Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Marine Fish Stocking in NSW Environmental Impact Statement Vol III

Prepared for: Department of Primary Industries

November 2011

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Marine Fish Stocking Vol III: Online version

Public Consultation Document

Cardno (NSW/ACT) Pty Ltd

ISBN 978 1 74256 223 0

Online Version

Cover Image: Courtesy of DPI.

Document Control

Report Number	Status	Date	Authors	
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Appendix 1

Director Generals Requirements

NSW GOVERNMENT
Department of Planning

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Our ref: S09/00068

Mr Bryan Van Der Walt
Manager, Fisheries Enhancement
NSW Department of Primary Industries (DPI)
PO Box 21
Cronulla NSW 2203

Dear Mr Van Der Walt

Director-General's Requirements – Marine Fish Stocking Program (NSW Coastal Waters)

I refer to your request for the Director-General's requirements for the preparation of an Environmental Impact Statement (EIS) under Part 5 of the *Environmental Planning and Assessment Act 1979* for the proposed Marine Fish Stocking Program for NSW Coastal Waters.

Statutory Issues
Attachment No.1 outlines the statutory matters that must be included in any EIS under clauses 229 and 230 of the *Environmental Planning and Assessment Regulation 2000* (the EP&A Regulation).

Department of Planning Guidelines
Pursuant to clause 231 of the EP&A Regulation, the Director-General requires the EIS to address the following specific issues:

Description of the Proposal: The EIS must include a full description of the proposal, identifying:

- Details of the activities undertaken including the species to be stocked, sources of broodstock, stocking methods and locations, and quantity of fish to be stocked. This should be supported by maps/plans clearly showing the various stocking locations. Natural environmental features should also be included; and
- Operational details including the ownership and responsibility for the ongoing operation and management of the fish stocking program.

Justification for the Proposal: The EIS must include a detailed justification for the need and location of the proposal including:

- Consideration of alternatives including the "no stocking" option and justify the preferred option considering social, environmental and economic factors;
- Detail the surrounding water use capability to host the proposal, also demonstrating its suitability and sustainability over the long term; and
- Current and future demand for fish stocking.

Planning Context: The EIS must assess the proposal against relevant environmental planning instruments, strategic and local planning documents. The EIS must also outline any licence/approvals applicable to the project.

Key Issues: The EIS must assess the following potential impacts of the proposal during construction and operation (as relevant):

- **Flora and Fauna** – including:
  - an assessment of any potential impacts on critical habitats, threatened species, protected species, populations or ecological communities and their habitats in the region, and measures to mitigate these impacts;
  - potential significant impacts to natural populations of predators and prey, trophic interactions and marine biodiversity in general;
  - ensuring that the genetics of the broodstock are compatible with the genetics of the stock in the receiving waters.

- **Disease Risks and Their Management**– including:
  - identification of any disease risks to fish and aquatic health from introducing hatchery fish into the marine environment;
  - details of proposed measures to be used in maintaining the genetic integrity of local wild stocks; and
  - detailed disease and pest management protocols.

- **Performance Monitoring** – including procedures to monitor: catch rates of stocked fish, migration of stocked fish, the location of specific stocking events and the number of fish stocked.

- **Marine Protected Areas** – including:
  - an assessment of how the proposed activity interacts with the management objectives of marine parks, aquatic reserves and marine areas of national parks and nature reserves;
  - release strategies for waters directly adjacent to marine protected areas.

- **Cost Benefit Analysis** – include an assessment that demonstrates the species to be stocked, size at stocking, stocking rates and the timing and location of stocking produce benefits that are optimal or near optimal.

- **Indigenous Cultural Heritage** – include the interests of Indigenous people in fish stocking, any important Aboriginal heritage sites/places impacted by the proposed activity and outline any existing protocols/measures that aim to minimise risk of harm to these sites.

- **Crown Land** – including likely direct or indirect impacts of Crown Land and assets such as breakwaters or boat ramps.

Please note that the above list of issues is not exhaustive and where the Proponent identifies other environmental impacts of the proposal, these issues must also be assessed in the EIS at an appropriate level of detail. The level of analysis of the issues should reflect the significance of their impacts and relevance for the proposal.

Environmental Monitoring and Management: The EIS must describe in detail what measures would be implemented to avoid, manage, mitigate and/or off-set the potential impacts of the activity, and describe how the environmental performance of the activity would be monitored and managed over time.

Other Determining Authorities
In your Form A you indicated that your proposal does not require additional approval(s) from other Government agencies.

Nonetheless, the Department has consulted with the Department of Primary Industries, Department of Lands, the Department of Water and Energy, Marine Parks Authority, Department of Environment and Climate Change and the Commonwealth Department of Environment, Water, Heritage and the Arts. Their requirements for the proposal are attached and these must be addressed in the EIS.

You should consult directly with all other agencies and address any requirements they may have in your EIS.

If any/further determining authorities are identified then you must conduct your own consultation with the relevant agencies and address their requirements in the EIS.

Consultation
During the preparation of the EIS, you must further consult with the Marine Parks Authority, Department of Environment and Climate Change, Department of Lands, Department of Primary Industries and the Commonwealth Department of Environment, Water, Heritage and the Arts and any other relevant local, State and Commonwealth government authorities, service providers and community groups. In particular, you should consult the surrounding landowners and occupiers that are likely to be impacted by the proposal. Details of the consultations carried out and issues raised must be included in the EIS.

The Commonwealth Environment Protection and Biodiversity Conservation Act
If your proposal contains any actions that is likely to significantly impact matters of National Environmental Significance, it will require an additional approval under the *Commonwealth Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). This approval is in addition to any approvals required under NSW legislation. It is your responsibility to contact the Department of Environment, Water, Heritage and the Arts in Canberra (6274 1111 or *http://www.environment.gov.au*) to determine if the proposal is likely to significantly impact on matters of National Environmental Significance, and would require an approval under the EPBC Act.
The Commonwealth Government has accredited the NSW environmental assessment process for assessing any impacts on matters of National Environmental Significance. As a result, if it is determined that an approval is required under the EPBC Act, you should contact the Department immediately as supplementary Director-General's requirements will need to be issued.

Administration
You should note that if the EIS is not exhibited within 2 years after this notice is given, you must consult further with the Director-General in relation to the preparation of the EIS.

Enquiries
If you have any enquiries about the above, please contact Nigel Parsons on (02) 9228 6467 or via e-mail on nigel.parsons@planning.nsw.gov.au.

Yours sincerely

Felicity Greenway 15/2/07

Felicity Greenway
Acting Manager, Industry
Major Development Assessment
as delegate of the Director-General

DEPARTMENT OF PLANNING

Attachment No. 1

STATUTORY REQUIREMENTS FOR THE PREPARATION AND EXHIBITION OF AN ENVIRONMENTAL IMPACT STATEMENT UNDER PART 5 OF THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

In accordance with the *Environmental Planning and Assessment Act 1979* (the Act), an environmental impact statement (EIS) must meet the following requirements.

Content of EIS
Pursuant to Schedule 2 and clause 230 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation), an EIS must include:

1. A summary of the environmental impact statement.
2. A statement of the objectives of the development or activity.
3. An analysis of any feasible alternatives to the carrying out of the development or activity, having regard to its objectives, including the consequences of not carrying out the development or activity.
4. An analysis of the development or activity, including:
   (a) a full description of the development or activity, and
   (b) a general description of the environment likely to be affected by the development or activity, together with a detailed description of those aspects of the environment that are likely to be significantly affected, and
   (c) the likely impact on the environment of the development or activity, and
   (d) a full description of the measures proposed to mitigate any adverse effects of the development or activity on the environment and
   (e) a list of any approvals that must be obtained under any other Act or law before the development or activity may lawfully be carried out.
5. A compilation, (in a single section of the environmental impact statement) of the measures referred to in item 4(d).
6. (1)The reasons justifying the carrying out of the development or activity in the manner proposed, having regard to biophysical, economic and social considerations, including the following principles of ecologically sustainable development:
   (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 possible, serious or irreversible damage to the environment, and
       (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 is 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,

(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.

Note

The matters to be included in item (4)(c) might include such of the following as are relevant to the development or activity:

(a) the likelihood of soil contamination arising from the development or activity;
(b) the impact of the development or activity on flora and fauna;
(c) the likelihood of air, noise or water pollution arising from the development or activity;
(d) the impact of the development or activity on the health of people in the neighbourhood of the development or activity;
(e) any hazards arising from the development or activity;
(f) the impact of the development or activity on traffic in the neighbourhood of the development or activity;
(g) the effect of the development or activity on local climate;
(h) the social and economic impact of the development or activity;
(i) the visual impact of the development or activity on the scenic quality of land in the neighbourhood of the development or activity;
(j) the effect of the development or activity on soil erosion and the silting up of rivers or lakes;
(k) the effect of the development or activity on the cultural and heritage significance of the land.

An environmental impact statement referred to in Section 112(1) of the Act shall be accompanied by the information specified in clause 229 of the Regulation.

The EIS must also take into account any matters required by the Director-General pursuant to clause 231 of the Regulation, which may be included in the attached letter. A copy of the Director-General's requirements should be included as an appendix to the EIS.

Attention is also drawn to clause 283 of the Regulation regarding false or misleading statements in EISs.

Nominated Determining Authority

Where there are a number of determining authorities (as defined under Part 5 of the Act), Section 110A of the Act provides for the Minister to make one of them the nominated determining authority. This avoids duplication of certain procedures and simplifies the exhibition of the EIS.

It is recommended that you discuss with the other determining authorities which one should become the nominated determining authority and advise the Department accordingly. Normally it is the proponent agency that becomes the nominated determining authority. The written agreements of all other determining authorities must be forwarded with the request to be made the nominated determining authority.

It should be noted that the onus is on the proponent agency to identify all other potential determining authorities.

Public Exhibition

When the EIS has been completed, four (4) copies should be forwarded to the Director-General (Attention: Director, Major Infrastructure Assessment) pursuant to Section 112(2) of the Act, together with details of the exhibition period and public display locations.

This should occur prior to public exhibition of the EIS in order that simultaneous exhibition of the EIS occurs in the offices of the Department and determining authority as required by Section 113 of the Act and clause 235 of the Regulation.

It is requested that a copy of the text of the EIS also be supplied on either a 1.44 MB floppy disk or CD ROM. This should be in a format readable by Microsoft Word or as plain text (RTF file format). Inclusion of files of supporting maps and diagrams is optional.

Procedures for public exhibition of the EIS are set down in clauses 234 and 235 of the Regulation.

Note

Should the EIS not be exhibited within 2 years from the date of issue of the Director-General's requirements, under clause 231 (e) of the Regulation the proponent is required to re-consult with the Director-General.

Representations

Any representations made in response to public exhibition of the EIS should, as soon as practicable and not less than 21 days before determining the activity, be forwarded to the Secretary in accordance with Section 113(3) of the Act.

Seeking the Minister's Approval

If Division 4 of Part 5 of the Act applies to the proposal, the proponent, pursuant to Section 115B, should seek the Minister's approval once it has obtained and exhibited an EIS, examined and considered any representations, and forwarded copies of all representations to the Department.

If a Species Impact Statement (SIS) has been prepared, the Proponent must have complied with Sections 112B and/or 112C of the Act (i.e. concurrence and/or consultation requirements) before seeking the Minister's approval.

The Department's *Best Practice Guidelines* encourage proponents when seeking approval to provide:

- a comprehensive report which addresses in detail its consideration of issues raised in representations;
- any proposed changes to the activity, and any further measures to mitigate impacts; and,
- all relevant technical information relating to the proposed activity.

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DEPARTMENT OF PLANNING

Attachment No. 2

AGENCY SUBMISSIONS

NSW National Parks and Wildlife Service

Our reference: DOC09/2310
Contact: Adrian Toovey, 9585 6589

Mr Chris Ritchie
Acting Director, Major Project Assessment
Department of Planning
GPO Box 39
Sydney NSW 2001

Dear Mr Ritchie

Thank you for your letter of 15 January 2009 seeking critical issues regarding environmental assessment of the marine fish stocking program for NSW coastal waters to be proposed by the Department of Primary Industries. This response sets out critical issues for DECC, including those concerning marine parks and other types of marine protected areas.

A total of 10 critical issues have been identified for consideration in the environmental assessment and are set out in the table attached. These issues are all documented on the basis that the proposal as currently described is for fishery stock enhancement and will occur outside of NSW and Commonwealth marine protected areas (pp. 1, 3 & 4, Form A – Request for Director-General's Requirements). According to NSW Government Policy, NSW marine protected areas include marine parks, aquatic reserves and marine areas of national parks and nature reserves.

The DECC would nevertheless recommend that the final proposal be informed by an environmental assessment process that examines the potential impacts and benefits of stock enhancement for marine protected areas. In particular, whether there are opportunities for the proposal to support the ecologically sustainable use of marine resources, including fishing within marine parks, or to assist with the recovery of threatened species.

Yours sincerely

MICHAEL WRIGHT
Director Protected Areas Policy and Programs
Parks and Wildlife

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Critical issues for consideration in marine environmental assessment of the proposed DPI marine fish stocking program for NSW coastal waters.

No.	Critical issue	Comment
1	Detailed description of the proposal, including: ▪ the objectives of stocking being proposed ▪ scope of the proposal and environmental assessment in considering restocking, stock enhancement and sea ranching.	The present proposal is vague (e.g. on size of the proposal). Objectives of stocking typically fall into three main categories: ▪ restocking ▪ stock enhancement ▪ sea ranching. A detailed description of the proposal should clearly describe the various types of stocking that are being proposed. Will the proposal and environmental assessment consider restocking of depleted species or threatened species (mentioned at p. 5 of Form A – Request for Director-General's Requirements) in addition to recreational fishery stock enhancement? The proposal and environmental assessment need to be clear on how different types of stocking will be handled, including in marine protected areas.
2	Delineation and formal assessment of threats of the stocking proposal to marine biodiversity.	Formal identification of key threats of stocking to marine biodiversity is required.
3	Need and cost-effectiveness for stock enhancement proposal, including: ▪ detailed comparison of proposal with alternative means of 'enhancing stocks' including size limits, marine protected areas, closed seasons, reduction in commercial fishing and protection/repair of habitats ▪ how the proposed stocking will help released juveniles of the species in question to complete their life cycles, grow to adults and contribute to spawning stocks ▪ details of changes required to fishery management practices to support the enhancement program.	Stock enhancement is typically not justifiable unless recruitment is limited and there is adequate habitat to support increased supply of juvenile fish. Enhancement program will be of very limited use if wild population of stocked species are not well managed for ecologically sustainable use. A package of measures may be required to achieve stock enhancement, including restoration and enhancement of existing and potential habitat areas.
4	Examination of positive and negative interactions between stocking and NSW marine protected areas (marine parks, aquatic reserves and marine areas of national parks and nature reserves). This should include examination of: ▪ interactions between stocking that is undertaken within waterways that also include marine protected areas (e.g. stocking in Botany Bay and interactions with Towra Point Aquatic Reserve within Botany Bay) ▪ how the stock enhancement program can add-value to marine protected areas.	NSW marine protected areas are marine parks, aquatic reserves and marine areas of national parks and nature reserves (NSW Government 2001, *Developing a representative system of marine protected areas in NSW: an overview*).

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6	Formal analysis to support the proposed list of areas where stocking can and can not occur and associated rationale.	Although the system of marine protected areas in NSW is established primarily to conserve biodiversity, it has a secondary goal of providing for ecologically sustainable use of marine resources. Marine parks are designed for multiple-use, including fishing. Many aquatic reserves support fishing and the marine components of national parks and nature reserves are typically available for fishing. In many cases, prime habitat occurs in marine parks, aquatic reserves and the marine component of national parks and nature reserves. The range of habitats conserved in marine protected areas are likely to include significant areas for the particular species being stocked.
7	Analysis of effects of the stocking proposal on genetic diversity and suitable arrangements to manage these effects	Genetic diversity is a key component of biodiversity.
8	Description of implementation processes for stocking activities, especially as relevant to marine protected areas, and including: ▪ approvals required ▪ community, stakeholder and agency consultation on individual proposed stocking activities ▪ disease and pest management protocols ▪ release strategies for waters in the vicinity of marine protected areas.	Particular consideration should be given to any implications of individual proposed stocking activities for local Aboriginal communities. Where relevant, targeted consultation should occur with Aboriginal groups.
9	Document the maximum size of stocking activities for which the environmental assessment, implementation processes and any approval of the proposal are valid.	The stocking proposal is predicated on activities being small in size (p. 4). Should the stocking activities prove larger in actuality (e.g. more frequent or more sites), then it is important to document the maximum size of stocking activities for which the environmental assessment, implementation processes and any approval of the proposal are valid.
10	Proposed research, monitoring, reporting and adaptive management programs for stocking activities, including for effects on biodiversity (including genetic diversity), interactions with marine protected areas and effectiveness for fishery enhancement.	This should also include processes to be implemented in the event that monitoring and reporting show adverse environmental impacts (for example, temporary or permanent cessation of stocking programs).

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Ref: OUT09/1138

Mr Chris Ritchie
Acting Director
Major Projects Assessment
Department of Planning
GPO Box 39
SYDNEY NSW 2001

⇒ Ms Sweeney

Dear Mr Ritchie

Marine Fish Stocking Program for NSW Waters

I refer to your letter dated 15 January 2009 concerning Director-General's Requirements for the preparation of an environmental impact statement for stocking of marine waters with fish.

Please find as follows a number of issues relevant to any assessment with specific concerns highlighted for your attention.

Proposed Director-General's Requirements:

Outline the objectives of the program and include the following issues:

(a) Conservation of biological diversity in an ecosystem and maintenance or re-establishments of ecologically viable stock levels.
(b) Conservation of protected or threatened species, populations or communities and their habitats
(c) Management of stocking activity so as not to place other aquatic species at risk.
(d) Meeting conservation, recreational and commercial fishing sector interests

Existing Commercial Fishery

Any environmental, economic and social impacts of estuarine and marine stocking that may impact on the existing operation of the commercial fishing industry should be considered. Such issues/impacts include but are not limited to the following:

- Resource allocation and access between and within fishery sectors;
- Consultation with commercial fishery advisory bodies; and
- Expectations of stakeholders with respect to 'ownership' of stock. .

Stocked Species

Describe the species stocked and sources of stock in terms of the following:
Identify the catchments and locations within the catchments where fish are stocked:
Outline the purpose of and/or demand for the stocking and identify
(a) the status of the species to be stocked in terms of whether they are currently
(i) under-fished, fully fished, over-fished or uncertain; Where stocks are currently overfished, describe how the stocking could contribute to rebuilding stocks to viable levels within nominated timeframes
(ii) protected from commercial and/or recreational fishing
(iii) threatened species, population or ecological community; or
(iv) target species of particular recreational or commercial fisheries;

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(b) the likelihood of the species becoming self-sustaining or would die-out following stocking - including the factors thought to be responsible.

Identify key species, populations, ecological communities and their life cycle, habitats, movement or migration that may be directly or indirectly affected by the stocking activities; indicate the local and regional scarcity. In particular, provide information on:

(a) impacts of the stocked fish on the life-cycle or movement of protected or threatened species, populations and ecological communities and their habitats

(b) incidental capture rates and mortality that might result from fishing due to the presence of stocked fish;

(c) any relevant measures identified in a relevant recovery plan.

Note: The "7 Part Test" must be used by the determining authority in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats. The 7 Part Test provides guidance on determining when a species impact statement (SIS) is required. An SIS must accompany any proposal where there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats.

Identify areas of high aquatic biodiversity/conservation significance; If relevant identify the following, indicating their incidence in catchment where stocking is undertaken or where broodstock are obtained, such as:

- marine parks, reserves, national parks or closure areas protected under the Fisheries Management Act 1994, NPW Act 1974 or Marine Parks Act 1997
- other areas such as RAMSAR wetlands, Japan Australia Migratory Bird Agreement (JAMBA), China Australia Migratory Bird Agreement (CAMBA), World Heritage Areas or areas registered in the National Estate or State Heritage Register.

Describe the species known to occur naturally in the catchments or locations

Outline the arrangements for undertaking the stocking including:-

- transport and temporary holding of stock
- stocking methods
- authorisation of stocking events
- involvement of associations/contractors/land owners/others in stocking events
- verification of stocking events
- any areas where fish stocking is to be restricted all or some of the time e.g. aquatic reserves and marine parks (protected zones)

For each of the species (and if relevant for each of those locations), outline:

Extent and magnitude of research-based stocking for each species i.e. how many into which waterways and when and the results of the research

Natural distribution and abundance of the stocked species on a catchment and statewide basis;

Sources of broodstock;

Method, timing and frequency of stocking

Identify any current issues affecting or affected by the proposed stocking activities

Any seasonal, life history and other major factors that could affect how stocking will operate;

Identify and discuss the importance of any areas of aquatic habitats to the success of stocking activities

Discuss the vulnerability of stock to impacts from stocking methods

Outline the management tools used to manage/minimise the impacts of the stocking including:

- Restrictions on species which can be stocked
- Restrictions on who can undertake the activity

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- Controls on levels, where and when the activity can occur including the protocols and/or research used to determine the level of stocking activity;
- Techniques to detect and mitigate/eradicate disease in both stocked and wild fish;
- Protocols to maintain genetic integrity of the stocked species and resident species;
- Protocols to maintain genetic diversity, including production details of any stocks designed as non-breeding fish (e.g. triploids

Trophic Structure

Consider the effects of stocking on trophic structure (food webs) and where possible provide an ecological systems model, in particular:

Identify the species (fish, invertebrates etc) that are likely to be affected directly or indirectly by marine stocking (including those caught as food for young fish) and identify which of, and why the stocked species is thought to be primarily responsible (where appropriate on a catchment basis)

Identify likely productivity/flows and assess the impacts of addition of predators, prey or competitors including replacement of existing taxa at a given trophic level or the creation of an additional trophic level/niche within different waterways;

Discuss the carrying capacity of the catchments (or waterways or locations) used for stocking and the extent to which stocking is likely to affect the system's capacity

Identify the risks and uncertainties of the stocked fish disrupting the trophic structure.

Identify the management measures to address these risks. Discuss the likely effectiveness of mitigation measures. Indicate the level of confidence that the management and mitigation measures would achieve the predicted outcomes and would effectively manage the impact and associated risks

Genetic Issues

Assess the implications of fish stocking on the genetics of stocked and wild populations including:

Review the current understanding of genetic variability in species (which have been or are likely to be stocked) in terms of the variability in catchments or locations where stocking is or may occur and in species populations that are currently used for broodstock; Identify major gaps in relation genetic information

Assess the implications of stocking species from one population, race or subspecies into receiving waters with wild fish of the same species, but from a different population, race or subspecies.

Discuss the appropriateness of stocking protocols as they pertain to distinct populations, races or subspecies in terms of broodstock and different populations, races or subspecies of wild fish in the catchments/sub-catchments or locations were stocking is to be undertaken

Assess the implications of any cross breeding as a result of the stocking activities

Assess the implications of the cross breeding particularly on any protected, threatened or vulnerable species.

Predict the likelihood and assess the significance that any species being considered for stocking has the ability to hybridize with other species occurring in the receiving waters.

Describe measures to ensure unacceptable adverse impacts do not occur to the genetic integrity of wild populations in the receiving environment.

Translocation of Organisms

Outline any potential impacts on the environment from the translocation of organisms (e.g. fouling organisms and other pests) in particular:

List any species of flora and fauna likely to be translocated

Review the past performance of research-based stocking in terms of translocation incidents and any implications on aquaculture, other water users and the environment; outline any changes in practice as a result of such incidence.

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Assess the risk associated with translocation from marine stocking

- Outline the likely implications of translocation on aquaculture, other water users and the environment;
- Provide details of proposed mitigation methods including information from any available pest species threat abatement plan; and
- Outline a contingency plan for any pest/fouling species likely to be translocated by the activity.

Fish Health and Disease

Assess the potential impacts on fish health and disease from the proposed activity, in particular

Review the past performance of research-based stocking activities in terms of stress and disease incidents because of broodstock collection and stocking activities and any implications on the health of wild stocks; outline any changes in practice as a result of such incidence.

Assess the implications of fish stocking on the health status of stocked and wild populations including:

- Review the current understanding of health status in species (which have been or are likely to be stocked) in terms of baseline health data in catchments or locations where stocking is or may occur and in species populations that are currently and/or proposed to be used for broodstock; Identify major gaps in relation to health information for such wild populations.
- Review the current understanding of health status in species (which have been or are likely to be stocked) in terms of diseases reported in production systems; Identify major gaps in relation to health information for such cultured populations
- Outline risks to the health of wild fish populations from the release of stock
- Discuss the appropriateness of stocking protocols as they pertain to aquatic health and disease

Describe measures to ensure unacceptable adverse health and disease impacts do not occur in wild populations in the receiving environment including protocols and quality control measures to minimise the risk of spread of disease into the receiving environment

Other Impacts

Evaluate the effects of fish stocking on the following physico-chemical aspects of the environment:

Water quality, including:

- Identify potential sources of pollutants/contaminants from the stocking programs (e.g. release of water with fry into receiving waters) that may affect water quality; outline the characteristics, magnitude and probable frequency of these events.
- Review any water quality information associated with existing stocking practices; identify any incidents which may have occurred in the past and practices which may have changed as a result
- Consider the risk to water quality taking into consideration proposed practices, the general condition or characteristics of the catchments, sub-catchments or locations and the likely assimilation capacity of the receiving water under stocking programs.

Noise, Light, Air quality, Energy Issues:

- Review past performance in relation to the above issues in relation to broodstock collection, stocking events and related activities.
- Outline the likely sources of impacts in relation to the implementation of stocking under the FMS. Consider the likely significance of these impacts taking into consideration any nearby dwellings and sensitive land uses
- Outline measures to manage impacts to an acceptable level.
- Outline measures to maximise energy efficiency

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Hatchery Production

Identify hatcheries currently producing stocks of marine fish and their current role

Identify the species produced
Provide information on the trends in the annual production
Describe their capacity or necessary upgrades required to meet the requirements of the marine stocking program
Identify health status and health issues associated with those hatcheries

Identify scope and status of the approvals, permits or licences for each of the hatcheries and their suitability to broad marine stocking programs

Identify any current issues affecting the performance of the hatcheries and their ability to meet the demands of broad marine stocking program.

Quality assurance programs for the production and release of fish, including measures to:

- ensure that genetics of the broodstock are compatible with the genetics of the stock in the receiving waters taking into consideration any distinct populations, races or subspecies in the target catchment/ location
- ensure the stock is disease free prior to release
- ensure that translocation of non-target species does not inadvertently occur
- ensure accidental releases do not occur

Monitoring and Responsive Management

Performance Indicators:

Identify performance indicators to monitor whether the objectives of the program are being achieved
Identify the "triggers for review" of the program based on the performance indicators
Identify the action to be taken when the triggers points are met

Monitoring Program: In outlining the monitoring program, consider the following:

Indicate how the monitoring program will be linked to performance indicators, triggers, management rules and the research program.
Indicate the relevance of information from the monitoring of existing research-based stocking
Indicate whether marking or tagging of stocked individuals will be undertaken (e.g. tetracycline markers);
Monitor to ensure that genetic attributes of wild populations are not unacceptably affected by the programs
Monitor key biodiversity or environmental parameters likely to indicate if adverse impacts are occurring to aquatic ecology or habitats (e.g. to key indigenous fish, frog or insect species)
Indicate how the extent of environmental impacts will be determined, and if they are found to be occurring whether they are at the frequency and magnitude predicted in the initial assessment

Identifying links from the monitoring program and research programs to provide information relevant for continuous improvement in fisheries management.

Fisheries, Compliance and Regional relations
Port Stephens Fisheries Centre
Locked Bag 1
NELSON BAY NSW 2315

ABN 51 734 124 190
www.dpi.nsw.gov.au
Tel: 02 4982 1232

Proposed Research Programs

A research program must be developed as part of the Management Strategy. The strategies should outline information deficiencies and identify appropriate research to be undertaken to provide valid information for the sustainable management of marine stocking activities. The program must:

Identify areas where further information is needed including improving knowledge of the stocked species and their receiving environment.

Specify short-term and long-term aims and objectives of the research;

Identify links with monitoring and continuous improvement/responsive management programs.

I would be happy to discuss these requirements with you further and can be contacted on (02) 4916 3836.

Yours sincerely

8/2/09

Bill Talbot
Director, Fisheries Conservation and Aquaculture

Fisheries, Compliance and Regional relations
Port Stephens Fisheries Centre
Locked Bag 1
NELSON BAY NSW 2315

ABN 51 734 124 190
www.dpi.nsw.gov.au
Tel: 02 4982 1232

Australian Government

Department of the Environment, Water, Heritage and the Arts

Mr Chris Ritchie
Acting Director
Major Project Assessment
Department of Planning
GPO Box 39
SYDNEY NSW 2001

Date: 3 February 2009

Dear Mr Ritchie

Thank you for your letter to Ms Dionne Cassanell dated 15 January 2009 regarding a proposal for a strategic fisheries assessment for the stocking of marine waters of NSW with fish. Your letter has been passed on to me for reply.

At this stage, it is not possible for the Department to provide formal comment on the proposal because the action has not been referred for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Once a valid referral is received, the Department will be able to formally advise on whether the project is likely to have a significant impact on protected matters, and therefore whether it will need formal assessment and approval under the EPBC Act. A referral form and information for making a referral is available from the Department's web site at www.environment.gov.au/epbc/assessments/referral-form.html

Under the EPBC Act, approval from the Minister for the Environment, Heritage and the Arts is needed for any proposed action that is likely to have a significant impact on a matter protected by the Act, which includes matters of national environmental significance and the environment, in relation to Commonwealth actions, and actions on, or that will impact on, Commonwealth land. Whether an impact on a protected matter is significant or not depends on the particular location, scope, timing and other circumstances of the proposed action.

If you would like surety in relation to the proposal, I would recommend making a referral. Once a referral has been submitted and checked to ensure it meets the regulations, a decision on whether there is any need for Commonwealth approval would be made within 20 business days.

Please find enclosed a fact sheet on the Environment Assessment Process which provides you with an overview of the process and references to the Department's web site where you will find the Referral Form and other information to assist in making a decision on whether to refer.

If you have any questions please call the Environment Impact Assessment Policy section on 02 6274 2744 or email epbc.referrals@environment.gov.au for assistance.

Yours sincerely

Roland Trease
Director
Southeast Queensland and New South Wales Section
Environment Assessment Branch

Encl. EPBC Act – Environment Assessment Process

Nigel Parsons - EIS requirements for proposed Marine Fish Stocking Program by NSWDepartment of Primary Industries

From: "Gregory Paine" <Gregory.Paine@lands.nsw.gov.au>
To: <nigel.parsons@planning.nsw.gov.au>
Date: 03/02/2009 11:54
Subject: EIS requirements for proposed Marine Fish Stocking Program by NSWDepartment of Primary Industries

Nigel,

Reference is made to the Department's letter of 15 January 2009 regarding the above matter.

The proposal is relevant to the following functions of the Department of Lands:

(i) the management of Crown land [which includes substential areas of waterfront/riparian land; and the seabed and the submerged area of estuaries and rivers etc (where not controlled by the NSW Maritime Authority)]

(ii) the management of port facilities (under the Minor ports Program) - where not controlled by the NSW Maritime Authority.

Advice from yourself is that the proposal as it stands is quite broad to allow the proposed EIS to be similarly wide-ranging – and that the proposal would become more specific depending on the EIS outcome. On this basis:

(i) the comments below have also had to be quite broad

(ii) given the potential implications for the abovementioned functions it is requested that a copy of the completed EIS be forwarded to the Department of Lands for comment as part of the required public consultation.

Based on the above, the following are submitted as matters the EIS should address:

(i) the need for stocking to occur in a targeted way, with priority given to particular sites

(ii) If so, the identification of what sites should be given priority, eg. (a) localities with existing habitat of high quality; (b) localities with priority habitat restoration/recovery plans; (c) localities with a low susceptibility to catastrophic events, eg. depletion of oxygen events; (d) sites within recreation fishing havens, where no commercial fishing occurs; (e) localities with guaranteed environmental flows.

(iii) the persons able to carry out stocking activities, and appropriate authorisation for those persons (where not NSW Fisheries)

(iv) the likely impact of the stocking program on Crown land and assets, such as breakwaters, boatramps, etc.

(v) the likely impact of the stocking program on activities on adjacent Crown land, particularly where such activities have been authorised under the *Crown Lands Act 1989* via a tenure (eg. lease or licence) and/or relate to a Plan of Management for that land.

(vi) the need for any lease, licence, permit or other approval under the *Crown Lands Act 1989* where Crown land is proposed to be used for the stocking program (eg. for access or other purpose).

The contact within NSW Fisheries (Sarah Martin) has been on leave. I have now been advised by Sarah Martin (3rd February 2009) that, as with the fresh-water stocking program, a principle aim is to identify areas where stocking should not occur. I will make further inquiries within the Department for advice as to any such locations from the Department's point of view – and will advise NSW Fisheries direct for consideration within the EIS.

Greg Paine

Acting Manager
Planning Policy
Crown Lands Policy Branch

Tel: 8236 7026

NSW Government

DEPARTMENT OF WATER AND ENERGY

Your Ref:
Our Ref: ERM2009/0067

23 Janaury 2009

Department of Planning
GPO Box 39
Sydney NSW 2300

Attention: Mr Chris Ritchie

Dear Sir,

Re: DPI Marine Fish Stocking Program - Request for DGR

Thank you for your letter of 15 January 2009 concerning the above project. The Department has considered the proposal and understands that there is no intention to extract water or undertake works in, on or adjacent a river (waterfront land).

Please note that if the EIS will be incorporating the infrastructure to grow the fingerlings, this activity has the potential to require either a licence or approval from the Department. The two key activities that may require addressing from the Departmnent pespective is the extraction of water and works on waterfront land. Clarification of this would be appreciated, to which DWE requirements could then be identified.

The activity as proposed will not attract the requirement for an licence or approval pursuant to either the Water Act 1912 not the Water Management Act 2000, hence the Department of Water and Energy has no role in assessing or considering this proposal any further.

Should you require clarification of any matter raised please contact me on 4904 2562.

Yours Sincerely

Andrew Phillippa
Licensing Officer
Newcastle

Level 3 26 Honeysuckle Drive Newcastle 2300 PO Box 2213 Dangar 2309
Telephone (02) 4904 2662 Facsimile (02) 4904 2503

Appendix 2

Threatened Species

(State Assessment of Significance)

Appendix 2. 'Assessment of Significance' for threatened species, populations and communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Fisheries Management Act 1994* (FM Act).

FISH

Four species of threatened fish listed under the FM Act were considered relevant to the proposal. Assessments of Significance for these species are given below.

Grey Nurse Sharks

Species Name: Grey Nurse Shark (*Carcharias taurus*)

Status: Critically endangered species – Schedule 4A FM Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Grey nurse sharks typically occur on shallow rocky reefs along the New South Wales (NSW) coast (Last and Stevens 1994). Young are born live and also occur on shallow rocky reefs, often segregated from the adults. Grey nurse sharks can be observed at day hovering or slowly swimming around high-relief reefs. It is thought that the species becomes more active at night where it hunts over rocky reef and over soft substrata for a wide range of bony fishes, rays, sharks, squids and crustaceans (Smale 2005). There is also evidence to suggest that grey nurse sharks migrate along the NSW coast (northwards in autumn/winter and southwards in summer (Pollard *et al.* 1996, Otway and Parker 2000).

The entire east coast population of grey nurse sharks has been listed as critically endangered under the EPBC Act and recent surveys estimate the population to be small (Otway and Burke 2004, Cardno Ecology Lab 2010). In such a small population the loss of only a few individuals could seriously affect the viability of the whole population.

The draft Fisheries Management Strategy (FMS) does not allow stocking to be done in areas where it is likely to have significant effects on grey nurse sharks. Currently there are no aggregation sites for grey nurse sharks within estuaries but it is probable that grey nurse sharks would enter estuaries to forage on occasion. Potential impacts from the proposal are associated with trophic impacts to the individuals that range into estuaries as well as from fishing activities associated with the proposal.

Although it is probable that grey nurse sharks would enter estuaries to forage there is no evidence to suggest that grey nurse sharks depend on estuarine habitat in particular. It is possible that some estuarine prey items of grey nurse sharks could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section E.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of grey nurse sharks would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for sharks.

Fishing activities associated with the proposal are a potential risk to grey nurse sharks. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. A substantial increase would potentially have a negative effect on grey nurse sharks as it would increase the risk of incidental hooking to individuals ranging into stocked estuaries. Under State and Commonwealth law it is illegal to catch or harm grey nurse sharks. Most estuarine recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large bodied sharks such as grey nurse sharks. Hooked sharks would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002). Although grey nurse sharks have

Species Name: Grey Nurse Shark (*Carcharias taurus*)

potential for becoming entangled in beach protection mesh nets (Krogh and Reid 1996) there are no data to suggest that grey nurse sharks are caught by nets in estuaries (NSW Fisheries 2001) and the NSW Grey Nurse Shark Draft Recovery Plan does not consider this type of fishing a threat to the species (NSW Fisheries 2002). Crab traps would be of little concern. However, grey nurse sharks are considered to be vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets (DEH 2003) and could therefore be placed at risk if the amount of lost or discarded gear increased as a consequence of the proposal (also see (g)).

Apart from the potential impacts that stocking may have to grey nurse sharks ranging into estuaries, stocking also has potential to affect grey nurse sharks occurring in coastal waters 'outside' of estuaries. Impacts would be possible if stocked fish or crustaceans were to move into coastal waters adjacent to the estuaries into which they had been stocked into. Stocked fish that move out of estuaries could potentially compete with grey nurse sharks for habitat or food or transfer disease. Competition of this form, if it were to occur, would most likely be with mulloway as this species can occur in nearshore gutters and caves and has a diet of small fish that may overlap with sharks (Silberschneider and Gray 2008). However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in, estuaries such competition outside of estuaries is considered unlikely. The risk of transfer of disease from the stocked species within an estuary to grey nurse shark populations outside estuaries is low.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in a viable local population of grey nurse sharks being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to grey nurse sharks, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan (see (f)).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The major habitat utilised by grey nurse sharks comprises offshore rocky reefs, with small sandy gutters within the reef matrix being often preferred microhabitat. There is some likelihood that the species ranges away from

Species Name: Grey Nurse Shark (*Carcharias taurus*)

reefs to feed at night; the extent of this range is unknown (Smale 2005) but it is probable that grey nurse sharks would enter estuaries to forage on occasion. The proposal would not modify or remove any core reef habitat or estuarine habitat of grey nurse sharks. The proposal would not isolate or fragment any reef or estuarine habitat from other habitat used by the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Many of the known aggregation sites for grey nurse sharks in NSW waters have been declared critical habitat for the species and are protected by the *Fisheries Management (General) Regulation 2010* Schedule 1A administered by NSW Department of Primary Industries (DPI). There are currently 10 aggregation sites along the NSW coast that have been declared as critical habitats and none of these are within estuaries. Many of these sites have also been further protected in marine parks or aquatic reserves administered by the Office of Environment and Heritage (OEH). Marine stocking would not take place in or around any known aggregation sites or critical habitats. Notwithstanding this, there is potential for competition for habitat or food with some of the species to be stocked, particularly mulloway, if some stocked fish move offshore. As discussed in (a), such effects are unlikely to be significant. Therefore no critical habitat would be directly or indirectly affected by the proposal to stock marine fish.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

State and Commonwealth recovery plans have been developed for the grey nurse shark. The specific objectives of the NSW recovery plan are to:

- improve our understanding of the abundance, reproductive biology, life history, ecology, migratory patterns and genetics of grey nurse shark populations;
- address the key threats to grey nurse sharks;
- provide enhanced protection for key grey nurse shark habitats;
- coordinate action by community groups, local councils, government agencies, scuba diving groups and other stakeholders;
- increase awareness of the status of and threats to grey nurse shark populations, and enhance community support for recovery actions; and
- establish an on-going monitoring program to document the status of grey nurse shark populations and habitat and evaluate the effectiveness of recovery actions.

Given that the majority of activities associated with the stocking proposal would take place in estuaries away from known aggregation areas and core habitat of grey nurse shark the impacts upon the species as a result of marine stocking are most likely to be negligible and would not directly contravene the objectives of the State recovery plan. Notwithstanding this, given that the predicted severity of many of the impacts associated with stocking are largely unknown but potentially related to changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to grey nurse sharks would be investigated (see (a)).

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

Under the FM Act '*Hook and line fishing in areas important for the survival of threatened fish species*' is listed as a KTP however, stocking is not proposed to take place in any habitat considered important to the survival of grey nurse sharks and this KTP is therefore not considered further (see (d)).

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth *Environmental Protection and*

Species Name: Grey Nurse Shark (*Carcharias taurus*)

Biodiversity Conservation Act 1999 (EPBC Act). Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on grey nurse sharks by increasing the risk of entanglement if the species were to occur within a stocked estuary. However, given that there is no evidence that grey nurse sharks have ever been entangled in nets in estuaries where there is already considerable fishing effort (see (a)), any increase in fishing effort in stocked estuaries would have to be substantial to significantly increase the risk of mortality to individuals. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to grey nurse sharks would be investigated (see (a)).

Conclusion:

The proposal would not have any significant direct or indirect impacts on the core habitat of the critically endangered grey nurse shark. It is possible, however, that grey nurse sharks could occur, on occasion, in estuaries where stocking has occurred. The entire east coast population of grey nurse sharks is critically endangered and the loss of only a few individuals could seriously affect the viability of the small population. Stocking is unlikely to cause any substantial trophic impacts to individuals that range into estuaries but there is potential for localised increased concentrations of fishing effort in stocked estuaries. Increased fishing effort could increase the risk of hooking on grey nurse sharks and some KTPs. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to grey nurse sharks would be investigated. The draft FMS proposes to review and modify the program if undesirable threats or harm to grey nurse sharks become apparent.

No species impact statement is recommended.

Great White Shark

Species Name: Great white shark (*Carcharodon carcharias*)

Status: Vulnerable species – Schedule 5, FM Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Great white sharks are large, highly predatory animals whose life cycle is poorly understood. They occur from cold temperate to tropical waters worldwide and generally frequent coastal waters, often close to shore. They also swim into bays and estuaries. Stockton Bight (Newcastle) is considered an important area for juvenile great white sharks. Great white sharks are live bearers that do not appear to frequent specific habitats. The exception is when they take up residence adjacent to rocky shores, particularly where seals or sea lions are present. Emerging evidence suggests that juveniles and adults can range widely, with one tagged individual recorded travelling from Tasmania along the NSW coast into southern Queensland (QLD). There is also anecdotal evidence that the species follows large schools of migrating fish (e.g. sea mullet, Australian salmon) and migrating whales, particularly those with calves. The sharks' prey also includes a wide array of teleost fishes (Environment Australia 2002).

