negligible relative to ambient conditions. Recirculating Aquaculture Systems (RAS) were also identified as a source of air pollution as they use ozone to inactivate a range of bacterial, viral, fungal and protozoan fish pathogens (I&I NSW 2005b), however, given the existing level of hatchery compliance that would be adhered to (under the HQAS) this risk was also considered to be low (Table G.35). Although no further mitigation is required, aquaculture operators may be able to further reduce greenhouse gas emissions by participation in programs run by State and Federal Governments although this would be at the discretion of the participating hatchery.

Table G.35: Summary of measures to address air quality issues.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Impact on air quality (e.g. from car/ boat emissions and aquaculture facilities)	Ensure that juvenile fish/crustaceans for stocking are reared in hatcheries that comply with the HQAS.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Section 1.5.5 of the FMS provides for the management of marine fish stocking consistent with principles of ESD.	Low

G.2.3.3 Energy

Key issues identified in Chapter D, Section D.6.1.2.4:

- Hatchery production fails to be energy efficient – low risk.

Although the overall level of risk relating to energy efficiency of hatchery production is 'low', there are further measures that can be implemented under principles of ESD which may help minimise energy consumption and improve efficiency in existing hatcheries (Table G.36). This might include energy conservation and cost reduction opportunities described in the NSW Land-Based Sustainable Aquaculture Strategy (2009) such as:

- monitoring of annual and quarterly energy expenditure;
- maintaining equipment performance;
- use of 'off-peak' energy; and
- identifying and rectifying actions or activities that waste energy or use energy inefficiently.

This would, however, be at the discretion of the participating hatchery.

Table G.36: Summary of measures to minimise energy consumption and improve efficiency in existing hatcheries.

Key Issue	Management Strategy	Relevant Section of the FMS	Residual Risk
Hatchery production fails to be energy efficient.	Ensure that juvenile fish/crustaceans for stocking are reared in hatcheries that comply with the HQAS.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Section 1.5.5 of the FMS provides for the management of marine fish stocking consistent with principles of ESD.	Low

G.3 Economic Feasibility Assessment

G.3.1 Overview

A specialist study was undertaken to investigate the potential economic impacts of the proposed marine harvest stocking program (Specialist Report B). As such, only a brief summary of the findings are reported here and the main report should be referred to for full details of the assumptions made, methodology and limitations of the study. The data required to undertake a standard, quantitative cost-benefit analysis (which would typically be reported as part of an EIS) was, generally, insufficient for this study and hence a non-standard 'feasibility assessment' was instead undertaken.

Although defined in broad terms due to the data limitation, the findings of the cost benefit analysis aimed to reflect the nature of likely impact of marine stocking which could then be utilised as a decision making tool to guide which species are economically feasible to stock and in which location the stocking would generate the greatest net benefits.

The feasibility assessment included:

1. Qualitative assessment: to investigate the likely costs and benefits associated with the marine stocking program based on the existing literature.

2. Quantitative assessments:

    a) An 'Economic Feasibility Analysis' – to investigate the feasibility of stocking each of the seven selected species. This was done using three different approaches:

        - Market Values;
        - Expenditure Value; and
        - Effort Value.

    b) A 'Regional Allocation Analysis' – to investigate the optimal allocation of stocking among ten regions across the NSW Coast.

The methodology used for each of the assessments is described in detail within Specialist Report B.

G.3.2 Results

1. The literature review provides an indication of the nature of the associated costs and benefits of marine stocking, but given the very site specific nature of recreational fishing behaviour does not attempt to accurately quantify the magnitude of the benefits. Such a study would require more detailed information regarding the detailed knowledge of the demand for recreational fishing, the extent to which demand is currently satiated, the relative role of fishing motivations, the value of fishing locations in terms of meeting these motivational requirements and so forth. Such detail is unavailable at the State/regional level at which this assessment was undertaken. The literature review indicated that the main costs associated with the marine stocking program would be:

- Research and monitoring costs;
- Environmental and social cost;
- Production costs;
- Negative perception costs;
- Administration costs; and
- Capital costs.

The main benefits of the program are considered to be:

- Direct increased expenditure;
- Economic multiplier impacts;
- Enhancement of fish populations; and
- Enhancement of recreational fishing quality.

2. The key finding of the Economic Feasibility Analysis, for both the qualitative and quantitative assessments is that, independent of location, all seven species are likely to be economically feasible stocking species. In particular, relative to the other species assessed the three species of crustaceans (eastern king prawn, giant mud crab and blue swimmer crab) are seen as more likely to be viable. It was, however, noted that the motivations behind the capture of crustaceans may be significantly different from the four species of finfish. Non-finfish capture generally requires specialist equipment and is generally undertaken by a smaller proportion of the fisher population. Finfish stocking is likely to reach a broader fisher population. Of the finfish, flathead are seen to be the most viable species relative to the other species assessed.

Using the 'Regional Allocation Analysis', preferred regions for fish-stocking were considered to be those with a high fishing effort (i.e. popular regions) yet low fish populations. Using data relating to fishing licence holders and a proxy population index, the Lower South Coast and Upper North Coast regions of NSW were considered to be the most preferred areas for implementing marine stocking programs.

In conclusion, it is considered that this assessment indicates marine stocking programs utilising any of the proposed species are likely to be economically viable. Similarly, it is considered that the recommended stocking regions identified are in areas where the greatest benefit would be received.

While the qualitative and quantitative assessments align, there is, however, a need for a robust cost benefit analysis to be undertaken given the extremely limited amount of data available for this study. Under the Goals and Objectives of the draft FMS, more specific data in regards to fish population levels, fisher behaviour, and environmental constraints would be obtained to undertake a more detailed cost benefit analysis. It is considered that local case studies may provide the best source of information which subsequently may be utilised to allow the application of more standard economic evaluation techniques.

Under the draft FMS, Goal 1, Objective 2.3 aims to maximise the economic benefits of and provide social equity from the activity. More specifically, Objective 2.3 (c) aims to monitor the level of socio-economic benefit from marine stocking surveys undertaken on an episodic basis. Objective 2.3 (d) would aim to monitor the level of fishing effort and changes in effort associated with marine stocking. These catch and effort surveys (initially focussed on regional areas) would contribute to measuring the benefits of the activity. Procedures for monitoring fishing catch and effort would be established following the development of the stocking plan.

G.4 Summary

A summary of the risks/issues identified through the EIS process, the mitigation/management measures proposed through the draft FMS to address those issues and the residual risks following mitigation/management are summarised in the following Table (G.37). A consolidated list of all mitigation/management measures and relevant parts of the draft FMS where these measures are addressed (and proposed monitoring and Research Topics) is provided in Table 38. There are no high or extreme residual risks that might occur as a result of implementing the draft FMS, although there are several residual risks that are moderate. In all cases, this is considered to be acceptable. Moderate risk levels may be further reduced to low once the uncertainty surrounding these risks is removed as a result of further monitoring and research as outlined in the draft FMS. Several of the residual risk levels are low and as such, no further mitigation or management is required.

Table G.37: Summary of risk levels before and after implementation of the Fisheries Management Strategy.