There is no evidence to suggest that great white sharks depend on estuarine habitat in particular, but it is probable that juvenile great white sharks would enter estuaries to forage on occasion. It is possible that some estuarine prey items of great white sharks could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, as many of the stocked species have potential to be the prey of great white sharks it is more likely that stocking would increase, rather than reduce, local estuarine food sources for sharks.

Fishing activities associated with the proposal are a potential risk to great white sharks. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. A substantial increase would potentially have a negative effect on great white sharks as it would increase the risk of incidental hooking to individuals ranging into stocked estuaries. Under State and Commonwealth law it is illegal to catch or harm great white sharks. Most estuarine recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large bodied sharks such as great white sharks. Hooked sharks would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002). Although great white sharks have potential for becoming entangled in beach protection mesh nets (Krogh and Reid 1996) there are no data to suggest that great white sharks are caught by nets in estuaries (NSW Fisheries 2001). Crab traps would be of little concern. However, all sharks are considered to be vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets (DEH 2003) and could therefore be placed at risk if the amount of lost or discarded gear increased as a consequence of the proposal (also see (g)).

Apart from impacts stocking may have to great white sharks visiting estuaries, stocking would have potential to affect great white sharks occurring in coastal waters 'outside' of estuaries if stocked fish or crustaceans were to move out of the estuaries into which they had been stocked into. Stocked fish that have moved out of the estuaries could potentially compete with great white sharks for habitat or food and may transfer disease. If competition with stocked species were to occur it would most likely be with mulloway as this species can also occur in nearshore beaches and may eat small fish that are also hunted there by juvenile great white sharks. However, given the scale of the project and that most of the stocked species are expected to remain within (Chapter D, Section D.4.1.2.5), or be caught in, estuaries such competition is unlikely. The risk of transfer of

Species Name: Great white shark (*Carcharodon carcharias*)

disease from the stocked species within an estuary to great white shark populations outside estuaries is low.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would have any adverse impacts such that a viable local population of great white sharks would be placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to great white sharks, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

It is unknown if great white sharks do prefer a particular habitat, however the area of sea close to rocky shores with seals or sea lions are likely to be important. There is also evidence to suggest that the species may also follow schools of migrating fish along the coast. On this basis, habitat within estuaries is not likely to represent significant habitat for great white sharks and would not be removed, modified, fragmented or isolated to the extent that the long-term survival of the species would be affected.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is an approved Commonwealth Great White Shark Recovery Plan (Environment Australia 2002). The specific objectives of this recovery plan are to:

- monitor and reduce the impact of commercial fishing on White Sharks;
- investigate and evaluate the impact of recreational fishing on White Sharks;
- monitor and reduce the impact of shark control activities on White Sharks;

Species Name: Great white shark (*Carcharodon carcharias*)

- identify and manage the impact of tourism on White Sharks;
- monitor and reduce the impact of trade in White Shark products;
- develop research programs toward the conservation of White Sharks;
- identify habitat critical to the survival of White Sharks and establish suitable protection of this habitat from threatening activities;
- promote community education and awareness in relation to White Sharks; and
- develop a quantitative framework to assess the recovery of the White Shark.

Prior to the implementation of protective legislation through the FM Act and the EPBC Act, commercial and recreational fishing were some of the most prominent threats to the great white sharks. Although protected from all commercial or recreational fishing, the species is still susceptible to incidental by-catch despite management measures. There are two key objectives of the recovery plan potentially relating to the proposal, they are to: 'monitor and reduce impacts of commercial fishing'; and further 'investigate and evaluate the impacts of recreational fishing' on the species. The proposal is not sufficiently inconsistent with the aims of the recovery plan to cause an impact on the species as described in (a). As such, the proposal would not directly contravene the aims of the recovery plan.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

Under the FM Act '*Hook and line fishing in areas important for the survival of threatened fish species*' is listed as a KTP however, stocking is not proposed to take place in any habitat considered important to the survival of great white sharks and this KTP is therefore not considered further.

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potential for increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing could potentially have a negative effect by increasing the risk of entanglement to great white sharks ranging into stocked estuaries. However, given that there is no evidence that great white sharks have ever been entangled in estuaries where there is already considerable fishing effort (see (a)), any increase in fishing effort in stocked estuaries would have to be substantial to significantly increase the risk of mortality to individuals. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to great white sharks would be investigated (see (a)).

Conclusion:

The proposal would not have any significant direct or indirect impacts on core habitat of the great white shark. It is possible, however, that great white sharks could occur, on occasion, in estuaries where stocking has occurred making them susceptible to incidental hooking and impacts from harmful marine debris. However, the frequency and extent of these impacts would mean the magnitude of that threat is likely to be very low and would not place a population at risk of extinction.

No species impact statement is recommended. This conclusion is justified given that there are very few, if any, recorded incidental captures or entanglements of great white sharks in estuaries that are already heavily fished. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the potential for localised increases to fishing effort with stocking would be monitored and, if it does occur, links to incidences of threats or harm to great white sharks would be investigated and the program reviewed and modified as necessary.

Black Cod

Species Name: Black Cod (*Epinephelus daemelii*)

Status: Vulnerable species – Schedule 5, FM Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Black cod, also known as black rockcod and saddled rockcod, occur from southern QLD to Kangaroo Island in South Australia (SA) and are found offshore at Lord Howe Island, Norfolk Island, Kermadec Islands and the North Island of New Zealand (Heemstra and Randall 1993). They are protogynous hermaphrodites (i.e. change sex from female to male) and at the time of spawning males establish a harem within their territory. Black cod are opportunistic carnivores, eating mainly other fish and crustaceans.

Black cod are mostly found in caves and gutters in coastal areas. Dispersal of eggs is thought to be pelagic and juveniles can recruit to rockpools (Griffiths 2003). Adults are highly territorial, usually adopting a cave as a core territory. Black cod have been observed by divers or caught by anglers in estuaries however the locations of these occurrences has generally been at the mouths of estuaries and involved juvenile fish. In many estuaries suitable black cod habitat is also available further upstream. Although black cod may not occur in these areas of suitable habitat now, they probably occurred there in the past when the species was more prevalent as there are past reports of many large individuals being caught in estuaries (I&I NSW 2009b). In the future, if populations of black cod were to recover, these areas may again become occupied. It is unlikely that viable populations of black cod currently occur in estuaries. The few individuals that occur are more likely to be part of one or many populations in adjacent coastal areas. Although no populations are listed as endangered, the loss of only a few individuals could still affect the viability of local populations.

Stocked species have potential to compete or displace black cod if they have similar food or habitat requirements. If competition with stocked species were to occur it would most likely be with yellowfin bream and mulloway as these species have the largest overlap of habitat with black cod (rocky reef habitat) and may also prey on small fish that are also consumed by black cod. Notwithstanding this, it is unlikely that yellowfin bream or mulloway would displace black cod from their home sites as these species are not territorial. It is possible that some estuarine prey items of black cod could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, as many of the stocked species (as juveniles) have potential to be the prey of black cod there is a potential that stocking would increase, rather than reduce, local estuarine food sources for black cod.

Fishing activities associated with the proposal pose the greatest risk to black cod. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. A substantial increase would potentially have a negative effect on local fish as it would increase the risk of incidental hooking or entanglement of those individuals residing in stocked estuaries. Assuming local populations are small, the loss of only a few individuals could seriously affect the viability of populations. Under State and Commonwealth law it is illegal to catch or harm black cod. Hooked fish would, however, be vulnerable to the effects of hooking injuries which have potential to cause lethal injuries (reviewed in I&I NSW 2009b). Black cod also have potential for becoming entangled in mesh nets or haul nets or could be caught in crab traps although the Recovery Plan has identified this risk to black cod from these methods to be low relative to line fishing (I&I NSW 2009b). Given that black cod are rarely caught in estuaries by fishing nets, netting is unlikely to significantly increase the risk of mortality to individuals and hence the viability of a population unless the proposal was to cause a substantial increase in fishing effort.

Species Name: Black Cod (*Epinephelus daemelii*)

Increased fishing activity within stocked estuaries also has potential to result in littering and accumulation of discarded or lost fishing gear. Black cod may be vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets and could therefore be placed at risk. As discussed in the previous paragraph, the risk to black cod of entanglement/ingestion of harmful marine debris as a consequence of stocking would probably depend on the size of any increase to fishing effort (also see (g)).

Apart from impacts stocking may have to black cod living in estuaries, stocking would have potential to affect black cod occurring in coastal waters 'outside' of estuaries if stocked fish or crustaceans were to move out of the estuaries into which they had been stocked into. Stocked fish that have moved out of the estuaries could potentially compete with black cod for habitat or food and may transfer disease. As already indicated, if competition with stocked species were to occur it would most likely be with yellowfin bream or mulloway. However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in, estuaries (Chapter D, Section D.4.1.2.5) such competition is unlikely. The risk of transfer of disease from the stocked species within an estuary to black cod populations outside estuaries is low.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in a viable local population of black cod being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to black cod, were they to occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Black Cod Draft Recovery Plan (see (f)).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

As indicated in (a), black cod habitat occurs in estuaries but the proposal is not expected to directly affect key areas of black cod habitat. There is very little risk that increased fishing activity could affect the quality of estuarine rocky reef habitat important for juvenile (including rock pools) or adult black cod (see Chapter G, Sections G.2.1.1.4 and G.2.1.2.5).

Species Name: Black Cod (*Epinephelus daemelii*)

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

A draft recovery plan for the black cod was placed on public exhibition in November 2009 (I&I NSW 2009b) The specific objectives of the recovery plan are to:

- mitigate medium and high risk threats to black cod;
- initiate and support scientific research to increase knowledge of the distribution, abundance, reproductive biology, life history, ecology, migratory patterns and genetics of black cod;
- monitor fishery management strategies where necessary to reduce potential for interaction with black cod (either directly or indirectly);
- establish an on-going monitoring program to document the status of black cod populations and their habitats and to evaluate the effectiveness of recovery actions;
- provide enhanced compliance and protection for important black cod habitats;
- educate the community about the identification of black cod, increase awareness of the status of and threats to black cod populations, and enhance community support for recovery actions; and
- improve understanding of the threats to the survival of black cod and contribute to management actions to ameliorate identified threats.

The key objective of the recovery plan is to mitigate medium and high risk threats to black cod. Some of the threats include hook and line fishing using soft plastic lures, bottom set-baited methods (e.g. setlining, trotlining, handlining, droplining) and spearfishing. As stocking has potential to increase the frequency of these types of activities it could increase known medium and high risk threats to black cod in stocked estuaries. Given that the draft FMS proposes monitoring of potential incidences to black cod and the potential for increased fishing effort, the risk to black cod would be lowered. The proposal is otherwise consistent with the objectives of the recovery plan.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

Under the FM Act '*Hook and line fishing in areas important for the survival of threatened fish species*' is listed as a KTP, the potential for stocking to increase the risk of *hook and line fishing in areas important for the survival of black cod* is discussed in (a).

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of increased fishing effort within estuaries if it were to occur with marine fish stocking. Lost/discarded fishing could potentially have a negative effect by increasing the risk of entanglement to black cod occurring within a stocked estuary. Black cod have some potential for entanglement in discarded mesh nets or haul nets but given that there is no evidence that black cod have ever been entangled in nets in estuaries where there is already considerable fishing effort, any increase in fishing effort in stocked estuaries would have to be substantial to significantly increase the risk of mortality to individuals. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to black cod would be investigated (see (a)).

Conclusion:

Black cod are known to occur in estuaries, particularly on rocky reefs. The proposal would not have any significant direct or indirect impacts on the habitat critical to the survival of black cod nor would it cause increased competition for food resources of this species. There would be potential, however, for increased risk of incidental hooking and netting and impacts from harmful marine debris if stocking were to result in localised increased fishing effort in stocked estuaries. Careful vigilance is proposed to determine whether there are consequences to black cod as a result of any increases to fishing effort and the program is to be reviewed and modified if undesirable threats or harm to black cod became apparent.

Given the controls on the proposal and a monitoring program that includes performance indicators for measuring impacts to threatened species, stocking would not place a population of black cod at risk of extinction.

No species impact statement is recommended.

Green Sawfish

Species Name: Green sawfish (*Pristis zijsron*)

Status: Presumed extinct – Schedule 4 FM Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Green sawfish, also known as narrowsnout sawfish or dindagubba, is a species of large ray from the family Pristidae. This species has a shark-like body, a flattened head and an elongated rostrum, which has numerous (usually over 23) pairs of unevenly-spaced rostral teeth or 'saws'. Green sawfish reach sexual maturity when they are between 2 and 3 m in total length and can grow up to 5 m length in Australian waters (Last & Stevens 1994; TSSC 2008 a, b). The low fecundity and late maturation of green sawfish render this species highly susceptible to anthropogenic mortality and limits the ability of this species to recover from anthropogenic threats (Stobutzki *et al*. 2002; Stevens *et al*. 2005).

Green sawfish were once widely distributed in the northern Indian Ocean, around south-east Asia and northern Australia, down the east coast through NSW and as far south as Lakes Entrance in Victoria (Stevens *et al*. 2005). While there is a lack of quantitative data, the number of sawfish appears to have declined substantially along the east coast of Australia over the last 40 to 60 years, with green sawfish now virtually extinct in NSW and south east Queensland. In NSW, the last confirmed sighting of this species was inside the north arm of the Clarence Estuary, near Yamba in 1972 (NSW DPI, 2005). Northern Australia may be the last region where significant populations of green sawfish remain (Stevens *et al*. 2005).

Green sawfish are demersal rays that live in mud or sandy-mud habitats, commonly found in near-shore, shallow, coastal waters, including estuaries, river mouths, embankments and along sandy and muddy beaches. In these coastal areas, this species actively pursue schools of baitfish, including shoaling fish such as mullet and prawns, which they stun with sideswipes of the snout. They also use their saw to sweep other prey, such as molluscs and small crustaceans, out of the sand and mud (Poganoski *et al*. 2002). Previously, this species has been found in waters as shallow as 1 m in depth. These shallow habitats may act as nursery and feeding areas, but juveniles occurring there may be vulnerable to anthropogenic disturbance (Stevens *et al,* 2005).

The disappearance of green sawfish from areas adjacent to dense human habitation, such as many of the estuaries along the NSW coast, suggests the species is sensitive to human disturbance, in particular to habitat alteration, degradation to the inshore soft bottom areas (required for feeding and breeding) and from fishing (NSW DPI, 2005; Stevens *et al*. 2005). Population numbers have been greatly reduced by fishing and accidental capture in prawn trawl and gill nets due to entanglement. Although the green sawfish is presumed to be extinct along the NSW coast, there is still a possibility that this species may occur in coastal estuaries. If populations of the green sawfish were to recover, than these areas may again become important habitats for this species.

Potential impacts from the marine fish stocking proposal are associated with trophic impacts to the individuals and fishing activities. It is possible that some estuarine prey items of the green sawfish may be displaced by stocked species. However, provided that juvenile fish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of the estuaries availability or competition for food and other resources, trophic impacts are not expected. For each of the proposed stocking species, modelling, including trophic impacts and estuarine productivity, was used to select stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section E.5.4). As additional information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. As green sawfish consume a wide variety of small fish and prawns, there may also be potential for stocking to increase, rather than decrease local food sources for the species.

Fishing activities associated with the proposal would be a potential risk to green sawfish if populations were to return to NSW estuaries. Although it is illegal to catch or harm green sawfish, their toothed rostrum, combined with their active hunting behaviour, makes them susceptible to incidental capture in all fishing activities that

Species Name: Green sawfish (*Pristis zijsron*)

utilise nets or baited lines and also for entanglement in lost or discarded fishing gear. A substantial increase in fishing effort would potentially have a negative effect on green sawfish as it would increase the risk of incidental hooking or entanglement to individuals ranging into stocked estuaries. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. Most estuarine recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large bodied rays such as green sawfish. Hooked rays would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002).

Apart from the discussed impacts that fish stocking may have to green sawfish living in estuaries, stocking may also have the potential to affect this species occurring in coastal waters 'outside' of estuaries, i.e. sandy or muddy beaches, if stocked fish or crustaceans were to move out of the estuaries. Stocked fish that have moved out of the estuaries could potentially compete with the green sawfish for habitat or food. However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in estuaries (Chapter D, Section D.4.1.2.5) such competition is unlikely.

The combination of restricted habitat, high susceptibility to entanglement in fishing nets and low fecundity renders green sawfish at high risk to overfishing and the effects of coastal development. It is possible that stocking may result in localised increases in fishing effort, which has the potential to impact this species. However, there is no evidence to suggest that viable populations of green sawfish occur in NSW estuaries. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown, but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort changes with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to green sawfish, should they occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

As indicated in (a), the habitat for green sawfish occurs in mud or sandy-mud shallow water environments such as estuaries. However, there is no evidence to suggest that viable populations of green sawfish occur within any NSW estuaries and therefore the proposal is not expected to directly affect key habitats of the green sawfish. There is minimal risk that increased fishing activity may affect the quality of estuarine habitats important for green

Species Name: Green sawfish (*Pristis zijsron*)

sawfish, for example, through trampling littering or habitat disturbance by fishers accessing the foreshore. Monitoring would, however, be carried out in representative estuaries to determine whether disturbance as a result of stocking is affecting estuarine habitat. If this was the case then mitigative action would be taken to address this, or stocking in that estuary may be precluded (see Chapter G, Sections G.2.1.1.4 and G.2.1.2.5).

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable – there is no designated critical habitat for the green sawfish in NSW.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no specific recovery plan or threat abatement plan for the green sawfish in NSW, although the *Approved Conservation Advice for Pristis zijsron* (Green Sawfish) (TSSC 2008a) recommends the following priority actions, which are aimed at existing populations that occur in other parts of Australia:

- Identify known sites of high conservation priority;
- Protect remnants of the listed species through the development of conservation agreements and covenants with the fishing community;
- Raise awareness of the species within the local, Indigenous and fishing communities, including species identification and handling techniques for bycatch specimens;
- Improve reporting of interactions with commercial, recreational and Indigenous fishers;
- Undertake research into the biology, ecology and threats to the species;
- Work with fishers to develop appropriate codes of conduct for handling specimens to reduce incidental mortality;
- Develop bycatch mitigation measures and gear technologies to reduce threats;
- Assess the efficacy of current incidental threat abatement measures; and
- Mitigate Illegal Unreported Unregulated (IUU) fishing pressure on the species.

The proposal is not inconsistent with any of these priority actions.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

Under the FM Act 'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a KTP. As discussed in (a), there is the potential for stocking to increase the risk of hooking and in the unlikely case that green sawfish did occur in NSW estuaries, then this would constitute an area important for the survival of the species. However, given that the green sawfish is presumed extinct in NSW, this is not likely to be the case. The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the risk of 'Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments' which is listed as a KTP under the TSC Act. A similar KTP, 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of increased fishing effort associated with marine fish stocking. Lost or discarded fishing gear could potentially have an effect on green sawfish by increasing the risk of entanglement within a stocked estuary. Green sawfish have a high susceptibility for entanglement in discarded mesh nets or haul nets but given that this species is presumed extinct in NSW estuaries, there is no evidence to suggest that this species may be at risk. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it did occur, links to incidences of threats or harm to green sawfish would be investigated and appropriate mitigative action will be taken in discussion with the DPI Threatened Species Unit (see (a)).

Conclusion:

The key habitat for green sawfish is shallow, soft sediment environments, particularly estuaries. There are however, no known populations of green sawfish occurring along the NSW coast. In the highly unlikely event that green sawfish did occur within a stocked estuary, they could potentially be affected by changes to trophic dynamics (e.g. competition for food resources with stocked fish) and be vulnerable to an increased risk of incidental catch or entanglement in harmful marine debris if stocking were to result in localised increased fishing effort. However, as juvenile fish or crustaceans would be stocked at appropriate densities so that stocking does not disrupt the ecological balance of the estuaries, trophic impacts are not expected. In order to address issues associated with incidental catch of threatened species and the potential for entanglement within harmful marine debris (associated with a localised increase in fishing effort), the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). The draft FMS also includes a monitoring program that includes performance indicators for measuring impacts to threatened species and stocking would not take place where a population of green sawfish were at risk. As such, the likelihood of marine stocking affecting a viable population of green sawfish would be highly unlikely and no species impact statement is recommended.

CETACEANS

Baleen Whales

There are two listed baleen listed in the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements.

Species Names and Status:

Southern Right Whale (*Eubalaena australis*) – vulnerable species – Schedule 2 TSC Act

Humpback Whale (*Megaptera novaeangliae*) – vulnerable species – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Baleen whales as a group form the Mysticeti, one of two suborders of the Cetacea (whales, dolphins, and porpoises). Baleen whales are characterized by having baleen plates for filtering food from water, rather than having teeth. This distinguishes them from the other suborder of cetaceans, the toothed whales or Odontoceti.

Baleen whales feed mainly on zooplankton, crustaceans (e.g. krill) and small schooling fish. There are three listed threatened species of baleen whales that occur in coastal waters of NSW and have potential to enter deep estuaries along the NSW coastline. Due to the potential overlap in habitat with the proposal, these species may be affected on some level by marine stocking and associated activities.

Southern right whales migrate between summer feeding grounds in Antarctica and winter breeding grounds around the coasts of southern Australia, New Zealand, South Africa and South America. They are thought to feed in the open ocean in summer and known to move inshore in winter for calving and mating. Calving females and females with young usually remain very close to the coast, often where the depth of water is only 5-10 m. Southern right whales are known to be present along the east coast of Australia between May and November where they occasionally enter estuaries such as Port Jackson, Botany Bay, Jervis Bay and Twofold Bay. Females travel to temperate waters to give birth and anecdotal evidence shows that mother and calf sightings are becoming more common in the Sydney region as the species' population increases. Twofold Bay is used intermittently by southern right whales for calving (DEH 2005a).

The east coast population of humpback whales migrates along the Victorian, NSW and QLD coasts to the Coral Sea from late autumn to early winter and back along the coast in late spring and early summer. Often on the return trip, adults swim close to the shore and are accompanied by new-born calves. At this time, humpback whales may rest in some of the larger estuarine embayment's (in particular, Twofold Bay) (DEH 2005b).

Potential impacts to humpback or right whales from the proposal could occur if there is increased fishing activity associated with stocking within estuaries important to the survival of these whales. On the occasions that humpback or right whales may enter stocked estuaries they could potentially be affected by acoustic pollution (from increased boating activity), increased risk of boat strike (NSW Fisheries 2001) and/or entanglement or ingestion of harmful marine debris (i.e. fishing gear), particularly as numbers increase.

If there were increased boating activity associated with stocking, this would most likely result in only a brief disturbance to individuals that had chosen to visit estuaries. However, most estuaries within the scope of the proposal do not represent important habitat for baleen whales. In the more populated, busy estuaries it is unlikely that boating activity associated with stocking would increase the risk substantially above normal levels as boating and fishing are already very common in these estuaries. Notwithstanding this, if there were increased fishing activity associated with stocking boat strike would be possible, but minimal and the risks reduced further *by The Australian national guidelines for whale and dolphin watching 2005* by Department of the Environment, Water, Heritage and the Arts (DEWHA).

Fishing activities associated with the proposal pose the greatest risk to humpback and right whales as it could potentially increase the risk of incidental entanglement to individuals if they were to range into a stocked estuary. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. It is possible that stocking may result in localised increases in fishing effort but it is not however,

Species Names and Status:

Southern Right Whale (*Eubalaena australis*) – vulnerable species – Schedule 2 TSC Act

Humpback Whale (*Megaptera novaeangliae*) – vulnerable species – Schedule 2 TSC Act

expected that this could occur to the extent that it would have a negative effect on humpback and right whales. As humpback or right whales are rarely entangled, if ever, in estuaries by active or discarded nets or trap lines, any increase in fishing effort would have to be substantial to increase the risk of mortality to individuals beyond current levels.

Given that the likelihood of humpback or right whales occurring in most of the estuaries proposed for stocking would be rare and that any impacts directly related to stocking would be relatively minor, the overall risk to baleen whales for most estuaries is considered to be negligible. Therefore, it is not expected that the 'local' population of any of the above mentioned species would be placed at risk of extinction due to the proposed stocking activity.

Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to humpback or southern right whales, were they to occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan's for these species (see (f)).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The important areas of habitat to the southern right whale are the feeding areas of the Southern Ocean, the mating and birthing areas of southern Australia (e.g. Great Australian Bight) and to a lesser extent some birthing areas along the east and west coasts, primarily adjacent to coastal sandy beaches and in some of the deeper embayments. Calving may occur intermittently in Twofold Bay.

Major habitats for humpback whales include the feeding, breeding and mating areas in the southern and northern extents of their range, respectively, and the migration corridors which extend at least the width of the continental shelf. In addition, some large coastal embayments such as Twofold Bay are also potentially important areas as

Species Names and Status:

Southern Right Whale (*Eubalaena australis*) – vulnerable species – Schedule 2 TSC Act

Humpback Whale (*Megaptera novaeangliae*) – vulnerable species – Schedule 2 TSC Act

they may be used by the whales for resting or lay ups during annual migrations.

Although not expected, a substantial increase in boating activity potentially associated with stocking may modify estuaries by increasing acoustic pollution and the risk of injury to whales from boat strike or entanglement (see (a)). Furthermore, marine fish stocking activity would not create any habitat fragmentation, essentially preventing any area of habitat becoming isolated from any other currently interconnecting or proximate areas of habitat utilised by baleen whales.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There are approved Commonwealth recovery plans for the southern right whale (DEH 2005a) and humpback whale (DEH 2005b).

In NSW, OEH has prepared Priority Action Statements to promote the recovery of threatened species within NSW they include the following priority actions for each species

Humpback whale:

- Improve knowledge of humpback whale feeding ecology, and the ecology of prey species to assist with determining areas of critical habitat for the species. (Low priority);
- In areas important to survival of this species, undertake research to determine the impacts & threats of human activities & implement management measures to ensure ongoing recovery. (Medium priority);
- Include best practice code of conduct conditions for commercial vessels operating under the Marine Parks Authority licences. (Low priority);
- Manage the potential impacts of tourism on whales, and educate marine users about best practice behaviours and regulations when interacting with whales. (Medium priority); and
- Use best practice methods to reduce the likelihood of whale entanglements in marine debris & marine industry equipment. (Medium priority).

Southern Right Whale:

- Improve knowledge of southern right whale feeding ecology, and the ecology of prey species to assist with the identification of critical habitat for the species. (Low priority);
- In areas important to survival of this species undertake research to determine the impacts & threats of human activities & implement management measures to ensure ongoing recovery. (Medium priority);
- Include best practice code of conduct conditions for commercial vessels operating under the Marine Parks Authority licences. (Low priority);
- Manage the potential impacts of tourism on whales and educate marine users about best practice behaviours and regulations when interacting with whales. (Low priority);
- Participate in the national recovery program to better define the characteristics (spatial, temporal, physical) of calving, feeding, and migratory areas for southern right whales. (Medium priority);
- Participate in the national recovery program to measure and model population abundance and trends in the Australian population. (Medium priority); and
- Use best practice methods to reduce the likelihood of whale entanglements in marine debris & marine

Species Names and Status:

Southern Right Whale (*Eubalaena australis*) – vulnerable species – Schedule 2 TSC Act

Humpback Whale (*Megaptera novaeangliae*) – vulnerable species – Schedule 2 TSC Act

industry equipment. (Medium priority).

In relation to the proposal, potential threats identified in the plans and priority actions include physical injury from boat strike, entanglement in marine debris and acoustic disturbance.

A potential increase in recreational boating activity due to marine fish stocking could potentially exacerbate the above risks within stocked estuaries (see (a)) which would be inconsistent with the recovery plans and priority actions. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to whales would be investigated (see (a)).

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase recreational and commercial fishing activity and could therefore exacerbate the *'Entanglement or ingestion of anthropogenic debris in marine and estuarine environments'* which is listed as a KTP under the NSW TSC Act. A similar KTP *'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* (such as discarded fishing gear)' is listed as a KTP under the Australian Government's EPBC Act.

The baleen whales are considered particularly vulnerable to these two KTPs. It is possible, that localised increases to fishing activity within stocked estuaries could contribute to these KTPs by increasing the risk of harmful marine debris (i.e. discarded nets or trap lines) being released into the marine environment. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on whales by increasing the risk of entanglement if whales were to enter a stocked estuary. However, given that there is no evidence that large baleen whales have ever been entangled in estuaries where there is already considerable fishing effort, any increase in fishing effort in stocked estuaries is unlikely to significantly increase the risk of mortality to unless it is substantial. It is therefore unlikely that marine fish stocking would increase the impact of these KTPs to the extent that a population of baleen whales would be affected. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to whales would be investigated (see (a)).

Conclusion

In most estuaries, the proposal is not considered to represent a significant threat to the life cycle or habitat of baleen whales such that viable populations of the species would be put at risk of extinction. Stocking is unlikely to cause any trophic impacts to individuals that range into estuaries but there is potential for increased concentrations of fishing effort within stocked estuaries. Increased fishing effort could potentially increase the risk of entanglement to whales or boat strike. Given that the predicted severity of these impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to whales would be investigated and the program reviewed and modified if undesirable threats or harm to whales became apparent.

No species impact statement is recommended for any of the baleen whales.

MARINE REPTILES

There are three listed marine turtles under the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements (e.g. come ashore to lay eggs).

Species Group: Marine Turtles

Species and Status:

Loggerhead turtle (*Caretta caretta*) - endangered species – Schedule 1 TSC Act

Green turtle (*Chelonia mydas*) – vulnerable species – Schedule 2 TSC Act

Leatherback turtle (*Dermochelys coriacea*) – vulnerable species – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Most of the threatened marine turtles that potentially would be affected in some way by the proposal tend to prefer warmer waters, ranging from tropical to warm temperate seas (Marquez 1990). For a large part of their life cycle, marine turtles are pelagic, particularly leatherbacks, although green turtles tend to stay in coastal waters. The green turtle is generally found in the more northern latitudes of Australia although resident groups of green turtles have been found in NSW, with some as far south as Jervis Bay. Regular reports of green turtles in Jervis Bay and in some other more southerly estuaries that suggests some individuals may make regular visits to these southern locations. Resident populations also appear to have established in some other estuaries particularly near warm water outfalls such as Lake Macquarie where a study is underway to assess the apparently resident populations of several turtle species in the vicinity of warm water outfalls from a power generation facility. Green turtles feed on seaweeds and seagrasses although juveniles may be carnivorous.

Loggerhead turtles occur in coral reefs, bays and estuaries in tropical and warm temperate waters off the coast of QLD, Northern Territory (NT), Western Australia (WA) and NSW. Like green turtles, there are also resident groups of loggerhead turtles in the waters of northern NSW. Loggerheads are carnivorous.

The leatherback turtle has a wide distribution and may be observed all around the coast of southern QLD and NSW. Leatherbacks are carnivorous feeding mainly in the open ocean on jellyfish and soft-bodied invertebrates. They are a highly pelagic species and as such would rarely occur in estuaries apart from some of the coastal embayments.

Marine turtles are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. Although these species occur within NSW estuaries, these waters are outside the range of known nesting and mating areas for the turtle species (although there is a record of leatherbacks nesting on Ballina Beach). The nesting and mating grounds for the listed turtle species generally occur in more northern latitudes.

By-catch of marine turtles in fisheries, entanglement and ingestion of marine debris, coastal development, loss of habitat and deterioration of water quality are significant threats to marine turtles. All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries, although the hunting of turtles within NSW waters is prohibited. Although no populations are listed as endangered, the loss of only a few individuals could still affect the viability of local populations.

Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, turtles would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information

Species Group: Marine Turtles

becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, as many of the stocked species (as juveniles) have potential to be the prey of loggerhead turtles there is a potential that stocking would increase, rather than reduce, local estuarine food sources for loggerheads. Stocking has little potential to affect marine turtles occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with turtles for their habitat or food or displace their food sources.

Fishing activities associated with the proposal pose the greatest risk to marine turtles. They would be potentially vulnerable to incidental hooking or entanglement to individuals if they were to range into a stocked estuary. Under State and Commonwealth law it is illegal to catch or harm marine turtles. Most inshore recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large turtles such as the listed species. Hooked turtles would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002). Turtles have greater potential for becoming entangled in mesh nets or haul nets and there is evidence that they can become entrapped in crab traps. Increased fishing activity within stocked estuaries also has potential to result in littering and accumulation of discarded or lost fishing gear. Marine turtles are considered to be particularly vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets and could therefore be placed at risk. There is special mention of eastern stock of loggerhead turtles being vulnerable to ingestion and entanglement in crab float lines (DEH 2003) and boat strike (Environment Australia 2003), although data on incidence of boat strikes is only available for QLD. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would potentially have a negative effect on turtles such that a viable local population of the species is likely to be placed at risk of extinction.

Given that the predicted severity of many of the impacts to marine turtles are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to marine turtles, were they to occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan's for these species (see (f)).

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the

Species Group: Marine Turtles

species, population or ecological community in the locality.

Estuarine habitats, including seagrass beds provide foraging habitat for marine turtles. There is a low risk that increased recreational fishing could potentially result in the trampling of seagrass by anglers but given that this would occur only in very shallow areas within the stocked estuaries, it is unlikely that trampling could occur to the extent that any area of marine turtle habitat would become isolated or removed to the extent that this would affect the long-term survival of a population.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is an approved Commonwealth Recovery Plan for Marine Turtles in Australia (Environment Australia 2003). The specific objectives of the recovery plan are as follows.

- To reduce the mortality of marine turtles and, where appropriate, increase natural survivorship, including through developing management strategies with Aboriginal and Torres Strait Islander communities for the sustainable use of marine turtles;
- To develop programs and protocols to monitor marine turtle populations in Australia, assess the size and status of those populations, the causes of their mortality and address information gaps;
- To manage factors that affect marine turtle nesting;
- To identify and protect habitats that are critical for the survival of marine turtles;
- To communicate the results of recovery actions and involve and educate stakeholders; and
- To support and maintain existing agreements and develop new collaborative programs with neighbouring countries for the conservation of shared turtle populations.

In NSW, OEH has prepared Priority Action Statements to promote the recovery of threatened species within NSW they include a total of 40 priority actions for marine turtle species, a high priority action within each species of marine turtles priority action plan is to 'liaise with the Australian and other State governments over the implementation of the national marine turtle recovery plan'. Objective A of the Commonwealth recovery plan for marine turtles aims to 'reduce the mortality of marine turtles'. There would potentially be negative effects of stocking (if there were increased boating and fishing activity) on marine turtles occurring within stocked estuaries. It is unlikely that either of these would potentially be of a magnitude to substantially reduce or increase mortality of marine turtles. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to marine turtles would be investigated (see (a)). The proposal is otherwise consistent with the objectives of the Commonwealth recovery plan for marine turtles.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase recreational and commercial fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Marine turtles are considered particularly vulnerable to these two KTPs as some species are thought to mistake plastic bags and other items for jellyfish prey (Mrosovsky 1981, Balazs 1985, Bjorndal *et al.* 1994 – in DEWHA 2008, Threat Abatement Plan for impacts of marine debris on vertebrate marine life), other species eat encrusting organisms that grow on floating plastics and nets and can become ensnared when attempting to feed. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. However lost/discarded fishing gear could potentially have a negative effect on turtles by increasing the risk of

Species Group: Marine Turtles

entanglement if the species were to occur within a stocked estuary. Marine turtles have some potential for entanglement in discarded mesh nets, haul nets or crab traps (see (a)). The draft FMS proposes to monitor for changes to fishing effort occurring with stocking and if it does occur, and is linked to incidences of threats or harm to threatened species, then the project would be reviewed and/or modified accordingly (see (a)).

Conclusion:

It is likely that green and loggerhead turtles could occur, on occasion, in estuaries where stocking has occurred. Stocking is unlikely to cause any significant trophic impacts to individuals that range into estuaries but there is potential for impacts to be associated with increased concentrations of fishing effort in stocked estuaries. There is potential for increased fishing effort as a result of stocking to increase the hooking rate of green and loggerhead turtles and some KTPs. Given that the predicted severity of these impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to green and loggerhead turtles would be investigated and the program reviewed and modified if undesirable threats or harm to green and loggerhead turtles became apparent.

No species impact statement is recommended for any of the marine turtles.

PINNIPEDS

There are two listed fur seals under the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements (i.e. have similar haul-out sites, eat fish and cephalopods).

Fur Seals

Species Name:

Australian Fur-Seal (*Arctocephalus pusillus doriferus*) – vulnerable – Schedule 2 TSC Act

New Zealand Fur-Seal (*Arctocephalus forsteri*) – vulnerable – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Australian fur seals (*Arctocephalus pusillus doriferus*) are coastal mammals that range over the continental slope and shelf waters of south-eastern Australia (Shaughnessy 1999). They may also move into estuaries occasionally. Australian fur seals eat pelagic and mid-water fish and cephalopods and can dive to depths of approximately 200 m whilst chasing food. They breed on 10 islands in the Bass Strait. Pregnant females feed intensively at sea in early spring before returning to colonies in late October/early November to give birth to a single pup (Menkhorst and Knight 2001). In the past, Australian fur seals were reported to have bred in NSW (prior to commercial sealing) at Seal Rocks and Montague Island but they no longer do so. There are other non-breeding (haul-out) colonies between Kangaroo Island in SA and Jervis Bay in NSW. These are Green Cape, Montague Island and Steamers Beach near Jervis Bay. In addition, other various locations along the NSW coast are used irregularly as haul-out sites. Although the species no longer breeds in NSW, habitat and resources within the State remain important to non-breeding individuals.

New Zealand fur seals (*Arctocephalus forsteri*) occur in coastal waters of Australia and New Zealand. In Australian waters, New Zealand fur-seals have been recorded in all of the southern States as well as in QLD (south of Fraser Island). They eat fish and cephalopods and to a lesser extent birds such as penguins, both in shallow waters and around the margins of the continental shelf. Breeding colonies in Australia are known from islands off WA, SA and Tasmania, including Macquarie Island. Although the species does not breed in NSW, habitat and resources within the State remain important to non-breeding individuals. Montague Island is a regular haul-out site in NSW (Shaughnessy 1999).

Both Australian and New Zealand fur seals may occasionally forage in estuaries although this is not generally considered a core habitat. Potential impacts from the proposal are associated with trophic impacts to the individuals that range into estuaries as well as from fishing activities associated with the proposal. Although no populations of seals are endangered, the loss of individuals could still affect the viability of local populations.

Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, seals would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, as many of the stocked species (as juveniles) have potential to be the prey of seals there is a potential that stocking would increase, rather than reduce, local estuarine food sources for seals. Stocking has little potential to affect seals occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with seals for their habitat or food or displace their food sources.

Fishing activities associated with the proposal pose the greatest risk to fur seals. Increased fishing activity within stocked estuaries has potential to result in littering and accumulation of discarded or lost fishing gear. Fur seals

Species Name:

Australian Fur-Seal (*Arctocephalus pusillus doriferus*) – vulnerable – Schedule 2 TSC Act

New Zealand Fur-Seal (*Arctocephalus forsteri*) – vulnerable – Schedule 2 TSC Act

are potentially vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets and could therefore be placed at risk. Previous assessments of fishing activities on fauna in NSW estuaries had not considered impacts to fur seals an issue (NSW Fisheries 2001). However, a substantial increase in fishing effort with stocking could potentially have a negative effect on fur seal populations as it would increase the risk of entanglement to individuals if they were to range into a stocked estuary. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would result in a viable local population of fur seals being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to fur seals, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable.

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The major habitat utilised by fur seals comprises coastal waters, with rocky shores of some islands off the mainland for haul-out. Although it is probable that fur seals would enter estuaries to forage on occasion this is not considered core habitat for either of the listed species. The proposal would not modify or remove any core habitat or estuarine habitat of fur seals. The proposal would also not isolate or fragment any reef or estuarine habitat from other habitat used by the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Species Name:

Australian Fur-Seal (*Arctocephalus pusillus doriferus*) – vulnerable – Schedule 2 TSC Act

New Zealand Fur-Seal (*Arctocephalus forsteri*) – vulnerable – Schedule 2 TSC Act

There are no approved recovery plans for these species, however there is an approved Commonwealth Action Plan for Australian seals (Shaughnessy 1999).

In NSW, OEH has prepared Priority Action Statements to promote the recovery of threatened species within NSW they include a series of priority actions for each species as detailed

New Zealand Fur-seal

- Include best practice code of conduct conditions for commercial vessels operating under Marine Parks Authority licences (Low priority);
- Maintain contingency plans for the treatment and rehabilitation of individuals in the event of an oil spill (Low priority);
- Maintain protocols for the surveillance, care, treatment, rehabilitation and if required euthanasia of individuals in the event of a haul-out of an injured seal (Low priority);
- Promote an education program with fishing tackle manufacturers that encourages the use of non-stainless steel hooks and traces (Low priority);
- Promote an education program with the commercial fishing industry that encourages self-regulation of activities that can lead to a reduction in by-catch of fur seals (Low priority);
- Reduce injury and/or mortality of individuals through surveillance and enforcement of *NSW National Parks and Wildlife Act* approach distances for marine mammal fauna (Low priority); and
- Restrict access to breeding and haul out colonies where practical (Medium priority)

Australian Fur-seal

- Include best practice code of conduct conditions for commercial vessels operating under OEH or Marine Parks Authority licences (Low priority);
- Maintain contingency plans for the treatment and rehabilitation of individuals in the event of an oil spill (Low priority);
- Maintain protocols for the surveillance, care, treatment, rehabilitation and if required euthanasia of individuals in the event of a haul-out of an injured seal. (Low priority);
- Promote an education program with fishing tackle manufacturers that encourages the use of non-stainless steel hooks and traces (Low priority);
- Promote an education program with the commercial fishing industry that encourages self regulation of activities that can lead to a reduction in by-catch of fur seals (Low priority);
- Reduce injury and/or mortality of individuals through surveillance and enforcement of *NSW National Parks and Wildlife Act* approach distances for marine mammal fauna. (Low priority); and
- Restrict access to breeding and haul out colonies where practical (Medium priority).

Although there is no approved recovery plan for either of these two species the proposal of marine fish stocking is consistent with the objectives of the Commonwealth action plan for Australian seals as well as the State priority actions.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase recreational and commercial fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine*

Species Name:

Australian Fur-Seal (*Arctocephalus pusillus doriferus*) – vulnerable – Schedule 2 TSC Act

New Zealand Fur-Seal (*Arctocephalus forsteri*) – vulnerable – Schedule 2 TSC Act

life caused by ingestion of, or entanglement in, harmful marine debris' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of marine fish stocking. Lost/discarded fishing gear could potentially have a negative effect on fur seals by increasing the risk of entanglement if species were to range into a stocked estuary. Previous assessments of fishing activities on fauna in NSW estuaries had not considered impacts to fur seals an issue (NSW Fisheries 2001) and any increase in fishing effort would have to be substantial to significantly increase the risk of mortality to individuals. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor for changes to fishing effort occurring with stocking and if it does occur, and is linked to incidences of threats or harm to threatened species, then the project would be reviewed and/or modified accordingly (see (a)).

Conclusion:

The proposal would not have any direct or indirect impacts on the core habitat of Australian and New Zealand fur seals. It is possible, however, that fur seals could occur, on occasion, in estuaries where stocking has been proposed to occur. Stocking in these cases is unlikely to cause any significant trophic impacts to individuals that range into estuaries but there is potential for stocking to increase concentrations of fishing effort in stocked estuaries. Increased fishing effort could lead to some KTPs being exacerbated. Given that the predicted severity of these impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to fur seals would be investigated and the program reviewed and modified if undesirable threats or harm to fur seals became apparent.

No species impact statement is recommended for any of the fur seals.

SIRENIANS

Dugong

Species Name: Dugong (*Dugong dugon*)

Status: Endangered – Schedule 1 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Dugongs (*Dugong dugon*) mainly occur in northern Australia but there is evidence to suggest that they occasionally occur well beyond the southern limit of their accepted range into NSW (Allen *et al*. 2004). Individuals that have been recorded in NSW are mostly thought to be non-breeding vagrants that are influenced by warm currents and the availability of seagrass further south. The largest remaining dugong population in the world, is the northern Australian population, which in 1991 was estimated at approximately 70,000 (QLD Department of Environment and Resource Management 2010). About 800 dugongs live in Moreton Bay, QLD, and it is possible that that dugongs ranging into northern NSW are part of that population. Dugongs prefer shallow coastal waters including estuaries where seagrass is abundant. They surface only to breathe and never come on to land. They like to live in large herds, but due to declining numbers are often now found in smaller 'family' groups of between one to three animals.

Although dugongs only live where there is seagrass, on which they feed, they may migrate between areas. Dugongs have been recorded from a number of NSW estuaries where suitable seagrass habitat occurs, namely Wallis Lake, Port Stephens, Lake Macquarie and Brisbane Water (Allen *et al*. 2004) but occurrences are rare. The animals are slow moving and spend the majority of their lifecycle within estuarine waters which makes them vulnerable to boat strike (QLD Department of Environment and Resource Management 2010) and entanglement in harmful marine debris.

Potential impacts from stocking are associated with a potential localised increase in fishing activities associated with the proposal. For a vulnerable species such as dugong the loss of only a few individuals could seriously affect the viability of the south QLD/northern NSW population due to their already reduced numbers in the wild.

Previous assessments of fishing activities on marine mammals in NSW estuaries had not considered impacts to dugongs an issue (NSW Fisheries 2001). However, a substantial increase in fishing effort with stocking could potentially have a negative effect on dugong populations. A substantial increase in fishing effort of fishers targeting stocked eastern king prawns could lead to trampling of seagrass in the shallowest areas of estuaries. However, as there would be very little overlap between the very shallow areas of seagrass which could potentially be trampled and the areas where dugongs feed, even a substantial amount of trampling would not reduce seagrass to levels that would affect the availability of food to the small number of dugongs occurring in NSW estuaries. A substantial increase in fishing effort could potentially have a negative effect on dugong populations as it would increase the risk of boat strike or entanglement (in active or discarded fishing nets) to individuals ranging into stocked estuaries. In the past, boat strike or entanglement of dugongs in NSW estuaries by commercial nets has been rare, if at all, and any increase in fishing effort would have to be substantial to increase the risk of mortality to individuals beyond current levels.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in a viable local population of dugongs being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to dugongs, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

Species Name: Dugong (*Dugong dugon*)

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Dugongs have been reported feeding in seagrass beds of the North and Central coast of NSW and vagrants may occur further south. Mating and birthing areas are normally in northern Australian waters between Shark Bay in WA and Moreton Bay in QLD. As discussed in (a), although not expected, a substantial increase in fishing effort could lead to trampling of seagrass which is an important habitat and food source for the species although this is most likely to occur in the shallowest areas of estuaries suitable for wading. However, even a substantial amount of trampling would not reduce seagrass to levels that would affect the availability of food (foraging habitat) to the small number of dugongs occurring in NSW estuaries.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is currently no recovery plan for this species, however in NSW OEH has prepared Priority Action Statements to promote the recovery of threatened species within NSW they include the following priority actions for dugongs:

- Include this species in threat abatement actions pertaining to the "Death or injury to marine species following capture in shark control programs on ocean beaches" KTP (Low priority); and
- The impacts of estuarine and coastal marine development on potential dugong habitat e.g. *Halophila* spp. seagrass meadows in northern NSW should be considered by consent and determining authorities (Medium priority).

A potential increase in fishing activity on seagrass beds due to marine fish stocking could potentially affect seagrass habitats which would be inconsistent with the priority actions (see (a)). However, the extent of overlap between the dugong grazing meadows and the seagrass beds that potentially may suffer trampling would be minimal (see (a)) and would be dependent on a substantial increase in fishing effort associated with stocking which is not expected. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to dugongs would be investigated and the stocking program reviewed and

Species Name: Dugong (*Dugong dugon*)

modified if undesirable threats or harm to dugongs become apparent.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a KTP under the TSC Act. A similar KTP, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potential increase to localised fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on dugongs by increasing the risk of entanglement if the species were to occur within a stocked estuary. Dugongs have some potential for entanglement in discarded mesh nets or haul nets but given that there is no evidence that dugongs have ever been entangled in nets in estuaries where there is already considerable commercial fishing effort, any increase in fishing effort in stocked estuaries would have to be substantial to significantly increase the risk of mortality to individuals. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to dugongs would be investigated and the stocking program reviewed and modified if undesirable threats or harm to dugongs become apparent.

Conclusion:

Stocking is unlikely to cause any trophic impacts to dugongs that range into estuaries but localised increases to fishing effort could lead to trampling of some seagrass beds and some KTPs. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to dugongs or their habitat would be investigated and the stocking program reviewed and modified if undesirable threats or harm to dugongs become apparent.

No species impact statement is recommended.

MARINE BIRDS

Little Penguin

Species Name: Little Penguin (*Eudyptula minor*)

Status: Endangered Population (Little Manly Point) - Schedule 1 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The population of little penguins at Manly is the only known breeding population on the mainland in NSW (NSW NPWS 2000). The population utilises a range of nest sites, including under rocks on the foreshore, under seaside houses and structures, such as stairs, in wood piles and under overhanging vegetation. The penguins appear to be opportunistic feeders, foraging in relatively shallow waters and preying on squid and small schooling fish such as anchovy and pilchards. The daily foraging range for adult penguins is between 10 km and 30 km. Immature birds however, are known to disperse hundreds of kilometres from their colonies. The foraging range and breeding success is considered to be very much dependant on the availability and abundance of food (NSW NPWS 2000). The species commonly dives to depths between 2 m and 10 m but may occasionally forage much deeper than this i.e. > 25 m (Ropert-Couldert *et al.* 2006).

Although little penguins feed mainly on small coastal, pelagic schooling fish, it is possible that some estuarine prey items of penguins could be displaced by stocked species. Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, little penguins would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, as many of the stocked species (as juveniles) have potential to be the prey of little penguins there is a potential that stocking would increase, rather than reduce, local estuarine food sources for little penguins. Stocking has little potential to affect little penguins occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with little penguins for their habitat or food or displace their food sources.

The major threat to the Manly population is the loss of suitable habitat for breeding nesting and moulting, while predation from dogs and foxes is also a significant threat. As the colony is located in an urbanised area, disturbance from noise, light and movement is also a problem (NSW NPWS 2000). The colony is located within North Harbour Aquatic Reserve but line fishing is permitted there. Hence, individuals from the colony are at risk from injury due to harmful marine debris such as discarded fishing gear within the Reserve but also in foraging areas further afield. It is possible that increased fishing activity in the area as a result of marine fish stocking could exacerbate potential impacts on the Little Manly penguin population, particularly disturbance from recreational fishers to nests (and therefore fledging of chicks) and entanglement from discarded fishing gear. However, as nests are generally located in seclusion in rocky areas above the shoreline in front of private property or in bushland there should be little disturbance from recreational fishers as there is little or no access. As fishing is not permitted in the Reserve between sunset and sunrise this would also protect penguins moving in out of the nests from disturbance. Little penguins have some potential for entanglement in actively fished or discarded recreational lines. There is some evidence that this occurred for little penguins in Manly in the past where there is and has been considerable fishing effort for some time. Given that fishing in Port Jackson (the most densely populated of all estuaries in NSW) and its surrounding coastal waters and nearby estuaries is already popular (i.e. areas where members of the colony may forage), stocking is unlikely to increase fishing effort in this estuary to a level that would substantially increase the risk of entanglement to little penguins at Manly.

Species Name: Little Penguin (*Eudyptula minor*)

It is therefore considered unlikely the proposal would disrupt the life cycle of this species such that the viable local population of little penguins at Manly is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

The colony of little penguins at Manly is listed as an endangered population under *Schedule 1* of the TSC Act. For an endangered population the loss of only a few individuals could seriously affect the viability of the whole population. The potential of the proposal to put individuals and hence the population at Manly at risk is discussed in (a). It is considered unlikely that the proposal would have an adverse effect on the Manly population of little penguins such that it was put at risk of extinction.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not Applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The major threat to the Manly population is the loss of suitable habitat for breeding nesting and moulting (NSW NPWS 2000). As stated in (a) the potential for nests (and therefore fledging of chicks) to be disturbed by increased recreational fishing activity is not considered an issue because nests are generally located in seclusion in rocky areas above the shoreline in front of private property or in bushland where there is little or no access. Fishing within the areas which are used by the penguins is also not permitted during the night when penguins are actively moving back and forth from the water to their nests.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Two areas of critical habitat have been declared for the little penguin population in the Manly Point area (Port Jackson). The critical habitat is in two areas:

Area A starts from west of Collins Beach and extends to the northern side of Cannae Point. It includes Collins, Store and Quarantine Beaches to the northern side of Cannae Point. The terrestrial boundary of the critical habitat in Sydney Harbour National Park includes ridge top areas where penguins currently nest or could potentially nest.

Area B starts at 11A Oyama Avenue and extends around Manly Point to 26 Addison Road. The land side of the critical habitat includes the area from the mean high watermark, up the rocky foreshore slope to the beginning of the ridge top in residential areas. The rocky foreshore upslope to the boundary of formed residential backyards is included as critical habitat, but formed backyards and residential areas are not included.

In the water

The critical habitat also includes the harbour (extending 50m out from the mean high water mark) to make it easier for penguins to get to nesting areas. Parts of this aquatic zone include seagrass beds that are likely to be

Species Name: Little Penguin (*Eudyptula minor*)

important feeding areas, especially during the rearing of chicks when little penguins are known to seek food closer to their nests.

As stated in (a), nesting habitat would not be affected by fishing activity that may be associated with the proposal due to the seclusion of nests and the protection already offered by North Harbour Aquatic Reserve. Although little penguin critical habitat in the water has some potential to accumulate lost or discarded fishing gear and hence entangle some individuals, stocking is unlikely to increase fishing effort in this estuary to a level that would substantially increase the risk of entanglement to little penguins at Manly. Hence, the proposal would not have any direct or indirect adverse effect on the Manly little penguin critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The recovery plan for the endangered population of little penguins at Manly (NSW NPWS 2000) has seven objectives. These are:

- To determine the current status of the population and extent of available habitat;
- To identify and ameliorate impacts of current threats;
- To maintain the population at current levels and increase the limits of potential habitat;
- To continue community education, awareness and involvement;
- To ensure the protection the Little Penguin population at Manly and its habitat in the long term;
- To support and coordinate research into the ecology of the population; and
- To re-assess recovery program priorities.

The proposal does not directly contravene the objectives of the recovery plan for the endangered population of little penguins at Manly.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase recreational and commercial fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a *KTP* under the TSC Act. A similar *KTP*, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on little penguins by increasing the risk of entanglement if the species were to occur within a stocked estuary. Little penguins have some potential for entanglement in discarded nets or lines but given that there is already considerable fishing effort in Port Jackson and its surrounds, and the area heavily utilised by the little penguin population is already protected by both the North harbour Aquatic Reserve and also the critical habitat listing under the TSC Act, any increase in fishing effort in Port Jackson is unlikely to significantly increase the risk of mortality to individuals.

Conclusion:

The proposal is unlikely to have any significant direct or indirect impacts on the critical habitat of the endangered colony of little penguins at Manly. Stocking is unlikely to cause any trophic impacts to penguins in the colony and a potential increase in fishing effort in Port Jackson is unlikely to significantly increase the risk of mortality to individuals given that there is already considerable fishing effort in Port Jackson and its surrounds.

No species impact statement is recommended.

Estuarine Birds (Wading Birds)

There are 13 listed wading birds under the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements.

Species Group: Wading birds:

Species and Status:

Hooded plover (*Thinornis rubricollis*) – critically endangered species – Schedule 1A TSC Act

Black necked stork (*Ephippiorhyncus asiaticus*) - endangered species – Schedule 1 TSC Act

Beach stone curlew (*Esacus neglectus*) – critically endangered species – Schedule 1A TSC Act

Pied oyster catcher (*Haematopus longirostris*) – endangered – Schedule 1 TSC Act

Sanderling (*Calidris alba*) – vulnerable – Schedule 2 TSC Act

Great knot (*Calidris tenuirostris*) - vulnerable – Schedule 2 TSC Act

Greater sand plover (*Charadrius leschenaultia*) - vulnerable – Schedule 2 TSC Act

Lesser sand plover (*Charadrius mongolus*) - vulnerable – Schedule 2 TSC Act

Sooty oyster catcher (*Haematopus fuliginosus*) - vulnerable – Schedule 2 TSC Act

Black bittern (*Ixobrychus flavicollis*) – vulnerable – Schedule 2 TSC Act

Broad-billed sandpiper (*Limicola falcinellus*) - vulnerable – Schedule 2 TSC Act

Black tailed godwit (*Limosa limosa*) - vulnerable – Schedule 2 TSC Act

Terek sandpiper (*Xenus cinereus*) - vulnerable – Schedule 2 TSC Act

Australasian bittern (*Botaurus poiciloptilus*) – vulnerable – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Shore birds or 'waders' are those birds commonly found on coastal shores, including beaches, rocky shores, mudflats, tidal wetlands and lagoons. These include plovers and sandpipers in the families Charadriidae and Scolopacidae, stone-curlews, snipes, oystercatchers, stilts and avocets among others (Australian Museum 2010). Wading birds feed on marine invertebrates (including molluscs, worms and crustaceans), small fish that live within intertidal sand and mudflats. Small reptiles, earthworms, seeds and vegetation may also form part of their diet. Waders feed in the shallows or over exposed mud by probing their long slender bills into the substratum. Bill length, legs, body-structure, size and foraging techniques may subtly or markedly differ between groups of waders (Pizzey and Knight 1997). Important nesting areas may include sandbanks, sandpits, islands in estuaries, mangroves and riparian vegetation adjacent to the waterway. Nesting often takes place close to the ground which can make these birds vulnerable to disturbance.

It is possible that some estuarine prey items of wading birds could be displaced by stocked species. Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, wading birds would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. Notwithstanding this, although no populations are listed as endangered, the loss of only a few individuals could still affect the viability of local populations. Stocking has little potential to affect wading birds occurring in coastal waters 'outside' of estuaries

Species Group: Wading birds:

as stocked fish that move into coastal waters are unlikely to compete with wading birds for food or displace their food sources. In addition, the diverse diet of wading birds would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for wading birds.

It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it could increase the potential for trampling or disturbance of wading bird feeding or nesting habitat. Disturbance to nesting areas is considered unlikely as many important sites are already protected from access by humans.

Hence, it is unlikely that the proposal would cause adverse impacts that would result in a viable local population of wading birds being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to wading birds, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Feeding habitat important to wading birds may include tidal sand and mud flats. Important nesting areas may include sandbanks, sandpits, islands in estuaries, mangroves and riparian vegetation adjacent to the waterway.

As a potential result of the proposal, it is possible that some trampling of habitat and increased human activity and noise could occur in stocked waterways. This increase in activity is unlikely to result in the removal, fragmentation or isolation of habitat important to estuarine wading birds, but some minor modification could occur. Furthermore stocking would not take place in any designated Ramsar wetlands that are internationally important for waterbirds.

In (a), it was considered that potential impacts would possibly occur if there were substantial increases in fishing effort within stocked estuaries although such an increase is not expected. Any incidences to wading bird habitat that were potentially linked to increased fishing effort that may have been associated with the proposal would be

Species Group: Wading birds:

investigated and the program reviewed and modified accordingly.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not Applicable

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Priority actions have been identified to help protect and/or recover all of the threatened wading birds. The proposal would be relevant to some of the priority actions relating to minimising human disturbance to species and/or their habitats as increased fishing effort has potential to be associated with stocking. The priority actions relevant to the proposal are listed below:

- Avoid disturbance of nesting sites from lake and estuary openings during breeding season (Medium priority) – hooded plover;
- Develop a Code of Conduct for beach users including clubs to minimise impact of human disturbance on beach stone curlew sites (High priority) – beach stone curlew;
- Monitor breeding colonies; identify threats to breeding success (Medium priority) – beach stone curlew;
- Protect foraging and roosting sites within the Bellinger, Tweed and Shoalhaven estuaries (Medium priority) – beach stone curlew;
- Protect foraging and roosting sites within the Clarence, Nambucca and Manning River (Farquhar Inlet) Estuaries on Crown land (High priority) – beach stone curlew;
- Avoid disturbance of nesting sites from lake and estuary openings during breeding season (Medium priority) – pied oyster catcher;
- Minimise human disturbance at identified key foraging sites (disturbance from 4WDs, recreational users, dog-walkers, fishermen etc.) (Medium priority) – sanderling, great knot, greater sand plover, lesser sand plover, black tailed godwit, terek sandpiper; and
- Assess threats at key breeding sites (Medium priority) – sooty oyster catcher.

As the potential for increased fishing effort associated with proposal is unknown the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to wading birds, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

As such the action proposed is not inconsistent with the actions of the recovery or threat abatement plans.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTPs.

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a *KTP* under the TSC Act. A similar *KTP*, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on wading birds by increasing the risk of entanglement if species were to occur within a stocked estuary. Wading birds have some potential for entanglement in discarded mesh nets or haul nets or lines. In (a), it was considered that potential impacts would possibly be associated with

Species Group: Wading birds:

substantial increases in fishing effort within stocked estuaries. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to wading birds would be investigated and the project reviewed and modified accordingly.

Conclusion:

Stocking is unlikely to cause any significant trophic impacts to wading birds living in stocked estuaries but increased fishing effort could lead to trampling of some foraging and nesting habitat, disturbance and potentially exacerbate some KTPs. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to wading birds would be investigated and the program reviewed and modified if undesirable threats or harm to wading birds became apparent.

No species impact statement is recommended for any of the wading birds.

Estuarine Birds (Diving Birds)

There are two listed diving birds under the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements.

Species Group: Diving birds

Species and Status:

Little tern (*Sterna albifrons*) - endangered species – Schedule 1 TSC Act

Collared kingfisher (*Todiramphus chloris*) – vulnerable species – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Diving birds are birds which plunge into water to catch fish or other food. They may enter the water from flight, or dive from the surface of the water.

The little tern is found on the north, east and south-east Australian coasts, from Shark Bay in WA to the Gulf of St Vincent in SA. Little terns are almost exclusively coastal, preferring sheltered environments; however may occur several kilometres from the sea in harbours, inlets and rivers (with occasional offshore islands or coral cay records). They nest in small, scattered colonies in low dunes or on sandy beaches just above the high tide mark near estuary mouths or adjacent to coastal lakes and islands. Little terns feed in flocks, foraging for small fish, crustaceans, insects, annelids and molluscs by plunging in the shallow water of channels and estuaries, and in the surf on beaches (NSW DECCW 2010f).

In NSW, the collared kingfisher is most commonly observed in the Tweed River estuary, where it breeds. It appears to be an irregular visitor further south. Collared kingfishers are virtually restricted to mangroves and other estuarine habitats and mainly occur about the mouths of the larger coastal rivers. They are frequently observed perched on rock walls, jetties, piles and tidal flats and sometimes occur in parks and gardens along foreshores. Nests are usually in a hollow in a mangrove tree or drilled into termite nests in a large eucalypt or paperbark adjacent to mangroves. Collared kingfisher mostly take food from the ground, from the surface of mud and sand, mainly along seaward fringe of mangroves. Sometimes take food from shallow water or from air. The diet consists mostly of crustaceans, especially crabs, but they also take insects, small fish, and lizards. They have also been reported to occasionally take young birds. (NSW DECCW 2010g).

It is possible that some estuarine prey items of diving birds could be displaced by stocked species. Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, diving birds would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. Notwithstanding this, although no populations are listed as endangered, the loss of only a few individuals could still affect the viability of local populations. Stocking has little potential to affect diving birds occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with diving birds for food or displace their food sources. In addition, the diverse diet of diving birds would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for diving birds.

It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it could potentially lead to trampling or disturbance of some diving bird feeding habitat or nesting habitat of little terns. Disturbance to nesting areas is considered unlikely as many important breeding sites are already protected to a large extent from access by humans. Increased fishing

Species Group: Diving birds

with line also has potential to increase the risk of entangling or hooking diving birds were they to dive after baited lines, although this behaviour has not been reported for little terns or collared kingfisher.

Hence, it is unlikely that the proposal would cause adverse impacts that would result in a viable local population of diving birds being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to diving birds, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not Applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The two listed diving birds feed primarily within estuaries although little terns may feed occasionally in nearshore coastal waters (NSW NPWS 2003). Important nesting areas may include sandbanks, sandpits, islands in estuaries, mangroves and riparian vegetation adjacent to the waterway (see (a)).

It is possible that some trampling of nesting habitat and increased human activity and noise could occur in stocked waterways but this is unlikely to occur to an extent that results in the removal, fragmentation or isolation of nesting habitat, although some minor modification could occur. Furthermore stocking would not take place in any designated Ramsar wetlands that are internationally important for waterbirds.

In (a), it was considered that potential impacts would possibly occur if there were substantial increases in fishing effort within stocked estuaries although such an increase is not expected. Any incidences to diving bird habitat that were potentially linked to increased fishing effort and may have been associated with the proposal would be investigated and the program reviewed and modified accordingly.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not Applicable.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Species Group: Diving birds

Collared kingfisher.

A total of three strategies have been identified to help recover collared kingfisher. Each of these strategies has a number of priority actions within it but none are relevant to the proposal.

Little tern

There is a recovery plan for little terns in NSW (NSW NPWS 2003) and 21 priority actions have been identified to assist the species recovery. The proposal is relevant to the following objectives of the recovery plan and priority actions.

'Site management' is a specific objective of the recovery plan that aims to increase breeding success. Action 2.1 (Intensive management of nesting, resting and fledgling feeding sites) provides plans for 'Control of human disturbance' so that this objective can be met.

'Minimise human disturbance (including 4WD activities, and dogs being walked) as part of the intensive management of nesting, resting and fledgling feeding sites (High priority)' is a priority action that also aims to control human disturbance.

While fishing activity is not specifically mentioned in the recovery plan or priority actions it would have potential to cause 'human disturbance' of little tern nesting habitat if fishing effort were to increase. As indicated in (a), the potential for stocking to increase fishing effort and possibly affect threatened species would be monitored and the program would be reviewed and/or modified if undesirable threats or impacts to threatened species became apparent.

As such the action proposed is not inconsistent with the actions of the recovery or threat abatement plans.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase recreational and commercial fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a *KTP* under the TSC Act. A similar *KTP*, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the program if were to increase fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on diving birds by increasing the risk of entanglement if species were to occur within a stocked estuary. Diving birds have some potential for entanglement in discarded mesh nets or haul nets or lines. In (a), it was considered that potential impacts would possibly be associated with substantial increases in fishing effort within stocked estuaries although such an increase is not expected. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to diving birds would be investigated and the project reviewed and modified accordingly.

Conclusion:

Stocking is unlikely to cause any significant trophic impacts to diving birds living in stocked estuaries but increased fishing effort could lead to trampling of some foraging habitat, disturbance and potentially exacerbate some KTPs. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to diving birds would be investigated and the program reviewed and modified if undesirable threats or harm to diving birds became apparent.

No species impact statement is recommended for any diving birds.

Estuarine Birds (Raptors)

There are three listed diving birds under the TSC Act and for the purposes of this assessment they have been grouped because they have similar distribution in NSW and many similar ecological requirements.

Species Group: **Raptors**

Species and Status:

Red Goshawk (*Erythrotriorchis radiates*) – critically endangered – Schedule 1 TSC Act

The osprey (*Pandion hailaetus*) - vulnerable species – Schedule 2 TSC Act

Black-breasted buzzard (*Hamirostra melanosternon*) – vulnerable species – Schedule 2 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Raptors are predatory birds that use their clawed feet rather than their beaks to catch their prey.

The red goshawk is very rare in NSW, extending south to about 30°S, with most records north of this, in the Clarence River Catchment, and a few around the lower Richmond and Tweed Rivers. Formerly, it was at least occasionally reported as far south as Port Stephens. Red Goshawks inhabit open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water, and are often found in riparian habitats along or near watercourses or wetlands. In NSW, preferred habitats include mixed subtropical rainforest, *Melaleuca* swamp forest and riparian *Eucalyptus* forest of coastal rivers. Red Goshawks mainly eat medium to large birds, including species as large as Australian Brush-turkeys *Alectura lathami*, but they also take mammals, reptiles and insects (NSW DECCW 2010k).

Ospreys occur around the entire Australian coastline, except for Victoria and Tasmania. They are most often seen around the northern coast of NSW, especially on rocky shorelines, islands and reefs. Ospreys favour coastal areas, particularly the mouths of estuaries, lagoons and lakes. They fish over clear, open water hovering before plunging into the water to catch their prey. Nests are made high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea. (NSW DECCW 2010h).

The black breasted buzzard lives in a range of habitats, especially along timbered watercourses which is the preferred breeding habitat, but also along coasts and offshore islands (Pizzey and Knight 1997). Their main type of prey is other birds, small mammals, insects and reptiles.

Although no populations of raptors are listed as endangered, all the species considered within this assessment are threatened and as such the loss of only a few individuals could still affect the viability of local populations.

The proposal is not considered to affect the food sources of the threatened raptors except for ospreys. It is possible that some estuarine prey items of ospreys could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, ospreys would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. Stocking has little potential to affect ospreys that feed in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete ospreys for food or displace their food sources. In addition, the diverse diet of ospreys would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for ospreys.

The possibility for increased fishing activity as a result of the proposal in stocked estuaries could potentially lead to the disturbance of raptors and their nesting areas but this is considered to be minimal and of much less

Species Group: Raptors

consequence than other anthropogenic activity (e.g. tree felling on foreshores associated with urbanisation). Even if fishing activity associated with stocking in some estuaries increased substantially raptors would be able to feed undisturbed in many parts of stocked estuaries. Given the minimal scale of the potential impacts on raptors, stocking is not considered to effect the life cycle of a species such that a local viable population is likely to become extinct.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not Applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Estuarine waters are important feeding habitat to ospreys. Important nesting areas to raptors include large trees adjacent to the waterway (see (a)).

The proposal would not modify or remove any core estuarine habitat of raptors. The proposal would not isolate or fragment any core habitat from other habitat used by the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not Applicable

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There are seven priority actions for the black-breasted buzzard (NSW DECCW 2010i) in NSW and 15 for the red goshawk (NSW NPWS 2010k) but none of these are relevant to the proposal.

As such the action proposed is not inconsistent with the actions of any recovery or threat abatement plans for raptors.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a *KTP* under the TSC Act. Osprey have been suggested as being vulnerable to this KTP (NSW DECCW 2010c). A similar *KTP*, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may be released

Species Group: Raptors

either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on osprey by increasing the risk of entanglement if species were to occur within a stocked estuary. In (a), it was considered that potential impacts would possibly be associated with localised increases in fishing effort within stocked estuaries although such increases are not expected. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to osprey would be investigated and the project reviewed and modified accordingly.

Conclusion:

Stocking is unlikely to cause any significant trophic or habitat impacts to raptors living in stocked estuaries but increased fishing effort could potentially lead to the exacerbation of some KTPs that affect osprey. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to osprey would be investigated and the program reviewed and modified if undesirable threats or harm to raptors became apparent.

No species impact statement is recommended for any of the raptors.

ESTUARINE VEGETATION

Species Name: Strapweed (*Posidonia australis*)

Status: Endangered Population - Schedule 4, FM Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Not applicable.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Posidonia australis meadows at Port Hacking, Botany Bay, Port Jackson, Pittwater, Brisbane Water and Lake Macquarie are listed as endangered populations under Part 2 Schedule 4 of the FM Act. Marine fish stocking has been proposed for all estuaries that support endangered populations of *Posidonia australis*.

Posidonia beds are distributed throughout Port Hacking, with the majority in shallow habitat close to shore, although there are significant beds to the west of Fishermans Bay and at the entrance to Gunnamatta Bay. In Botany Bay, there are significant beds in the south, some mixed with *Zostera*. These stretch from Kurnell to the west side of Quibray Bay and Carters Island Nature Reserve. In Port Jackson there are small isolated beds in Vaucluse Bay, off Wellings Reserve and mixed *Posidonia* and *Zostera* beds around Manly Cove. Within Pittwater, a large bed occurs opposite Whale Beach and south of Barrenjoey Headland. There are significant, relatively unbroken narrower beds fringing Pittwater (particularly the eastern edge) and Scotland Island. The majority of Brisbane Water and Kincumber Broadwater are fringed by thin meadows of *Posidonia australis* with the exception of the openings to Erina Creek and Narara Creek. At Lake Macquarie the most significant beds are either side of Swansea Channel, to the north running from Belmont to Marks Point and to the north west of Coons Island (south of the Channel).

Posidonia australis beds are composed of a rhizome mat buried under the sediment with vertical shoots emerging through the sediment. Each shoot carries 2 – 4 strap-like leaves up to 60 cm long and 1 – 2 cm wide and can be found just below the water surface to depths of up to 15 m depending on light attenuation, but are more commonly restricted to shallower depths in disturbed bays (such as Botany Bay)(Edgar 1997, Watford and Williams 1998).

Sexual reproduction in *Posidonia australis* is by the production of monoecious flowers that are pollinated underwater. Fruits are produced that float and can be distributed by currents. However, seedlings are rarely observed (except in some coastal lakes) and it has been estimated that seedlings can take decades to develop into mature plants (Kirkman 1998, Meehan and West 2004). The development of mature meadows from seedlings has not been observed for any *Posidonia* species (FSC 2010). As a result, *Posidonia australis* bed establishment and regrowth occurs primarily through the slow process of horizontal rhizomatous growth (West 1983, Meehan & West 2000) and this is the most critical life cycle component for the persistence and recovery of *Posidonia australis* populations. The slow development of individual plants, the likely low level of dispersal of fruit and seeds and the slow expansion rate of meadows mean that existing areas of *Posidonia australis* within these estuaries and embayments can effectively be considered as isolated populations in respect to their long-term survival (FSC 2010).

Threats to the persistence of *Posidonia australis* meadows relevant to the proposal include:

- Physical damage (from boat propellers, anchors and moorings);
- Spread of the invasive pest alga *Caulerpa taxifolia*;
- Bait collection;
- Trophic impacts; and

Species Name: Strapweed (*Posidonia australis*)

- Trampling.

Potential physical impacts are associated with the potential for localised increases in fishing activities associated with the proposal, however, potential impacts are expected to be minimal or mitigated for the following reasons:

There are a number of aquatic reserves and marine parks which provide some protection for the species at certain locations (e.g. Towra Point Aquatic Reserve in Botany Bay). In addition, fishers in boats represent only a portion of boat traffic in the densely populated estuaries of Port Jackson, Botany Bay, Pittwater, Brisbane Water, Port Hacking and Lake Macquarie. A relatively small localised increase in fisher boat use would not represent a substantial increase in boat traffic. Anglers are increasingly aware of the ecological importance of seagrass habitat and the possible impacts boating can have on it. All seagrasses, including *Posidonia australis*, are protected within NSW and cannot be harmed or removed and there are boating guidelines and regulations enforced by NSW Maritime and DPI to address this issue.

Caulerpa taxifolia already occurs in the estuaries where the threatened populations of *Posidonia australis* occur. There are existing guidelines for boat users to avoid the further spread of *Caulerpa taxifolia*.

A localised increase in fishing effort has potential to increase bait increase collection in the estuaries where the threatened populations of *Posidonia australis* occur. Bait collection in estuaries may disturb benthic habitat where it involves the use of spade or fork or other implement (such as a yabbie pump) to collect worms or other organisms (e.g. cockles). However, there are regulations that do not permit the use of such implements for bait collection in NSW.

It is possible that there could be trophic effects within the *Posidonia australis* meadows due to the recruitment of stocked species into this habitat. The majority of species that have been proposed for stocking may utilise seagrass habitat (including *Posidonia australis*) as juveniles or adults (SPCC 1981b, Middleton *et al*. 1984, Kangas 2000, Rotherham and West 2002, Poore 2004, York *et al.* 2006, Ochwada *et al*. 2009). The types of trophic impacts are unknown but there are many possibilities. For example, an increased predation of grazers (that feed on epiphytes) by stocked juveniles could hypothetically cause an increase in *Posidonia australis* epiphyte load and a subsequent reduction in seagrass health and resilience. However, provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F. Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities.

Trampling of endangered *Posidonia australis* beds by fishers is another possible concern associated with the proposal. Fishers may not be targeting species living within seagrass beds but may incidentally harm seagrass while accessing other parts of the estuary. Eastern king prawns, however, may be found at a harvestable size within seagrass beds and a substantial increase in effort of fishers targeting stocked eastern king prawns could lead to trampling of *Posidonia australis* in the shallowest areas of estuaries. Fishers on foot use scoop nets, scissor nets and hand haul nets to target prawns in shallow estuarine waters and gear interaction with seagrass could potentially cause damage. However, there are restrictions on the use of these gears at many of the locations supporting endangered *Posidonia australis* populations. Hand haul and scissor nets are prohibited in Lake Macquarie, Pittwater and Port Hacking and scoop nets are prohibited from Pittwater as part of the *Caulerpa* closure. Similarly, not all *Posidonia australis* beds are easily accessible and/or suitable for prawn netting. Although *Posidonia australis* can be found close to shore in shallow water, it is also found seaward of *Zostera capricorni* beds, commonly down to 3 – 5 m (depending on light attenuation) on sloping a seabed where netting on foot would be difficult. Section 7.9 of the 'Fish Habitat Protection Plan No. 2: Seagrasses' (NSW DPI 1997) reports that short-term effects of hauling on live seagrass causes no significant damage. Mesh-netting, traps, line and recreational fishing gear are also reported to be generally non-destructive to seagrass (NSW DPI 1997). As such, small localised increases in effort distributed across an entire estuary may have little ongoing impacts to

Species Name: Strapweed (*Posidonia australis*)

persistence of *Posidonia australis* meadows within that location.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in a viable local population of *Posidonia australis* being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to *Posidonia australis*, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not Applicable

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Habitat for *Posidonia australis* populations in NSW is restricted to soft sedimentary subtidal environments, usually sandy, in the protected waters of marine embayments and marine-dominated coastal lakes, from Twofold Bay in the south to Wallis Lake in the north (West *et al.* 1985, West *et al*. 1989). There are a few isolated populations at sheltered sites along the open coastline and offshore islands (FSC 2010). The endangered populations are restricted to Port Hacking, Botany Bay, Port Jackson, Pittwater, Brisbane Water and Lake Macquarie.

Threats to *Posidonia australis* habitat relate primarily to physical damage to the beds themselves and introduction of the invasive alga, *Caulerpa taxifolia*. As outlined in (b) it is considered unlikely that the proposal would result in the removal, modification, fragmentation or isolation of habitat important for the persistence of the population.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat has been declared for this endangered population.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No recovery plan or threat abatement plan has been prepared for this endangered population. As discussed in (b) the proposal would not significantly add to the ongoing threatening processes that continue to operate in Port Hacking, Botany Bay, Port Jackson, Pittwater, Brisbane Water and Lake Macquarie.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

Species Name: Strapweed (*Posidonia australis*)

The proposal would not result in any KTPs that would affect endangered populations of *Posidonia australis*.

Conclusion:

The proposal is unlikely to have any significant direct or indirect impacts on the endangered *Posidonia australis* populations at Port Hacking, Botany Bay, Port Jackson, Pittwater, Brisbane Water and Lake Macquarie. Stocking is unlikely to cause any significant trophic impacts to endangered *Posidonia australis* populations but localised increases to fishing effort could potentially lead to trampling. Given that the predicted severity of trampling is largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to endangered *Posidonia australis* populations would be investigated and the program reviewed and modified if undesirable threats or harm became apparent.

No species impact statement is recommended.

Endangered Ecological Communities

There are approximately 90 different ecological communities listed within NSW listed under the TSC Act and FM Act. The majority of these are found in inland forests/rainforests, swamps, shrubland and grassland and are not considered to be within the scope of the proposal. There are seven endangered ecological communities which occur within estuarine ecosystems and have potential to be affected by marine fish stocking. These communities have been considered as a group in the assessment of significance.

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

Status: Endangered Ecological Community - Part 3 of Schedule 1 TSC Act

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Not Applicable

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not Applicable

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or

ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

The ecological communities considered in this assessment may be found in some parts of the fringes of estuaries, low lying coastal floodplains and/or coastal dune sand. Coastal saltmarsh community and the Shorebird community occurring at Taren Point (Botany Bay, NSW) occur across the estuarine intertidal zone and have the greatest degree of overlap with the proposal and therefore have been considered in the greatest detail within this assessment. The other communities (forests and freshwater wetlands) are on the fringes of estuaries.

The *Shorebird community occurring on the relict tidal delta sands at Taren Point*, occurs on the relict marginal shoal of the Georges River between Taren Point and Shell Point in Botany Bay. The characteristic assemblage includes 20 species of shorebird (DECCW 2010j) (also called waders, and see assessment of waders in this appendix for a list of threatened species) that utilises roosting and foraging habitat (intertidal mud flats and sand flats) not only at the relic marginal shoal at Taren Point but at other sites including Penrhyn Inlet, Sandringham and the shoreline adjacent to the north-east side of the Captain Cook Bridge. For some species (Terek Sandpiper, Grey-tailed Tattler), the proximity of mangroves (*Avicennia marina*) is important as roosting habitat.

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

Each year most of the shorebirds leave Australia between April and May, migrating to the northern hemisphere, however juveniles, non-breeders or under-weight individuals often will not migrate north, remaining in their southern foraging grounds over winter. Human disturbance at roost and feeding sites is a threat to this community.

As shorebirds feed on marine invertebrates (including molluscs, worms and crustaceans) and small fish that live within intertidal sand and mudflats, it is possible that some estuarine prey items of the *Shorebird community occurring on the relict tidal delta sands at Taren Point*, Botany Bay could be displaced by stocked species. However, provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of shorebirds would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for shorebirds.

The *Shorebird community occurring on the relict tidal delta sands at Taren Point* would also be vulnerable to an increased risk of trampling of nests, feeding and roosting habitat and general disturbance from humans if, as a consequence of the proposal, fishing effort were to increase beyond current levels in the Georges River and Botany Bay. Increased fishing effort could also increase marine debris that may pose a risk of entanglement to the shorebirds living at Taren Point (the impacts to shore birds from the proposal has previously been considered (see wading birds within this appendix)).

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions) occurs in the intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. It is frequently found as a zone on the landward side of mangrove stands. Characteristic plants include *Baumea juncea*, *Juncus krausii*, *Sarcocornia quinqueflora*, *Sporobolus virginicus*, *Triglochin striata*, *Isolepis nodosa*, *Samolus repens*, *Selliera radicans*, *Suaeda australis* and *Zoysia macrantha*. Occasionally mangroves are scattered through the saltmarsh. Tall reeds may also occur, as well as salt pans. Threats to coastal saltmarsh include physical damage from human disturbance (DECCW 2010q).

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions) is vulnerable to the effects of trampling and direct damage from vehicles. Increased fishing effort could increase the risk of trampling from fishers who incidentally walk or drive on saltmarsh while accessing fishing sites. It is considered, however, that small localised increases in effort distributed across an entire estuary may have little ongoing impacts to persistence of saltmarsh.

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions) is found on the coastal floodplains of NSW. The structure of the community may vary from open forests to low woodlands,

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

scrubs or reedlands with scattered trees. It has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species northwards from Bermagui. Other trees including *Acmena smithii* (lilly pilly), *Glochidion* spp. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. The understorey is characterised by frequent occurrences of vines, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter. On the fringes of coastal estuaries the ground layer may include the threatened grass species, *Alexfloydia repens*, as well as *Baumea juncea*, *Juncus kraussii*, *Phragmites australis*, *Selliera radicans* and other saltmarsh species. A number of threats to this community have been identified (DECCW (2010l) but as none of these are relevant to the proposal it has not been considered any further.

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions) is a swamp community has an open to dense tree layer of eucalypts and paperbarks although some remnants now only have scattered trees as a result of partial clearing. The trees may exceed 25 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality where the tree stratum is low and dense. The community also includes some areas of fernland and tall reedland or sedgeland, where trees are very sparse or absent. The most widespread and abundant dominant trees include *Eucalyptus robusta* (swamp mahogany), *Melaleuca quinquenervia* (paperbark) and, south from Sydney, *Eucalyptus botryoides* (bangalay) and *Eucalyptus longifolia* (woollybut). Other trees may be scattered throughout at low abundance or may be locally common at few sites. A layer of small trees may be present, including *Acacia irrorata* (green wattle), *Acmena smithii* (lilly pilly), *Elaeocarpus reticulatus* (blueberry ash), *Glochidion ferdinandi* (cheese tree), *Melaleuca linariifolia* and *M. styphelioides* (paperbarks) and shrubs. Occasional vines occur and groundcover is composed of abundant sedges, ferns, forbs, and grasses. Given that the community occurs in floodplain and the identified threats to this community (DECCW 2010m) are not relevant to the proposal it has not been considered any further.