Environmental Aspect	Risk Description (event and consequence)	Risk Level Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Level		
		L	C	Risk Level			L	C	Risk Level
Ecology									
Conspecifics	Decrease in abundance of wild conspecifics e.g. from overstocking and/or increased fishing effort	C	3	High	Maximum stocking rates would not be exceeded Routine compliance inspections Research and monitoring (Section G.2.1.1.1)	Reduce likelihood and consequence	E	4	Low
	Alteration of size-structure in populations	C	3	High	Maximum stocking rates would not be exceeded Routine compliance inspections Research and monitoring (Section G.2.1.1.1) Stocking to be timed with natural recruitment patterns	Reduce likelihood and consequence	E	4	Low
	Alteration of the natural species distribution	E	3	Moderate	Species would be stocked into habitats and estuaries in which they occur naturally and within their natural range	Reduce consequence	E	5	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Level		
		L	C	Risk Level			L	C	Risk Level
Ecology									
Competitors	Alteration of the distribution, abundance or structure of populations e.g. through inter-specific competition and/overstocking/increased fishing effort	B	3	High	Maximum stocking rates would not be exceeded Routine compliance inspections Research and monitoring (Section G.2.1.1.2)	Reduce likelihood and consequence	D	4	Low
Other trophic levels	Alteration of the distribution, abundance or structure of populations	B	3	High	Maximum stocking rates would not be exceeded Routine compliance inspections Research and monitoring (Section G.2.1.1.3)	Reduce likelihood and consequence	D	4	Low
Habitat	Direct effects (e.g. overgrazing of seagrass by stocked crustaceans)	C	3	High	Maximum stocking rates would not be exceeded Consistency with habitat protection programs Research and monitoring (Section G.2.1.1.4)	Reduce likelihood and consequence	D	4	Low
Habitat	Indirect effects (e.g. trampling, littering, habitat disturbance)	C	3	High	Ensure releases take place at suitable access points or by boat Consistency with habitat protection programs Research and monitoring (Section G.2.1.1.4)	Reduce consequence	C	4	Moderate
Adjacent coastal waters	Potential ecological impacts beyond the estuary e.g. trophic effects and competitive interactions	D	4	Low	No mitigation required Maximum stocking rates would not be exceeded Research and monitoring (Section G.2.1.1.5)	Reduce likelihood	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Level		
		L	C	Risk Level			L	C	Risk Level
Threatened and Protected Species, Populations and Ecological Communities									
Key Threatening Processes (KTPs)	Hook and line fishing in areas important for the survival of threatened fish species (FM Act)	C	3	High	Stocking would not take place into declared critical habitat of a threatened species of fish Monitor incidence of hooking mortality and fishing effort and manage as appropriate Education on responsible fishing	Reduce likelihood	D	3	Moderate
	Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (EPBC Act)	C	3	High	Monitoring incidence of injury/fatality and fishing effort and manage as appropriate Education on responsible fishing	Reduce likelihood	D	3	Moderate
	Entanglement or ingestion of anthropogenic debris in marine and estuarine environments (TSC Act)	C	3	High	Monitor incidence of injury/fatality and fishing effort and manage as appropriate Education on responsible fishing	Reduce likelihood	D	3	Moderate
Trophic impacts	Alteration of the distribution, abundance or structure of populations	C	3	High	Maximum stocking rates would not be exceeded Research and Monitoring (Section G.2.1.2.2)	Reduce likelihood and consequence	D	4	Low
Increase/concentration of boating activity	Acoustic disturbance (marine mammals)	C	4	Moderate	No mitigation required Ensure compliance with existing restrictions on approach distance to baleen whales Monitoring fishing catch/effort	Reduce likelihood	C	5	Low
	Boat strike (marine mammals)	D	4	Low	No mitigation required. Monitoring fishing catch/effort	Reduce likelihood	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Level		
		L	C	Risk Level			L	C	Risk Level
Threatened and Protected Species, Populations and Ecological Communities									
Incidental capture of threatened / protected species	Injury/mortality	C	3	High	Education on threatened species identification and best practice in the release of incidentally caught fish Monitor incidence of hooking mortality and fishing effort and manage as appropriate Use of existing DPI mechanisms to report incidence of incidental capture or sightings of threatened and protected species Stocking would not occur in areas of conservation significance	Reduce likelihood	D	3	Moderate
Habitat	Trampling/ habitat disturbance	C	3	High	Stocking would not take place into Areas of Conservation significance Stocking would not take place at Taren Point Releases would take place from suitable access points or by boat Research and Monitoring (G.2.1.2.5)	Reduce consequence	C	4	Moderate

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Areas of Conservation Significance									
Areas of conservation significance	Potential impacts on Ramsar wetlands (indirect). Note that estuaries occurring within a Ramsar would not be stocked	D	4	Low	No mitigation required Maximum stocking rates would not be exceeded Research and monitoring (Section G.2.1.3.1)	Reduce likelihood	E	4	Low
	Potential impacts on the conservation value of Marine Parks. Note that estuaries occurring within a Marine Park would not be stocked	D	4	Low	No mitigation required Maximum stocking rates would not be exceeded Research and monitoring (Section G.2.1.3.1)	Reduce likelihood	E	4	Low
	Potential impacts on the conservation value of Aquatic Reserves	C	3	High	Estuaries that have Aquatic Reserves would not be excluded from stocking, but stocking would not take place within Aquatic Reserves	Reduce likelihood and consequence	D	4	Low
	Potential impacts on the conservation value of National Parks with marine extensions and Nature Reserves	D	4	Low	No mitigation required Stocking would not take place in marine extensions of National Parks or Nature Reserves	Reduce likelihood	E	4	Low
	Potential impacts on the conservation value of Critical Habitats	D	4	Low	No mitigation required Stocking would not take place in declared Critical Habitats	Reduce likelihood	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Yellowfin bream									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	A	1	Extreme	A buffer zone would be established between the southern-most yellowfin bream stocking location and the northern-most black bream estuarine population to control the possible flow of stocked yellowfin bream southwards into black bream habitat HQAS measures to preserve genetic integrity	Avoid risk	E	5	Low
	Naturalisation leading to fragmentation	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics - Mulloway									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.2)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Dusky flathead									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.2)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Sand whiting									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.2)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Eastern king prawn									
Direct effects	Ryman-Laikre effect	E	3	Moderate	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be sourced from the genetic regions specified in the draft FMS	Accept risk level	E	3	Moderate
	Introgression	E	3	Moderate	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be sourced from the genetic regions specified in the draft FMS	Accept risk level	E	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Giant mud crab									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur Research & monitoring (Section G.2.1.4.2)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	D	3	Moderate	Fish would be stocked at appropriate densities to prevent overstocking or swamping Variation of stockings in space and time HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur	Reduce likelihood and consequence	E	4	Low

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Giant mud crab									
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Blue swimmer crab									
Direct effects	Ryman-Laikre effect	C	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be sourced from the genetic regions specified in the draft FMS Research & monitoring (Section G.2.1.4.1)	Reduce likelihood	D	3	Moderate
	Introgression	B	3	High	HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be sourced from the genetic regions specified in the draft FMS Research & monitoring (Section G.2.1.4.2)	Reduce likelihood	D	3	Moderate
Indirect effects	Wastage of gametes	E	4	Low	No mitigation required (HQAS measures would help preserve genetic integrity)	Accept risk level	E	4	Low
	Naturalisation leading to fragmentation	D	3	Moderate	Fish would be stocked at appropriate densities to prevent overstocking or swamping Variation of stockings in space and time HQAS developed to include marine species Fish would only be stocked by HQAS accredited hatcheries Broodstock would be collected from the estuary where stocking is to occur	Reduce likelihood and consequence	E	4	Low

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Population Genetics – Blue swimmer crab									
	Overfishing of mixed stock fisheries leading to a reduction in genetic diversity	D	3	Moderate	Routine compliance inspections Appropriate monitoring of catch rates and fishing effort	Reduce likelihood and consequence	E	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Disease, Parasites and Pests									
Fish/Crustaceans	Infection of hatchery-reared fish with exotic disease/parasite causing contamination of farm and adjacent waterways	C	3	High	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries. Health authorities would be notified immediately of any potential disease risk	Reduce likelihood	E	3	Moderate
	Infection of hatchery-reared fish with endemic disease/parasite causing contamination of farm and adjacent waterways	C	4	Moderate	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries. Obtain further knowledge of disease risks in stocking zones Health authorities would be notified immediately of any potential disease risk	Reduce likelihood	E	4	Low
	Translocation of exotic fish disease/parasite from hatcheries into wild populations	C	3	High	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries	Reduce likelihood	E	3	Moderate
	Translocation of endemic fish disease/parasite from hatcheries into wild populations	C	4	Moderate	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries Obtain further knowledge of disease risks in stocking zones	Reduce likelihood	E	4	Low
	Translocation of non-target species	C	3	High	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries Fish would not be stocked outside their natural range Contingency plans would be in place	Reduce likelihood and consequence	D	4	Low