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions), as the name suggests, is found on the river flats of the coastal floodplains. It has a tall open tree layer of eucalypts, which may exceed 40 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality. While the composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus tereticornis* (forest red gum), *E. amplifolia* (cabbage gum), *Angophora floribunda* (rough-barked apple) and A. *subvelutina* (broad-leaved apple). *Eucalyptus baueriana* (blue box), *E. botryoides* (bangalay) and *E. elata* (river peppermint) may be common south from Sydney, *E. ovata* (swamp gum) occurs on the far south coast, *E. saligna* (Sydney blue gum) and *E. grandis* (flooded gum) may occur north of Sydney, while *E. benthamii* is restricted to the Hawkesbury floodplain. A layer of small trees may be present. The groundcover is composed of abundant forbs, scramblers and grasses. Given that the community occurs in floodplain and the identified threats to this community (DECCW 2010n) are not relevant to the proposal it has not been considered any further.

Subtropical coastal floodplain forest (NSW North Coast Bioregion) occurs on the coastal floodplains of the North Coast of NSW. It has a tall open tree layer of eucalypts, which may exceed 40 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality. While the composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus*

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

tereticornis (forest red gum), *E. siderophloia* (grey ironbark), *Corymbia intermedia* (pink bloodwood) and, north of the Macleay floodplain, *Lophostemon suaveolens* (swamp turpentine). Other trees may be scattered throughout at low abundance or locally common at few sites. A layer of small trees may be present and scattered shrubs. Occasional vines occur and the groundcover is composed of abundant forbs, scramblers and grasses. Given that the community occurs in floodplain and the identified threats to this community (DECCW 2010o) are not relevant to the proposal it has not been considered any further.

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions) typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes but may also occur in backbarrier landforms where floodplains adjoin coastal sandplains. They are dominated by herbaceous plants and have very few woody species. Those that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 metre tall and dominated by amphibious plants. Where they are subject to regular inundation and drying the vegetation may include large emergent sedges over 1 metre tall, as well as emergent or floating herbs. As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant. The threatened aquatic plants, *Aldrovanda vesiculosa* and *Najas marina*, also occur within this community. Given that the community occurs in floodplain and the identified threats to this community (DECCW 2010p) are not relevant to the proposal it has not been considered any further.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in the *Shorebird community occurring on the relict tidal delta sands at Taren Point* or *Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)* communities being placed at risk of extinction. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat or communities would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to these two coastal communities, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species or community.

d) In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

As discussed in (c), the risk of habitat in the *Shorebird community occurring on the relict tidal delta sands at*

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

Taren Point or *Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)* being trampled by fishers or their vehicles could be increased beyond current levels if stocking were to increase fishing effort. It is not expected, however, that this would occur to the extent that it would remove, fragment, modify or isolate habitat so that it would affect the long-term survival of the ecological community. Notwithstanding this, as there is direct access to the habitat of these communities in some places, it would be precautionary to monitor for potential changes in fishing effort as well as incidences to these communities so that action could be taken to modify the proposal were adverse impacts to occur. This would be done under the draft FMS (see (c)).

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Not Applicable

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There are a number of 'priority actions' developed for the *Shorebird community occurring on the relict tidal delta sands at Taren Point* and *Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)*. The proposal would be relevant to some of the priority actions relating to minimising human disturbance to species and/or their habitats as increased fishing effort has potential to be associated with stocking. The priority actions relevant to the proposal are listed below:

Shorebird community occurring on the relict tidal delta sands at Taren Point

- Protect important shorebird habitat elsewhere that is used by these species (e.g. exclude dogs and vehicles from known important roosting sites such as Crown reserve on Bate Bay and Merries Reef) (High priority); and
- Restrict threatening activities at EEC site including bait collection and fishing on intertidal flat and adjacent shoreline, unleashed dogs on adjacent shoreline, boat launching, clearing of shoreline vegetation, building boat ramps (High priority).

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

- Liaise with landholders and undertake and promote programs that ameliorate threats such as weeds, grazing and human disturbance (Low priority).

An increased incidence of human disturbance (shore-based fishing, trampling and four wheel driving) is possible as a consequence of stocking due to the potential for increased fishing effort. The draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to endangered ecological communities, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect an endangered ecological communities.

Community Name/s:

Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)

Swamp oak floodplain forest (NSW North Coast, Sydney Basin and South East Corner bioregions)

Swamp sclerophyll forest on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

River-flat eucalypt forest on coastal floodplains (North Coast, Sydney Basin and South East Corner Bioregions)

Subtropical coastal floodplain forest (NSW North Coast Bioregion)

Freshwater wetlands on coastal floodplains (NSW North Coast, Sydney Basin and South East Corner Bioregions)

The shorebird community occurring on the relict tidal delta sands at Taren Point

As such the action proposed is not inconsistent with the actions of recovery or threat abatement plans.

g) Whether the action proposed constitutes or is part of a key threatening process (KTP) or is likely to result in the operation of, or increase the impact of, a KTP.

The proposal to stock marine fish has the potential to increase fishing activity and could therefore exacerbate the '*Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments*' which is listed as a *KTP* under the TSC Act. A similar *KTP*, '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth EPBC Act. Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore. Some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potential for localised increases to fishing effort within estuaries where marine fish stocking takes place. Lost/discarded fishing gear could potentially have a negative effect on wading birds in the *Shorebird community occurring on the relict tidal delta sands at Taren Point* by increasing the risk of entanglement. Wading birds have some potential for entanglement in discarded mesh nets or haul nets or lines. In (c), it was considered that potential impacts would possibly be associated with localised increases in fishing effort within stocked estuaries. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to wading birds in the *Shorebird community occurring on the relict tidal delta sands at Taren Point* would be investigated and the project reviewed and modified accordingly.

Conclusion:

Increased fishing activity as a result of marine stocking has potential to affect two endangered ecological communities both directly and indirectly. These are the *Shorebird community occurring on the relict tidal delta sands at Taren Point* and *Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)*. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to endangered ecological communities of the *Shorebird community occurring on the relict tidal delta sands at Taren Point* or *Coastal saltmarsh (NSW North Coast, Sydney Basin and South East Corner Bioregions)* would be investigated and the program reviewed and modified if undesirable threats to these communities became apparent..

No species impact statement is recommended.

Appendix 3

Threatened Species (Commonwealth Assessment of Significance)

Appendix 3: 'Assessment of Significance' for Threatened Species, Populations and Communities Protected Under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

FISH

Species Name: The east coast population of Grey Nurse Shark (*Carcharias taurus*)

Status: Critically endangered population – Part 13, Section 179(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

a) Lead to a long-term decrease in the size of a population.

The entire east coast population of grey nurse sharks is critically endangered and recent surveys estimate the population to be small (Otway and Burke 2004, Cardno Ecology Lab 2010). In such a small population the loss of only a few individuals could seriously affect the viability of the whole population.

Potential impacts from the proposal that could lead to a long-term decrease in the size of the east coast population are associated with trophic impacts to grey nurse sharks that range into estuaries as well as from fishing activities associated with the proposal.

Although it is probable that grey nurse sharks would enter estuaries to forage there is no evidence to suggest that grey nurse sharks depend on estuarine habitat in particular. It is possible that some estuarine prey items of grey nurse sharks could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft Fishery Management Strategy (FMS) proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of grey nurse sharks would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for sharks.

Fishing activities associated with the proposal are a potential risk to grey nurse sharks. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. Under State and Commonwealth law it is illegal to catch or harm grey nurse sharks butt is possible that stocking may result in localised increases in fishing effort and this would have potential to increase the risk of incidental hooking to individuals ranging into stocked estuaries. Most estuarine recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large bodied sharks such as grey nurse sharks. Hooked sharks would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002).

Grey nurse sharks have potential for becoming entangled in beach protection mesh nets (Krogh and Reid 1996) and are considered to be vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets (DEH 2003) and could be placed at risk if the amount of lost or discarded gear increased as a consequence of the proposal. Crab traps would be of little concern. This could exacerbate the key threatening process (KTP), '*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris*' is listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999 (*EPBC Act). Fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore but some harmful marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potential localised increase to fishing effort within estuaries where marine fish stocking takes

Species Name: The east coast population of Grey Nurse Shark (*Carcharias taurus*)

place. However, given that there are no data to suggest that grey nurse sharks are caught by nets in estuaries where there is already considerable fishing effort (NSW Fisheries 2001), it is unlikely that the proposal would cause adverse impacts that would result in or lead to a long-term decrease in the size of the east coast population.

Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to grey nurse sharks, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan (see (f)).

b) Reduce the area of occupancy of the species.

Core habitat for grey nurse sharks is the shallow rocky reefs along the New South Wales (NSW) coast (Last and Stevens 1994). Young are born live and also occur on shallow rocky reefs, often segregated from the adults. Grey nurse sharks can be observed at day hovering or slowly swimming around high relief reefs. It is thought that the species becomes more active at night where it hunts over rocky reef and over soft substrata for a wide range of bony fishes, rays, sharks, squids and crustaceans (Smale 2005) and individuals enter estuaries to forage on occasion see (a)).

The draft FMS does not allow stocking to be done in areas where it is likely to have significant effects on grey nurse sharks. This could occur if stocking were done in or near aggregation sites. Currently there are no aggregation sites for grey nurse sharks within estuaries. Impacts to shark aggregation sites would be possible if stocked fish or crustaceans were to move into coastal waters adjacent to the estuaries into which they had been stocked into. Stocked fish that move out of estuaries could potentially compete with grey nurse sharks for habitat or food or transfer disease. Competition of this form, if it were to occur, would most likely be with mulloway as this species can occur in nearshore gutters and caves and has a diet of small fish that may overlap with sharks (Silberschneider and Gray 2008). However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in, estuaries such competition outside of estuaries is considered unlikely. Hence, the area of occupancy of grey nurse sharks in aggregation sites or other core habitat would not be affected.

c) Fragment an existing population into two or more populations.

There is also evidence to suggest that grey nurse sharks migrate along the NSW coast (northwards in autumn/winter and southwards in summer (Pollard *et al.*1996, Otway and Parker 2000). As migration would not be affected by stocking it is unlikely that the entire east coast population of grey nurse sharks would be fragmented as a consequence of the proposal.

d) Adversely affect habitat critical to the survival of a species.

Many of the known aggregation sites for grey nurse sharks in NSW waters have been declared critical habitat for the species and are protected by the *Fisheries Management (General) Regulation 2010* Schedule 1A administered by NSW Department of Primary Industries (DPI). There are currently 10 aggregation sites along the NSW coast that have been declared as critical habitats and none of these are within estuaries. Many of these sites have also been further protected in marine parks or aquatic reserves administered by the Office of Environment and Heritage (OEH). Marine stocking would not take place in or around any known aggregation sites or critical habitats. Notwithstanding this, there is potential for competition for habitat or food with some of the species to be stocked, particularly mulloway, if some stocked fish move offshore. As discussed in (b), such effects are unlikely to be significant. Therefore no critical habitat would be directly or indirectly affected by the proposal to stock marine fish.

e) Disrupt the breeding cycle of a population.

Species Name: The east coast population of Grey Nurse Shark (*Carcharias taurus*)

As discussed in (b), core habitat for grey nurse sharks is the shallow rocky reefs along the NSW coast (Last and Stevens 1994) but individuals may range into estuaries occasionally, presumably to forage. Young are born live and also occur on shallow rocky reefs, often segregated from the adults. Given that trophic impacts and the potential for increased fishing mortality associated with the proposal are considered unlikely and there is very little chance of the proposal affecting core coastal habitat of grey nurse sharks including aggregation sites, the breeding cycle of the east coast population would not be affected.

f) Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline.

The major habitat utilised by grey nurse sharks comprises offshore rocky reefs, with small sandy gutters within the reef matrix being often preferred microhabitat. There is some likelihood that the species ranges away from reefs to feed at night; the extent of this range is unknown (Smale 2005) and grey nurse sharks would enter estuaries to forage on occasion. Young also occur on shallow rocky reefs, often segregated from the adults. As discussed in (b) and (e), the proposal would not modify, destroy, isolate or remove any core reef habitat, estuarine habitat or any other habitat of grey nurse sharks.

g) Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.

No invasive species harmful to grey nurse sharks are likely to be released or have their populations enhanced as a consequence of the proposal.

h) Introduce disease that may cause the species to decline, or

- Intensive rearing of juvenile fish in hatcheries at high densities for stocking can create a favourable climate for disease which can in turn potentially be released into the natural environment. To reduce the potential of this occurring, the current NSW Hatchery Quality Assurance Scheme (HQAS) would be developed to accredit marine hatcheries intending to supply species for marine enhancement purposes, and that this would closely reflect considerations that are in place for species used for freshwater stocking. Key aspects of the quality assurance program would likely include controls over the source and management of broodstock, biosecurity measures of the hatchery and farm, the adequacy of water quality management, and disease prevention and treatment protocols that form part of a written Health Management Plan.
- Given this system would be in place, the risk of diseases being released into the environment as a consequence of the proposal and potentially affecting grey nurse sharks would be low.

i) Interfere with the recovery of a species.

State and Commonwealth recovery plans have been developed for the grey nurse shark. The specific objectives of the Commonwealth recovery plan are to:

- A. Reduce the impact of commercial fishing on Grey Nurse Sharks;
- B. Reduce the impact of recreational fishing on Grey Nurse Sharks;
- C. Reduce the impact of shark finning on Grey Nurse Sharks;
- D. Reduce the impact of shark control activities on Grey Nurse Sharks;
- E. Manage the impact of ecotourism on Grey Nurse Sharks;
- F. Eliminate the impact of aquaria on Grey Nurse Sharks;
- G. Identify and establish conservation areas to protect Grey Nurse Sharks from threatening activities such as commercial and recreational fishing;
- H. Develop research programs to assist conservation of Grey Nurse Sharks;
- I. Develop population models to assess Grey Nurse Shark populations and monitor their recovery;
- J. Promote community education about Grey Nurse Sharks; and
- K. Develop a quantitative framework to assess the recovery of the species.

Species Name: The east coast population of Grey Nurse Shark (*Carcharias taurus*)
Given that the majority of activities associated with the stocking proposal would take place in estuaries away from known aggregation areas and core habitat of grey nurse shark the impacts upon the species as a result of marine stocking are most likely to be negligible and would not directly contravene the objectives of the recovery plan. Notwithstanding this, given that the predicted severity of many of the impacts associated with stocking are largely unknown but potentially related to changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to grey nurse sharks would be investigated (see (a)) and the project reviewed and modified accordingly.

Conclusion:

It is not considered that marine stocking would have a significant impact on the critically endangered east coast population of grey nurse shark.

The proposal would not have any significant direct or indirect impacts on the core habitat of the critically endangered grey nurse shark. It is possible, however, that grey nurse sharks could occur, on occasion, in estuaries where stocking has occurred. The entire population of grey nurse sharks in NSW is critically endangered and the loss of only a few individuals could seriously affect the viability of the small population. Stocking is unlikely to cause any substantial trophic impacts to individuals that range into estuaries but there is potential for it to cause localised increases to fishing effort in stocked estuaries. Increased fishing effort could increase the hooking rate of grey nurse sharks and a key threatening process. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to grey nurse sharks would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

MARINE REPTILES

As the hawksbill turtle is listed as both vulnerable and migratory, it does not need to be additionally assessed under the 'Significant Impact Guidelines' for migratory species.

Species Name: Hawksbill Turtle (*Eretmochelys imbricata*)

Status: Vulnerable –Part 13, Section 179(5) EPBC Act

Migratory –Part 13, Section 209(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

a) Lead to a long-term decrease in the size of an important population of a species.

Hawksbill turtles tend to prefer warmer waters, ranging from tropical to warm temperate seas (Marquez 1990). Australia holds the largest breeding populations of hawksbill turtles in the world, and the largest rookeries (nesting aggregations). There have been serious population declines of hawksbill turtles worldwide, including in Australia (Environment Australia 2003).

For a large part of their life cycle, hawksbill turtles are pelagic, spending their first five to ten years drifting on ocean currents. Once hawksbill turtles reach 30 to 40 cm curved carapace length, they settle and forage in tropical tidal and sub-tidal coral and rocky reef habitat. They are omnivorous, eating a variety of animals and plants including sponges, hydroids, cephalopods (octopus and squid), gastropods (marine snails), cnidarians (jellyfish), seagrass and algae (Carr and Stancyk 1975).

Nesting is mainly confined to tropical beaches. Hawksbill turtles nest in the northern Great Barrier Reef and Torres Strait, on Truant Island in north east Arnhem Land, and on Rosemary Island on the North West Shelf.

There are resident groups of marine turtles in the waters of northern NSW. Resident populations appear to have established in some estuaries particularly near warm water outfalls. A study is underway in Lake Macquarie on the NSW Central Coast to assess the apparently resident populations of several turtle species in the vicinity of warm water outfalls from a power generation facility, although it is not known whether hawksbill turtles are one of these (Environment Australia 2003).

In Australia, the main current threats to hawksbill turtles are disturbance and habitat damage due to coastal development; by-catch from fisheries and shark control; predation on nests; boat strikes; entanglement and ingestion of marine debris; and unsustainable levels of indigenous harvest in some areas. Potential threats include climate change, chance disasters (e.g. oil spills) and feral predator invasions (Environment Australia 2003). Although no populations are listed as endangered, the loss of only a few individuals could still affect the viability of local populations. Marine turtles are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. Although hawksbill turtles can occur within NSW estuaries, these waters are outside the range of known nesting and mating areas for the species.

Provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, the availability of food and other resources to hawksbill turtles would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. None of the stocked species (as

Species Name: Hawksbill Turtle (*Eretmochelys imbricata*)

juveniles) have potential to be the prey of hawksbill turtles. Stocking has little potential to affect marine turtles occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with turtles for their habitat or food or displace their food sources.

Fishing activities associated with the proposal pose the greatest risk to hawksbill turtles. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much. A large localised increase would potentially increase the risk of incidental hooking, entanglement to hawksbill turtles or boat strike if they were to range into a stocked estuary. Under State and Commonwealth law it is illegal to catch or harm marine turtles. Most inshore recreational fishing tackle is constructed with lines of low breaking strain and without wire traces. This sort of fishing gear is unlikely to be capable of landing large turtles such as the listed species. Hooked turtles would, however, be vulnerable to the effects of hooking injuries which have potential to cause harm over time (NSW Fisheries 2002). Turtles have greater potential for becoming entangled in mesh nets or haul nets and there is evidence that they can become entrapped in crab traps. Increased fishing activity within stocked estuaries also has potential to result in littering and accumulation of discarded or lost fishing gear. Marine turtles are considered to be particularly vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets and could therefore be placed at risk. Although is possible that stocking may result in localised increases in fishing effort it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in or lead to a long-term decrease in the size of a population.

Given that the predicted severity of many of the impacts to marine turtles are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to hawksbill turtles, were they to occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan's for this species (see (f)).

b) Reduce the area of occupancy of an important population.

As indicate in (a), young hawksbill turtles are pelagic before settling and foraging in tropical tidal and sub-tidal coral and rocky reef habitat. Hawksbill turtles in NSW are probably at the limit of their distribution in eastern Australia. There is some estuarine reef habitat potentially affected by the proposal but given there would be no significant trophic impacts or direct or indirect disturbance to this habitat the area of occupancy of an important population of hawksbill turtles would not be affected.

c) Fragment an existing important population into two or more populations.

Hawksbill turtles are known to migrate long distances but there are also thought to be resident groups of hawksbill turtles in the waters of northern NSW (Environment Australia 2003). Given that migration would not be affected by stocking and that there is no reason why stocking would cause the separation of parts of populations it is unlikely that the proposal would fragment an existing important population into two or more populations.

d) Adversely affect habitat critical to the survival of a species.

Not applicable.

e) Disrupt the breeding cycle of an important population.

As discussed in (a), nesting is mainly confined to tropical beaches. Given that these do not occur in NSW and there is no chance of the proposal affecting core migration, the breeding cycle of the hawksbill turtles would not be affected.

f) Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline.

As discussed in (a) and (b) this would not occur as a consequence of the proposal.

Species Name: Hawksbill Turtle (*Eretmochelys imbricata*)

g) Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat.

No invasive species harmful to hawksbill turtles are likely to be released or have their populations enhanced as a consequence of the proposal.

h) Introduce disease that may cause the species to decline, or

- Intensive rearing of juvenile fish in hatcheries at high densities for stocking can create a favourable climate for disease which can in turn potentially be released into the natural environment. To reduce the potential of this occurring, the current NSW Hatchery Quality Assurance Scheme (HQAS) would be developed to accredit marine hatcheries intending to supply species for marine enhancement purposes, and that this would closely reflect considerations that are in place for species used for freshwater stocking. Key aspects of the quality assurance program would likely include controls over the source and management of broodstock, biosecurity measures of the hatchery and farm, the adequacy of water quality management, and disease prevention and treatment protocols that form part of a written Health Management Plan.
- Given this system would be in place, the risk of diseases being released into the environment as a consequence of the proposal and potentially affecting hawksbill turtles would be low.

i) Interfere with the recovery of a species.

There is an approved Commonwealth Recovery Plan for Marine Turtles in Australia (Environment Australia 2003). The specific objectives of the recovery plan are as follows.

- To reduce the mortality of marine turtles and, where appropriate, increase natural survivorship, including through developing management strategies with Aboriginal and Torres Strait Islander communities for the sustainable use of marine turtles;
- To develop programs and protocols to monitor marine turtle populations in Australia, assess the size and status of those populations, the causes of their mortality and address information gaps;
- To manage factors that affect marine turtle nesting;
- To identify and protect habitats that are critical for the survival of marine turtles;
- To communicate the results of recovery actions and involve and educate stakeholders; and
- To support and maintain existing agreements and develop new collaborative programs with neighbouring countries for the conservation of shared turtle populations.

Objective A of the Commonwealth recovery plan for marine turtles aims to 'reduce the mortality of marine turtles'. There would potentially be negative effects of stocking (if there were increased boating and fishing activity) on marine turtles occurring within stocked estuaries. It is unlikely that either of these would potentially be of a magnitude to substantially reduce or increase mortality of marine turtles. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to hawksbill turtles would be investigated (see (a)). The proposal is otherwise consistent with the objectives of the Commonwealth recovery plan for marine turtles.

Conclusion:

It is not considered that marine stocking would have a significant impact on hawksbill turtles.

The proposal would not have any significant direct or indirect impacts on the core habitat of hawksbill turtles. It is possible, however, that hawksbill turtles could occur, on occasion, in estuaries where stocking has occurred. Stocking is unlikely to cause any substantial trophic impacts to individuals that range into estuaries but there is potential for it to cause localised increases fishing effort in stocked estuaries. Increased fishing effort could

many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to hawksbill turtles would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

PINNIPEDS

As the sub-Antarctic fur-seal is listed as both vulnerable and migratory, it does not need to be additionally assessed under the 'Significant Impact Guidelines' for migratory species.

Species Name: Sub-Antarctic fur-seal *(Arctocephalus tropicalis)*

Status: Vulnerable –Part 13, Section 179(5) EPBC Act

Migratory –Part 13, Section 209(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

a) Lead to a long-term decrease in the size of an important population of a species.

The sub-Antarctic fur seal is distributed widely across the Southern Ocean and north of the Antarctic convergence. In Australian waters, it breeds, moults and hauls out mainly on Macquarie Island. The estimated world population is currently 277 000 - 356 000 individuals but the population breeding on Macquarie Island is only in the hundreds. World-wide, the sub-Antarctic fur seal is considered to be recovering following a period of widespread exploitation (DEH 2004a).

Like all pinnipeds, the sub-Antarctic fur seal comes ashore to mate, give birth and nurse their young. On shore they utilise rocky coastal habitat containing rock platforms and beaches with exposed boulders (Shaughnessy 1999). The sub-Antarctic fur seal is thought to be resident, but long movements of up to 3 000 km have been recorded from dispersing juveniles and adult males. Some individuals from Macquarie Island are thought to occasionally find their way to southern Australia. These stragglers are thought mostly to be juveniles that are dispersing post-weaning.

Sub-Antarctic fur seals forage in the ocean. Important feeding habitat for the species includes the waters immediately surrounding Macquarie Island. They forage mainly at night on surface, mid-water and bottom dwelling fish, squid and octopus. The diet varies seasonally and according to location (e.g. Bester and Laycock 1985, in DEH 2004a). Sub-Antarctic fur seals are known to forage at oceanographic frontal zones where food is expected to be most abundant. Little is known about where individuals on mainland Australia feed and it is possible that they may enter estuaries occasionally.

The major Australian breeding colonies of the sub-Antarctic fur seal are secured within protected areas, namely the Macquarie Island Nature Reserve and Heard Island Wilderness Reserve. In the Australian jurisdiction, the most important population of the sub-Antarctic fur seal is based at Macquarie Island. The island supports less than 1% of the world population. The juveniles occasionally found on the Australian mainland are probably part of the Macquarie Island population. Although the population is not listed as endangered, the loss of only a few individuals could still affect its viability.

Potential threats to sub-Antarctic fur seals (DEH 2004a) that may potentially arise from the marine stocking proposal are from:

- Ecological impacts to the prey on which the seals depend;
- Direct interaction between sub-Antarctic fur seals and fishing operations, for example, seals can be entangled or hooked because they interfere with nets and damage nets; and
- Harm from marine debris including:
    - fishing hooks and squid jigs with attached material that can become embedded in flesh and cut into the animal as it grows;
    - nets, lines and rings can loop around a seals' neck, flipper, mouth or teeth and drown the animal, catch on something later or slowly strangle constrict a seal's growth;

Species Name: Sub-Antarctic fur-seal *(Arctocephalus tropicalis)*

- seals can swallow plastic bags and other debris, which can cause blockages and death.

Although sub-Antarctic fur seals could potentially forage in estuaries in NSW, and some of the stocked species (as juveniles) have potential to be the prey of sub-Antarctic fur seals, provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, sub-Antarctic fur seals would not be affected by the proposal. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. Stocking has little potential to affect sub-Antarctic fur seals occurring in coastal waters 'outside' of estuaries as stocked fish that move into coastal waters are unlikely to compete with sub-Antarctic fur seals for their habitat or food or displace their food sources.

Fishing activities associated with the proposal pose the greatest risk to fur seals. Localised increased fishing activity within stocked estuaries has potential to result in littering and accumulation of discarded or lost fishing gear. Fur seals are potentially vulnerable to entanglement in or ingestion of lost or discarded line, lures and nets and could therefore be placed at risk. Few entanglements of sub-Antarctic fur seals have been observed (DEH 2004a) but studies of Australian seal populations indicate 0.2-2% of seals at colonies are entangled in debris. Previous assessments of fishing activities on fauna in NSW estuaries had not considered impacts to fur seals an issue (NSW Fisheries 2001). However, associated with the species recovery is an apparent extension in the species range and as increasing numbers of sub-Antarctic fur seal venture north beyond the sub-Antarctic to reach Tasmania and mainland Australia, the potential for interactions with humans also increases. A localised increase in fishing effort with stocking could potentially have a negative effect on fur seal populations as it would increase the risk of entanglement to individuals if they were to range into a stocked estuary. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much but it is not expected that this could occur to the extent that it would lead to a long-term decrease in the size of an important population.

Given that the predicted severity of many of the impacts to sub-Antarctic fur seals are largely unknown but potentially related to changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would also be monitored (Performance Indicator 2 of Goal 1), it would be possible to identify links between increased concentrations of fishing effort and adverse impacts to sub-Antarctic fur seals, were they to occur. Such links would provide a basis for reviewing and/or modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of the Recovery Plan's for these species (see (f)).

b) Reduce the area of occupancy of an important population.

As indicate in (a), young sub-Antarctic fur seals from Macquarie Island are thought to occasionally find their way to southern Australia and these individuals would potentially occasionally forage in estuaries. Sub-Antarctic fur seals in NSW are probably at the limit of their distribution in eastern Australia. There is some estuarine reef habitat potentially affected by the proposal but given there would be no significant trophic impacts or direct or indirect disturbance to this habitat the area of occupancy of an important population of sub-Antarctic fur seals would not be affected.

c) Fragment an existing important population into two or more populations.

Sub-Antarctic fur seals are known to migrate long distances but given that migration would not be affected by stocking and that there is no reason why stocking would cause the separation of parts of the Macquarie Island population it is unlikely that the proposal would fragment an existing important population into two or more

Species Name: Sub-Antarctic fur-seal *(Arctocephalus tropicalis)*

populations.

d) Adversely affect habitat critical to the survival of a species.

Not applicable.

e) Disrupt the breeding cycle of an important population.

As discussed in (a), breeding in Australian waters is mainly confined to Macquarie Island. Given that there is no breeding in NSW and there is no chance of the proposal affecting core migration, the breeding cycle of sub-Antarctic fur seals would not be affected.

f) Modify, destroy, remove, isolate or decrease the availability of quality of habitat to the extent that the species is likely to decline.

As discussed in (a) and (b) this would not occur as a consequence of the proposal.

g) Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat.

No invasive species harmful to sub-Antarctic fur seals are likely to be released or have their populations enhanced as a consequence of the proposal.

h) Introduce disease that may cause the species to decline, or

Seals are gregarious animals on land and sometimes at sea, which increases the risk of transmission of infectious disease. Infectious diseases, some of which occur in Australian seals, have been identified as the cause of mass seal deaths in the northern hemisphere and, to a much lesser extent, the southern hemisphere (DEH 2004a).

- Intensive rearing of juvenile fish in hatcheries at high densities for stocking can create a favourable climate for disease which can in turn potentially be released into the natural environment. To reduce the potential of this occurring, the current NSW Hatchery Quality Assurance Scheme (HQAS) would be developed to accredit marine hatcheries intending to supply species for marine enhancement purposes, and that this would closely reflect considerations that are in place for species used for freshwater stocking. Key aspects of the quality assurance program would likely include controls over the source and management of broodstock, biosecurity measures of the hatchery and farm, the adequacy of water quality management, and disease prevention and treatment protocols that form part of a written Health Management Plan.
- Given this system would be in place, the risk of diseases being released into the environment as a consequence of the proposal and potentially affecting sub-Antarctic fur seals would be very low.

f) Interfere with the recovery of a species.

There is an approved Commonwealth Recovery Plan for Sub-Antarctic Fur Seals in Australia (DEH 2004b). The specific objective of the recovery plan is to:

- maintain existing levels of protection for the sub-Antarctic fur seals to enable population growth so that it may be removed from the threatened species list under the EPBC Act, and to ensure that any future anthropogenic impacts are not limiting.

The proposal is otherwise consistent with the objectives of the Commonwealth recovery plan assuming it causes no adverse impacts to vagrant juveniles were they to venture into stocked estuaries. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to sub-Antarctic fur seals would be investigated (see (a)).

Conclusion:

It is not considered that marine stocking would have a significant impact on sub-Antarctic fur seals.

The proposal would not have any significant direct or indirect impacts on the core habitat of sub-Antarctic fur seals. It is possible, however, that sub-Antarctic fur seals could occur, very occasionally, in estuaries where stocking has occurred. Stocking is unlikely to cause any substantial trophic impacts to juvenile sub-Antarctic fur seals that range into estuaries but there is potential for it to cause localised increases to fishing effort in stocked estuaries. Increased fishing effort could increase disturbance and the risk of entanglement to sub-Antarctic fur seals. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to sub-Antarctic fur seals would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

CETACEANS

There are five toothed whales listed as migratory in the EPBC Act with potential to be affected by the proposal and for the purposes of this assessment they have been grouped because of their similar habitat and food requirements.

Species Group: Toothed Whales (Odontoceti)

- Killer Whale (*Orcinus orca*)
- Dusky Dolphin (Lahgenorrycus obscurus)
- Indo-Pacific Hump-Backed Dolphin (*Sousa chinensis*)
- Long Snouted Spinner Dolphin (*Stenella longirostris*)
- Long-Beaked Bottlenose Dolphin (*Tursiops aduncus*)

Status: Migratory –Part 13, Section 209(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

a) Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

The toothed whales (systematic name Odontoceti) form a suborder of the cetaceans, including sperm whales, beaked whales, dolphins, and others. As the name suggests, the suborder is characterized by the presence of teeth rather than the baleen of other whales. Most toothed whales are smaller than the baleen whales.

The killer whale (orca) is the largest member of the toothed whales. The killer whale is found in all oceans and seas of the world usually in family groups (Culik 2004). In Australia they can be found across all States with concentrations reported around Tasmania and many sightings reported in Victoria. Killer whales are generally thought to prefer pelagic, oceanic waters and can be found in large concentrations over the continental shelf but can occur in shallow bays, inland seas and estuaries and are often sighted within 800 m of the coastline and near seal colonies. In previous whaling days a resident pack lived in Twofold Bay. Killer whales are carnivores and one of the most efficient large predators of the ocean. They often work in packs and will take a broad range of vertebrates including other whales, seals, penguins, fish, sea otters, and turtles. Killer whales have marked territorial behaviour and home ranges. Their prey is determined by what is available in their home range but they also seek out areas of seasonal abundance such as seal pupping sites.

Dusky dolphins are southern hemisphere dolphins usually found in temperate waters and often seen in large groups of hundreds. The species is usually found over the continental shelf and slope preferring waters with surface temperatures between 10 ºC and 18 ºC (Culik 2004). They can be seen inshore in the warmer months and may frequent bays. Hence, they could enter estuaries where stocking is proposed. Low rates of observations or strandings suggest that the dusky dolphin is rare along the south-east Australian coast and are unlikely to be resident (Culik 2004).

The Indo-Pacific hump backed dolphin occurs in northern NSW, throughout Queensland (QLD) and parts of Western Australia (WA) and the Northern Territory (NT). According to Carwardine (1995), this species is rarely found more than a few hundred kilometres from shore, preferring coasts with mangrove swamps, lagoons and estuaries as well as areas with reef, sand and mudbanks. On occasion they may also enter rivers, but within the tidal range. They are thought to prefer shallow water (< 25 m) and are typically found in the surf zone of open coastlines. According to Ross (2002), food consists mainly of fish and cephalopod molluscs.

Long-snouted spinner dolphins are primarily pelagic (occurring in open ocean) associating with tuna, pantropical

Species Group: Toothed Whales (Odontoceti)

- Killer Whale (*Orcinus orca*)
- Dusky Dolphin (Lahgenorrycus obscurus)
- Indo-Pacific Hump-Backed Dolphin (*Sousa chinensis*)
- Long Snouted Spinner Dolphin (*Stenella longirostris*)
- Long-Beaked Bottlenose Dolphin (*Tursiops aduncus*)

spotted dolphins and sea birds under certain oceanographic conditions. They can occur over the continental shelf in some regions and have some potential to occur in estuaries. They are suspected to have a calving interval of two to three years which leads to a relatively slow reproductive capacity. Over deep oceanic water, long-snouted spinner dolphins feed on pelagic fish, squids and shrimps taken at depths greater than 250 m (DEWHA 2009d).

In Australia, the long-beaked bottlenose dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments and shallow offshore waters including coastal areas around oceanic islands. They have been confirmed to occur in estuarine and coastal waters of NSW (DEWHA 2009e). Populations occurring in eastern Australia feed mainly on fish and cephlapods.

All of the migratory toothed whales listed in this assessment have potential to occur in estuaries. Although the proposal has very little potential to have direct effects on estuarine habitat it has potential to cause indirect effects to estuaries if fishing effort were to increase as a consequence of the proposal. The indirect effects to estuarine habitat that could occur with increased fishing effort are an increase to boat traffic and active and lost fishing gear. In turn, these effects could make toothed whales more vulnerable to boat strike, entanglement and noise in estuaries.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would substantially modify, destroy or isolate an area of important habitat for a migratory species. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to toothed whale habitat, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2(a) to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of any Recovery Plans.

b) Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat for the migratory species.

No invasive species harmful to toothed whales are likely to be released or have their populations enhanced as a consequence of the proposal.

c) Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Toothed whales can feed on small fish in estuaries and hence would potentially affected by the proposal if it were to cause trophic impacts. It is possible that some estuarine prey items of toothed whales could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft

Species Group: Toothed Whales (Odontoceti)

- Killer Whale (*Orcinus orca*)
- Dusky Dolphin (Lahgenorrycus obscurus)
- Indo-Pacific Hump-Backed Dolphin (*Sousa chinensis*)
- Long Snouted Spinner Dolphin (*Stenella longirostris*)
- Long-Beaked Bottlenose Dolphin (*Tursiops aduncus*)

FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of toothed whales would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for toothed whales.

Apart from the potential impacts that stocking may have to toothed whales ranging into estuaries, stocking also has potential to affect toothed whales occurring in coastal waters 'outside' of estuaries. Impacts would be possible if stocked fish or crustaceans were to move into coastal waters adjacent to the estuaries into which they had been stocked into. Stocked fish that move out of estuaries could potentially compete with toothed whales for habitat or food or transfer disease. However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in, estuaries such competition outside of estuaries is considered unlikely. The risk of transfer of disease from the stocked species within an estuary to toothed whale populations is low.

As indicated in (a), the risks to toothed whales of entanglement, boat strike and general noise have potential to increase if fishing effort were to increase as a consequence of the proposal. This could lead to disturbance or mortality of individuals to the extent that breeding of toothed whales was affected. It is not however, expected that this would seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to toothed whales would be investigated (see (a)).

Conclusion:

It is not considered that marine stocking would have a significant impact on migratory toothed whales.

The proposal would not have any significant direct or indirect impacts on the habitat of toothed whales or result in invasive species that are harmful to toothed whales becoming established in estuaries. Stocking is unlikely to cause any substantial trophic impacts to toothed whales in estuaries but there is potential for it to case localised increases to fishing effort in stocked estuaries. Given that the predicted severity of many of the impacts to migratory toothed whales are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to toothed whales would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

MIGRATORY ESTUARINE BIRDS - Wading Birds

There are 20 species of wading birds listed as 'migratory' under the Commonwealth EPBC Act (including sandpipers, sanderlings, knots, dowitchers, godwits, curlews and whimberals among others) which are known to or likely to occur within NSW estuaries and have not already been assessed under the State Assessment of Significance. For the purposes of this assessment they have been grouped because of their similar habitat and food requirements.

Species Group: Wading Birds

- Common Sandpiper (*Actitis hypoleucos*)
- Sharp-tailed Sandpiper (*Calidris acuminata*)
- Grey-tailed Tattler (*Heteroscelus brevipes*)
- Wandering Tattler (*Heteroscelus incanus*)
- Asian Dowitcher (Limnodromous semipalmatus)
- Bar-tailed Godwit (*Limosa lapponica*)
- Little Curlew (*Numenius minutus*)
- Whimberal (Numenius phaeopus)
- Red-necked Phalarope (*Phalaropus lobatus*)
- Ruff (Philomachus pugnax)
- Glossy Ibis (Plegadis falcinellus)
- American Golden Plover (*Pluvialis dominica*)
- Pacific Golden Plover (*Pluvialis fulva*)
- Grey Plover (Pluvialis squatarola)
- Lewin's Rail (Rallus pectorallis)
- Wood Sandpiper (*Tringa glareola*)
- Common Greenshank (*Tringa nebularia*)
- Marsh Sandpiper (*Tringa stagnatilis*)
- Common Redshank (*Tringa tetanus*)
- Buff-breasted Sandpiper (*Tryngites subruficollis*)

Status: Migratory –Part 13, Section 209(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

a) Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

Shore birds or 'waders' are those birds commonly found on coastal shores, including beaches, rocky shores, mudflats, tidal wetlands and lagoons. These include plovers and sandpipers in the families Charadriidae and Scolopacidae, stone-curlews, snipes, oystercatchers, stilts and avocets among others (Australian Museum 2010). Wading birds feed on marine invertebrates (including molluscs, worms and crustaceans), small fish that live within intertidal sand and mudflats. Small reptiles, earthworms, seeds and vegetation may also form part of their diet. Waders feed in the shallows or over exposed mud by probing their long slender bills into the substratum. Bill length, legs, body-structure, size and foraging techniques may subtly or markedly differ between groups of waders (Pizzey and Knight 1997). Important nesting areas may include sandbanks, sandpits, islands in estuaries, mangroves and riparian vegetation adjacent to the waterway. Nesting often takes place close to the ground which can make these birds vulnerable to disturbance.

Species Group: Wading Birds

- Common Sandpiper (*Actitis hypoleucos*)
- Sharp-tailed Sandpiper (*Calidris acuminata*)
- Grey-tailed Tattler (*Heteroscelus brevipes*)
- Wandering Tattler (*Heteroscelus incanus*)
- Asian Dowitcher (Limnodromous semipalmatus)
- Bar-tailed Godwit (*Limosa lapponica*)
- Little Curlew (*Numenius minutus*)
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- Red-necked Phalarope (*Phalaropus lobatus*)
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- Glossy Ibis (Plegadis falcinellus)
- American Golden Plover (*Pluvialis dominica*)
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- Wood Sandpiper (*Tringa glareola*)
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- Marsh Sandpiper (*Tringa stagnatilis*)
- Common Redshank (*Tringa tetanus*)
- Buff-breasted Sandpiper (*Tryngites subruficollis*)

Although the marine stocking proposal has very little potential to have direct effects on estuarine habitat it has potential to cause indirect effects to some estuarine habitat if fishing effort were to increase as a consequence of the proposal. The indirect effects to estuarine habitat that could potentially occur with increased fishing effort are a general increase to disturbance and noise and trampling of riparian vegetation.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would substantially modify, destroy or isolate an area of important habitat for a migratory species. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to wader habitat, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2(a) to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

b) Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat for the migratory species.

No invasive species harmful to waders are likely to be released or have their populations enhanced as a consequence of the proposal.

c) Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Waders feed on small fish and invertebrates in estuaries and hence would potentially affected by the proposal if it were to cause trophic impacts. It is possible that some estuarine prey items of waders could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any

Species Group: Wading Birds

- Common Sandpiper (*Actitis hypoleucos*)
- Sharp-tailed Sandpiper (*Calidris acuminata*)
- Grey-tailed Tattler (*Heteroscelus brevipes*)
- Wandering Tattler (*Heteroscelus incanus*)
- Asian Dowitcher (Limnodromous semipalmatus)
- Bar-tailed Godwit (*Limosa lapponica*)
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- Wood Sandpiper (*Tringa glareola*)
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- Marsh Sandpiper (*Tringa stagnatilis*)
- Common Redshank (*Tringa tetanus*)
- Buff-breasted Sandpiper (*Tryngites subruficollis*)

stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of waders would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for waders.

As indicated in (a), the risks to waders of general noise or disturbance have potential to increase if fishing effort were to increase as a consequence of the proposal. This could lead to disturbance or mortality of individuals to the extent that breeding of waders was affected. It is not however, expected that this would seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to waders would be investigated (see (a)).

Conclusion:

It is not considered that marine stocking would have a significant impact on wading birds.

The proposal would not have any significant direct or indirect impacts on the habitat of wading birds or result in invasive species that are harmful to wading birds becoming established in estuaries. Stocking is unlikely to cause any substantial trophic impacts to wading birds in estuaries but there is potential for it to cause localised increases to fishing effort in stocked estuaries. Given that the predicted severity of many of the impacts to migratory wading birds are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to wading birds would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

Diving Birds/Scavengers

There are eight species of diving birds/scavengers listed as 'migratory' under the Commonwealth EPBC Act including terns, frigatebirds and jaegers which are known to or likely to occur within NSW estuaries and have not already been assessed under the State Assessment of Significance. For the purposes of this assessment they have been grouped because of their similar habitat and food requirements.

Species Group: Diving Birds/Scavengers

- Black tern (Chlidonias niger)
- Lesser Frigatebird (*Fregata ariel*)
- Great Frigatebird (*Fregata minor*)
- Arctic Jaeger (Stercorarius parasiticus)
- Pomarine Jaeger (Stercorarius pomarinus)
- Lesser Crested Tern (*Sterna bengaiensis*)
- Common Tern (*Sterna hirundo*)
- Black-naped Tern (*Sterna sumatrana*)

Status: Migratory –Part 13, Section 209(3) EPBC Act

Significant Impact Criteria:

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

a) Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.

The common tern is widespread and common in NSW but does not breed here. Common terns are marine, pelagic and coastal. In Australia, they are recorded in all marine zones, but are commonly observed in near-coastal waters, both on ocean beaches, platforms and headlands and in sheltered waters, such as bays, harbours and estuaries with muddy, sandy or rocky shores. Common terns are fairly opportunistic, with a diet predominantly of small fish (greater than or equal to 15 cm in length), though also often taking crustaceans or insects, and occasionally squid (DSEWPC 2011). The rest of the terns, as well as the frigate birds and jaegers, are rare vagrants to NSW (Department of Sustainability, Environment, Water, Population and Communities website). Hence estuaries are considered important habitat for common terns but not for the other birds.

Although the marine stocking proposal has very little potential to have direct effects on estuarine habitat it has potential to cause indirect effects to some estuarine habitat of common terns if fishing effort were to increase as a consequence of the proposal. The indirect effects to estuarine habitat that could potentially occur with increased fishing effort, and that may affect common terns, are a general increase to disturbance and noise.

It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would substantially modify, destroy or isolate an area of important habitat for a migratory species. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to wader habitat, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2(a) to appropriately manage stocking in areas where the activity may adversely affect a threatened species.

Species Group: Diving Birds/Scavengers

- Black tern (Chlidonias niger)
- Lesser Frigatebird (*Fregata ariel*)
- Great Frigatebird (*Fregata minor*)
- Arctic Jaeger (Stercorarius parasiticus)
- Pomarine Jaeger (Stercorarius pomarinus)
- Lesser Crested Tern (*Sterna bengaiensis*)
- Common Tern (*Sterna hirundo*)
- Black-naped Tern (*Sterna sumatrana*)

b) Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat for the migratory species.

No invasive species harmful to diving birds/scavengers are likely to be released or have their populations enhanced as a consequence of the proposal.

c) Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

As indicated in (a) none of the birds in this assessment breed in NSW and most are rare vagrant apart from the common tern. Common terns are fairly opportunistic, with a diet predominantly of small fish, though also often taking crustaceans or insects, and occasionally squid. It is possible that some estuarine prey items of common terns could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section 5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of common terns would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for common terns.

As indicated in (a), the risks to common terns of general noise or disturbance have potential to increase if fishing effort were to increase as a consequence of the proposal. This could lead to disturbance or mortality of individuals to the lifecycle of common terns was affected. It is not however, expected that this would seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a common terns. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to waders would be investigated (see (a)).

As the other birds in this assessment are rare vagrants in NSW the proposal is not considered too seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of these species.

Conclusion:

It is not considered that marine stocking would have a significant impact on diving/scavenger birds.

The proposal would not have any significant direct or indirect impacts on the habitat of diving/scavenger birds or result in invasive species that are harmful to diving/scavenger birds becoming established in estuaries. Stocking is unlikely to cause any substantial trophic impacts to diving/scavenger birds in estuaries but there is potential for it to cause localised increases to fishing effort in stocked estuaries. Given that the predicted severity of many of

the impacts to migratory diving/scavenger birds are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to wading birds would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

Raptors

There is one species of raptor listed as 'migratory' under the Commonwealth EPBC Act which are known to or likely to occur within NSW estuaries and have not already been assessed under the State Assessment of Significance.

Species Group: Raptor White-bellied Sea-eagle (*Haliaeetus leucogaster*)
Status: Migratory –Part 13, Section 209(3) EPBC Act
Significant Impact Criteria: *An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:*
a) Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species. Estuaries in NSW are important habitat to the white-bellied sea eagle where it may reside, forage and breed (DEWHA 2010a). The white-bellied sea eagle generally forages over large expanses of open water; this is particularly true of birds that occur in coastal environments close to the sea-shore, where they forage over estuaries or in-shore waters. The white-bellied sea eagle feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal. It nests in large trees in forest or woodland often adjacent to a waterway. The main threats to the white-bellied sea eagle are the loss of habitat due to land development, and the disturbance of nesting pairs by human activity. The white-bellied sea eagle is sensitive to disturbance when nesting, especially during the early stages of the breeding season, and may desert nests and young if confronted by humans or exposed to human activity (Clunie 1994). Although the proposal has very little potential to have direct effects on estuarine habitat it has potential to cause indirect effects to estuaries if fishing effort were to increase as a consequence of the proposal. The indirect effects to estuarine habitat that could occur with increased fishing effort, and that would be considered as a modification of the habitat of the white-bellied sea eagle, are an increase to boat traffic and general noise. It is possible that stocking may result in localised increases in fishing effort but it is not however, expected that this could occur to the extent that it would cause adverse impacts that would substantially modify, destroy or isolate an area of important habitat for white-bellied sea eagles. Notwithstanding this, given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to white-bellied sea eagle habitat, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2(a) to appropriately manage stocking in areas where the activity may adversely affect a threatened species and so that the activity is consistent with objectives of any Recovery Plans.
b) Result in invasive species that are harmful to the migratory species becoming established in an area of important habitat for the migratory species. No invasive species harmful to white-bellied sea eagles are likely to be released or have their populations

Species Group: Raptor

White-bellied Sea-eagle (*Haliaeetus leucogaster*)

enhanced as a consequence of the proposal.

c) Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

As indicated in (a), the risks to white-bellied sea eagles of general noise have potential to increase if fishing effort were to increase as a consequence of the proposal. The disturbance of nesting pairs by human activity can lower breeding success, and has been associated with some local population declines. There are also occasional records of white-bellied sea eagles drowning after becoming entangled in fishing nets (Clunie 1994) and this risk also has potential to increase with increased fishing effort. It is not however, expected that this would seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of a population of white-bellied sea eagles. Notwithstanding this, the potential for fishing effort to increase with stocking would be monitored and, if it does occur, links to incidences of threats or harm to white-bellied sea eagles would be investigated (see (a)).

White-bellied sea eagle can feed on small fish in estuaries and hence would potentially affected by the proposal if it were to cause trophic impacts. It is possible that some estuarine prey items of white-bellied sea eagles could be displaced by stocked species but provided that juvenile finfish or crustaceans are stocked at appropriate densities, so that stocking does not disrupt the ecological balance of estuaries, availability or competition for food and other resources, trophic impacts would potentially not occur. For each species to be stocked, modelling, that included trophic impacts and estuarine productivity, was used to choose stocking densities that would not disrupt the ecological balance of estuaries (Chapter E, Section E.6.3). The proposed stocking densities are predicted to result in stocked fish or crustaceans using a maximum of 5 % of the total productivity of an estuary in any stocking event. This level of allocation of productivity to stocked fish is precautionary (Chapter F, Section F.5.4). As more information becomes available about potential trophic impacts of stocked fish or crustaceans, the draft FMS proposes to refine the process for estimating the most appropriate stocking densities. In addition, the diverse diet of white-bellied sea eagles would suggest that there is a potential for stocking to increase, rather than reduce, local estuarine food sources for white-bellied sea eagles.

Apart from the potential impacts that stocking may have to white-bellied sea eagles foraging into estuaries, stocking also has potential to forage in coastal waters 'outside' of estuaries. Impacts would be possible if stocked fish or crustaceans were to move into coastal waters adjacent to the estuaries into which they had been stocked into. Stocked fish that move out of estuaries could potentially compete with white-bellied sea eagle food or transfer disease. However, given the scale of the project and that most of the stocked species are expected to remain within, or be caught in, estuaries such competition outside of estuaries is considered unlikely. The risk of transfer of disease from the stocked species within an estuary to white-bellied sea eagle populations is low.

Conclusion:

It is not considered that marine stocking would have a significant impact on white-bellied sea eagles.

The proposal would not have any significant direct or indirect impacts on the habitat of white-bellied sea eagles or result in invasive species that are harmful to white-bellied sea eagles becoming established in estuaries. Stocking is unlikely to cause any substantial trophic impacts to white-bellied sea eagles in estuaries but there is potential for it to cause localised increases to fishing effort in stocked estuaries. Given that the predicted severity of many of the impacts to white-bellied sea eagles are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to white-bellied sea eagles would be investigated and the project reviewed and modified as necessary.

A referral is not recommended.

THREATENED ECOLOGICAL COMMUNITIES

There is one critically endangered and one endangered ecological community under the Commonwealth EPBC Act. For the purposes of this assessment they have been grouped.

Threatened Ecological Community: Eastern Suburbs Banksia Scrub of the Sydney Region
Status: Endangered ecological community – Part 13, Section 182(2) EPBC Act
Threatened Ecological Community: Littoral Rainforest and Coastal Vine Thickets of Eastern Australia Eastern Suburbs Banksia Scrub of the Sydney Region
Status: Critically endangered ecological community – Part 13, Section 182(1) EPBC Act
Significant Impact Criteria: *An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:*
a) Reduce the extent of an ecological community; *Eastern Suburbs Banksia Scrub of the Sydney Region* generally forms a sclerophyllous heath or scrub community. Some remnants contain small patches of woodland, low forest or limited wetter areas, depending on site topography and hydrology. Common species include *Banksia ericifolia, Banksia serrata, Eriostemon australasius, Lepidosperma laterale, Leptospermum laevigatum, Monotoca elliptica, Pteridium esculentum, Ricinocarpos pinifolius* and *Xanthorrhoea resinifera*. *Banksia aemula* is also a typical species of the community and occurs at its southern limit in La Perouse (NSW DEC 2004). Today, less than 3 % of the original distribution of *Eastern Suburbs Banksia Scrub of the Sydney Region* remains in isolated remnants, ranging in size from 0.06 to 69 ha. Surviving stands totalling 146 ha have been recorded from the local government areas of Botany, Randwick, Waverley and Manly. Only 33 ha of *Eastern Suburbs Banksia Scrub of the Sydney Region* has been recorded from within conservation reserves (Botany Bay National Park at La Perouse and Sydney Harbour National Park at North Head). Threats to *Eastern Suburbs Banksia Scrub of the Sydney Region* that are relevant to the marine stocking proposal include erosion and/or physical damage from surface water run-off, bicycles, motor vehicles, horses, rabbits and excessive pedestrian use. Maps of the known distribution of *Eastern Suburbs Banksia Scrub of the Sydney Region* are presented in the Recovery Plan for this community (NSW DEC 2004). These maps indicate that this community generally does not occur adjacent to any estuaries or along access routes to estuaries and hence it would not be affected by fishers on foot or those using vehicles. The only instance where the community is close to an estuary is at North Head but this pocket would be unaffected by fishers as they would not be able to access Sydney Harbour from this area due to the presence of very steep cliffs. Hence, as the proposal is not relevant to the threats to this community it has not been considered any further. *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* represents a complex of rainforest and coastal vine thickets, including some that are deciduous, on the east coast of Australia. Typically, the ecological community occurs within two kilometres of the coast or adjacent to a large salt water body, such as an estuary and, thus, is influenced by the sea. It is naturally distributed as a series of disjunct and localised stands occurring on a range of landforms derived from coastal processes that can include dunes and flats, cheniers, berms, cobbles, headlands, scree, seacliffs, marginal bluffs, spits, deltaic deposits, coral rubble and islands. As a result, the ecological community is not associated with a particular soil type and can occur on a variety of geological substrata (Threatened Species Scientific Committee 2008). The canopy height varies with the degree of exposure and can range from dwarf to medium (<1-25 m). Due to extreme exposure to salt laden winds, the canopy often demonstrates a continuum of heights. Highly exposed patches will display the effect of windshear in the canopy. In more sheltered sites, for example, around estuaries,

Threatened Ecological Community: Eastern Suburbs Banksia Scrub of the Sydney Region

wind shear may not be evident in the canopy. The canopy is typically closed but may also be patchy and may include emergents. Those stands that occur in exposed coastal situations can have many rainforest gaps caused by storm events which, in turn, may lead to canopy decapitation. In these exposed sites, there is often a secondary canopy that has developed below the old canopy. The ecological community provides important stepping stones along the eastern Australian coast for various migratory and marine birds.

Emergents may be present, for *Littoral Rainforest and Vine Thickets of Eastern Australia* from the genera *Araucaria* (northern bioregions only), *Banksia* or *Eucalyptus*. The ground stratum of the vegetation typically is very sparse. The ecological community contains a range of plant life forms including trees, shrubs, vines, herbs, ferns and epiphytes. To the north, most plant species diversity is in the tree and shrub (i.e. canopy) layers rather than in lower strata. The converse generally occurs from the Sydney Basin Bioregion southwards. Feather palms, fan palms, large leaved vascular epiphytes and species that exhibit buttressing are generally rare. Ground ferns and vascular epiphytes are lower in diversity in littoral rainforests compared to most other rainforest types.

Threats to *Littoral Rainforest and Vine Thickets of Eastern Australia* that are relevant to the marine stocking proposal include tourism and visitor disturbance. Visitor disturbance in conservation areas includes soil compaction and disturbance, erosion from foot, cycle, trail bike and four wheel drive tracks, the introduction of pests and the creation of new planned and unplanned tracks. Increased visitation results in increased demand for and use of visitor facilities, such as walking tracks, viewing platforms, toilet blocks and picnic areas, many of which are located in littoral rainforest patches because of their attractive landscape features (shade, open understorey and proximity to the sea). These impacts hinder the recruitment of key canopy species, slowing regeneration rates and facilitating establishment of weeds. Other impacts in such areas include the dumping of rubbish.

Fishing activities associated with the proposal for marine stocking could contribute to threats to *Littoral Rainforest and Vine Thickets of Eastern Australia* identified above as visitor disturbance to the community could potential increase if more fishers were to access estuaries through the community. It is difficult to predict whether stocking would increase fishing effort in estuaries that are stocked and if so, by how much but if it did occur, the main impact would be from trampling and compaction from 4WD vehicles and weeds could also be spread. Recreational and commercial fishers operating within stocked estuaries are obliged by law to store all waste for appropriate disposal ashore but some marine debris may potentially be released either accidentally or deliberately into estuaries as a direct result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Although it is possible that stocking may result in localised increases in fishing effort it is not however, expected that this could occur to the extent that it would cause adverse impacts that would result in the extent of *Littoral Rainforest and Vine Thickets of Eastern Australia* being reduced. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, the draft FMS proposes to monitor the potential for fishing effort to change with stocking (Management Response 2.3 d). As incidences to threatened species/communities or their habitat would be also be monitored (Performance Indicator 2 of Goal 1), it will be possible to identify links between increased concentrations of fishing effort and adverse impacts to communities of *Littoral Rainforest and Vine Thickets of Eastern Australia*, were they to occur. Such links would provide a basis for reviewing/modifying the project if necessary, in accordance with Management Response 1.2a to appropriately manage stocking in areas where the activity may adversely affect a threatened community and so that the activity is consistent with objectives of the Recovery Plan (see (f)).

b) Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines;

There is no reason why this the proposal would fragment or increase fragmentation of communities of *Eastern Suburbs Banksia Scrub of the Sydney Region* or *Littoral Rainforest and Vine Thickets of Eastern Australia.*

c) Adversely affect habitat critical to the survival of an ecological community;

Not applicable.

Threatened Ecological Community: Eastern Suburbs Banksia Scrub of the Sydney Region
d) Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns; As discussed in (a), there would be potential for trampling and compaction from 4WD vehicles to *Littoral Rainforest and Vine Thickets of Eastern Australia* if fishing effort were to increase and fishers were passing through this community to access estuaries. As discussed in (b), such effects are unlikely to be significant. Notwithstanding this, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to *Littoral Rainforest and Vine Thickets of Eastern Australia* would be investigated and the project reviewed and modified as necessary.
e) Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting; There is no reason why this the proposal would cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species of communities of *Eastern Suburbs Banksia Scrub of the Sydney Region* or *Littoral Rainforest and Vine Thickets of Eastern Australia.*
f) Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ *assisting invasive species, that are harmful to the listed ecological community, to become established, or* ▪ *causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or;* As discussed in (a), weeds could be spread as a result of the potentially increased fishing effort within estuaries where marine fish stocking takes place. Although it is possible that stocking may result in localised increases in fishing effort it is not however, expected that this could occur to the extent that it would cause the spread of weeds that would result in a substantial reduction in the quality or integrity of an occurrence of *Littoral Rainforest and Vine Thickets of Eastern Australia*. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to *Littoral Rainforest and Vine Thickets of Eastern Australia* would be investigated and the project reviewed and modified as necessary.
g) Interfere with the recovery of an ecological community. Approved Conservation Advice for the *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* includes Local Priority Actions to conserve and restore the community (Threatened Species Scientific Committee 2008). The proposal for marine stocking would not interfere with any of the Priority Actions.

Conclusion:

Threats from the proposal for marine stocking to the critically endangered community of *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* include soil compaction and disturbance, erosion from foot, cycle, trail bike and four wheel drive tracks, the introduction of pests and the creation of new planned and unplanned tracks. These are possible with an increase in fishing effort. It is not however, expected that this could occur to the extent that it would cause adverse impacts to *Littoral Rainforest and Vine Thickets of Eastern Australia*. Given that the predicted severity of many of the impacts are largely unknown but related to potential changes in fishing effort, any potential links of increased concentrations of fishing effort associated with stocking to reported incidences to *Littoral Rainforest and Vine Thickets of Eastern Australia* would be investigated and the project reviewed and modified as necessary.

It is not considered that marine stocking would have a significant impact on the endangered community of *Eastern Suburbs Banksia Scrub of the Sydney Region*

A referral is not recommended.

Appendix 4

Consultation

Table 1: Summary of stakeholder groups consulted during the marine fish stocking EIS.

Agency / Stakeholder	Identified in DGRs	Type of Consultation	Date of Consultation	Details	Response
Department of Environment, Climate Change and Water (includes the Marine Park Authority and Parks and Wildlife Service)	Yes	Letter	4-Sep-09	Request confirmation that critical issues raised in the DGRs are still relevant and current.	Verbal response given, letter pending
Land and Property Management Authority (formerly NSW Department of Lands)	Yes	Email	7-Sep-09	Confirm whether the Authority has any concerns that need to be addressed in the assessment process, and/or whether there are any estuaries, or parts of, that should be excluded from stocking because of statutory requirements or existing Plans of Management made under the Crown Lands Act.	Verbal response given, letter pending
Department of Primary Industries	Yes	Internal consultation between Sarah Boyd and other DPI units.	Month of August 2009	Request confirmation that critical issues raised in the DGRs are still relevant and current.	Yes
Commonwealth Department of Sustainability, Environment, Water, Population and Communities.	Yes	DPI advised that consultation is to be done at a later stage of the project	N/A	N/A	N/A
Advisory Council on Recreational Fishing	-	Letter	Week of 24 August 2009	Rank factors (associated with recreational fishing) in terms of their importance in the process of selecting estuaries for stocking.	Yes
Seafood Industry Advisory Council	-	Letter	Week of 7 September 2009 with follow-ups	Advise commercial fishing sector of the proposal and invite comment.	Yes
Commercial Fishing Management Advisory Committees (Estuary General, Estuary Prawn Trawl, Ocean Haul, Ocean Trap and Line, Ocean Trawl)	-	Letter	Week of 7 September 2009 with follow-ups	Advise commercial fishing sector of the proposal and invite comment.	Yes
Peak Oyster Advisory Group	-	Letter	4-Sep-09	Rank factors (associated with the proposal and having potential to affect oyster farming) in terms of their importance in the process of selecting estuaries for stocking.	Yes
Nature Conservation Council of NSW	-	Meeting	18-Sep-09	Advise NCC of proposal and invite comment and discussion on key ecological issues associated with it.	Yes

Agency / Stakeholder	Identified in DGRs	Type of Consultation	Date of Consultation	Details	Response
Catchment Management Authorities (Southern Rivers, Sydney Metropolitan, Hunter Central Rivers, Northern Rivers)	-	Letter	Week of 14 September 2009	Advise aboriginal stakeholders of proposal and invite responses with respect to cultural issues potentially associated with the proposal and selection of estuaries.	Yes
NTSCORP (formerly NSW Native Title Services Ltd)	-	Letter	Week of 14 September 2009	Advise aboriginal stakeholders of proposal and invite responses with respect to cultural issues potentially associated with the proposal and selection of estuaries.	Yes
Registrar of Aboriginal Owners	-	Letter	Week of 14 September 2009	Advise aboriginal stakeholders of proposal and invite responses with respect to cultural issues potentially associated with the proposal and selection of estuaries.	Yes
NSW Aboriginal Land Council	-	Letter	Week of 14 September 2009	Advise aboriginal stakeholders of proposal and invite responses with respect to cultural issues potentially associated with the proposal and selection of estuaries.	Yes
Local Aboriginal Land Councils (x40)	-	Letter	Week of 14 September 2009	Advise aboriginal stakeholders of proposal and invite responses with respect to cultural issues potentially associated with the proposal and selection of estuaries.	Yes

Appendix 5

Recreational Fishing in NSW

Social Case Studies

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1. Introduction

The Department of Primary Industries (DPI) is proposing a marine fish-stocking program within New South Wales (NSW) estuaries to enhance recreational fishing opportunities within the State. In considering the potential social benefits and impacts of the marine fish stocking program and how fish stocking events, marine or otherwise, may impact on the behaviour of recreational fishers within a certain area, two case studies have been prepared; a regional case study and a metropolitan case study. Each case study involves:

- A brief description of the key estuaries in the case study area and their recreational and commercial fishing characteristics;
- Identification of potential social impacts of marine fish stocking in the case study area.
- A summary of the demographic and recreational fishing licence data for the case study area; and

Following analysis of both metropolitan and regional case studies conclusions are drawn as to:

- the feasibility of stocking each of the regions; and
- the potential social impacts of fish-stocking on each region.

A literature review was also undertaken which showed that stock enhancement research has largely concentrated on determining optimal stocking strategies and investigating the ecological impacts of stocking on aquatic ecosystems. (Lorenzen and Garaway 1998, Garaway, C. 2006). Although the socio-economic importance of recreational fisheries is well documented (Linløkken 1995; Peirson, Tingley, Spurgeon & Radford 2001; Ross & Loomis 2001; Wedekind, Hilge & Steffens 2001; Arlinghaus & Mehner 2002; Cooke & Cowx 2006), there is little information available on the social impacts of fish stocking.

However, the review did identify the importance of recreational fishers' attitudes to fishery management strategies (Sutton 2007, Granek *et al*. 2008, Sutton & Tobin 2009, Arlinghaus *et al.* 2010). Sutton & Tobin (2009) highlight the importance of involving local stakeholders in the consultation process with regards to significant fisheries initiatives. More specifically the authors, who focused on the rezoning of the Great Barrier Reef in 2004, found that while stakeholders generally supported actions that were seen to be improving conservation values, support decreased when stakeholders perceived the consultation process was not inclusive (2009, p. 5 – 7).

Granek *et al*, (2008) used a series of case studies to demonstrate the benefits of the involvement of recreational fishers in management activities to achieve successful socio-economic and ecological outcomes. As such, the literature suggests that an inclusive stakeholder strategy will assist with the management of the social elements of any proposed marine fish stocking program. The authors describe a partnership between researchers and anglers implementing a re-introduction stocking program of diadromous salmonids into the Stepenitz catchment in Germany. Active engagement and participation of fishers facilitated development of the program as well as associated habitat management activities to enhance success of the program.

A recent study revealed that recreational fishers in Queensland place high value on conservation of fisheries resources and strongly support fisheries management tools designed to improve and prevent overfishing by the recreational sector (Sutton 2006). Consequently, it is doubtful that the recreational fishing community would support an ongoing marine stocking program if stocking was demonstrated to have high negative impacts and low conservation outcomes.

Sutton (2006) identified a wide range of motivation dimensions illustrating the importance of the social benefits of fishing. Sutton demonstrated that catching fish is not the only motivation for people who enjoy recreational fishing but that relaxation/escape and excitement were also important. Within each of these categories, Sutton identified a subset of dimensions and measured their importance to fishers

Table 1: Motivation dimensions for recreational fisher (Sutton 2006)

Catching Fish	Relaxation/escape	Excitement
To catch a fish for eating	To get away from regular routine	To experience new and different things
For the experience of the catch	For relaxation	To experience adventure and excitement
For the fun of catching fish	To experience solitude or tranquillity	To have thrills
To catch a 'record' or 'trophy' fish	To get away from the demands of other people	
For the challenge or sport of fishing	To get away from crowds of people	

Arlinghaus *et al.* (2010) also recognised that motivations of recreational fishers are very diverse and differ among individuals and fishing trips, which can further complicate social analyses.

Therefore it would appear that the impact and viability of a fish stocking program, within a social context, would also be seen to be dependent upon fisher characteristics, including:

- the number and location of fishers within the region;
- the motivation of fishers; and
- fishing participation within the region.

This social assessment aims to identify the key issues that influence the marine stocking program and to evaluate the potential interactions and impacts of marine fish stocking activities with non-Aboriginal cultural heritage values for each of the two estuarine landscapes. Where appropriate, relevant literature and results of consultation with the fishing community have been referenced.

2. Case Study 1 – Regional Area - Bega Valley, NSW

Bega Valley, known as the Sapphire Coast, is located on the far south coast of NSW approximately halfway between Sydney and Melbourne (Bega Valley Shire Council 2011). The Bega Valley is approximately three hours drive from Canberra, and one hour by plane from Sydney or Melbourne. The following estuaries were considered as marine fish stocking locations for the case study:

- Merimbula Lake;
- Pambula Lake; and
- Curalo Lagoon.

All of these estuaries are within 35 km of each other, sharing the main commercial centres of Merimbula and Eden. The estuaries are popular holiday locations with one of the main attractions being recreational fishing. During the peak holiday months (January to May) the resident populations of Merimbula, Pambula and Eden increase up to threefold in number (Bega Valley Shire Council 2011b). During 2009/10, there were approximately 2,751,000 domestic overnight visitors and 5,028,000 domestic day visitors to the South Coast (Tourism Research Australia 2011). Obviously, different areas within the South Coast Region attract visitors from different origins. The Sapphire Coast (particularly Merimbula) is popular with Melbourne and rural Victorian residents (NSW Tourism Commission 1990). More families with school age or younger children and more older non-working married people visit the South Coast Region, compared to the State average (Bureau of Tourism Research 2000).

A brief description of each estuary in the case study area and their fishing characteristics is provided below.

Merimbula Lake

Merimbula Lake is an open inlet/lake system of approximately 465 hectares comprising a natural entrance, inlet channels, a marine delta and a main lake basin. The depth of the primary lake basin averages 3-4 m with a smaller basin on the southern side averaging 0.3 m. The Princes Highway that joins the Merimbula and Pambula townships crosses the inlet at the narrowest point via a 250 m causeway and short bridge (NSW DECCW 2011). The shoreline is characteristically rocky, with the exception of the shoreline of the smaller basin being predominantly mangrove and sand based. The condition of the waterway is 'modified' according to the National Land and Water Resources Audit and this classification was based on changes of land use to rural/residential. Table 2 displays information on a number of activities related to fishing in Merimbula Lake.

Table 2: Fishing related activities and regulations at Merimbula Lake.

Activity	Details
Recreational Fishing and Regulations	Merimbula Lake is a popular recreational fishing location for residents and visitors to the area due to its excellent and varied fishing throughout the year. Flathead and bream are commonly fished, and the channel is also good for whiting, flathead and luderick. General NSW regulations apply to fishing in the Lake.
Commercial fishing and associated	Some commercial fishing is permitted in Merimbula Lake, which is part of the State-wide estuary general commercial fishery. This fishery is managed under the *Fisheries Management Act 1994* (FM Act), Fisheries Management (Estuary General Share Management Plan) Regulation 2006,

Activity	Details
regulations	Fisheries Management (General) Regulation 2010 and the Fisheries Management (Supporting Plan) Regulation 2006. Types of gear commercial fishers may use within Merimbula lake include hand hauled prawn net, dip or scoop net, crab trap, hand lining, push or scissor net, fish trap, eel trap and hand gathering.
Aquaculture	There are 64 active aquaculture (oyster) leases currently being utilised in Merimbula Lake (Data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations across this estuary. Examples include bank fishing, wharves, rocky points, boats, fishing platforms, boat ramps, breakwalls, retaining walls and potentially private jetties.
Fishing Charters	There are a total of 37 charter fishing boat operators in the Merimbula area stretching from Narooma to Eden. Off these operators, 26 have endorsements that enable them to fish in the estuary and 22 have their licences issued. Charter operators, however, are not zoned and it is likely that operators from within this region may also operate in other estuaries such as Pambula Lake and Curalo Lake. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational fishing, snorkelling, diving, boat hire, sailing, boat launching, fishing charters, boating (51 berths present), water cruises, jet skiing, yachting.
Cultural heritage sites	Merimbula Wharf and Cargo Sheds – Aquarium, shops and cafes. Recreational fishing, however, is not considered to interfere with cultural heritage sites (Bega Valley Shire Council, 2010).
Cultural activities	Numerous cultural activities occur in and around this estuary including: a wide range of water sports walking, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch) and a range of festivals and events.

Pambula Lake

Pambula Lake, sometimes referred to as the "Broadwater", is located approximately 5 km south of the town of Pambula. With its relatively deep and shoal-free inlet, the estuarine tidal range is near ocean range throughout the majority of the estuary (NSW DECCW 2011). It has a catchment of approximately 275 km^2 and a waterway area of approximately 397 hectares. The lake is relatively deep in the centre and shallower inshore. A large proportion of the shallow areas are leased for aquaculture by oyster producers (NSW DECCW 2011). The condition of Pambula Lake is considered largely unmodified, this is based on the minimal disturbance from catchment land uses such as forestry and low levels of grazing/cropping. The Pambula River was declared a recreational fishing haven in 2002 to

Table 3 displays information on a number of activities related to fishing in Pambula Lake.

Table 3: Fishing related activities and regulations at Pambula Lake.

Activity	Details
Recreational Fishing and Regulations	Pambula Lake is a popular recreational fishing location. Tailor, flathead, bream whiting and luderick are concentrated at the entrance to the Pambula River, while the Lake is fished predominately for bream (Explore Australia, 2006). General NSW regulations apply to fishing in the Lagoon.
Commercial fishing and associated regulations	Some commercial fishing is permitted in Pambula Lake (although not permitted in the Pambula River), which is part of the State-wide estuary general commercial fishery. This fishery is managed under the FM Act, Fisheries Management (Estuary General Share Management Plan) Regulation 2006, Fisheries Management (General) Regulation 2010 and the Fisheries Management (Supporting Plan) Regulation 2006. Types of gear commercial fishers may use within Pambula lake include hauling net (general purpose), prawn net (hauling), hoop or lift net, push or scissor net, fish trap, eel trap, hand gathering, garfish net (bull ringing), meshing net, hand hauled prawn net, dip or scoop net, crab trap and hand lining.
Aquaculture	There are 118 active aquaculture (oysters) leases currently being utilised in Pambula Lake (Data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations within this estuary, examples include bank fishing, wharves, rocky points, fishing platforms, boat ramps, breakwalls, retaining walls, jetties and from boats
Fishing Charters	Although charter vessels do not operate out of Pambula Lake, there are a total of 37 charter fishing boat operators in the area stretching from Narooma to Eden. 26 of these operators have endorsements that enable them to fish in the estuary and 22 have their licences issued. As these charter operators are not zoned, it is likely that operators from within this region also operate in other estuaries such as Merimbula Lake and Curalo Lake. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational and charter fishing, snorkelling, diving, boating, sailing, water cruises, jet skiing.
Cultural heritage sites	The estuary entrance channel and the eastern shoreline of the main basin is located within the Ben Boyd National Park, however, recreational fishing is still permitted in this area (DECCW 2011).
Cultural activities	Numerous cultural activities occur on and around this estuary including: a wide range of water sports, walking, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch) and a range of festivals and events.

Curalo Lagoon

Curalo Lagoon (also known as Lake Curalo) is located adjacent to the township of Eden with a waterway area of approximately 74 hectares. Aslings Beach forms a narrow barrier that separates Curalo Lagoon and Calle Bay. Table 3 displays information on a number of activities related to fishing in Curalo Lagoon. Curalo Lagoon is considered to be 'extensively modified' under the National Land and Water Resources Audit, based on changes to land use for intensive agriculture or urbanisation causing significant disturbance to streams. Table 4 displays information on a number of activities related to fishing in Curalo Lagoon.

Table 4: Fishing related activities and regulations at Curalo Lagoon.

Activity	Details
Recreational Fishing and Regulations	Curalo Lagoon offers bream and flathead fishing from the shore bank and prawning in the summer. General NSW regulations apply to fishing in the Lagoon.
Commercial fishing and associated regulations	Some commercial fishing is permitted in Curalo Lagoon, which is part of the State-wide estuary general commercial fishery. This fishery is managed under the FM Act, Fisheries Management (Estuary General Share Management Plan) Regulation 2006, Fisheries Management (General) Regulation 2010 and the Fisheries Management (Supporting Plan) Regulation 2006. Types of gear commercial fishers may use within Curalo Lagoon include hauling net (general purpose), prawn net (hauling), hoop or lift net, push or scissor net, fish trap, eel trap, hand gathering, garfish net (bull ringing), meshing net, hand hauled prawn net, dip or scoop net, crab trap and hand lining.
Aquaculture	There are no active aquaculture leases currently being operated in Curalo Lagoon (Data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations across this estuary. Examples include bank fishing, wharves, rocky points, fishing platforms, breakwalls, retaining walls and jetties.
Fishing Charters	Although charter vessels do not operate out of Curalo Lake, there are 37 charter fishing boat operators in the area stretching from Narooma to Eden. Of these, 26 operators are endorsed to fish in the estuary and 22 have their licences issued. Charter operators, however, are not zoned and it is likely that operators from within this region may also operate in other estuaries such as Pambula Lake and Merimbula Lake. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational fishing, snorkelling and diving.
Cultural heritage sites	No known cultural heritage sites that may affect recreational fishing are located in the estuary (Bega Valley Shire Council 2010). The general cemetery, located immediately to the south of Lake Curalo, is classified as an

Activity	Details
	historic cemetery by the National Trust (Curalo estuary management plan). Fish stocking, however, would not be anticipated to have any impact on this cultural heritage site.
Cultural activities	Numerous cultural activities occur in and around this estuary including: a range of water sports, walking, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch), and a range of festivals and events.

3. Case Study 2 – Metropolitan Area - Sydney, NSW

Sydney is the largest metropolitan region in NSW with a population of over 4.1 million people (Australian Bureau of Statistics 2006). For the case study the following estuaries were considered as marine fish stocking locations:

- Hawkesbury River;
- Botany Bay; and
- Port Hacking.

All of these estuaries are less than one hour drive from the Sydney CBD, sharing the main commercial centre of Sydney.

The Hawkesbury River, Botany Bay and Port Hacking waterways are heavily used for recreational and commercial purposes by the population of Sydney and surrounds as well as by tourists. The large urbanised catchments have led to the majority of these waterways being extensively modified (noting that there are many areas which are not modified). The waterway traffic is generally very high, particularly during weekends and holiday periods where use of the waterways constitutes a popular cultural pastime for many residents and visitors to Sydney.

A brief description of each estuary in the case study area and their fishing characteristics is provided below.

Hawkesbury River

The Hawkesbury River is the northernmost estuary of the metropolitan case study estuaries with the largest waterway area of 11,149 hectares. The tidal influence extends approximately 145 km upstream, there are a number of weirs and reservoirs throughout the catchment which provide drinking water for much of Sydney's metropolitan area. The lower estuary sub-catchment of the Hawkesbury River is dominated by bushland, and interspersed with small local settlements along the foreshore. The condition of the waterway and lower catchment has been extensively modified based on catchment land use changes causing significant disturbance to streams such as intensive agriculture or urbanisation.

A number of National Parks and Nature Reserves have been established throughout the catchment to protect valuable foreshore ecosystems such as mangroves from further degradation. These reserves include Ku-ring-gai Chase, Marramarra and Dharug National Parks and Muogamarra Nature Reserve.

The Hawkesbury River is used extensively for recreational purposes including fishing and supports one of the largest commercial fisheries in NSW. Table 5 displays information on a number of activities related to fishing in the Hawkesbury River.

Table 5: Fishing related activities and regulations in the Hawkesbury River Catchment

Activity	Details
Recreational fishing and regulations	The Hawkesbury River provides numerous recreational fishing opportunities. Groper and drummer can be fished at full tide at the entrance to Pittwater. Luderick, kingfish, snapper and black bream can be found towards the head of Pittwater. Bream, snapper, flathead and mulloway are all able to be fished in the lower Hawkesbury, with bream, mulloway, flathead and flounder more common in the upper Hawkesbury (Explore Australia, 2006). General NSW regulations apply to fishing in the River.

Activity	Details
Commercial fishing and regulations	Commercial fishing is permitted in the Hawkesbury River, the main commercial fisheries operating in the river are the estuary general commercial fishery and the estuary prawn trawl fishery. These fisheries are managed under the FM Act, Fisheries Management (Estuary General Share Management Plan) Regulation 2006, Fisheries Management (General) Regulation 2010, Fisheries Management (Estuary Prawn Trawl Share Management Plan) Regulation 2006 and the Fisheries Management (Supporting Plan) Regulation 2006. Types of gear commercial fishers may use within the Hawkesbury River include garfish net (hauling), garfish net (bull ringing), meshing net, whitebait species net (by permit only), push or scissor net, fish trap, eel trap, hand gathering, hauling net (general purpose), prawn net (hauling), hoop or lift net, hand hauled prawn net, dip or scoop net, crab trap and hand lining.
Aquaculture	There are 127 active aquaculture (oyster) leases currently operating in the Hawkesbury Estuary, with 118 being located in the Hawkesbury River and 9 located in Patonga Creek (Data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations across this estuary. Examples include fishing from wharves, rocky points, fishing platforms, boat ramps, breakwalls, retaining walls and jetties and from boats.
Fishing Charters	There are a total of 14 charter fishing boat operators in the Hawkesbury River area of which 13 have endorsements enabling them to fish in the estuary. Of these,10 have current licences. Charter operators, however, are not zoned and it is likely that operators from within this region may also operate in other estuaries such as Sydney Harbour/Port Jackson, Botany Bay and Port Hacking. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational fishing, snorkelling, diving, boating, sailing, recreational and charter fishing, kayaking, water cruises, jet skiing.
Cultural heritage sites	There are numerous cultural heritage sites along the foreshores of the Hawkesbury River. There are no known sites that would prohibit recreational fishing.
Cultural activities	Numerous cultural activities occur on and around this estuary including: a wide range of water sports, walking, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch) and a range of festivals and events.

Botany Bay

Botany Bay is a major sea and airport and approximately half the people of Metropolitan Sydney live within its catchment. The area of the waterway is around 5,121 hectares. The waterway condition has been classed as extensively modified based on changes to catchment land uses causing significant disturbance to streams such as intensive urbanisation and is used heavily by recreational fisher, recreational boat craft and cargo ships.

Botany Bay is currently closed to all commercial fishing with the exception of abalone gathering and rock lobster trapping and was designated a recreational fishing haven in 2002 (I&I NSW 2011). Table 6 displays information on a number of activities related to fishing in Botany Bay.

Table 6: Fishing related activities and regulations in Botany Bay

Activity	Details
Recreational fishing and regulations	Popular land based locations for recreational fishing identified by Explore Australia (2006) include Bare Island, the retaining wall at Molineaux Point, Brighton Wharf, Lady Robinsons beach, Ramsgate Baths, end of the new airport runway and Dolls Point. From these locations, fish commonly caught include bream, luderick, flathead, tailor, yellowtail kingfish and occasional mulloway (Steffe *et al*. 1996). Inshore fishing around the bay is mainly for bream, whiting, tailor and mulloway. General NSW regulations apply to fishing in the Bay. Botany Bay also includes an Aquatic Reserve at Towra Point that has a Refuge Zone and a Sanctuary Zone, which are managed under the FM Act.
Commercial fishing and regulations	Botany Bay a recreational fishing haven and is closed to all types of commercial fishing with the exception of abalone gathering and rock lobster trapping. These fisheries are managed under the FM Act, Fisheries Management (General) Regulation 2010, Fisheries Management (Abalone Share Management Plan) Regulation 2000, Fisheries Management (Lobster Share Management Plan) Regulation 2000 and the Fisheries Management (Supporting Plan) Regulation 2006.
Aquaculture	There are 15 active aquaculture (oyster) leases currently being operated in Botany Bay, with 13 being located within Botany Bay and 2 located in the Georges River(data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations across this estuary. Examples include fishing from banks, wharves, rocky points fishing platforms, boat ramps, breakwalls, retaining walls, jetties and from boats.
Fishing Charters	There are a total of 15 charter fishing boat operators in the Botany Bay area of which 11 have endorsements enabling them to fish in the estuary. Of these and 11 have current licences. Charter operators, however, are not zoned and it is likely that operators from within this region may also operate in other estuaries such as Port Jackson (Sydney Harbour), the Hawkesbury River and Port Hacking. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational fishing, snorkelling, diving, sailing, boating, recreational and charter fishing, water cruises, jet skiing, yachting.

Activity	Details
Cultural heritage sites	Botany Bay National Park includes a number of cultural heritage sites including lighthouses, cemeteries, fortifications, monuments and a ship wreck of SS Minmi. There are numerous other cultural heritage sites along the foreshores of Botany Bay.
Cultural activities	Numerous cultural activities occur on and around this estuary including: a wide range of water sports, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch) and a range of festivals and events.