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Disease, Parasites and Pests									
Fish/Crustaceans	Translocation of other pest organisms	D	3	Moderate	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries Contingency planning	Reduce likelihood and consequence	E	4	Low
	Release of stock selected for reduced disease/parasite susceptibility causing undesirable modification of wild genotypes	C	3	High	Fish would only be reared and stocked by HQAS accredited hatcheries	Reduce likelihood	D	3	Moderate
Hatchery, Transport and Release Procedures									
	Hatchery/farm culture system failure causing poor on-farm stock health and culminating in stock which have difficulty withstanding stresses associated with harvest, transport and/or handling procedures	C	4	Moderate	Fish/crustaceans would only be reared and stocked by HQAS accredited hatcheries	Reduce likelihood and consequence	D	5	Low
	Transport system failure causing poor stock health prior to release	C	4	Moderate	Conduct practically achievable (visual) health assessments immediately prior to release and retain fish (do not release) if significant health issues are apparent Develop a code of practice for the safe transport and release of stock	Reduce likelihood and consequence	D	5	Low
	Release system failure causing poor stock health and/or mortalities at the release site	C	4	Moderate	Post-stocking surveillance Recover and dispose of dead/contaminated fish appropriately Develop a code of practice for appropriate release of stock	Reduce likelihood and consequence	D	5	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Aboriginal Social Issues									
Aboriginal cultural heritage	Impingement on areas of Aboriginal cultural importance (sites and Places)	D	3	Moderate	Further consultation with Aboriginal community groups at each estuary that would be stocked Stocking would not occur inside estuarine Aboriginal Places or in areas where the local Aboriginal community expresses a concern about the spiritual or cultural values of a place	Reduce Likelihood	E	3	Moderate
Aboriginal social issues	Lack of involvement of Aboriginal stakeholders in fishery management and stocking activities	D	4	Low	No mitigation required Consultation with local Aboriginal stakeholders prior to stocking of any new sites. The FMS aims to provide opportunity for Aboriginal communities to participate in stocking activities where feasible and ensure local communities and stakeholders are informed of outcomes of stocking	Reduce likelihood	E	4	Low
	Fish stocking not seen as adequate or good value or a sustainable approach to looking after sea country	D	3	Moderate	Ongoing long-term habitat restoration and protection programs would complement marine fish stocking Stockings would initially be small-scale Monitoring of stocking success	Accept risk level	D	3	Moderate

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Aboriginal Social Issues									
	Competition from other fishing sectors reduces Aboriginal access to stocked fish for a healthy diet	C	4	Moderate	Ensure a balance between the number of RFHs and non RFHs Research and monitoring Maintain records of the effects of fish stocking ensure stakeholders are informed of relevant outcomes. Monitoring and research	Reduce likelihood	D	4	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Non-Aboriginal Social Issues									
Non-Aboriginal cultural heritage	Fish stocking not consistent with objectives of State-wide template LEP zone for waterways or other State-wide requirements for the coastal zone	D	3	Moderate	Consultation with relevant State agencies and local government would ensure that the proposal is consistent with planning requirements for sensitive coastal waterways	Avoid risk	E	5	Low
	Impacts to Crown Land and assets (e.g. boating facilities, wharves, banks and bed etc.)	D	4	Low	No mitigation required	Accept risk level	D	4	Low
Resource sharing	Resource sharing (e.g. conflict among fishing sectors)	D	4	Low	No mitigation required Ensure provision of mechanisms to report concerns and conflict through an administrative framework Ensure that there is a balance between the number of RFHs and non RFHs	Accept risk level	D	4	Low
Other waterway users	Conflict between fishing groups and other waterway users	D	4	Low	No mitigation required	Accept risk level	D	4	Low
Aquaculture industry	Impacts on oyster leases	C	3	High	Stocking would be avoided in parts of estuaries where oyster leases are present Further consultation with oyster farmers and industry representatives Monitoring and research to determine the distance moved by stocked fish	Reduce likelihood	E	3	Moderate
	Impacts on other aquaculture	D	5	Low	No mitigation required	Accept risk level	D	5	Low

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Non-Aboriginal Social Issues									
Community support, interaction and fishing effort	Perceived negative environmental impact of fish stocking	C	4	Moderate	Further community consultation and education during the stocking process to ensure awareness and support	Reduce likelihood	D	4	Low
	Lack of community support	D	4	Low	No mitigation required Further community consultation and education during the stocking process to ensure awareness and support	Accept risk level	D	4	Low
	Increase/concentration of fishing participation/effort	B	5	Moderate	No mitigation required	Accept risk level	B	5	Moderate

Table G.37: Continued.

Environmental Aspect	Risk Description (event and consequence)	Risk Severity Before Treatment			Fisheries Management Strategy (FMS)	Treatment Type	Residual Risk Severity		
		L	C	Risk Level			L	C	Risk Level
Physico-Chemical									
Water quality	Direct reduction in water quality from increased boating (large, well flushed, open estuary)	D	5	Low	No mitigation required Promote existing best practice boating guidelines	Accept risk	D	5	Low
	Direct reduction in water quality from increased boating (small, poorly flushed, semi-enclosed water body)	C	4	Moderate	Promote existing best practice boating guidelines and ensure mechanisms are in place to report water quality concerns. Action to be taken as and when required	Accept risk	C	4	Moderate
	Indirect reduction in water quality from aquaculture operations	D	4	Low	No mitigation required Ensure that juvenile fish/crustaceans for stocking are reared in hatcheries that comply with the HQAS. Any unauthorised release of untreated water into natural waterways would be reported	Accept risk	D	4	Low
Noise	Noise disturbance from increased recreational fishing/stocking activity	D	4	Low	No mitigation required	Accept risk	D	4	Low
Light	Light pollution from increased recreational fishing/stocking activity	D	4	Low	No mitigation required	Accept risk	D	4	Low
Air quality	Impact on air quality (e.g. from car/ boat emissions/hatchery facilities)	D	5	Low	No mitigation required (Note: HQAS includes provisions to maintain air quality)	Accept risk	D	5	Low
Energy	Hatchery production fails to be energy efficient	D	5	Low	No mitigation required	Accept risk	D	5	Low

Table G.38: Summary of all mitigation and management measures to minimise potential impacts of marine stocking activity.

Ecology		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence in estimates). Monitoring of fishing catch and effort. DPI would carry out routine inspections to ensure compliance with existing fisheries regulations. Stocking would be timed in relation to natural life cycles and species recruitment patterns. Species would be stocked only in estuaries occurring within their natural geographic range. Ensure stocking releases take place at suitable access points or by boat. Research and monitoring for potential impacts on wild conspecifics.	Appendix E.3 of the FMS outlines the approved stocking regions for each species permitted for stocking. Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.3 (b): Develop and implement species specific stocking guidelines directly relevant to species ranges in NSW. Objective 1.4 (a, b): To implement the FMS in a manner consistent with Commonwealth and State endorsed programs designed to protect aquatic biodiversity. Objective 1.6 (a): To initiate research relating to the activity. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques (This would ensure preferred timing and release locations).	Research Topic 1.1 (Priority level 1): To investigate genetic distribution of native species and sub populations. Research Topic 1.2 (Priority level 1): To research impacts of stocking activities on the native populations within stocking areas. Research Topic 2.1 (Priority Level 1) Investigate distance stock travel from point of release. Research Topic 2.3 (Priority level 2): To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. Research outcomes would help support the GPIM. Research Topic 3.2 (1) (Priority Level 1): Optimisation of harvest stocking techniques.

Table G.38: Continued.

Threatened Species, Populations and Ecological Communities		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
Stocking would not take place into declared critical habitat of a threatened species of fish. Monitor incidence of injury/fatality from harmful marine debris and/or hooking and manage as appropriate. Education on threatened species and responsible fishing. Maximum stocking rates would not be exceeded (new data would be incorporated into the GPIM to improve confidence of estimates). Monitoring and research to determine potential trophic impacts through food chain interactions. Monitoring of fishing catch and effort. Use of existing DPI mechanisms in place to report incidental catch or sightings of threatened or protected species. Stocking would not take place at Taren Point (Botany Bay) where there is an endangered ecological community of shorebirds. Releases would take place from suitable access points or by boat.	Table E.4: Waters permanently closed to stocking. Table E.5: Waters with restrictions to stocking. Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (a): To appropriately manage stocking in areas where the activity may adversely affect a threatened species. Objective 1.2 (b): to record and monitor sightings and incidences involving threatened and protected species within stocked estuaries. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.2 (d): to educate stakeholders regarding threatened species including reporting sightings and incidences involving threatened and protected species within stocked estuaries. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters.	Research Topic 1.2 (Priority Level 1): To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of conservation significance and MPAs. Research Topic 2.2 (Priority level 2) Impacts of native fish stocking on threatened species and areas of conservation significance. Research Topic 2.3 (Priority level 2): To establish reliable data regarding food chain interactions between stocked fish and the aquatic environment. Research outcomes would help support the GPIM. Research Topic 2.3 (d): Monitor the level of fishing effort and changes in effort associated with stocking.

Table G.38: Continued.

Areas of Conservation significance		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
Ramsar wetlands would be completely closed to marine fish stocking. Marine Parks would be completely closed to marine fish stocking. Estuaries that have Aquatic Reserves would not be excluded from stocking, but stocking would not take place within Aquatic Reserves. Stocking would not take place within marine extensions of Nature Reserves or National Parks. Stocking would not take place within declared Critical Habitats.	Table E.4: waters permanently closed to stocking. Table E.5: Waters with restrictions to stocking. Table E.6: Factors for listing and de-listing waters with restricted stocking. Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements.	Research Topic 1.2 (Priority Level 1): To research the impacts of stocking activities on the biodiversity of native populations within stocking areas, having specific regard to areas of conservation significance and MPAs. Research Topic 2.1 (Priority Level 1): To determine the distance that stock may travel from the point of release. Research Topic 2.2 (Priority Level 1): To determine interactions between stocked native fish and threatened species and areas of conservation significance.

Table G.38: Continued.

Population Genetics		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
HQAS would be developed to include the selected marine species. Fish/crustaceans would only be stocked by HQAS accredited hatcheries or equivalent recognised standard. • Hatchery management procedures outlined in the HQAS would be implemented to maintain high genetic effective population size e.g. an N_e of 50 broodstock per generation. • Broodstock used for stocking would be from the same genetic stock as that in the estuary to be stocked (except for eastern king prawn and blue swimmer crab which have specific requirements). Research and Monitoring • Research on the genetic stock structure of yellowfin bream, mulloway, dusky flathead, whiting, mud crab, blue swimmer crab and eastern king prawn should be carried out to reduce broodstock collection constraints. Research and monitoring to assess changes in genetic diversity (e.g. every 5 years). Yellowfin bream should not be stocked south of the Manning River (including a 50 km buffer zone). All other HQAS measures to preserve genetic integrity as outlined in Section G.2.1.4. Variation of stockings in space and time. Maximum stocking rates would not be exceeded to minimise risk of overstocking or swamping, (new data would be incorporated into the GPIM to improve confidence in estimates).	Appendix E.3 of the FMS outlines the approved stocking regions for each species permitted for stocking. Appendix E.3 (Chapter E.5.2) Broodstock collection regions. Appendix E.6 of the FMS outlines appropriate stocking rates for each approved species and estuary according to the GPIM. Objective 1.2 (c): Apply empirical methods to determine optimum stocking density rates (in terms of efficacy and effectiveness) to minimise potential for overstocking. Objective 1.3 (a): To develop and implement genetic resource management guidelines for marine fish stocking in NSW. Objective 1.3 (b): To develop and implement species specific stocking guidelines directly relevant to species ranges in NSW. Objective 2.1 (a): To commence provision for the stocking of approved fish species at appropriate densities to provide or enhance quality recreational fishing opportunities in estuarine waters. Objective 2.3 (d): Monitor the level of fishing effort and changes in effort associated with fish stocking. Objective 3.1 (a): To develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.2 (a): Ensure the use of appropriate technology in genetic resource management.	Research Topic 1.1 (Priority Level 1): To research and map the genetic distribution of native species used in the activity. Research Topic 1.3 (1)(Priority Level 1): Review current literature and research the most appropriate genetic protocols under NSW conditions with regard to native species breeding programs and broodstock management arrangements. Research Topic 1.3 (2) (Priority Level 1): determine the genetic effective population size of the target species population in each estuary where stocking is occurring. As part of this exercise, samples must be collected from target estuaries and species before stocking commences in order to establish pre-stocking benchmark conditions. Research Topic 1.3 (3) (Priority level 1): research into the most appropriate genetic markers that can be applied to potential broodstock to test their ancestry. Interbreeding between native and stocked individuals would lead to offspring of mixed ancestry.

Table G.38: Continued.

Population Genetics Continued		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
	Objective 3.3 (a, b, c): To implement best practice in broodstock collection and management.	
Appropriate monitoring (e.g. of catch rates and fishing effort) carried out as part of the monitoring and research plan. DPI would carry out routine inspections to ensure compliance with existing fisheries regulations.	Objective 4.2 (a, b): Maintain and report on accurate information relating to the activity.	

Table G.38: Continued.

Disease, Parasites and Pests		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
Fish would only be stocked by HQAS accredited hatcheries or equivalent recognised standard. This specifically includes: • implementing stringent farm containment and disinfection plans; • disease zoning policies; and • immediate notification of biosecurity authorities if there is potential disease risk. Broodstock would be screened to be clinically healthy and treated for external parasites as part of HQAS quarantine procedures any diseases identified would assist with the knowledge of the disease status of the broodstock source area and further species specific risk assessments would be carried out if required. Ensure adequate number of broodstock through hatcheries compliant with the HQAS prevent risk of undesirable modification of wild genotypes (e.g. disease susceptibility). Ensure adequate health and conditioning by using stock reared in hatcheries that comply with the NSW HQAS. Conduct practically achievable (visual) health assessments immediately prior to release and retain fish if significant health issues are apparent. Develop a code of practice for the safe transport and release of marine fish. Post-stocking surveillance. Recover and dispose of any dead/contaminated fish appropriately. Carry out further species specific risk assessment. Fish/crustaceans would not be stocked outside of their natural geographic range. As a contingency the DPI Biosecurity Branch would be enlisted to control any unpredicted pest incursions.	Objective 1.5 (a): To manage the activity consistently with State and National policies governing the translocation of live aquatic organisms. Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 3.1 (b): Ensure that any fish, eggs or larvae procured from interstate hatcheries for import into NSW for the activity of fish stocking meets QA standards. Objective 3.1 (c): Ensure that any disease risks associated with fish, fish eggs or larvae procured from hatcheries for the purposes of fish stocking are mitigated. Objective 3.3 (a): Implement best practice in broodstock collection and management. Objective 3.4 (a): Develop a code of practice that defines and promotes best practice in stocking techniques, transport medium management, ethical treatment and care of stock, stocking verification procedures and the assessment of disease and fish health.	Research Topic 1.4: Identify diseases which pose a translocation risk in NSW waters. Research Topic 1.5: Identify diseases which pose a genetic resistance risk in hatcheries.

Table G.38: Continued.