Port Hacking

Port Hacking is fed by the Hacking River and several small creeks forming a branching estuary with a waterway area of approximately 471 hectares. The estuary has two mobile sand bodies; one is located near the entrance where water depth is around 12 m and another at the riverine delta upstream. Throughout the estuary and particularly upstream, substantial areas are exposed at low tide. The condition of the waterway is classified as 'modified', based on changes to land use, mainly urbanisation. The estuary is essentially a boating waterway as there are few accessible land-based fishing points due to the rocky shores.

The majority of boat ramps and wharves are located along the northern side of Port Hacking which is urbanised. The southern shoreline of Port Hacking has been incorporated into the Royal National Park including wetlands, marine grasses, shoals and tidal waterways. The National Park has important cultural and natural heritage significance and is used by many recreational users for swimming, kayaking, dinghy sailing, and low impact foreshore use. Table 7 displays information on a number of activities related to fishing in Port Hacking.

Table 7: Fishing related activities and regulations in Port Hacking

Activity	Details
Recreational fishing and regulations	The top ten species caught by recreational fishers and spear fishers in Port Hacking include squid, yellowtail, yellowfin bream, sand whiting, dusky flathead, silver trevally, tailor, blue swimmer, luderick and yellow-finned leatherjacket. Recreational fishing includes shellfish collecting in locations such as Costens Point, Gunnamatta Bay, netting and trapping. Good fishing locations include Hungry Point, Gunnamatta Bay, Bonnievale Spit, Dolans Bay Wharf, South West Arm and Lilli Pilli Baths (Explore Australia 2006). General NSW regulations apply to fishing in the Port.
Commercial fishing and regulations	Commercial fishing is permitted in Port Hacking, the main commercial fisheries operating in the lake is the estuary general commercial fishery. This fishery is managed under the FM Act, Fisheries Management (Estuary General Share Management Plan) Regulation 2006, Fisheries Management (General) Regulation 2010 and the Fisheries Management (Supporting Plan) Regulation 2006. Types of gear commercial fishers may use within Port Hacking include Hand lining, and Hand gathering.
Aquaculture	No aquaculture leases have been issued for Port Hacking (data obtained from the NSW DPI Aquaculture database and correct as of the 21 July 2011).
Popular fishing locations	There are numerous popular fishing locations across this estuary. Examples include fishing from wharves, rocky points, fishing platforms, boat ramps, breakwalls, retaining walls, jetties and from boats.
Fishing Charters	There are a total of 14 charter fishing boat operators in the Port Hacking area of which 13 have endorsements enabling them to fish in the estuary. Of these,12 have current licences. Charter operators, however, are not zoned and it is likely that operators from within this region may also operate in other estuaries such as Sydney Harbour / Port Jackson, Botany Bay and the Hawkesbury River. The numbers of charter operators actively fishing in the estuaries is likely to be lower than the number listed here as a large proportion of these operators will be working under their other endorsements fishing offshore (information obtained from the NSW DPI

Activity	Details
	Licensing database and correct as of 20 July 2011).
Recreational water sports	Swimming, kayaking, recreational fishing, snorkelling, diving, boating, sailing, , recreational and charter fishing, water cruises and jet skiing..
Cultural heritage sites	There are some cultural heritage sites along the foreshores of the Hawkesbury River. There are no known sites that would prohibit recreational fishing.
Cultural activities	Numerous cultural activities occur on and around this estuary including: a wide range of water sports, walking, community based environmental activities (rehabilitation works such as Bushcare and Coastwatch), and a range of festivals and events.

4. Comparison of the Demographic and Recreational Fishing Licence Data for the Bega Valley and the Sydney Metropolitan Area

Socio-economic information on the residents in the Bega Valley Local Government Area (Bega Valley) and in the wider Sydney metropolitan area comes from the most recent Australian Bureau of Statistics Census 2006. At the time of the Census the population of the Bega Valley was 31,062 and the resident population of Sydney was 4,119,190, with the majority of the population (37 % and 44 % respectively) was aged between 24 and 54 years (Figure 1).

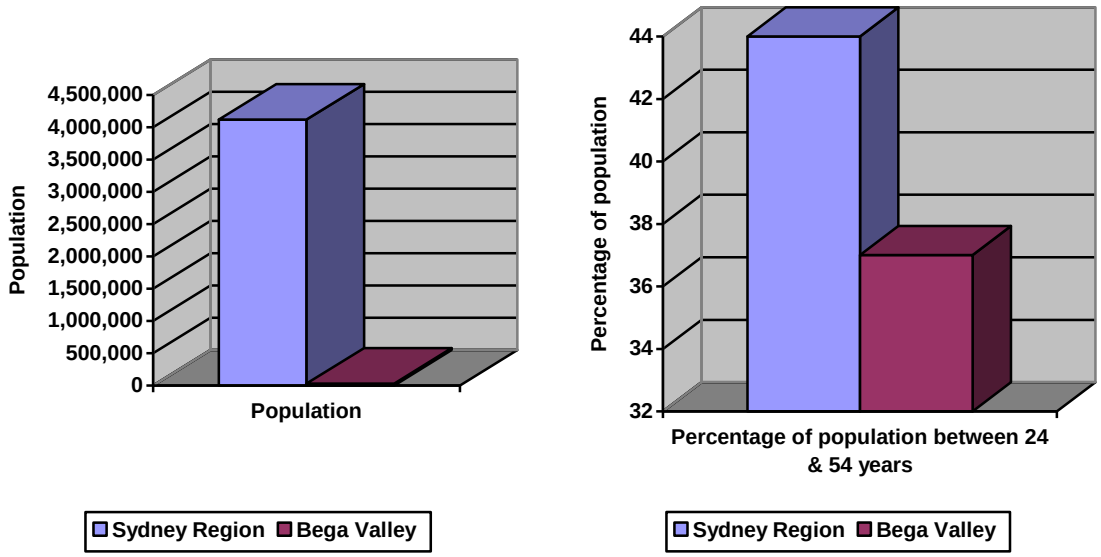


Figure 1: Resident populations of the Sydney and Bega Valley regions (2006).

Just over 60 % of the Sydney population were residents born in Australia. Of the residents in Sydney, 63.1 % were employed full-time and 25.7 % were employed part time, compared with 50 % full time and 35 % part-time work in the Bega valley (Figure 2).

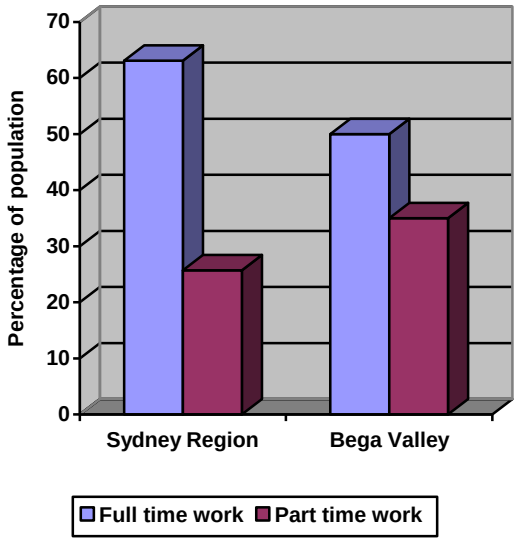


Figure 2: Percentage of the Sydney and Bega Valley populations in full and part-time employment (for 2006).

In the Sydney region, occupations as indicated by the census data are more heavily distributed towards professional businesses rather than the tourism or holiday industry, unlike the regional case study, with employment as professionals being (23.8 %) followed by clerical and administrative workers (16.7 %), managers (13.2 %) and technicians and trades workers (2.8 %). In the Bega valley employment was fairly equally distributed across positions of management, technicians/ trade workers, professionals, labourers, clerical and administration. The most common industries of employment for residents in the Sydney region were education (4.0 %), cafes, restaurants and takeaway food services (3.6 %), hospitals (3.2 %), legal and accounting services (2.8 %). Whereas in the Bega regions the most common industries of employment were education (5.2 %), accommodation (4.1 %), dairy product manufacturing (3.9 %) (inland) and cafes, restaurants and takeaway food services (3.9%) (Figure 3). The relatively high percentages of people working in accommodation and food services reflects the popularity of the location as a holiday spot, and these percentages become greater for the postcodes that are adjacent to the coastal areas such as Merimbula (Post code 2548) where accommodation and cafes, restaurants, and takeaways were the most popular industries of employment.

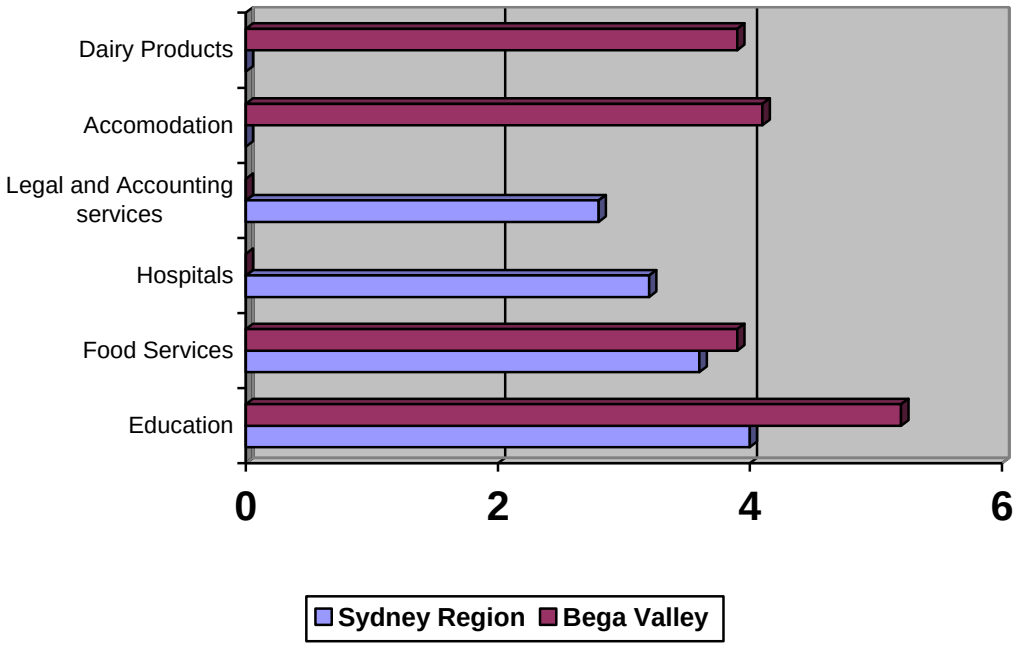


Figure 3: Comparison of occupations of people employed in the Bega Valley and Sydney regions (2006).

The State average for recreational fishing licences is approximately 6.9 %, derived from comparing the 2006 census NSW population of 6,817,182 with the 473,342 recreational fishing licences held throughout NSW in the year 2009/10 (NSW DPI 2011f). These licence sales consisted of 41,864 3-year licences, 178,996 1-year licences, 75,652 1-month licences and 176,830 3-day licences. The recreational fishing licence data obtained from DPI from the 2009/10 data show that Bega Valley has a much higher percentage of fishing licences per resident population than the estimated State average of 6.9 % (Table 9) while the Sydney region although having more licence sales has a lower percentage of fishing licences per resident of population than the estimated state average (Table 10). Within the Bega Valley post codes closest to the coast (i.e. Merimbula, Pambula and Eden) have the highest percentage of licenced fishers per resident population, with the greatest being 11.7 % of the overall population for post code 2551. Recreational fishing licence data obtained from DPI revealed that the Sydney region has a much lower percentage of fishing licences per resident population, with an average of 2.0 % as compared to the Bega Valley regional case study of 8.7 % (Figure 4). Within the Sydney Region, post codes closest to the coast again have the highest percentage of licenced fishers per resident population, with the greatest being 3.54 % of the overall population for post code 2083 (Hawkesbury estuary area).

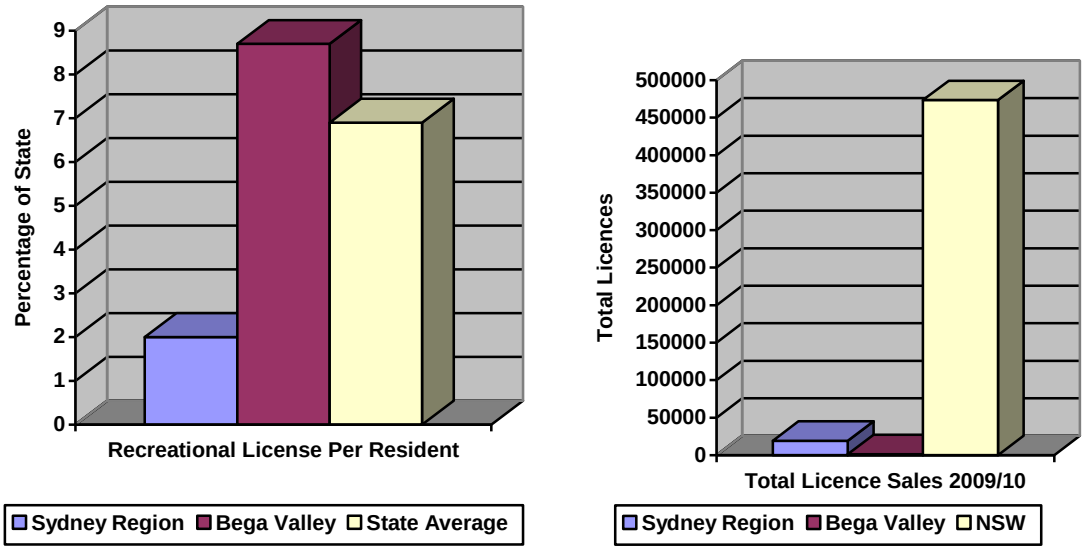


Figure 4: Percentage of recreational fishing licence holders living in the Bega Valley and Sydney regions compared with the NSW State average.

Based on these percentages shown in Tables 9 and 10, recreational fishing is clearly an important activity for the Bega valley local residents and the economy. This is even more prevalent during the peak holiday season with the influx of recreational fishers visiting the area (Bega Valley Shire Council 2011b). The number of businesses relating to recreational fishing or relying on fish produce (i.e. fishing charters, hire boats, takeaways, accommodation etc.) indicates that fishing is important to the local economy as well as being a social and cultural activity directly pursued by residents and visitors. Commercial fishing in the region also contributes to the local economy with Eden having the largest fishing port in NSW.

Although the overall percentage of residents in Sydney and surrounds that hold fishing licences is less than in the regional case study, the proximity of the waterways examined to the highly urbanised environments means that there is heavy usage by recreational fishers and for other recreational water activities by sheer population size. The use of the waterways becomes more intense during weekends and holiday periods. The National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003) showed that participation rates of recreational fishers in Sydney was relatively high, with 13.1 % of people over 5 years of age having fished in the previous 12 months. Similarly 17.2 % of private households contained persons who fished recreationally in the previous 12 months. These survey results revealed the importance of recreational fishing for residents and visitors to Sydney with a choice of large waterways to choose from that include Port Hacking, Botany Bay, Port Jackson and the Hawkesbury River.

Table 9: Recreational fishing licence data for post codes directly adjacent to the case study waterways of Merimbula Lake, Pambula Lake and Curalo Lagoon

Post Code	Population (2006 Census Data)	Number of Fishing Licences Per Post Code (2009/10 licence sales)	Percentage of Fishing Licences Per Population
2548	6,595	452	6.9 %
2549	3,167	284	9.0 %
2551	3,800	444	11.7 %
Total	***13,562***	***1,180***	***8.7 % (Avg. 9.2%)***

Table 10: Recreational fishing licence data for post codes directly adjacent to the case study waterways of Port Hacking, Botany Bay and the Hawkesbury River

Post Code	Population (2006 Census Data)	Number of Fishing Licences Per Post Code (2009/10 licence sales)	Percentage of Fishing Licences Per Population
2019	9,672	141	1.5 %
2020	8,517	175	2.1 %
2036	25,064	320	1.3 %
2044	6,743	119	1.8 %
2080	1,551	37	2.4 %
2081	4,865	115	2.4 %
2082	5,182	107	2.1 %
2083	1,697	60	3.5 %
2084	3,753	52	1.4 %
2101	16,317	321	2.0 %
2102	4,994	99	2.0 %
2103	9,540	170	1.8 %
2104	3,088	33	1.1 %
2105	1,928	44	2.3 %
2106	8,507	184	2.2 %
2107	14,422	223	1.5 %
2108	1,708	36	2.1 %
2133	10,458	141	1.3 %
2136	3,581	84	2.3 %
2159	5,107	104	2.0 %
2163	11,714	152	1.3 %
2166	47,319	1,148	2.4 %

Post Code	Population (2006 Census Data)	Number of Fishing Licences Per Post Code (2009/10 licence sales)	Percentage of Fishing Licences Per Population
2170	85,336	1,832	2.1 %
2171	22,131	583	2.6 %
2173	12,969	240	1.9 %
2191	5,711	82	1.4 %
2193	12,964	208	1.6 %
2194	21,577	394	1.8 %
2198	8,051	189	2.3 %
2200	37,959	712	1.9 %
2203	12,207	149	1.2 %
2204	23,771	335	1.4 %
2205	14,137	276	2.0 %
2206	16,562	308	1.9 %
2210	27,013	469	1.7 %
2211	14,484	281	1.9 %
2212	13,853	248	1.8 %
2213	19,514	363	1.9 %
2214	3,887	91	2.3 %
2216	23,421	520	2.2 %
2217	22,223	397	1.8 %
2219	11,807	242	2.0 %
2221	15,247	261	1.7 %
2223	19,620	329	1.7 %
2224	13,223	243	1.8 %
2226	10,981	253	2.3 %
2227	12,956	245	1.9 %
2228	16,810	326	1.9 %
2229	25,952	502	1.9 %
2231	2,109	62	2.9 %
2232	31,621	638	2.0 %
2234	31,125	508	1.6 %
2250	63,833	1,353	2.1 %
2251	31,451	657	2.1 %
2256	14,786	413	2.8 %
2257	26,788	896	3.3 %

Post Code	Population (2006 Census Data)	Number of Fishing Licences Per Post Code (2009/10 licence sales)	Percentage of Fishing Licences Per Population
2756	30,764	715	2.3 %
2775	1,564	47	3.0 %
Total	***964,134***	***19,232***	***2.0 % (Avg. 2.0%)***

5. Potential Social Impacts of Marine Fish Stocking for the Bega Valley Area

A study in Germany (Arlinghaus *et al.* 2010) found that urban residents who fish exclusively outside the city of Berlin represented a unique target market for rural areas as these anglers travelled long distances, had high expenditure within the local area, but generally caught low numbers of fish.

Within the Bega Valley Shire, the economy of coastal towns is becoming increasingly dependent on tourism, which is the most important tertiary industry in the region.

Popular recreational fishing locations in the case study area include the wharf at Merimbula, boat ramps, onshore banks and beaches, bars, headlands, rocky shores and boat fishing. Flathead and bream are popular fish catches in the estuaries, lakes and lagoons, whereas whiting, prawns, snapper, tailor, tuna, salmon, leather jacket and trevally are common in the coastal waters.

There are likely to be potential social impacts of marine fish stocking in the case study area. Some of these impacts are identified below:

- Stocking can be expected to boost recreational fishing opportunities for fishers living locally in the region and those travelling to the region to fish.
- It is not expected that the marine stocking proposal will increase overall fishing effort in NSW (D 5.2.2.7). At a State level the net effect would be insignificant as declines in fishing activity in one area is likely to be offset by an increase in activity in another. A potential change may occur among the more active recreational fishing groups trying to pursue a greater catch. Therefore fishing effort may increase at a local scale if there is a clear increase in the volume of fish in the stocked waterways.
- Fishers may be motivated to fish a stocked estuary for purposes other than just to catch fish (such as an appreciation for the outdoors or relaxation).
- Both commercial and recreational fishing occurs in the case study area. The historical commercial fishing activity in Eden, Pambula Lake, Curalo Lagoon and Merimbula Lake and their popularity for recreational fishing (demonstrated in the high proportion of fishing licence holders in the area) indicates that the two sectors can coexist and interact in the same waterway. Stocking activities would be expected to improve fishing opportunities and benefit both commercial and recreational fishers and the local economy in these areas.
- Commercial fishing in Pambula River is prohibited, therefore no conflict is likely to arise over allocation of resources between recreational and commercial fishers at this location.
- The fishing charter businesses which are registered in Merimbula and within the Bega Valley Shire would be likely to benefit from a marine stocking program. Charter operators not based in the case study area would also benefit as they area may temporarily move their business activity into stocked estuaries.
- Research into the case study area indicates that there are no known cultural heritage sites that would be adversely impacted by marine fish stocking or that would prohibit recreational fishing from taking place on or near the site;
- Recreational fishers share the waterways with other water users that partake in popular cultural activities such as sailing, diving, kayaking, swimming and water skiing. Marine fish stocking is not considered to exacerbate conflicts between recreational fishers and other water users. Recreational fishers and other water users currently coexist in many other waterways, including urbanised waterways with very high levels of usage. Regulations such as no wash zones, speed limits and navigation closures, currently minimise and manage interaction between user groups and minimise potential for conflict. The case study area offers numerous locations for recreational fishing (including shallow banks, deep holes, tidal flow areas and reef), such that competition for space and disturbance of fishing activities by other recreational activities is not expected to escalate beyond current levels.

6. Potential Social Impacts of Marine Fish Stocking in the Sydney Metropolitan Area

There are numerous popular recreational fishing locations in the case study areas including wharves, boat ramps, platforms, retaining walls, rocky points, shore areas, reefs, beaches and fishing from water craft. The popular fish caught across these waterways include bream, flathead, leatherjacket, luderick, tailor, trevally, whiting, mulloway, tailor and kingfish (Steffe *et al.*, 1996). Fish considered for stocking as an outcome of this project would include yellowfin bream, mulloway, flathead, sand whiting, eastern king prawn, giant mud crab and blue swimmer crab.

The potential social impact of stocking of the species outlined above in the case study area is likely to be both positive and adverse. Some of these impacts are identified below:

- Stocking can be expected to boost recreational fishing opportunities for fishers living locally in the region and those travelling to the region to fish.
- It is not expected that the marine stocking proposal will increase overall fishing effort in NSW (D 5.2.2.7). At a state-level the net effect would be insignificant, as declines in fishing activity in one area is likely to be offset by an increase in activity in another. A potential change may occur among the more active recreational fishing groups trying to pursue a greater catch. Therefore fishing effort may increase at a local scale if there is a clear increase in the volume of fish in the stocked waterways.
- Fishers may be motivated to fish a stocked estuary for purposes other than just to catch fish (such as an appreciation for the outdoors or relaxation).
- Both commercial and recreational fishing occur in the Hawkesbury River (very limited commercial fishing occurs in Port Hacking while there is substantial fishing activity in the Hawkesbury River). Recreational fishing is very popular in all three case study locations given the high population in Sydney. Reports of some conflicts may exist between local recreational fishers and commercial fishers. In the Hawkesbury River (particularly Mooney Creek, Marramarra Creek and Berowra Creeks) there was some discontent expressed by some local fishers at a consultation meeting regarding commercial fishing practices in the Hawkesbury System. However, given this high level of recreational and commercial fishing activity in the Hawkesbury, marine fish stocking may serve to alleviate any existing conflict issues resulting from interaction between the sectors potentially augmenting the existing resource. There is very limited commercial fishing activity in Botany Bay and Port Hacking therefore no conflict is expected to arise over allocation of resources between recreational and commercial fishers at this location.
- There are a number of spatial and gear related fishing closures within some of the waterways due to a combination of regulations and management strategies to address conservation and public safety. It is considered that marine fish stocking will not require any change to the status of these regulations and strategies.
- Potential conflicts may arise between recreational fishers and aquaculture operators if stocked species had an impact on cultured species.
- There are a number of charter businesses operating in estuaries that could benefit from marine stocking in the Sydney metropolitan area.
- Potential conflicts would likely continue between noisy waterway users such as jet skis and recreational fishers, where competition over space occurs (this is particularly an issue in Port Hacking).
- Research into the case study area indicates that there are no known cultural heritage sites that would be adversely impacted by marine fish stocking.
- National Parks and sites of cultural heritage significance across the study areas permit recreational fishing to take place.
- Recreational fishers share the waterways with other water users that partake in popular cultural activities such as sailing, diving, kayaking, swimming and water skiing. Marine fish stocking is not considered to exacerbate conflicts between recreational fishers and other water users. Recreational fishers and other water users currently coexist in these highly urbanised waterways with very high levels of usage. Current

management strategies already exist, such as no wash zones, speed limits and navigation closures, to minimise and manage interaction between user groups. The case study area is very large and offers numerous locations for recreational fishing (including shallow banks, deep holes, tidal flow areas and reef), such that competition for space and disturbance of fishing activities by other recreational activities is not expected to escalate beyond current levels.

7. Conclusion of Social Case Studies

A social assessment of the proposed fish stocking program is necessary to understand how human interaction with the process affects what biological and ecological outcomes are achieved.

Given that it was not feasible to review and describe the social conditions for all 80 estuaries within the scope of the EIS, two case studies were used as a representative portion of those estuaries in a regional and metropolitan context. The key social issues identified to influence the marine stocking program included:

- Non - Aboriginal cultural values;
- Resource sharing;
- Community support interaction and regulation;
- Fishing participation and effort;
- Conflict between fishing groups and other waterway users

Sutton & Tobin (2009) highlighted the importance of stakeholder engagement to improve stakeholder support for management strategies. Similarly Granek *et al*. (2008) recommend meaningful participation and involvement of anglers in management activities and strategies. The NSW stocking program will involve ongoing consultation with relevant stakeholder groups during the development and implementation of stocking plans, which will continue to enhance the social elements of the proposed program overt time.

Sutton (2006) identifies a wide range of motivations for people to participate in recreational fishing, which illustrates the social benefits of fishing. Enhancing recreational fishing can improve fishing opportunities; however, Sutton's study highlights the potential additional benefits of enhancement activities, which can include appreciation of the overall experience and associated social and health benefits of relaxing, being outdoors and spending time with family and friends. It is with this in mind that fish stocking should also be considered when evaluating the social impact of the proposal.

Appendix 6

SERM Outputs

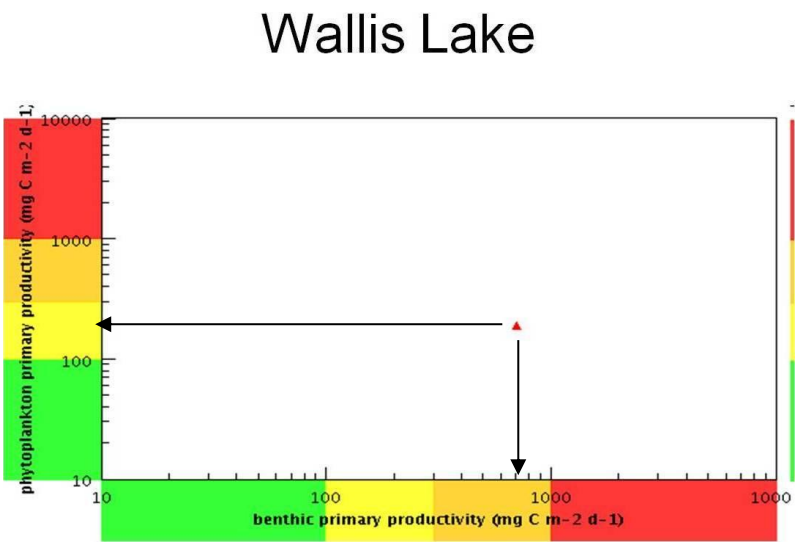
Appendix 6: The CSIRO Simple Estuarine Response Model (SERM) Estimates for Estuaries Proposed for Marine Stocking

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 GPIM. 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). An example SERM output and its result is given below.

Example of SERM output and its result for a single estuary (Wallis Lake).



The total productivity can be read from the individual plots as the benthic primary productivity (x-axis) + phytoplankton primary productivity (y-axis) as indicated by the two arrows.

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

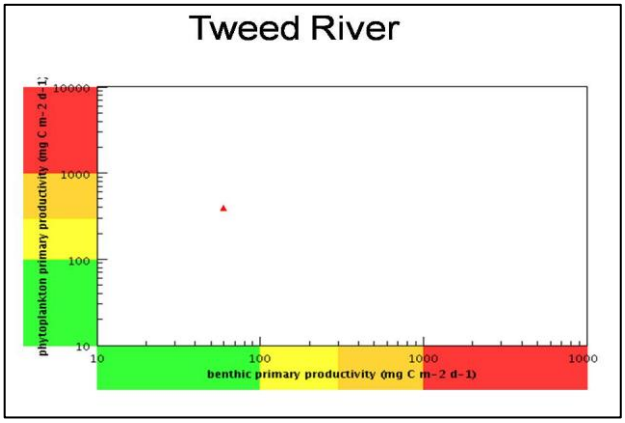
Coastal lagoon - Low productivity (<1 g m^{-2} d^{-1})

Coastal lagoon - High productivity (≥1 g m^{-2} d^{-1})

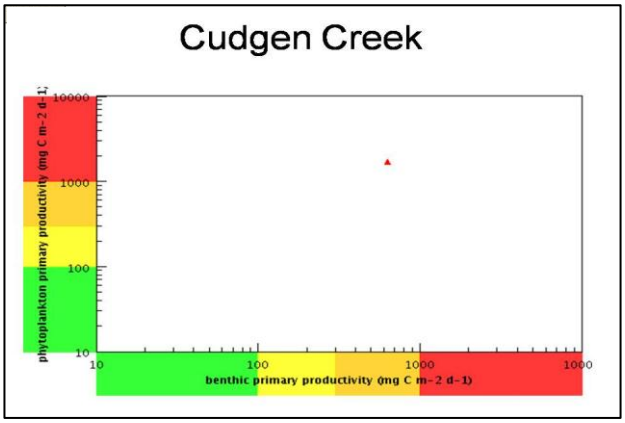
Riverine estuary - Low Productivity (<1 g m^{-2} d^{-1})

Riverine estuary - High Productivity (≥1 g m^{-2} d^{-1})

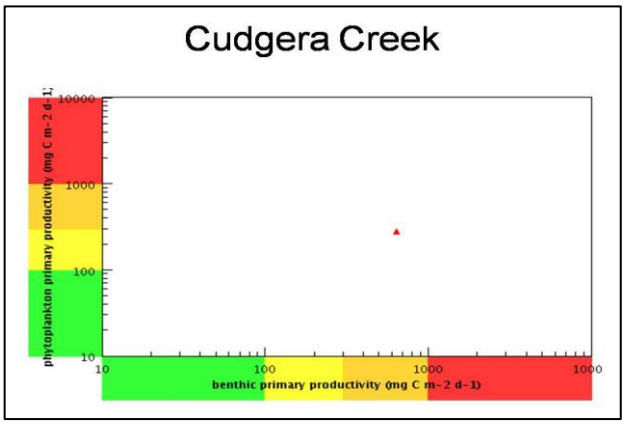
SERM estimates of primary productivity were averaged for all estuaries assigned to each category and a separate GPIM run undertaken for each category.



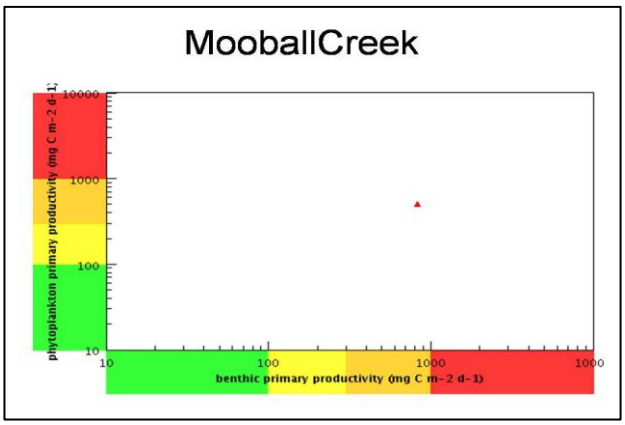
Riverine Estuary – Low Productivity



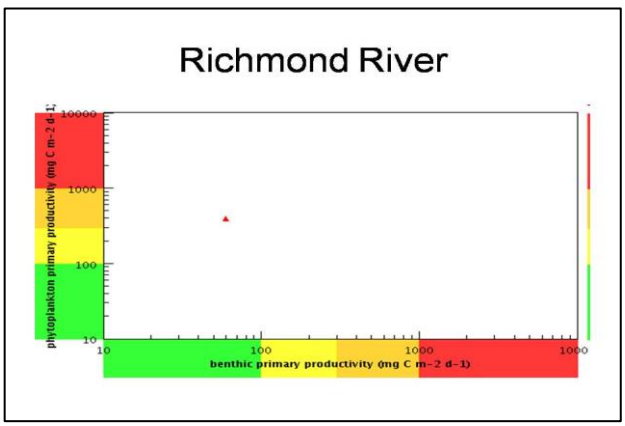
Riverine Estuary – High Productivity



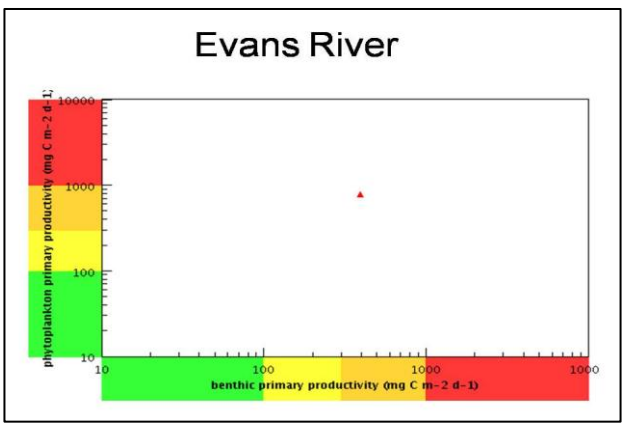
Riverine Estuary – Low Productivity



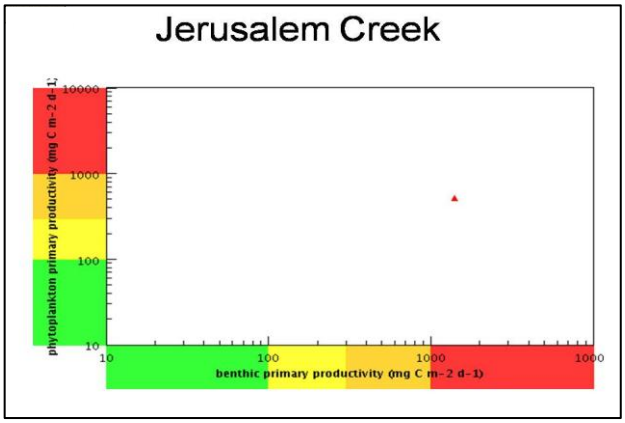
Riverine Estuary – High Productivity



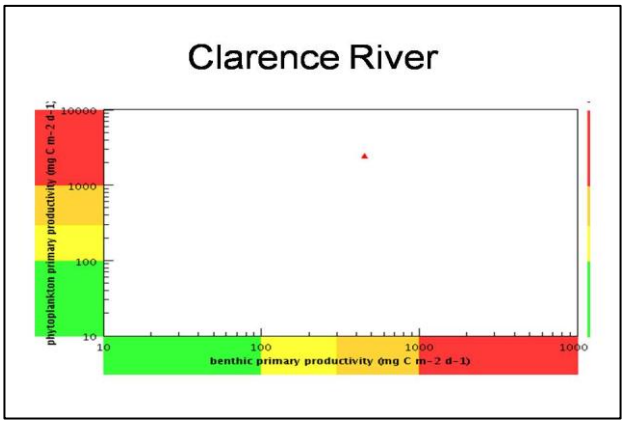
Riverine Estuary– Low Productivity



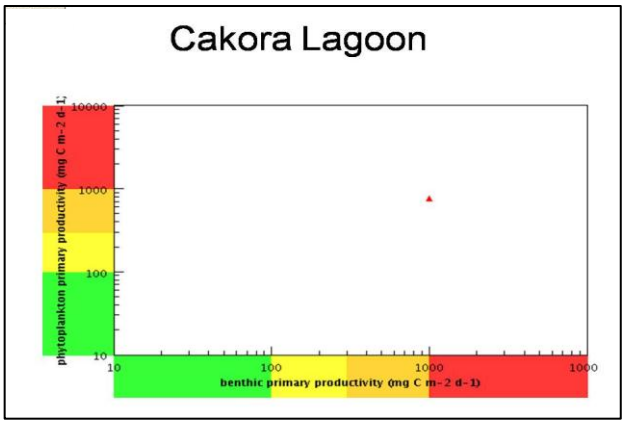
Riverine Estuary – High Productivity



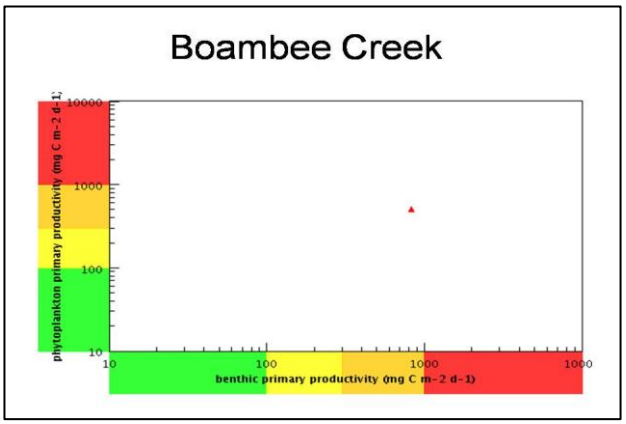
Coastal Lagoon – High Productivity



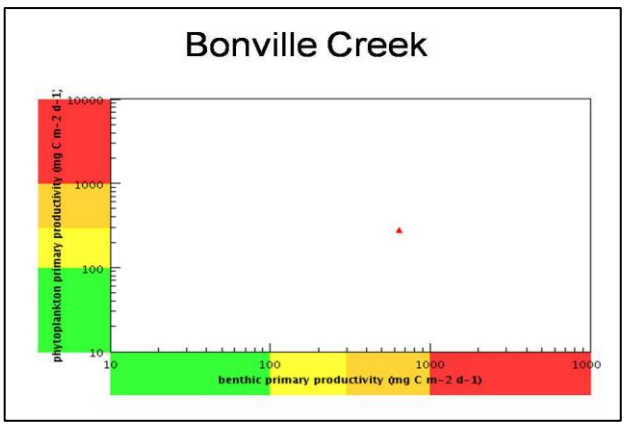
Riverine Estuary – High Productivity



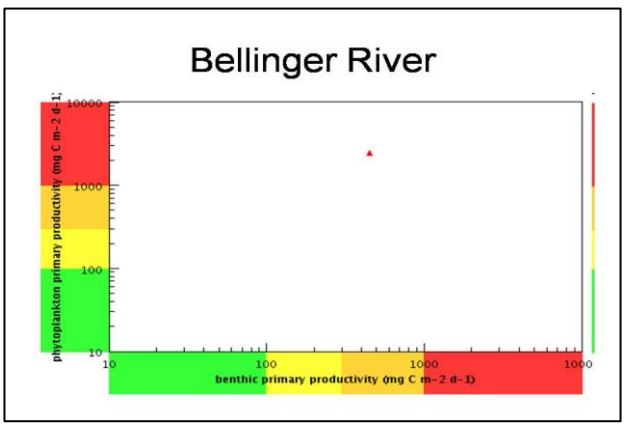
Coastal Lagoon – High Productivity



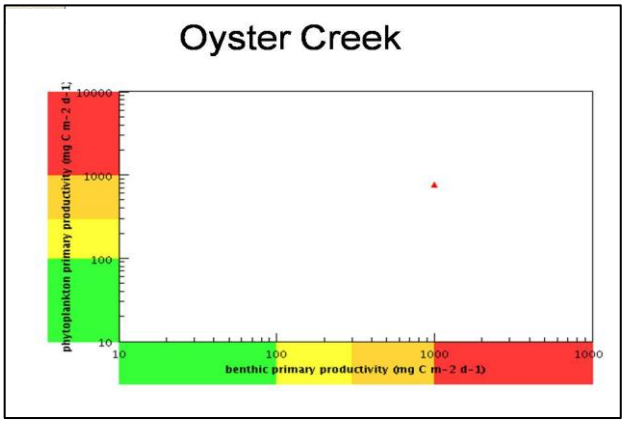
Riverine Estuary – High Productivity



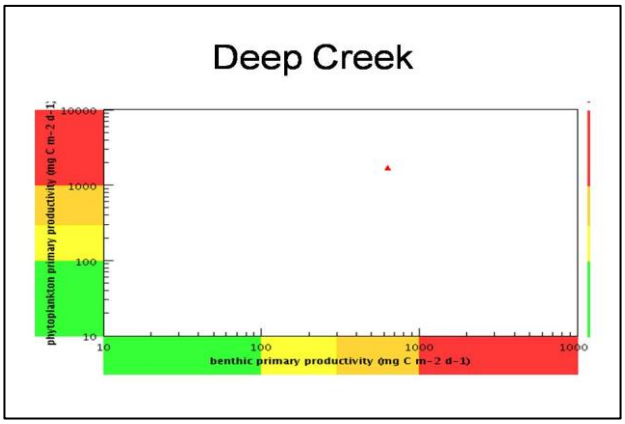
Riverine Estuary – Low Productivity



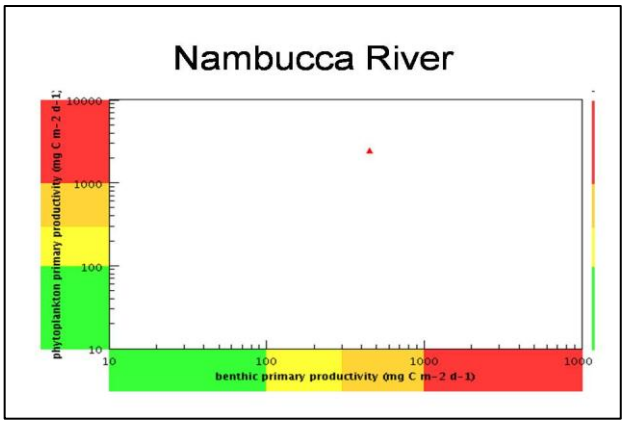
Riverine Estuary – High Productivity



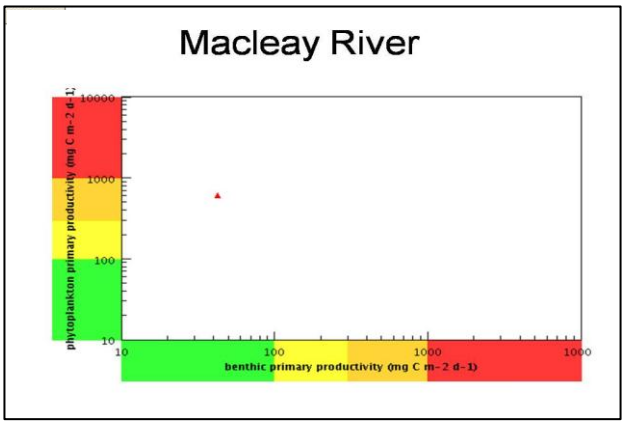
Coastal Lagoon – High Productivity



Riverine Estuary – High Productivity



Riverine Estuary – High Productivity



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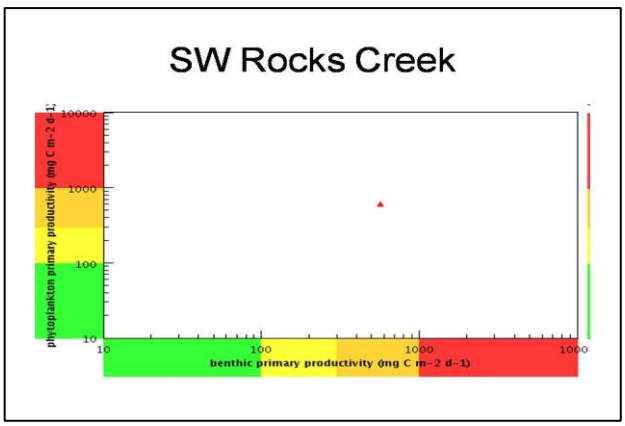