Aboriginal Social Values		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
DPI would not conduct stocking inside estuarine Aboriginal Places without the approval of the relevant local Aboriginal stakeholder groups and the OEH. Stocking would not be conducted in areas where the local Aboriginal community expresses a specific cultural concern about the detrimental impact of fish stocking on the spiritual or other cultural values of a place. DPI would consult with representatives of the local Aboriginal community groups at new estuaries that may be stocked. DPI would provide opportunities for Aboriginal stakeholders and the local community to be involved in planning, implementation and monitoring. Representative stocked estuaries would be monitored and outcomes of stocking reported. DPI would ensure local communities and stakeholders are informed of relevant outcomes of stocking activities. DPI would maintain sound records of the effects of fish stocking and ensuring local communities and stakeholders are informed of relevant outcomes of stocking activities. DPI would continue to run long-term habitat restoration and protection programs that would complement fish stocking. Stockings would be monitored to ensure success in line with appropriate management objectives.	Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements (including programs designed to protect aquatic environments and biodiversity). Objective 2.2: To minimise any negative impacts of the activity on cultural heritage values and provide opportunities for Aboriginal communities to participate in stocking activities and to support cultural fishing practices". Objective 2.2 (b): to ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework. Objective 2.2 (c): Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked. Objective 4.2 (a): To maintain all records of stocking events centrally. Objective 4.2 (b): Periodically report on the activity. Objective 4.3 (a): Develop and implement a culturally appropriate educational (communication) plan.	Research Topic 3.2 (2): Optimisation of harvest stocking releases. Objective 2.3 (c): Monitor the level of socio-economic benefit for fish stocking using surveys undertaken on an episodic basis.

Table G.38: Continued.

Non-Aboriginal Social Values		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
Review relevant LEPs prior to stocking to ensure the activity is consistent with LEP zoning. Review relevant LEPs prior to stocking for listings of heritage places or objects. Monitoring of fishing effort. Consultation was undertaken as part of the EIS process and MCA to identify estuaries where stocking could have a detrimental impact on social values. Ensure that there is a balance between the number of RFHs and non RFHs that are stocked. Ensure provision of mechanisms to report concerns and conflict through an administrative framework. Stocking would be avoided in parts of estuaries where oyster leases occur. DPI would undertake further consultation with oyster farmers and industry representatives and monitor for any impacts. Further research to investigate stock movements. Further community consultation and education during the stocking process to ensure awareness and support.	Appendix E.1 (Marine Stocking Review Guidelines), Part 3 (Local Environmental Issues), Issue 3.1 of the FMS requires that stocking must be consistent with local management plans. Objective 1.4 (a, b): To manage the activity having regard to cross-jurisdictional and DPI management arrangements (including programs designed to protect aquatic environments and biodiversity). Objective 2.3 (d): Monitor levels of fishing effort and changes in effort associated with fish stocking. Objective 4.2 (a): To maintain all records of stocking events centrally. Objective 4.2 (b): Periodically report on the activity. Objective 4.2 (b): Periodically report on the activity. Objective 4.3 (a): To improve community understanding and public perception of the activity through an education strategy.	Research Topic 2.1 (Priority Level 1) Investigate distance stock travel from point of release. Objective 2.3 (c): Monitor the level of socio-economic benefit for fish stocking using surveys undertaken on an episodic basis.

Table G.38: Continued.

Other (Physico-Chemical) Impacts		
Management Strategy	**Relevant Sections of the draft FMS**	**Research and Monitoring**
DPI would ensure there are mechanisms in place to report water quality concerns for further investigation where necessary. Promote existing best practice boating guidelines. Ensure that juvenile fish/crustaceans for stocking are reared in hatcheries that comply with the HQAS. Reporting of unauthorised release of untreated water into natural waterways.	Objective 3.1 (a): Develop and implement QA standards and an accreditation system for hatcheries supplying fish stocking. Objective 4.2 (a): To maintain all records of stocking events centrally. Section 1.5.5 of the draft FMS provides for the management of marine fish stocking consistent with principles of Ecologically Sustainable Development (ESD).	Water Quality monitoring would take place within hatcheries as part of the HQAS. Objective 2.3 (c): Monitor the level of socio-economic benefit from fish stocking using surveys undertaken on an episodic basis.

Chapter H
Justification for Marine Fish Stocking

Chapter H Contents

CHAPTER H JUSTIFICATION FOR MARINE FISH STOCKING

H.1 The Need for Marine Stocking

This Chapter examines the need for undertaking the activity proposed in the draft fisheries management strategy (FMS) (Chapter E) and the consequences of not undertaking the activity.

Recreational fishing is an important leisure activity for approximately 17 % of the New South Wales (NSW) population (approximately 1 million people) and is considered by the government to provide significant social and economic benefits (Cardno Ecology Lab 2010). Results of the National Recreational and Indigenous Fishing Survey undertaken in 2000/2001 (Henry and Lyle 2003) indicates that NSW has the greatest number of recreational fishers in the country (999,000). As identified throughout this document, the activity of marine fish stocking in NSW is likely to deliver enhanced fishery management outcomes for the marine fishing sector (including recreational and Aboriginal fishers). The proposed marine stocking program would contribute long term socio-economic benefits to local communities by enhancing fishing opportunities and expenditure on fishing related items and services.

It is well recognised that in addition to input and output controls on fishing effort and habitat protection and restoration programs (which aims to allow fish stocks and estuarine systems to naturally regenerate), aquaculture based marine stock enhancement is another means by which fisheries can be enhanced (Lorenzen *et al*. 2010, Munro and Bell 1997, Blaxter 2000, Bell *et al.* 2006). The proposed marine stocking program would complement other existing enhancement projects managed by NSW Department of Primary Industries (DPI), such as freshwater fish stocking, fish aggregation devices, estuarine and offshore artificial reefs.

The proposed marine stocking program provides a mechanism to enhance existing fisheries at both species and location levels, therefore contributing to the management objectives of NSW publicly owned fisheries resources. Marine stocking satisfies a number of significant community needs and contributes to achieving primary and secondary objectives of the *Fisheries Management Act 1994* (FM Act). Marine fish stocking as described within the proposal as a fisheries enhancement tool is consistent with these objectives.

H.2 Biophysical Considerations

Based on the risk assessment carried out for the proposed activity (Section D.3), it is evident that stocking of native marine fish into estuaries, without the stringent management and mitigation measures described within the draft FMS (Chapter E), would pose risks to various components of the biophysical environment. In particular, these risks include impacts to ecological processes, threatened and protected species, areas of conservation significance, population genetics, disease, parasites and fish health. The assessment of impacts (Section G.3) identifies the management and mitigation measures and the various Goals and Objectives that would be implemented through the draft FMS to address each identified risk. These measures, including stocking in recruitment limited situations only, are considered to reduce the level of risks identified in the assessment of impacts to a level that is considered to be environmentally acceptable. Where some uncertainty remains the draft FMS also outlines a prioritised list of research and management responses which would be carried out in conjunction with the marine stocking program to provide additional information on the potential risk for impact or to mitigate the impact.

H.3 Social Considerations

Recreational fishing is an important leisure activity and provides significant social benefits (Henry and Lyle 2003). NSW has large urban population centres located adjacent to estuarine systems. Consequently, a large proportion (approximately 45 %) of fishing occurs in estuaries in NSW. The National Recreational and Indigenous Survey indicated that in NSW, the main motivation for recreational fishing was relaxation (40 % of those surveyed), followed by fishing for sport (21 %), to be outdoors (15 %), to be with family (13 %) and fishing for food (5 %). The high utilisation of estuarine areas for fishing raises several social issues which must be addressed when considering the proposal. Without the implementation of the draft FMS, many of these issues relating to the non-Aboriginal social aspects are likely to include conflict regarding resource sharing and waterway use, particularly in more populated regions. Without proper education relating to responsible fish stocking practises and community interaction with planning of fish stocking programs, there is a risk that the proposal will fail to gain the community support which is considered important for the long-term success of a program. Noting that the draft FMS addresses these social issues, the proposed marine fish stocking program is likely to improve the quality and actual and/or perceived satisfaction of recreational fishers in NSW by improving catch rates and promoting fishing opportunity in urban and regional areas.

The freshwater fish stocking Environmental Impact Statement (EIS) (NSW DPI 2003a) recognised the high level of awareness of the activity of fish stocking within the general community (greater than 75 %) and a broad perception that stocking provides unique social benefits such as healthy recreational opportunities, tourism and local employment from related industries whilst also providing fishery outcomes for certain fish species.

For Aboriginal people, fishing is an integral part of cultural lifestyle, as it is important for ceremonial occasions, a source of food and nutrition and is connected to the traditional responsibilities of coastal management and kinship (Henry and Lyle 2003). The marine fish stocking program provides opportunity though the enhancement of fishing opportunities to benefit the Aboriginal community. However without the management responses and goals proposed in the draft FMS, marine fish stocking is unlikely to achieve its potential to benefit the Aboriginal community. The draft FMS proposes to manage the marine fish stocking program in a way which would enable fish stocking to improve Aboriginal access to valued fish resources, encourage community involvement and provide training and satisfaction in caring for estuarine health. Opportunity for Aboriginal people to be involved in the implementation of marine fish stocking would benefit local communities and could potentially have a positive impact if stakeholders can see that their issues and concerns are fully integrated into marine stocking projects. Participation of Aboriginal community members in the planning and implementation of stocking events is likely to improve communication and relationships between Aboriginal stakeholders and fisheries managers and may also provide the marine stocking program with valuable local knowledge that may contribute to successful stocking results. Stocking of native species for religious and ceremonial purposes into estuaries also occurs within NSW waters and would be provided for under the draft FMS harvest stocking policy. Only the approved species produced from accredited hatcheries may be stocked for these purposes consistent with the proposal and scope of the draft FMS.

Enhancement of recreational fishing opportunity has the added benefit of providing a source of food, which is generally perceived by the community as an appropriate use of public utilities (NSW DPI 2003b). According to Henry and Lyle (2003), fishing for food is the main motivation for approximately 8 % of fishers nationwide and for 5 % of the NSW fishing population. Fishing for food is also an important part of maintaining social networks within Aboriginal communities.

H.4 Economic Considerations

Recreational fishing generates significant economic benefit for NSW, particularly for regional communities (NSW Government 2010a). As described in Chapter C.10, recreational fishers in NSW spent $554 million on fishing related items during the year 2000/2001, which equates to an average expenditure of about $550 per angler per year (Henry and Lyle 2003). As around 45 % of fishing effort within NSW takes place in estuaries, this leads to an estuarine recreational fishing expenditure of over $260 million.

Under the draft FMS the marine fish stocking program can occur in 80 suitable estuaries, in recruitment limited situations only and any stocked estuaries located adjacent to popular urban and regional areas have potential to directly and indirectly contribute to the local economies of these areas. For example, expenditure on recreational fishing was examined in two case studies by Dominion Consulting (2005) in Port Macquarie on the north NSW coast and Narooma/Bermagui on the south coast. Results of the surveys indicated the importance of recreational fishing to these regional economies through expenditure on fishing related items, employment and tourism. Expenditure was estimated to be $23 million and $25 million in Port Macquarie and Bermagui/Narooma respectively in 2003/4 and supported between 260 and 276 jobs. Approximately 50 % of people fishing in Bermagui and 75 % of those fishing in Port Macquarie were visitors, indicating that people are willing to travel to participate in fishing.

Stocking events under the DPI harvest stocking program would be distributed across the three EIS identified ‘stocking regions’ (i.e. north, central and southern, refer to Figure B.1 of Section B.4) to ensure the distribution of stocking events and potential economic benefits are not concentrated in any one region. Fishing related expenditure is also likely to be more widespread than the areas adjacent to stocked estuaries as ancillary purchases (such as fuel, food, ice and bait) for example, may occur during a journey to reach a fishing destination rather than at the destination itself.

By allowing the marine fish stocking program to occur in estuaries that are open to commercial fishing and also in Recreational Fishing Havens (RFHs), there is potential for the enhanced fishing opportunities arising from the program to relieve fishing pressure on stocked commercially and recreationally important species, thus helping to enhance populations and sustain economic benefits in the long-term. Although, the marine fish stocking program is primarily to improve opportunity for recreational fishing, commercial fishers may also benefit from enhanced catch if they operate within stocked estuaries.

The aquaculture industry (predominantly located in regional NSW), directly employs over 1500 full and part-time jobs and 3000 jobs indirectly from flow on effects (NSW DPI 2009a). Following the implementation of the marine fish stocking program, Hatchery Quality Assurance Scheme (HQAS) accredited hatchery operators, which are registered to breed the stocked species, may directly benefit from financial contracts and may employ extra staff to handle the additional work. In future, success of the proposed marine stocking program may require new hatcheries to be developed or existing hatcheries to be redeveloped to supply larger numbers of juveniles or to develop technologies for other potentially suitable species for stocking. This has potential to contribute to additional revenue and direct employment within the aquaculture industry.

Economic Feasibility Analysis

An economic feasibility analysis (EFA) involving cost benefit analyses was carried out in Specialist Report B and indicates that a marine fish stocking program based on any combinations of the species proposed in the EIS, within the selected estuaries in NSW, is likely to be economically beneficial. The data available in regards to fishing effort and success of capture within NSW was insufficient to undertake a standard quantitative cost-benefit analysis which would typically be reported as part of an EIS. Consequently, both a qualitative discussion of the associated costs and benefits as well as three distinct nonstandard quantitative cost-benefit analyses (CBA) were undertaken within the EFA to determine the feasibility of stocking each of the seven selected species. The cost benefit analysis identified three species (from the seven proposed) as being the most economically viable:

- Eastern king prawn;
- Giant mud crab; and
- Dusky flathead.

If the crustacean species are removed from the program the three finfish species identified as being the most economically viable included:

- Dusky flathead;
- Yellowfin bream; and
- Mulloway.

All species proposed to be stocked into estuarine waters were found to be economically viable. Although sand whiting were the least viable they still represented a worthwhile undertaking. Similarly, stocking is considered to be economically feasible for all the regions included in the economic assessment, although, in terms of maximising the economic return from stocking, some regions are likely to be more viable and in turn more suitable than others. In order to gain the greatest economic benefit to a region from the marine fish stocking proposal, it would also be necessary to select the species that provide the greatest economic value from stocking (i.e. eastern king prawn, giant mud crab and dusky flathead). For each of these species the North Coast Northern region is identified as the region in which these species are in greatest demand and to stock here may be economically more viable. Regions identified as most likely to benefit from marine fish stocking in terms of overall populations and current effort levels for stocking across all species include:

- Lower South Coast Northern;
- North Coast Northern ; and
- Lower South Coast Southern (refer to Chapter G.4.3, Figure G.3).

In order to establish a direct numerical benefit from stocking of a species within a region, and compare and contrast between regions/species, more detailed local data (i.e. estimates of 'catchabilities') would, however, need to be obtained.

H.5 Contribution to Biological Information

In addition to the socio-economic benefits described in previous Sections, implementation of a marine fish stocking program provides opportunity to address other core ecological assumptions and hypotheses that underpin fisheries management strategies. Bell *et al.* (2008) identifies some of these biological insights as follows:

- Monitoring the survival and growth of cultured juveniles can help develop an understanding of the carrying capacity of coastal ecosystems for target species;
- Stocking programs can provide information to assist in the design of marine reserves to protect nursery habitats and spawning areas and other forms of spatial management;

- Monitoring of tagged individuals through stocking programs can provide information on movement patterns, dispersal and site fidelity; and
- Opportunity to quantify the spawning biomass i.e. the amount of sexually mature fish in a population (e.g. black bream in Western Australia, Potter *et al*. 2008);

Several Research Topics have been outlined within the draft FMS to increase knowledge in a number of these areas (Chapter E. 2.8). The research topics have been specifically generated to address the goals of the draft FMS but would also provide new information relevant to fisheries management and conservation in general. Some of the more widely applicable research topics include:

- Genetics studies to determine the population structure of target species;
- Research to determine what diseases pose greatest translocation risk in NSW waters;
- Movement of stocked fish; and
- Interactions between stocked fish associated fishing activity and estuarine ecosystems.