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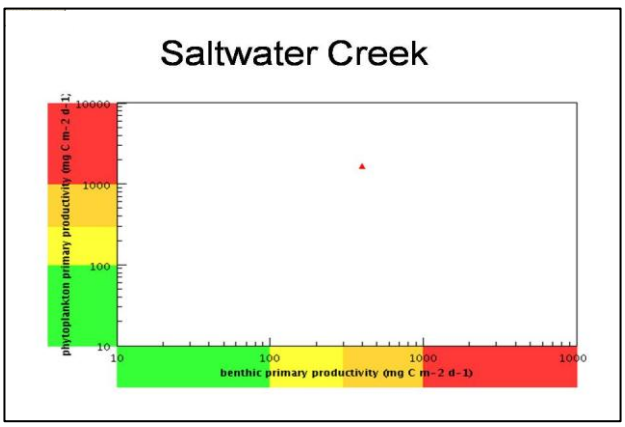

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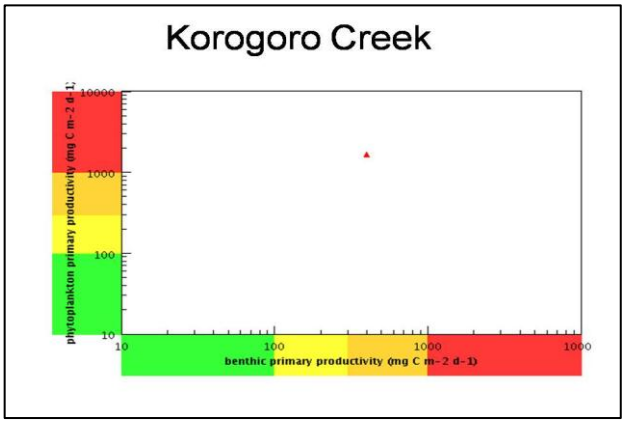

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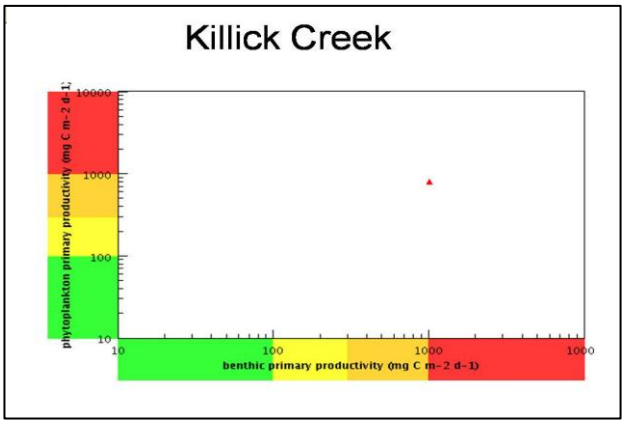
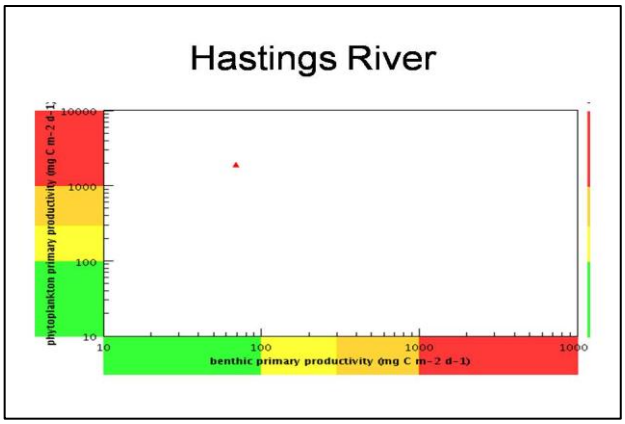


Coastal Lagoon – High Productivity



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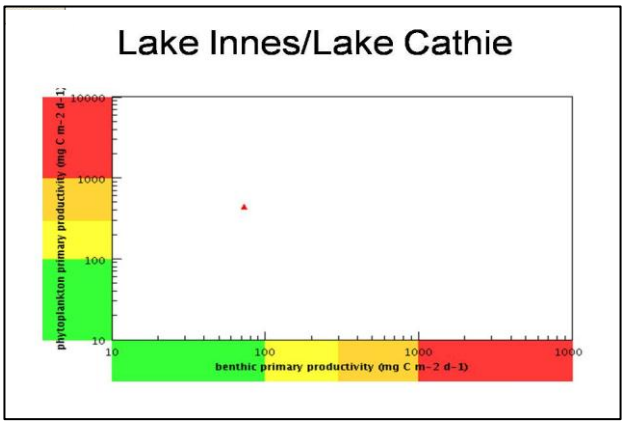

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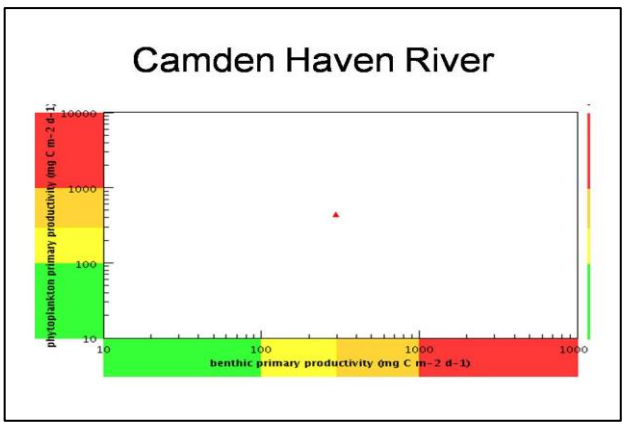

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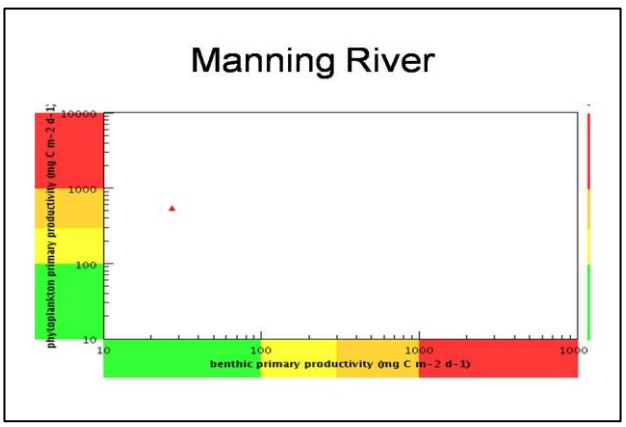

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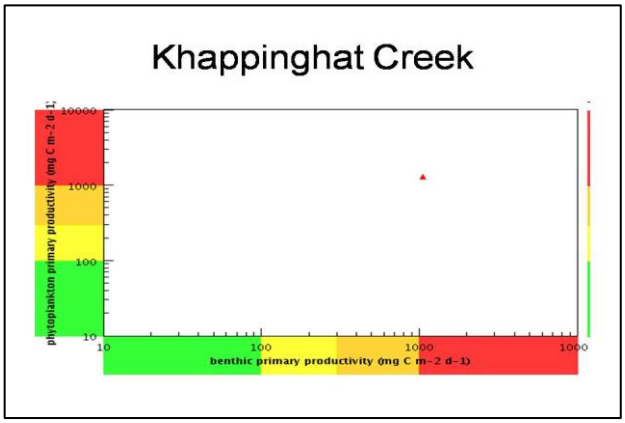

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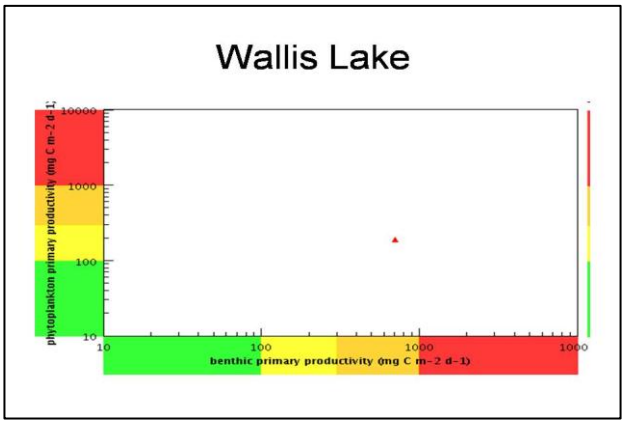

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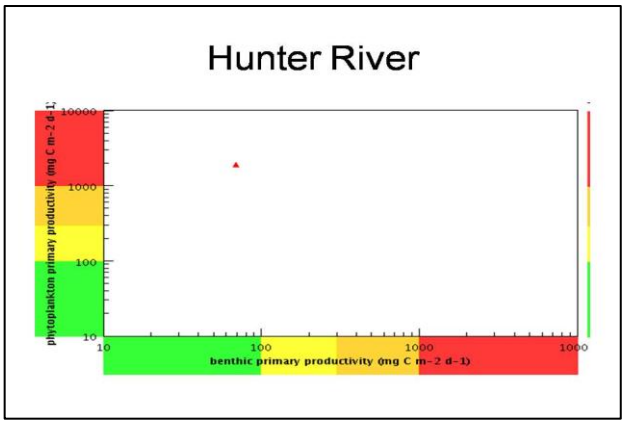

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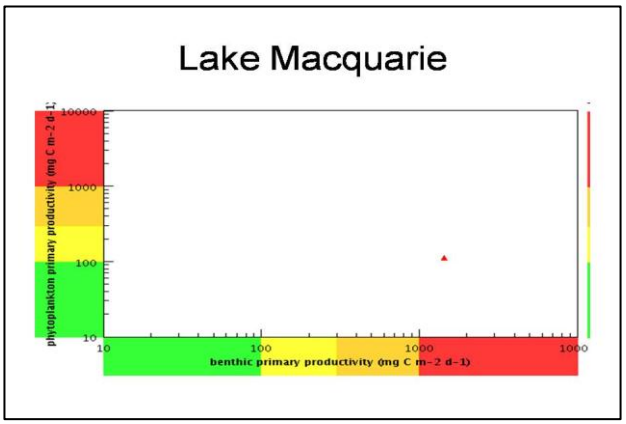

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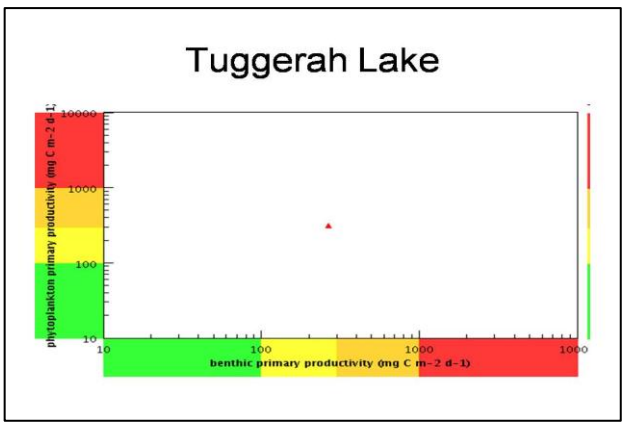
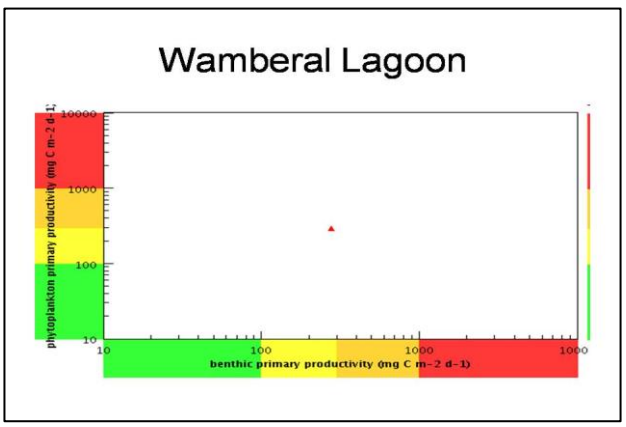
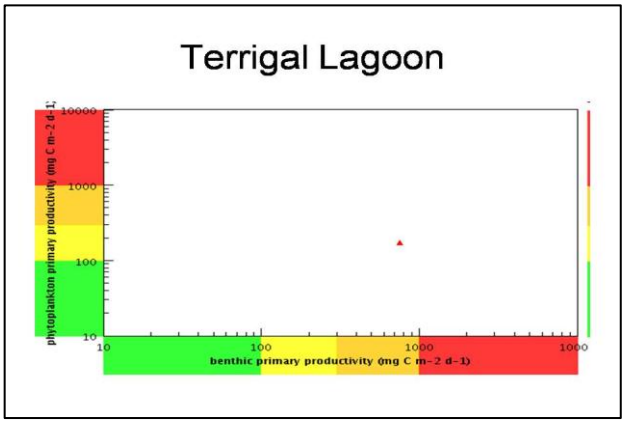


Coastal Lagoon – Low Productivity



Coastal Lagoon – Low Productivity



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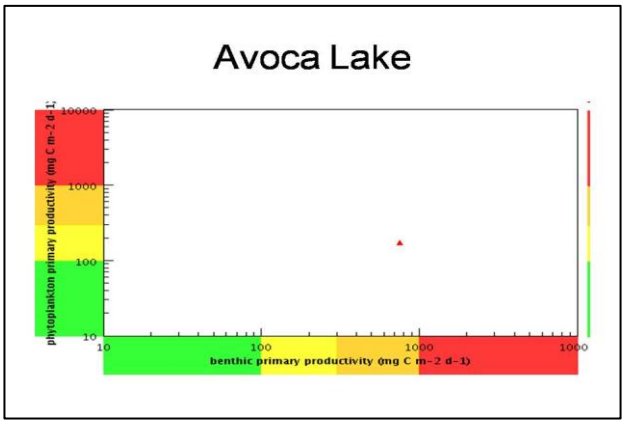

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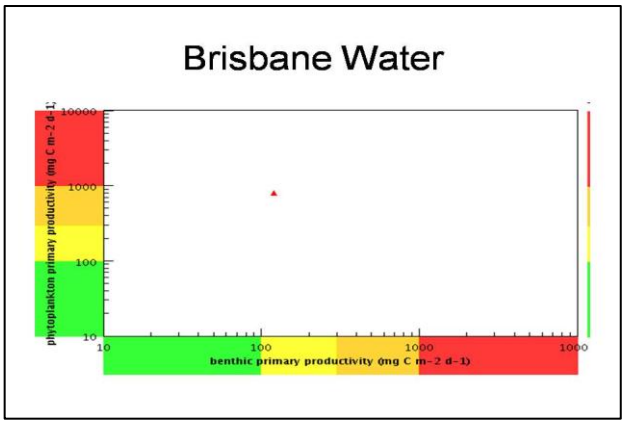

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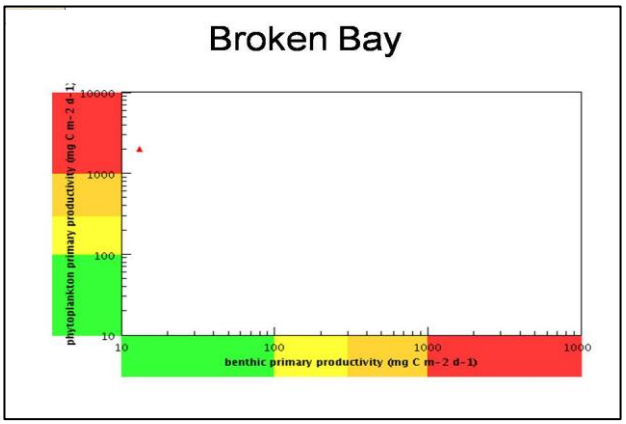

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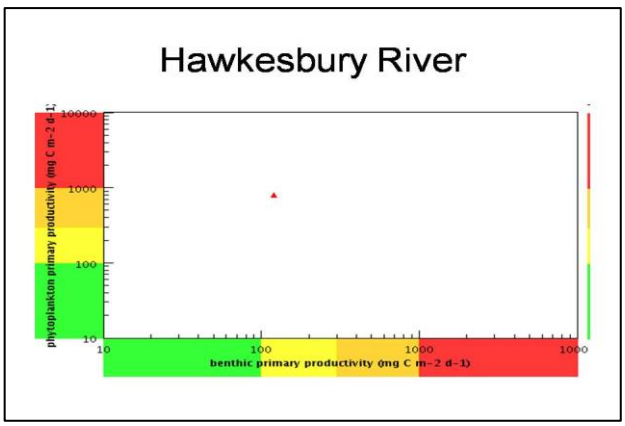

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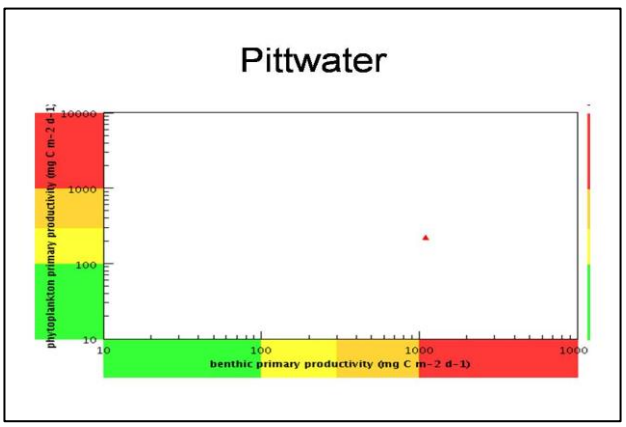

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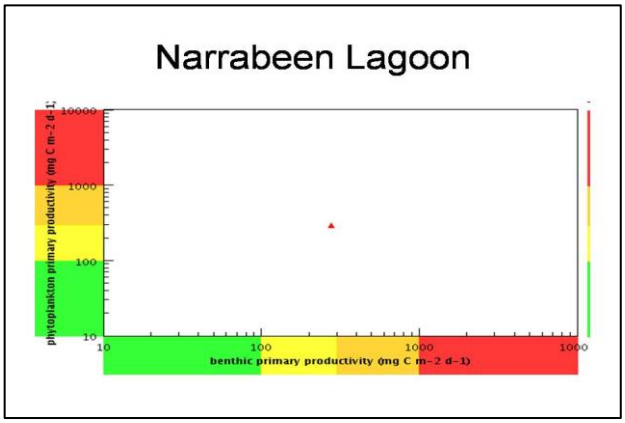

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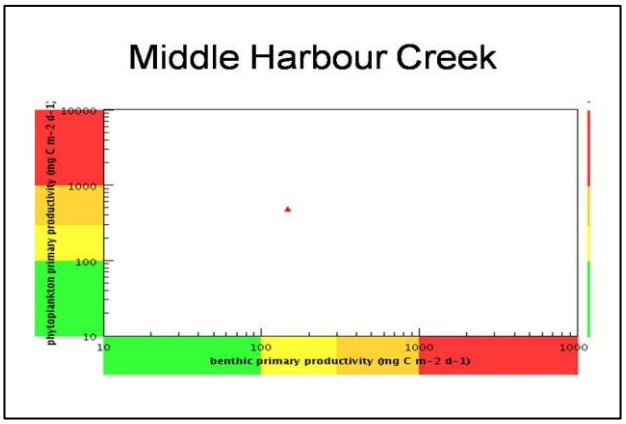

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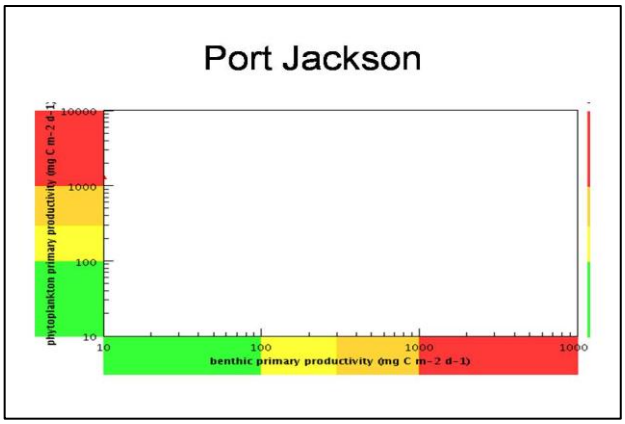

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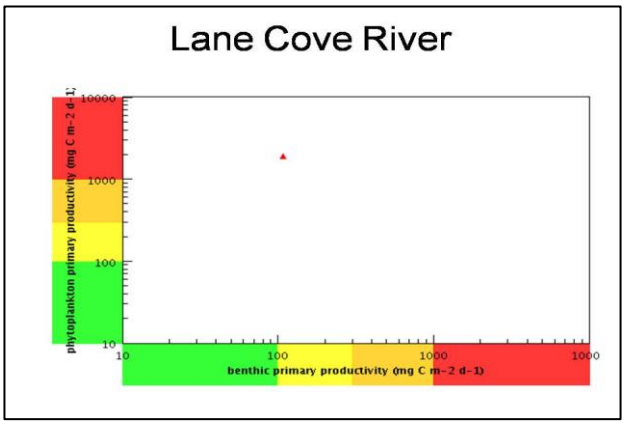

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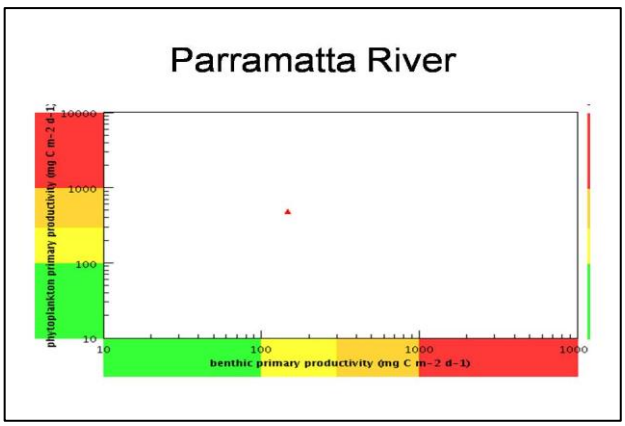

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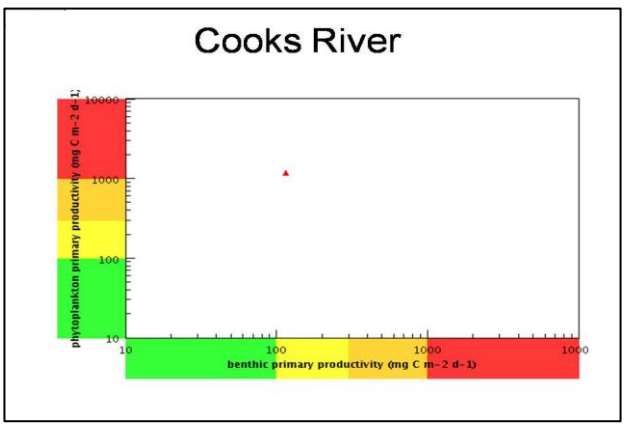

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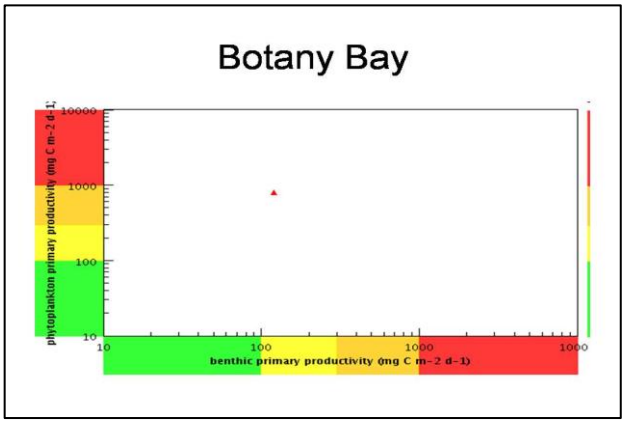

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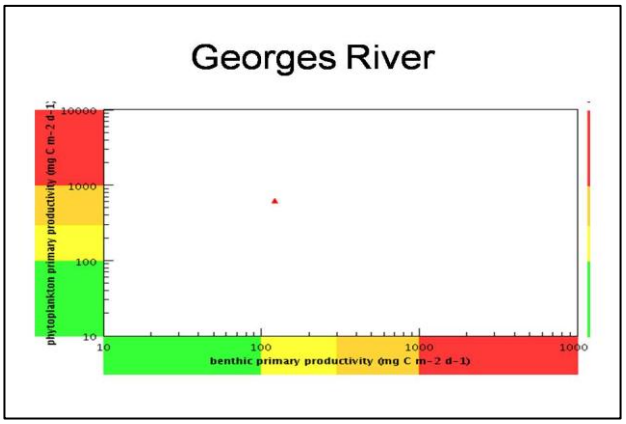

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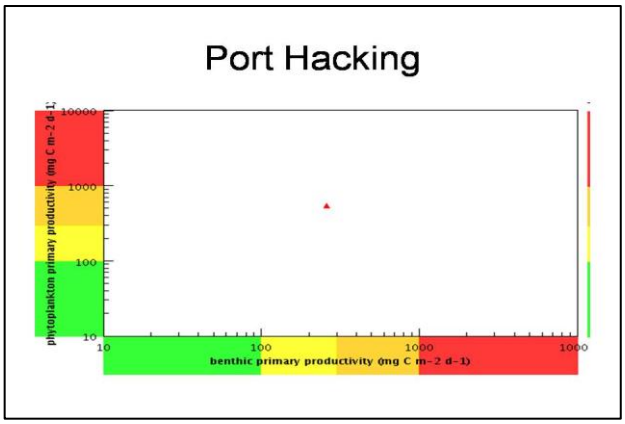

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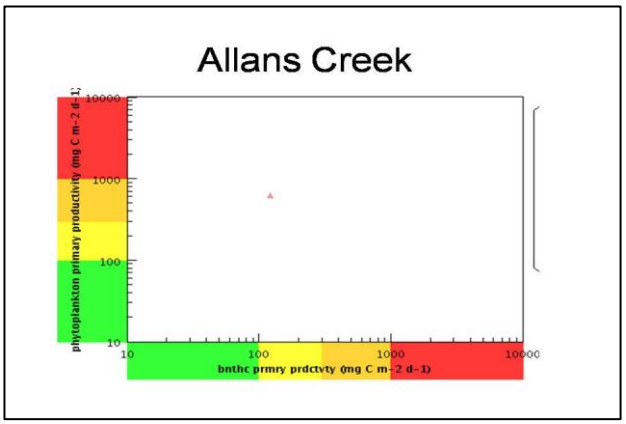

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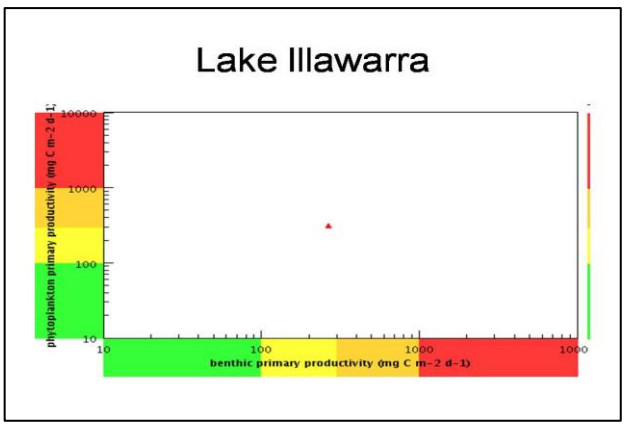
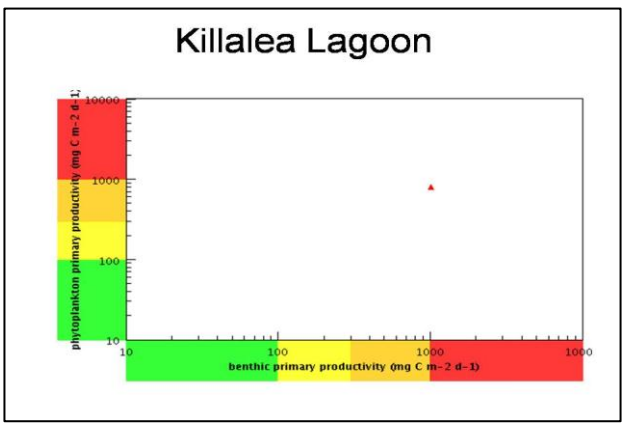
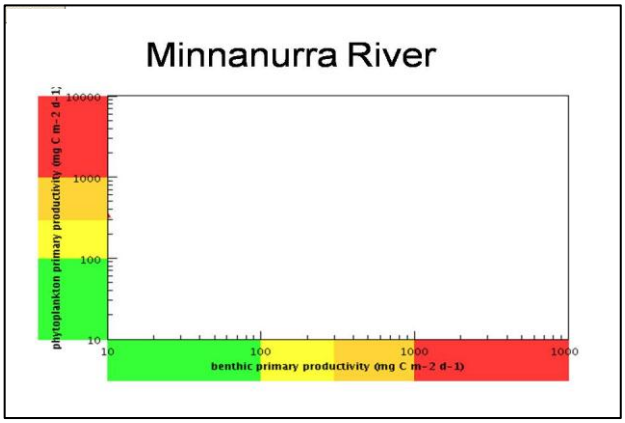


Coastal Lagoon – Low Productivity



Coastal Lagoon – High Productivity



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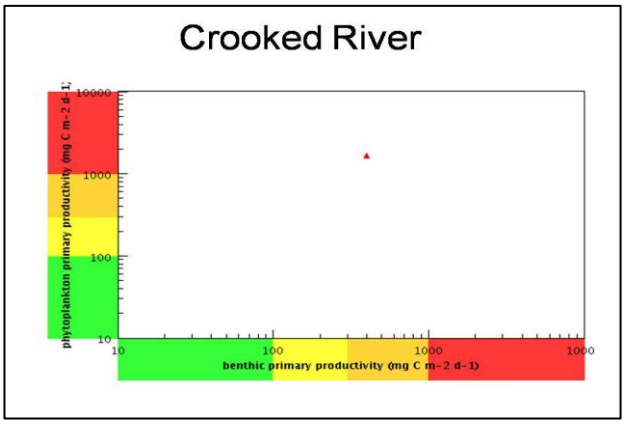

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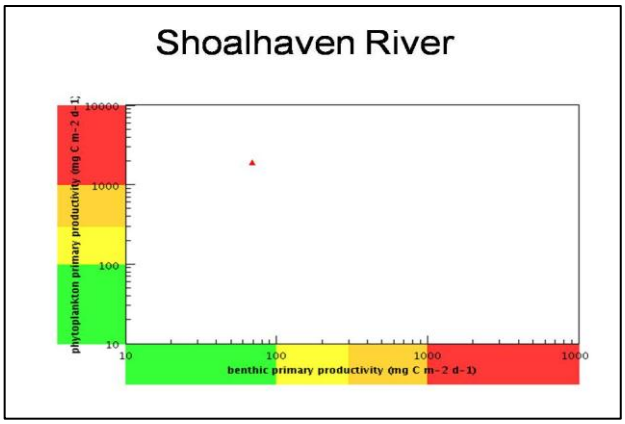
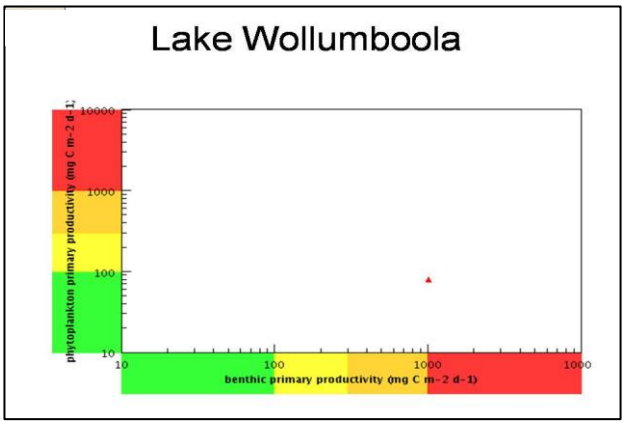
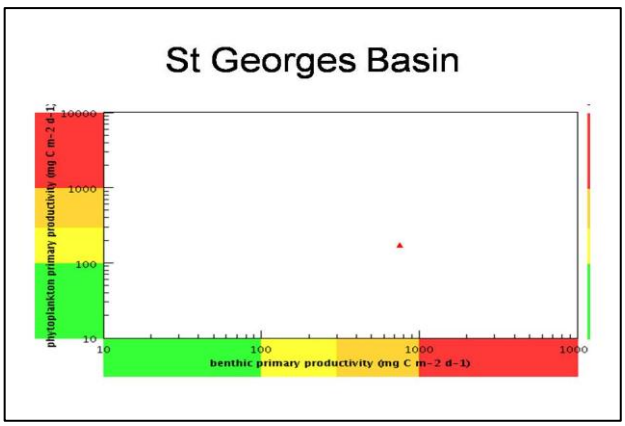


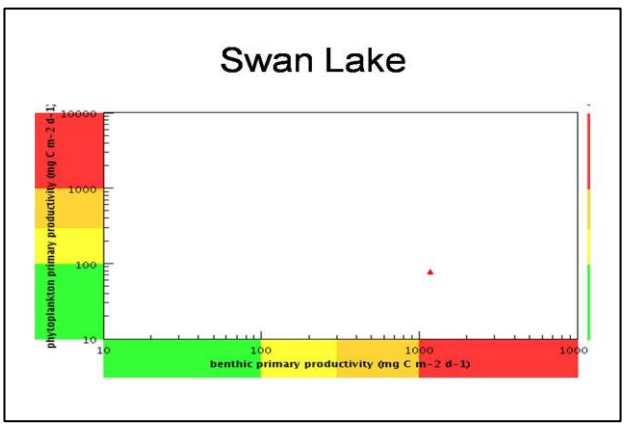
Riverine Estuary – High Productivity



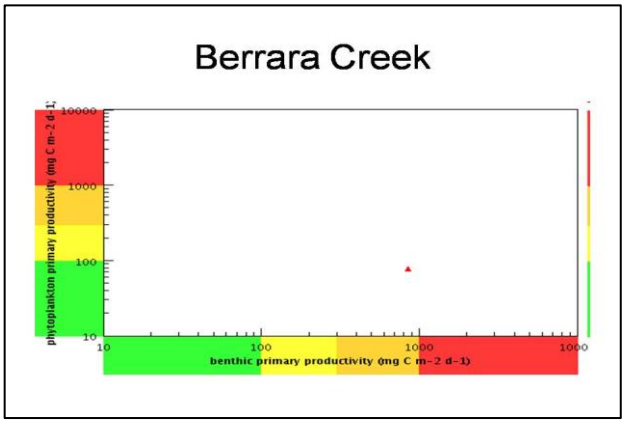
Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



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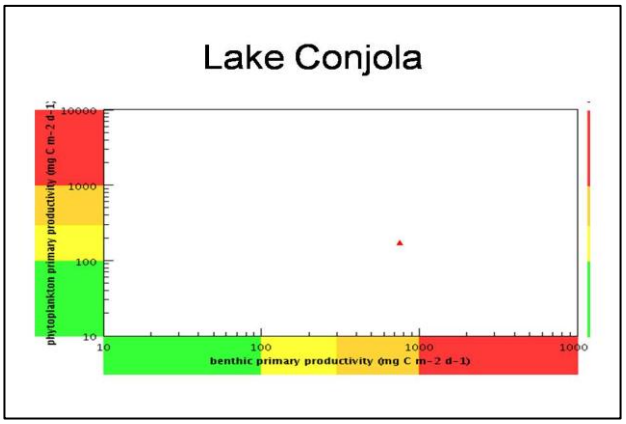

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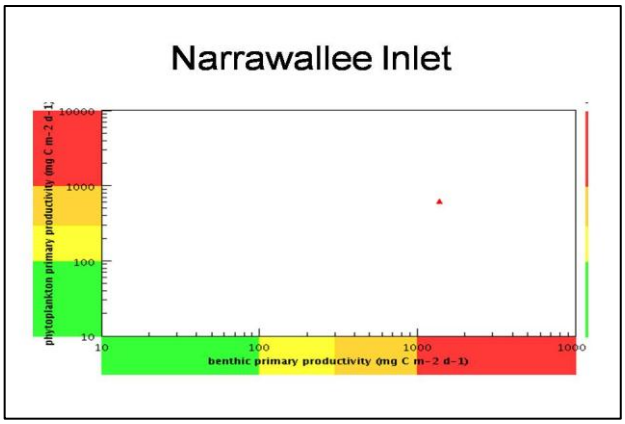

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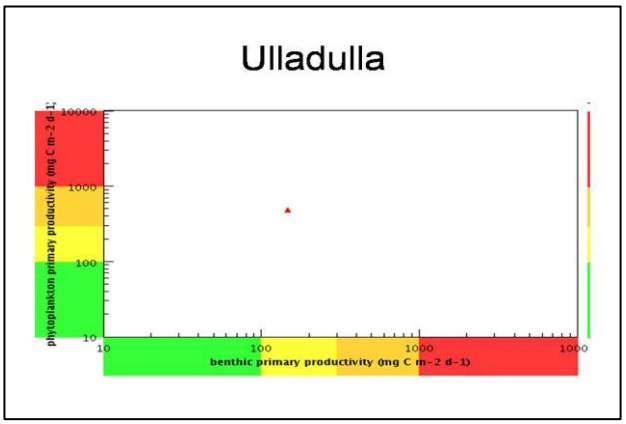

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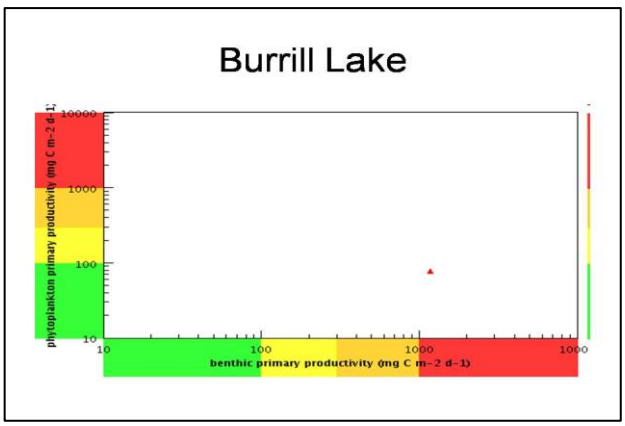
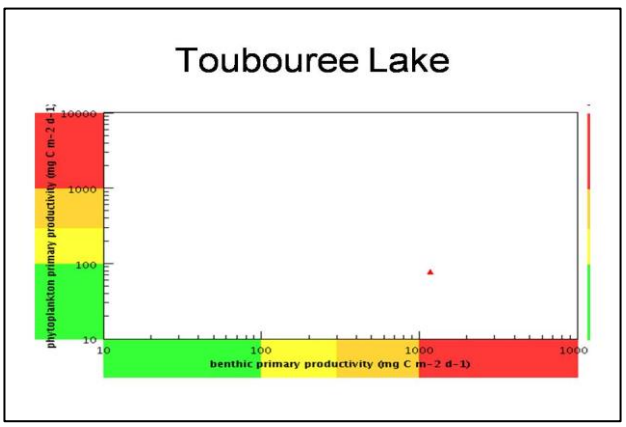
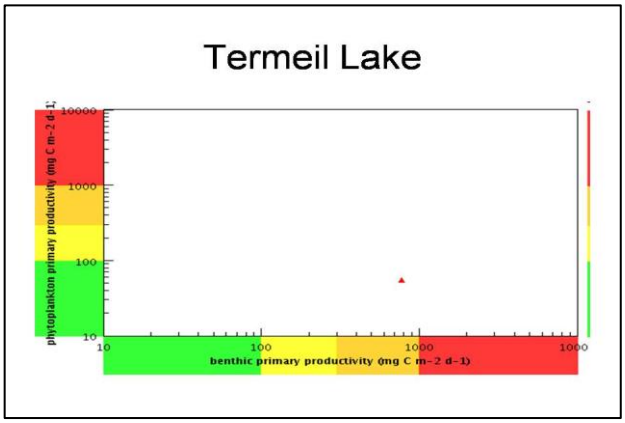


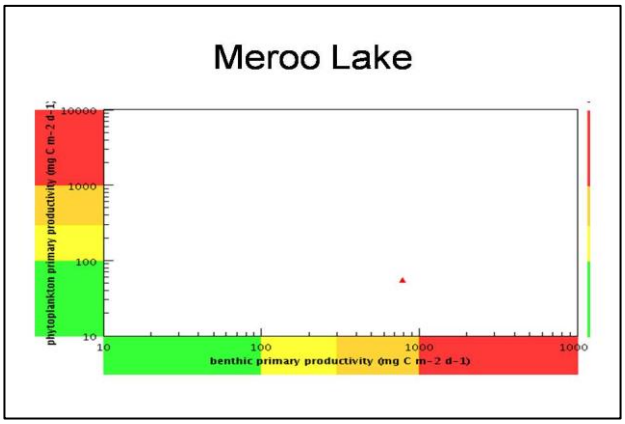
Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