H.6 Justification of Measures in the Draft FMS in Terms of the Principles of Ecologically Sustainable Development (ESD)

As outlined in the Director General's Requirements (DGRs) and pursuant to Schedule 2 and clause 230 of the *Environmental Planning & Assessment Regulation (2000)*, the proposal to stock marine fish should be carried out in a manner that has regard to biophysical, economic and social considerations, including the principles of ESD.

The principles of ESD consider the environment in terms of both natural and anthropological outcomes. Actions supporting ESD are proposed to ensure that not only present generations and environments are protected, but also that present and future generations have an opportunity to enjoy the benefits of a well managed activity thereby ensuring intergenerational and intragenerational equity (NSW DPI 2003a).

The proposed marine stocking activity in NSW would involve the releasing juveniles of up to seven native fish species into estuaries in recruitment limited situations only to enhance recreational fishing opportunities. The frequency of stocking events and stocking rates would be controlled through the FMS, so that the activity improves the total quality of fishing, now and in the future, but does not harm the ecological processes on which estuaries depend.

The impact of the marine fish stocking proposal on the environment has been assessed in the EIS by an initial analysis of the risks associated with the activity of uncontrolled fish stocking. The risks associated with the activity are portioned into components related to the impacts on ecology, threatened species, areas of conservation significance, population genetics, disease parasites and health, Aboriginal social impacts, non-Aboriginal social impacts and other associated impacts. These risks have been fully reviewed and discussed in Chapter D and Chapter G of this EIS.

The draft FMS, as outlined in Chapter E of the EIS, proposes goals, objectives and management responses for the proposed activity, having regard to the risks identified in the Chapter D. The preferred suite of rules (including management responses) in the draft FMS, provides for appropriate access to the resources ad incorporates the tools necessary to achieve resource sustainability.

The draft FMS provides a framework for managing marine fish stocking and describes a range of programs to be implemented; some of which are immediate actions, others are longer term programs with a development stage and a need to undertake further stakeholder consultation built in. For these longer term programs, the draft FMS outlines many of the proposals in broad terms omitting fine detail, consequently there has only been a negligible or minor reduction of risk in some areas of the environmental assessment. In order to ensure that the activity 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 activity. With this qualification, it can be stated that the draft FMS addresses the principles of ESD in the following ways.

H.6.1 Precautionary Principle

The precautionary principle is defined in the 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" (Deville and Harding 1997).

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 justify conclusions that the activity will not have serious or irreversible impacts on the environment, which exceed the long-term benefits of the action (Deville and Harding 1997).

Scientific research into the impacts of stocking and the ecosystem into which it is proposed to occur is inherently complex and costly. Estuarine environments and the diverse range of populations inhabited by them are extremely dynamic. This means that the level of scientific uncertainty associated with the environmental impacts of stocking on estuarine communities is generally high, especially for estuarine species that are of low commercial or recreational value. This situation is by no means unique to stocking in NSW or indeed Australia. It is important to note, however, a considerable amount of research on stocking trials for some of the species proposed for the program has been carried out. Some of the risks associated with fish stocking are not exclusive to marine fish releases and are already being investigated as part of the DPI existing freshwater fish stocking program.

Many of the management measures that are to be applied to the marine stocking program, as described within the draft FMS, such as genetic resource management and disease control, have been adopted on a precautionary basis to provide assistance with reducing the potential for impacts to natural populations. For example, to maintain natural levels of genetic diversity for species where there is insufficient information on their population structure broodstock must be collected from within the estuary which is to be stocked. Measures proposed in the draft FMS embrace this approach and place further conservative controls on where broodstock can be collected until the genetic extents of natural populations is known and by proposing research initiatives to pro-actively address the information deficiencies.

The performance monitoring system proposed to be established by the draft FMS also provides a necessary safeguard in case of changes in either the operation, or impacts, of the proposed stocking program, which could compromise the long term sustainability of the program.

H.6.2 Inter and Intra-generational Equity

Inter-generational equity requires that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

In the context of marine stocking, inter-generational equity consists of ensuring that stocking operates in a manner that minimises the impact to habitat, bycatch and threatened species, populations and ecological communities, as well as maintaining estuarine fishing at sustainable levels for future generations.

The four broad goals proposed in the draft FMS, work together to, help maintain and potentially improve the benefit that estuarine fishing provides to future generations. Some management measures which have been designed within the draft FMS specifically to help achieve these goals, and hence intergenerational equity, include:

Objective 1.2: To minimise and/or eliminate any negative impact from the activity on threatened species, populations and ecological communities (including mammals, birds, reptiles, amphibians, fish, invertebrates and vegetation), and where possible promote their recovery.

Objective 1.3: To provide reliable genetic resource management in the activity.

Objective 1.5: To appropriately manage the risks associated with translocation of live aquatic organisms during stocking activities.

Objective 1.6: To initiate research relating to the activity.

Objective 2.4: To support research into the potential for stocking of other species to provide for improved understanding of species biology, associated ecological processes, advances in technology and broadening fishing opportunities.

Objective 3.2: To promote the use of appropriate technology for genetic resource management in all hatcheries involved in the activity.

Objective 3.3: Implement best practice in broodstock collection and management.

Objective 3.4: To promote best practice techniques for marine stocking.

As there are no restrictions on who can purchase recreational fishing licences future generations can also participate in recreational fishing and would also benefit from marine stocking and the associated enhancement of recreational fishing activities.

Intra-generational equity requires that the costs and benefits of pursuing ESD strategies are distributed as evenly as practicable within each generation (i.e. among the stakeholders of marine stocking and other parts of the community).

The Commonwealth and NSW State legislations require public consultation in the preparation of fishery environmental impact statements. The EIS (including the FMS) process included community consultation and stakeholder involvement throughout its development. This included a series of workshops, face to face meetings, letters and emails.

If the four broad goals of the draft FMS are realised, the current generation would have improved opportunities to benefit from fishing. Management objectives proposed within the draft FMS to achieve these goals, and hence intra-generational equity, include:

Objective 1.1: To develop and maintain a framework to guide appropriate assessment of stocking activities.

Objective 1.2: To minimise and/or eliminate any negative impact from the activity on threatened species, populations and ecological communities (including mammals, birds, reptiles, amphibians, fish, invertebrates and vegetation), and where possible promote their recovery.

Objective 1.3: To provide reliable genetic resource management in the activity.

Objective 1.4: To implement the draft FMS in a manner consistent with related commonwealth and State endorsed programs designed to protect aquatic environments and biodiversity.

Objective 1.5: To appropriately manage the risks associated with translocation of live aquatic organisms during stocking activities.

Objective 1.6: To initiate research relating to the activity.

Objective 1.7: To minimise any competitive advantage of the stocked species over wild conspecifics.

Objective 2.1: To provide quality stock to enhance recreational fisheries

Objective 2.2: To minimise any negative impacts of the activity on cultural heritage values and provide opportunities for Aboriginal communities to participate in marine stocking activities and to support cultural fishing practises.

Objective 2.3: Maximise economic benefits and provide social equity from the activity.

Objective 2.4: To support research into the potential for stocking of other species to provide for improved understanding of species biology, associated ecological processes, advances in technology and broadening fishing opportunities.

Objective 3.1: Ensure stock is of the highest standard in terms of fish health.

Objective 3.2: To promote the use of appropriate technology for genetic resource management in all hatcheries involved in the activity.

Objective 3.3: Implement best practice in broodstock collection and management.

Objective 3.4: To promote best practice techniques for marine stocking.

Objective 4.1: To provide a clear and efficient administrative framework for reviewing stocking events.

Objective 4.2: To maintain and report accurate information relating to the activity.

Objective 4.3: To improve community understanding and public perception of the activity through an education strategy.

Objective 4.4: To develop and deliver an effective compliance program.

The measures in the draft FMS distribute, as far as practicable, a fair and equitable sharing of the stocked fish amongst the recreational, commercial and Aboriginal cultural sectors, within broader resource sharing arrangements. Marine fish stocking has the potential to boost fish catch and provide a source of food to satisfy an ever increasing consumer demand, particularly for popular species, such as those proposed for stocking. Stocking in some estuaries

where all sectors can operate is important to appropriately share the enhanced resource among recreational fishers and other legitimate users. Where stocking is carried out in estuaries where commercial fishers operate, commercial fishers are likely to take a share of stocked fish. Where stocking is done in recreational fishing havens, recreational and Aboriginal cultural fishers would benefit. Other non-fishing members of the community would benefit from the economic flow-on of fishing activity.

H.6.3 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. The impact of marine stocking upon biophysical aspects of the marine environment has been assessed in the EIS by an analysis of the risks associated with the proposal. Biophysical risks associated with marine stocking are partitioned into two components related primarily to the ecological impacts of marine stocking on (1) conspecifics in the wild and (2) competitors, predators, threatened and protected species and habitat. These risks have been reviewed and discussed in Chapters D and G.

Goal 1 of the draft FMS is to 'manage the activity in a manner that minimises impacts on aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates'. Within this goal there are five objectives and ten management responses describing how this would be done. The management responses directly address biodiversity and ecological integrity issues by managing stocking where there are sensitive ecological issues, stocking at densities that would minimise impacts to estuaries, implementing stringent genetic resource and disease management guidelines, monitoring the effects of marine stocking on native species, associated habitat and ecosystems. The draft FMS proposes that policies be developed to incorporate 'best practice' hatchery operations (i.e. the 'HQAS' and 'Genetic Resource Management Guidelines') for minimising potential genetics and disease impacts of stocked fish on estuarine ecosystems. The policies would be adaptive to incorporate new information such as knowledge and techniques.

In conclusion, the draft FMS contains a comprehensive and appropriate package of measures for ensuring that the impacts of marine stocking on biodiversity and ecological integrity are properly managed.

H.6.4 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. As described in Section G.4, an economic feasibility assessment was undertaken to estimate the viability of the proposal and specifically focused on the species proposed and to determine which regions are likely to generate the greatest cost-benefits. Through the feasibility assessment all species, proposed for stocking were considered to be economically viable, although some as expected, more so than others. Further surveys would be undertaken to assess the benefits of the activity compared with the expenditure of funds and empirical methods would be used to assess the most efficient long-term stocking rates. Goal 2 of the draft FMS specifically aims to 'enhance fishing opportunities through cost-effective stocking programs that maximise economic benefits and provide social equity from the activity'.

In consideration of alternative management approaches and stocking practises, (Chapter F), further research would be undertaken to determine the most cost-effective and reliable marking techniques (used to identify stocked individuals), optimum size at release and stocking techniques (conditioning, timing and release methods).

The marine fish stocking program would initially be funded by the NSW Government using funds from the Recreational Fishing Trust. All revenue resulting from the recreational fishing licence fees is placed in the Recreational Fishing Trusts as prescribed by Sections 234 and 235 of the FM Act.

H.7 Alignment with the NSW State Plan 2021

Marine fish stocking would help the people of NSW meet some of the key objectives of the NSW State Plan (NSW Government 2011). The ways in which the aims of the State Plan are addressed is described below:

- Drive economic growth in regional NSW:
    - The implementation of the marine stocking program would increase the demand for juvenile fish to be produced from aquaculture facilities, which would in turn potentially drive investment and may support existing jobs or create new ones.

  - Many of the species which have been selected for release as part of the marine fish stoking program have the ability to have their production improved through the innovation of better breeding techniques. The success of stocking may also increase with improved innovation with regard to release techniques.
- Protect our natural environment
  - If carried out responsibly and in locations where it is likely to be beneficial, marine stocking may assist in relieving pressure on existing recreationally important populations. Marine fish stocking would complement existing management approaches which underpin sustainable recreational fishing (i.e. bag and size limits, gear restrictions and threatened species regulations).
- Enhance cultural, creative, sporting and recreational opportunities
  - One of the main aims of the marine stocking program is to enhance fishing opportunities, which would increase the likelihood of people catching fish and potentially encourage use of outdoor facilities such as parks and green spaces.
  - Recreational fishing is considered to be an important past time and cultural activity for a significant proportion of the NSW population. Marine stocking would enhance fishing opportunities across the State.

H.8 Adopting a Responsible Approach to Marine Stocking

A number of peer reviewed papers have been published on the responsible approach to marine stock enhancement and management (Section C.5). The steps detailed in Blankenship and Leber (1995) in particular, have gained widespread acceptance as the 'responsible approach' to marine stock enhancement. Many aspects of fisheries science in general and fisheries enhancement have developed rapidly since the responsible approach was first formulated; hence, an update to this approach has been published in light of these developments (Lorenzen *et al.* 2010). The updated approach emphasises the need for a broad and integrated view of the role of enhancements within fisheries management systems, the importance of stakeholder participation in the planning process, and the assessment of the potential contribution of enhancement and alternative measures to fisheries management goals early on in the development process. The main areas of concern and impact within the published guidelines for a responsible approach to marine fish stocking are generally consistent with the DGRs issued for this proposal.

In particular, the updated responsible approach identifies the need for a fisheries management plan which defines clear goals, measures of success and decision rules (Lorenzen *et al.* 2010). The draft FMS for marine stocking has defined goals relating to fisheries and environmental management (Section E.3), performance indicators and trigger points, which provide targets for environmental performance monitoring and provide for improvements through research and monitoring. The proposed marine fish stocking program builds upon the detailed research and technology of previous marine stocking research in NSW (Taylor and Suthers 2008, Taylor *et al*. 2009, and Ochwada *et al.* 2009). Lorenzen *et al*. (2010) also highlights the need for adaptive management in enhancement stockings. The draft FMS provides for adaptive management enabling evaluation of performance of hatchery releases and a means to resolve uncertainties, improve the efficiency of release strategies, refine operational plans and achieve the goals of enhancement (consistent with Lorenzen *et al.* 2010).

H.9 Conclusion

Marine fish stocking in NSW has the potential to greatly enhance a valuable community owned marine resource, which some 17 % of the NSW population would benefit from whilst also making a socio-economic contribution to the State. The risks associated with the marine fish stocking program would be managed as proposed under the draft FMS which provides a rigorous management regime and broadly reflects the accepted best practice approach to responsible marine stocking. The operation and management of marine stocking, as proposed in the draft FMS, is justified in terms of protecting the natural environment, maintaining and enhancing stocks and protecting the interests of stakeholders in estuarine fisheries and the community at large. Appropriately managed stock enhancement is likely to help enhance the quality of estuarine fishing in NSW and contribute to the overall experience and enjoyment of recreational fishers.

In relation to the draft FMS, the focus of the economic development component of marine stocking is not intended to exploit the environment to satisfy only short-term community benefits. Under the draft strategy, marine stocking is designed to meet community expectations with regard to fishing opportunities and conservation outcomes by maximising the benefits of the activity within ecologically acceptable boundaries. The suite of management provisions provided would ensure that as the activity continues it will be complemented by better information and

review systems to continually improve the performance of the activity, thus safeguarding the welfare of future generations.

Chapter I
References

CHAPTER I REFERENCES

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