Riverine Estuary – Low Productivity



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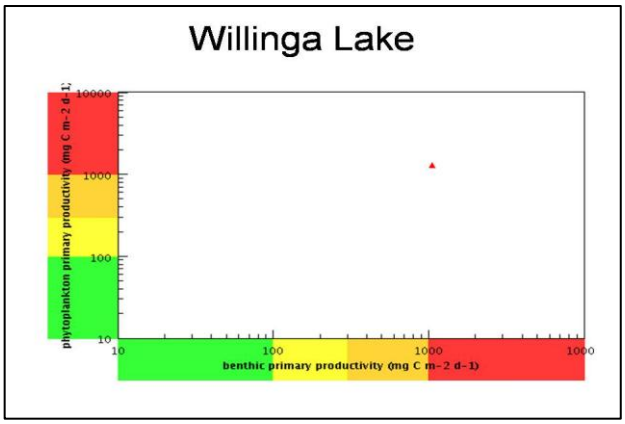
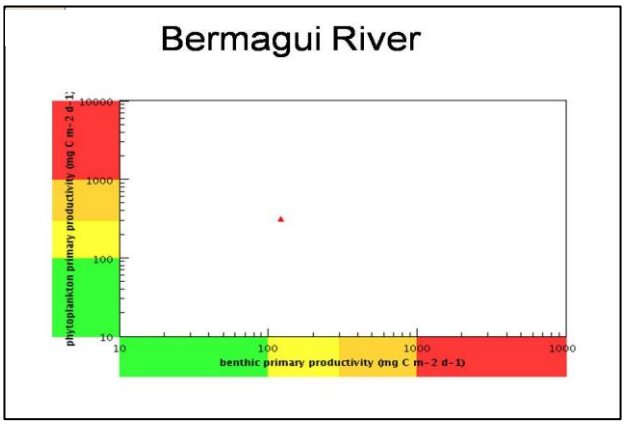
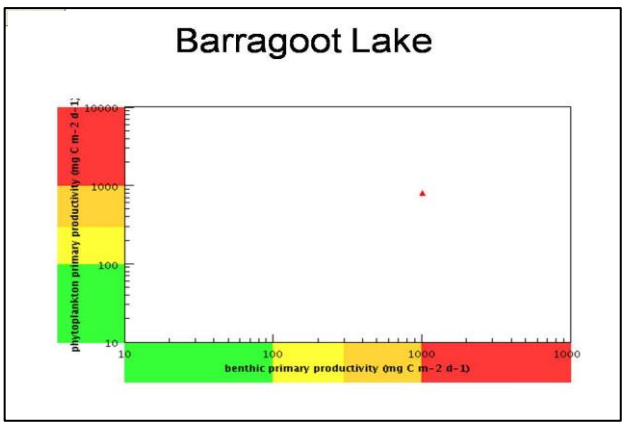


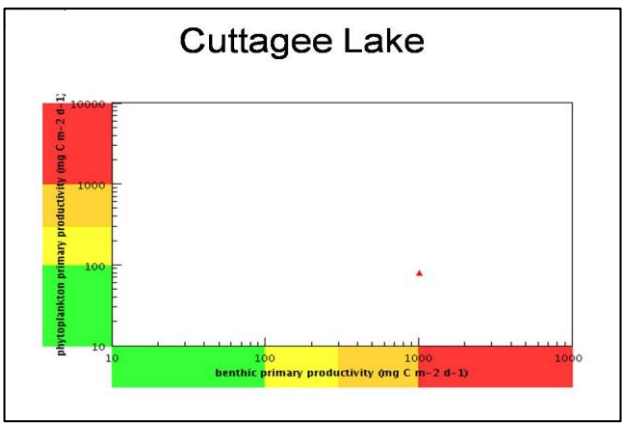
Riverine Estuary – High Productivity



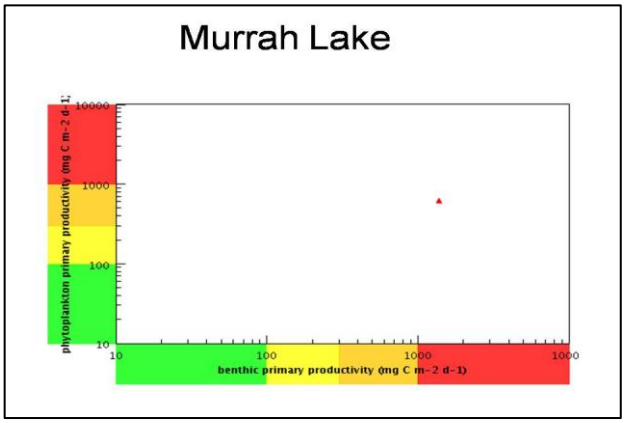
Coastal Lagoon – Low Productivity



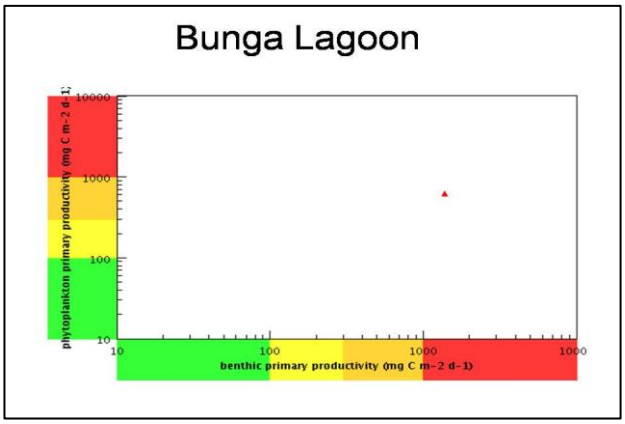
Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



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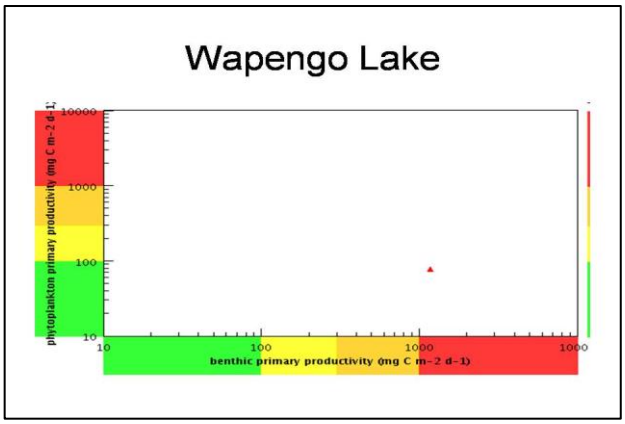
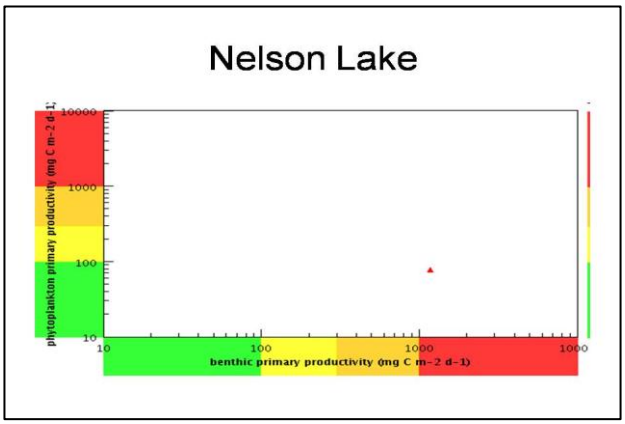
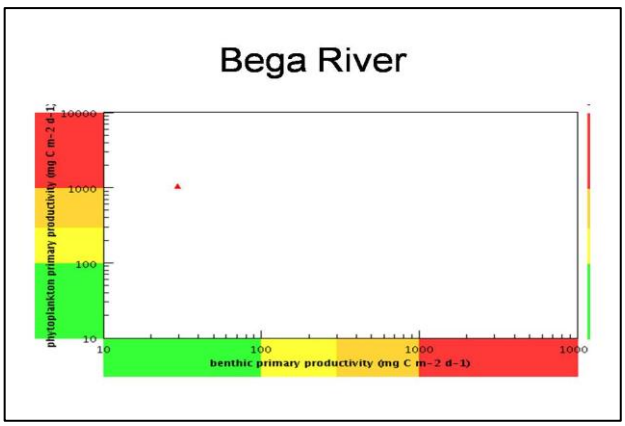


Coastal Lagoon – High Productivity



Coastal Lagoon – High Productivity



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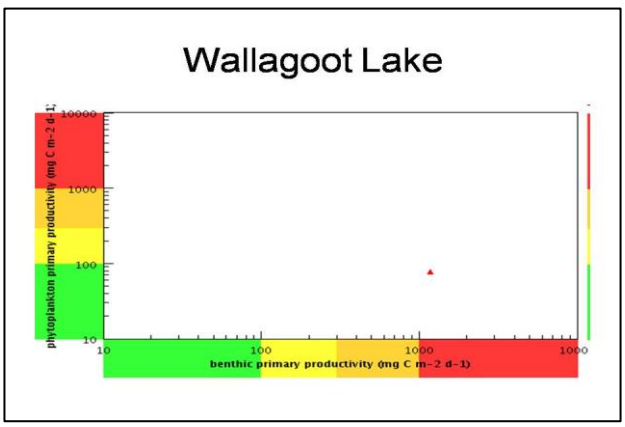

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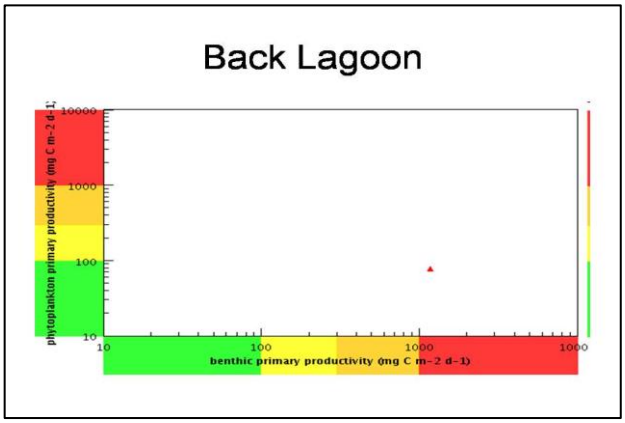

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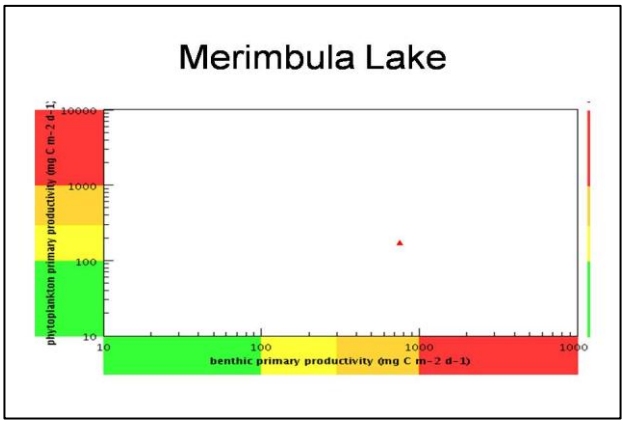

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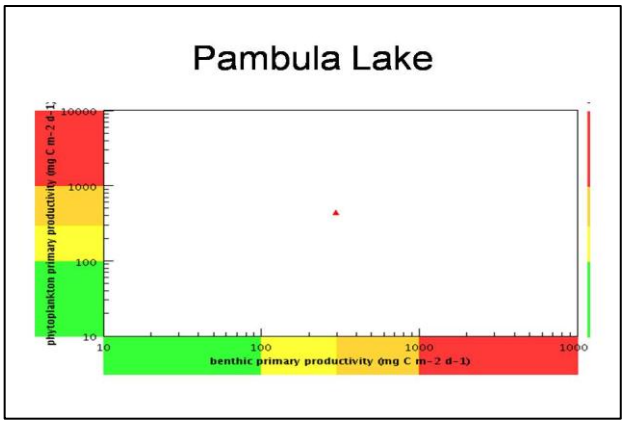

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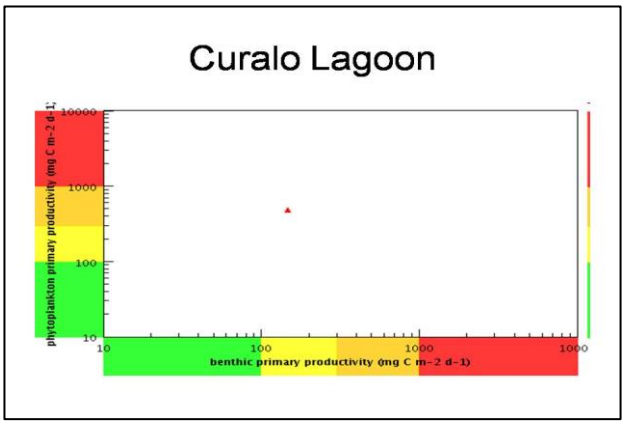

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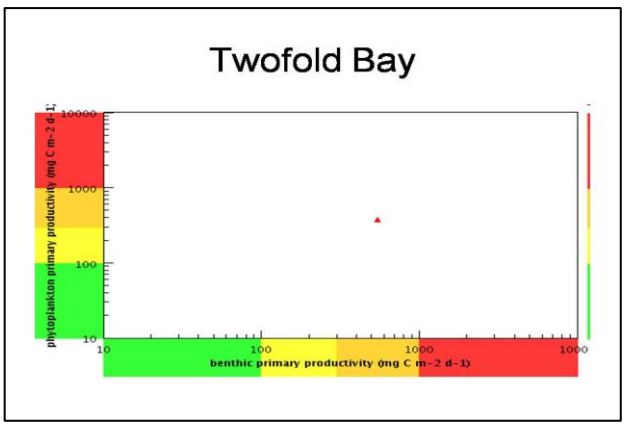

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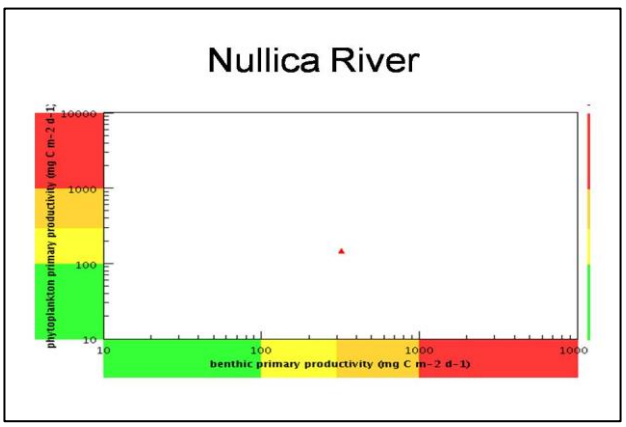

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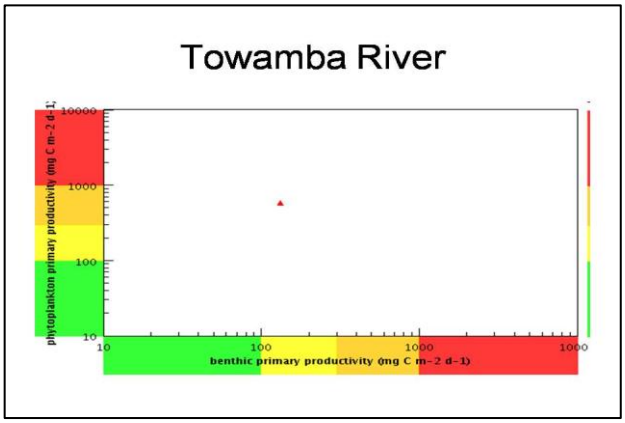

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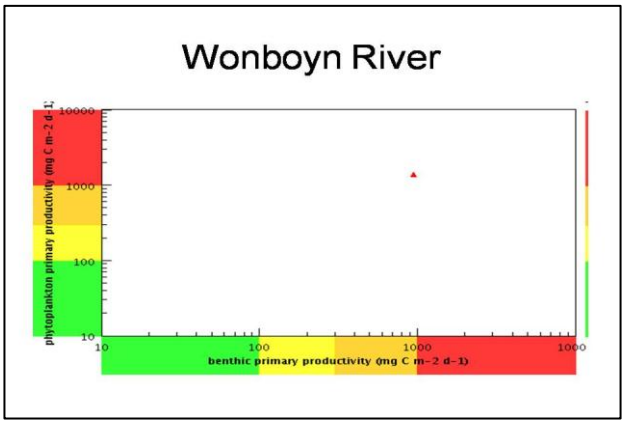

Riverine Estuary – High Productivity

Specialist Report A

Aboriginal Issues Assessment

Cardno Ecology Lab

Marine Fish Stocking in NSW Estuaries:

Aboriginal Issues Assessment

March 2011
Revised 4 November 2011

Marine Fish Stocking in NSW Estuaries: Aboriginal Issues Assessment

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Cardno Ecology Lab

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Report No.	2698/R01/V3	Date: March 2011 Revised 4 November 2011

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APPENDICES

1.0 Introduction, Context and Scope

This report has been prepared as part of an environmental impact statement (EIS) for the activity of marine fish stocking into suitable New South Wales (NSW) estuaries, under Part 5 of the *Environmental Planning and Assessment Act 1979.* The EIS considered the possibility of marine fish stocking in 158 estuaries in NSW (see **Section 2.0**). After Cardno Ecology Lab conducted a multi-criteria analysis (MCA), 80 estuaries were identified as suitable locations for fish stocking.

This report evaluates the potential interactions and impacts of marine fish stocking activities with the Aboriginal cultural heritage values of estuarine landscapes.

The report is based on a combination of review of literature about traditional and contemporary Aboriginal estuarine fisheries and consultation with Aboriginal community representatives.

1.1 Key Features of the Aboriginal Community Perspective of Fish Stocking

Coastal Aboriginal people have a strong interest in the health of estuarine waterways. Healthy waterways are part of the identity and well-being of Aboriginal people. Aboriginal community groups support, in principle, activities which will contribute to habitat restoration and native fish stock replenishment in estuarine waterways.

Aboriginal community groups have expressed the view that fish stocking should not be conducted in isolation from other activities which care for the health of estuarine waterways and estuarine species. Aboriginal community groups have also expressed the view that they should have opportunities for direct involvement in the fish stocking program. This applies not only to estuarine waterways where there are Aboriginal Owners or Native Title rights, but to all estuarine waterways.

Aboriginal communities could be involved through local scale consultation about when and where fish stocking will occur in any estuary, through conducting the actual stocking activity and/or through contributing to monitoring and evaluation of the ecological, recreational and cultural outcomes of fish stocking. Details about how Aboriginal people can be effectively involved in fish stocking to give effect to their interests in managing the fishery resources of estuarine waterways are discussed in **Section 6**.

This assessment concludes that with appropriate management measures in place, the risks to Aboriginal cultural heritage values are low and there are likely to be improvements to Aboriginal access to valued fish resources and to employment, training and satisfaction with caring for sea country. However, without risk management, fish stocking is unlikely to achieve its potential for benefits to the Aboriginal community and may be perceived by Aboriginal stakeholders as a poor and un-sustainable investment in estuary health and fishery resources.

1.2 Purpose of this Assessment

This assessment has been prepared to:

- Provide information about the potential risks and benefits of the proposed NSW marine fish stocking program to the Aboriginal cultural heritage values of NSW estuarine waterways.

- Evaluate other potential benefits or impacts of fish stocking for Aboriginal people along the NSW coast.

1.2.1 Director General's Requirements

The NSW Department of Planning and Infrastructure (NSW DoP) issued Director General's Requirements (DGRs) for the preparation of an EIS for the proposed Marine Fish Stocking program for NSW Coastal Waters under Part 5 of the *Environmental Planning and Assessment Act 1979*, on 13 February 2009.

The requirements include the following in relation to Aboriginal Cultural Heritage:

Include the interests of Indigenous people in fish stocking, any important Aboriginal heritage sites/places impacted by the proposed activity and outline any existing protocols/measures that aim to minimise risk of harm to these sites.

1.2.2 Scope of Response to DGR

To address the DGR, this assessment considers:

- The risk that any known Aboriginal sites or Places, as identified in registers maintained by the Office of Environment and Heritage (OEH), formerly the Department of Environment, Climate Change and Water (DECCW) would be damaged or otherwise impacted by the activity of fish stocking.

- Whether and in what ways (positive and negative) the practice of fish stocking interacts with Aboriginal cultural values in estuarine landscapes.

- The relevance of fish stocking to fishing by Aboriginal people in NSW estuaries, for cultural purposes.

- Whether the species involved in the practise of fish stocking are of particular social or cultural significance to Aboriginal people.

- Whether fish stocking would be consistent with Aboriginal community kinship ties and obligations to look after estuarine species

- The opportunities for the practice of fish stocking to support Aboriginal cultural heritage activities, such as gatherings for ceremony, transfer of traditional cultural knowledge, continuation of cultural fishing practices or other aspects of Aboriginal cultural identity.

- Opportunities for Aboriginal communities to participate in the fish stocking activities including through potential employment with natural resource management (NRM) agencies.

1.2.3 Scope and Methods of Aboriginal Issues Assessment

The assessment of the impacts of marine fish stocking on Aboriginal cultural heritage values is based on information derived from the following sources.

- Literature review, including archaeological and ethnographic reports and reports of studies of contemporary Aboriginal cultural expression and practice.

  The literature review considers reports about the significance of wild estuarine fisheries in Aboriginal culture and heritage, addressing topics such as:

  - the coastal Aboriginal population;
  - contemporary Aboriginal community fishing;
  - intergenerational historical values of estuarine fisheries – Port Stephens, Corindi, other places;
  - Aboriginal estuarine fisheries from the archaeological record;
  - Aboriginal sites and Places – types of sites and where they occur;
  - the social and economic value of estuarine fisheries;
  - coastal cultural landscapes.

  This information is presented in **Section 5**.

- Written and telephone comments from Local Aboriginal Land Councils (LALCs), NSW Aboriginal Land Council (NSW ALC) and other Aboriginal community groups along the NSW coast. These comments were received in response to letters sent to all of these groups, advising them of the proposal, the assessment and inviting them to be involved in the assessment. This information is reported in **Section 3** and taken into account in **Section 6**.

- Written comments and advice from CMAs, OEH regional Aboriginal staff, the Native Title Services Corporation (NTSCORP), and the Registrar of Aboriginal Owners. This information is included in **Section 3** and **4**.

- Discussion at Aboriginal community meetings held on the north coast and central coast. At the time of the consultation, Aboriginal groups on the south coast were not available for face to face meetings. This information is included in **Section 3** and the community suggestions are incorporated into the risk reduction strategies in **Section 6**.

- Application of a risk assessment framework (**Section 6**).

- Development of management strategies and protocols to ensure that the practice of fish stocking supports and complements Aboriginal cultural heritage values wherever possible. Management approaches to integrate Aboriginal cultural heritage outcomes with other fishery management outcomes are discussed in **Section 6**.

- Discussion of potential fishery management options with DPI and Aboriginal community groups. Results of these discussions are reported in **Section 6**.

2.0 The Proposal

DPI proposes to implement a marine stocking program in estuaries throughout NSW, for selected marine species. The program will involve the release of cultured juveniles into wild population(s) in recruitment limited situations to augment the natural supply of juveniles and to optimise harvests.

DPI is preparing an EIS under Part 5 of the *Environmental Planning and Assessment Act 1979*, to evaluate the impacts of fish stocking on the sustainability of estuarine ecology and human uses of estuarine waterways. As part of the EIS for the proposal, a Fisheries Management Strategy (FMS) will be developed specifically for marine fish stocking to outline a management approach for marine fish stocking practices, which until now has not existed.

There are currently no ongoing marine fish stocking programs in Australia, but freshwater fish stocking has been used to boost fish stocks in rivers and dams for over 50 years. DPI has been researching the feasibility of fish stocking in estuaries with species such as mulloway and eastern king prawns. For instance, trials have been conducted in Smiths Lake, Swan Lake, Khappinghat Creek, Botany Bay, Wallagoot Lake, Back Lake and the Georges River.

2.1 Goals and Vision

2.1.1 Vision for the Activity

The draft FMS identifies the long-term vision for the activity of fish stocking as:

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.

This statement makes it clear that the proposed activity is intended to benefit fishing for Aboriginal cultural purposes in NSW.

2.1.2 Goals for the Activity

The draft FMS lists proposed goals that have been designed to achieve this vision for the activity. These goals are:

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.

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 with 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.

Stocking would be carried out in a structured program, so that results can be monitored and the program adapted as necessary to continue to be environmentally sustainable.

2.1.3 Components of the Activity

The current proposal is that marine fish stocking could be conducted in suitable estuaries with one or more of the following species:

- Dusky flathead;
- Mulloway;
- Eastern king prawn;
- Giant mud crab;
- Blue swimmer crab;
- Sand whiting; and
- Yellowfin bream.

These are all popular recreational fishing species that have a widespread distribution in NSW estuaries and grow to catchable size relatively quickly. They are also species that Aboriginal people catch today and are present in many Aboriginal archaeological sites around estuaries. Species would be stocked into estuaries within their natural range and where there is evidence that low recruitment of juvenile fish is limiting the growth of the wild population.

The program provides opportunities to promote community awareness of responsible stocking and the link between stocking and other fishery management activities, such as habitat rehabilitation.

The fish and crustaceans for stocking would be grown at hatcheries with DPI recognised quality controls. The actual stocking into estuaries may be carried out by DPI personnel, recreational fishing groups, Aboriginal people or other relevant stakeholders (see **Section 6**).

2.1.4 Where will Fish Stocking Take Place?

There are around 158 estuarine waterways along the NSW coast. Because of physical and ecological factors, not all of these estuaries are suitable for fish stocking.

Given the large number of estuaries, a multi-criteria analysis (MCA) was carried out to identify a list of suitable estuaries that would be considered for future stocking events. Through the MCA a total of 80 estuaries were identified as suitable locations for fish stocking although not all species are suitable for stocking in every estuary because of ecological constraints.

Each estuary was ranked in terms of its suitability for each species. The analysis also indicates estuaries where certain species cannot be stocked, for example because the estuary is located outside the natural geographic range of that species. Estuaries that would not be permitted for stocking under any circumstances have also been identified through a series of ‘knock-out’ factors (for example, if an estuary is part of a Marine Park or Ramsar wetland, is too small, or intermittently dries out). The specific criteria that were used to determine the list of suitable estuaries included, physical, geographical, ecological and demographic indices all of which are described in detail in Chapter B.5.1.5.

2.1.5 Aboriginal Communities and Estuaries which may be Stocked

After considering the knock-out factors and other criteria on the suitability of fish stocking, 80 estuaries were identified where fish stocking could feasibly take place. Not all estuaries would be stocked at once and DPI proposes to stock across the various stocking regions (northern, central and southern) along the coast.

The 80 estuaries determined as suitable for stocking with one or more of the seven selected species are listed in **Table 2.1**. Aboriginal stakeholders have expressed the view that stocking should focus on estuaries where commercial fishing activity is excluded (see **Section 3**). Therefore estuaries managed as a Recreational Fishing Haven (RFH) and/or commercial fishery are indicated on **Table 2.1**.

Table 2.1 also shows which Aboriginal stakeholder groups (in this case, LALCs) correspond to areas where estuaries or coastal lakes are RFHs or commercial fisheries. The boundaries of Aboriginal Land Council regions are not the same as the stocking regions for planning fish stocking.

It is apparent from initial observation that Land Council members in the Central Coast Region of LALCs (from Port Stephens north to Coffs Harbour) would have access to more RFHs which may be stocked than would members of Land Councils in the Sydney/Newcastle Region, where only Lake Macquarie and Botany Bay are RFHs. However, a large number of the estuaries in the Sydney Newcastle region are considered suitable for stocking. The Sydney Newcastle Region has a high Aboriginal population (but still less than about 3% of the total population). Aboriginal people living along the lower north coast, central coast and in the Sydney Metropolitan Area would potentially have access to multiple stocked waterways, but would have to share the fisheries resources with other fishery stakeholders, to benefit from increased stocks.

On the south coast, many of the small coastal lakes south of Jervis Bay are RFHs. There is at least one RFH present within the jurisdiction of most LALCs.

Aboriginal stakeholder views on access to healthy fish stocks and management of healthy estuarine waterways are discussed in **Section 3**.

Table 2.1 - Potential Fish Stocking by Estuary and by Fishery Access Management

Waterway	Recreational fishing haven	Commercial fishery allowed	LALC and Aboriginal access
Tweed River	Partial	Partial, some closures to netting and at weekends	*North Coast Region* Tweed Heads
Cudgen Creek	No	Yes (netting restrictions)	*North Coast Region* Tweed Heads
Cudgera Creek	No	Yes (netting restrictions)	*North Coast Region* Tweed Heads
Mooball Creek	No	Yes (netting restrictions)	*North Coast Region* Tweed Heads
Richmond River	Partial	Partial	*North Coast Region* Jali Ngulingah
Evans River	No	Yes (netting restrictions)	*North Coast Region* Jali

Waterway	Recreational fishing haven	Commercial fishery allowed	LALC and Aboriginal access
			Ngulingah
Jerusalem Creek	No	Yes (netting restrictions)	*North Coast Region* *Ngulingah*
Clarence River	Partial	Partial (netting restrictions)	*North Coast Region* Grafton Ngerrie Birrigan Dargle
Cakora Lagoon	No	Yes	*North Coast Region* Birrigan Dargle
Boambee Creek	No	Yes (netting restrictions)	*Central Coast Region* Coffs Harbour
Bonville Creek	No	Yes (netting restrictions)	*Central Coast Region* Coffs Harbour
Bellinger River	Yes	Closed	*Central Coast Region* Coffs Harbour
Oyster Creek	No	Yes (netting restrictions)	*Coffs Harbour Region* Coffs Harbour
Deep Creek	Yes	Closed	*Central Coast Region* Coffs Harbour
Nambucca River	No	Yes	*Central Coast Region* Nambucca Heads
Macleay River	No	Yes (netting restrictions)	*Central Coast Region* Kempsey Yaegl
SW Rocks Creek	No	Yes	*Central Coast Region* Kempsey
Saltwater Creek	No	Yes (netting restrictions)	*Central Coast Region* Kempsey
Korogoro Creek	No	Yes (netting restrictions)	*Central Coast Region* Kempsey
Killick Creek	No	Yes (netting restrictions)	*Central Coast Region* Kempsey
Hastings River	Yes	Closed	*Central Coast Region* Birpai Bunyah
Lake Ines/Lake Cathie	No	Yes (netting restrictions and weekend closures)	*Central Coast Region* Birpai Bunyah
Camden Haven River	Partial	Partial	*Central Coast Region* Birpai Bunyah
Manning River	Partial	Partial	*Central Coast Region* Purfleet Taree
Khappinghat Creek	No	Yes	Central Coast Region Purfleet Taree
Wallis Lake	No	Yes	Central Coast Region

Waterway	Recreational fishing haven	Commercial fishery allowed	LALC and Aboriginal access
			Forster
Hunter River	No	Yes	*Sydney Newcastle Region* Awabakal Mindaribba
Lake Macquarie	Yes	Closed	*Sydney Newcastle Region* Awabakal Bahtabah Koompahtoo
Tuggerah Lake	No	Yes	*Sydney Newcastle Region* Darkinjung
Wamberal Lagoon	No	Yes	*Sydney Newcastle Region* Darkinjung
Terrigal Lagoon	No	Yes	*Sydney Newcastle Region* Darkinjung
Avoca Lake	No	Yes	*Sydney Newcastle Region* Darkinjung
Brisbane Water	No	Yes	*Sydney Newcastle Region* Darkinjung
Broken Bay	No	Yes (some restrictions on weekends and types of netting)	*Sydney Newcastle Region* Metropolitan
Hawkesbury River	No	Yes	*Sydney Newcastle Region* Metropolitan
Pittwater	No	Yes	*Sydney Newcastle Region* Metropolitan
Narrabeen Lagoon	No	Yes	*Sydney Newcastle Region* Metropolitan
Middle Harbour Creek	No	Yes	*Sydney Newcastle Region* Metropolitan
Port Jackson	No	Yes	*Sydney Newcastle Region* Metropolitan
Lane Cove River	No	No	*Sydney Newcastle Region* Metropolitan
Parramatta River	No	Yes	*Sydney Newcastle Region* Metropolitan
Cooks River	No	No	*Sydney Newcastle Region* Metropolitan
Botany Bay	No	Closed	*Sydney Newcastle Region* La Perouse
Georges River	No	Yes	*Sydney Newcastle Region* La Perouse Tharawal
Port Hacking	No	Yes	*Sydney Newcastle Region* La Perouse Illawarra
Allans Creek			*South Coast Region*

Waterway	Recreational fishing haven	Commercial fishery allowed	LALC and Aboriginal access
			Illawarra
Lake Illawarra	No	Yes	*South Coast Region* Illawarra
Killalea Lagoon		No	*South Coast Region* Illawarra
Minnamurra River	No	Yes	*South Coast Region* Illawarra
Crooked River	No	Yes (some netting restrictions)	*South Coast Region* Illawarra
Shoalhaven River	No	Yes	*South Coast Region* Jerrinja Nowra
St Georges Basin	Yes	Closed	*South Coast Region* Jerrinja
Swan Lake	No	Yes	*South Coast Region* Jerrinja
Berrara Creek	No	Yes	*South Coast Region* Jerrinja
Lake Conjola	Yes	Closed	*South Coast Region* Jerrinja
Narrawallee Inlet	Yes	Closed	*South Coast Region* Ulladulla
Ulladulla	No	Yes	*South Coast Region* Ulladulla
Burrill Lake	Yes	Closed	*South Coast Region* Ulladulla
Tabourie Lake	Yes	Closed	*South Coast Region* Ulladulla
Termeil Lake	No	Yes	*South Coast Region* Batemans Bay
Meroo Lake	Yes	Closed	*South Coast Region* Batemans Bay
Willunga Lake	No	Yes (netting restrictions)	*South Coast Region* Batemans Bay
Clyde River	No	Yes	*South Coast Region* Batemans Bay
Coila Lake	No	Yes (netting restrictions)	*South Coast Region* Cobowra
Tuross Lake	Yes	Closed	*South Coast Region* Cobowra
Lake Brou	No	Yes	*South Coast Region* Bodalla
Lake Dalmeny	Yes	Closed	*South Coast Region* Wagonga
Wagonga Inlet	Yes	Closed	South Coast Region Wagonga

Waterway	Recreational fishing haven	Commercial fishery allowed	LALC and Aboriginal access
Wallaga Lake	No	Yes	*South Coast Region* Merrimans
Bermagui River	Yes	Closed	*South Coast Region* Merrimans
Barragoot Lake	No	Yes	*South Coast Region* Merrimans
Murrah Lake	No	Yes	*South Coast Region* Merrimans
Cuttagee Lake	No	Yes	*South Coast Region* Merrimans
Murrah lake	No	Yes	*South Coast Region* Merrimans
Bunga Lagoon	No	Yes	*South Coast region* Merrimans
Wapengo Lagoon	No	Yes (netting closures)	*South Coast Region* Merrimans
Nelson Lake	Yes	Closed	*South Coast Region* Merrimans
Bega River	Yes	Closed	*South Coast Region* Bega
Wallagoot Lake	No	Yes (netting closures)	*South Coast Region* Bega
Back Lagoon	Yes	Closed	*South Coast Region* Bega
Merimbula Lake	No	Yes (netting closures)	*South Coast Region* Bega
Pambula Lake	Yes	Closed	*South Coast Region* Eden
Curalo Lagoon	No	Yes	*South Coast Region* Eden
Twofold Bay	No	Yes	*South Coast Region* Eden
Nullica River	Yes	Closed	*South Coast Region* Eden
Towamba River	Yes	Closed	*South Coast Region* Eden
Wonboyn Lake	Yes	Closed	*South Coast Region* Eden
Merrica River	No	Yes	*South Coast Region* Eden
Nadgee River	No	Yes	*South Coast Region* Eden
Nadgee Lake	No	Yes	*South Coast Region* Eden

2.2 Aboriginal Culture

DECCW (2009) defines Aboriginal cultural heritage as:

> 'Aboriginal cultural heritage consists of places and items that are of significance to Aboriginal people because of their traditions, observances, customs, beliefs and history. It is evidence of the lives of Aboriginal people right up to the present. Aboriginal cultural heritage is dynamic and may comprise physical (tangible) and non physical (intangible) elements. As such it includes things made and used in earlier times, such as stone tools, art sites and ceremonial or burial grounds, as well as more recent evidence such as old mission buildings, massacre sites and cemeteries.
>
> Aboriginal people have occupied the NSW landscape for more than 50,000 years. The evidence and important cultural meanings relating to this occupation are present throughout the landscape, as well as in the memories, stories and associations of Aboriginal people. Therefore, any activity that impacts on the landscape may impact on Aboriginal cultural heritage.'

From this definition, Aboriginal cultural heritage values are associated with:

- Aboriginal sites – the physical evidence of past Aboriginal use of the landscape.
- Aboriginal Places – locations that are associated with stories about the landscape or with personal or community totemic associations with the natural world. DECCW 2009 notes '*plants, animals and ecosystems are at the core of their attachment to the land and the sea. Plants and animals are valued as part of 'country' and may also act as totems.'*
- Aboriginal cultural landscapes and cultural values of biodiversity. English (2002) highlights five key Aboriginal cultural values associated with biodiversity. These apply to all landscape types, not just estuaries:
  - flora, fauna and landscape features are integral components of people's cultural construction of 'country' or significant lands. The health and well-being of ecological communities are fundamental parts of Aboriginal attachment to country.
  - individual species can be identified as totems and in turn may be related to family and kinship
  - social benefits accrue from obtaining, processing and utilising wild foods and medicines including strengthening of group bonds and identity, passing on and using cultural knowledge, using and interacting with valued places, sharing and instilling respect for elders
  - Medicinal and health benefits associated with wild resources that are seen as being important for treating health problems such as diabetes, high cholesterol, colds, flu and migraines.
  - Wild resources can provide economic benefits that supplement incomes and provide fresh foods. Peoples ecological knowledge can also be an important foundation for cultural or eco tourism.
- Aboriginal cultural practices and traditional cultural knowledge.
- Ongoing Aboriginal community attachment to the sea and the land.

2.2.1 Aboriginal Perspectives on the Estuarine Landscape

From the Aboriginal cultural heritage perspective, an estuarine landscape comprises:

- Tidal waterways, including tidal creeks, rivers and lakes. Coastal lakes may be closed to the sea for extended periods and their salinity can be close to fresh water at times. However, all the waterways included in this assessment are open to the sea at some time and have habitats featuring marine waters and marine species.

- The entrance areas of tidal waterways, where they interact with ocean waters, through channels across beaches and dunes.

- The rocky, sandy or muddy bed and shoreline of tidal waterways.

- Creeks that flow into tidal waterways and bring sediment and nutrients into the waterway. Sometimes these creeks also provide habitat for part of the life cycle of estuarine fish and crustacean species.

- Vegetation in and on the shore of tidal waterways, such as mangrove, saltmarsh, sea grass, and a range of wetland species, for instance *Melaleuca quinquinervia*, swamp mahogany, *Casuarina glauca* and diverse reed species. The cultural value of this vegetation derives both from its part in a healthy and functioning landscape but also for the raw materials that may be obtained from spears, lines, etc.

- Fallen timber that adds to the habitat value of tidal waterways.

- Birds that use the waterway, including waders, sea eagles, pelicans, cormorants, ducks and other species.

- Fish, shellfish and crustacean species.

- Cultural kinship with any of the plants and animals that live in and around the estuarine waterway.

- Places that have been or are used for fishing, shellfish gathering, gathering plant foods, story telling, transfer of cultural knowledge and respect or spiritual activities.

2.2.2 Environmental, Social and Cultural Integration

Aboriginal cultural attachment to sea country and Aboriginal obligations for looking after sea country both have environmental, cultural and social aspects.

Aboriginal people value healthy functioning ecological systems where wild biodiversity and productivity provide for a healthy diet in the community, allow people to practice and teach traditional cultural knowledge, and support family and social obligations.

This assessment considers whether fish stocking can be managed in a way that contributes to the well-being of Aboriginal communities along the coast, by supporting healthy functioning ecological systems and providing opportunities for Aboriginal people to be involved in looking after the cultural values of sea country.

2.3 Statutory and Policy Context

In NSW, three key pieces of legislation have direct relevance to the protection of Aboriginal cultural heritage values:

- *National Parks and Wildlife Act 1974* (see **Section 4.2** for details of protection afforded to Aboriginal sites and places under the Act).

- *Aboriginal Land Rights Act 1982.*
- *Environmental Planning and Assessment Act 1979.*

This assessment is required under the *Environmental Planning and Assessment Act 1979* (see **Section 1.1.1**).

The NSW *Heritage Act 1977* is also relevant to some sites/places. The Commonwealth Native Title legislation and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) also protect Aboriginal cultural heritage values and enduring attachment to country, where these values are considered to be of National significance. Places around estuaries that are listed as National Heritage places are discussed in **Section 4.1**.

2.3.1 Aboriginal Owners and Land Claims

Aboriginal Owners have been recognised under the *Aboriginal Land Rights Act 1989* for some parts of the NSW coast, such as in the traditional country of the Yuin people on the far south coast (including Wallaga Lake in Gulaga National Park), the Bundjalung people on the north coast, Birpai people on the mid north coast and the Worimi people around Port Stephens.

On the south coast, Merrimans LALC and Wagonga LALC hold freehold title to the lands within Gulaga National Park, on behalf of the Aboriginal Owners. Gulaga National Park is leased to the Minister for the Environment for 30 years under the *National Parks and Wildlife Act 1974.* The land is part of the conservation estate of NSW, but is under the care, control and management of a Board of Management, with the majority of the Board being Aboriginal Owners. The lease over the National Park (December 2005) requires that it is managed in accordance with a Plan of Management, which reflects the cultural significance of the land to the Yuin people.

The Wagonga LALC also owns a parcel of land on the shore of the Wagonga Inlet, between Black Bream Point and Paradise Point. It has plans for a cultural centre on this land. Other Land Councils also own land around the shores of estuaries, but not extending into the estuarine waters.

In Port Stephens, some Worimi Aboriginal Owners are members of an advisory group which contributes to the management of the Port Stephens Great Lakes Marine Park.

In the Nambucca area, the Gaagal Wanggaan (South Beach) National Park is on land owned by the Gumbaynggirr people. This park which includes coastal dune country and the estuary of Warrell Creek is the subject of a Joint Management Agreement between the NSW government and the Traditional Aboriginal Owners. It includes high quality fishery habitat and is a traditional fishing area for local Aboriginal people.

Fish stocking is not precluded by the presence of Aboriginal Owners, but Aboriginal Owners should be consulted when fish stocking is proposed for an estuary in their country.

There are no native title holders along the NSW Coast (under the Commonwealth *Native Title Act*).

2.3.2 NSW Indigenous Fisheries Strategy and Implementation Plan

The then NSW Fisheries released an Indigenous Fisheries Strategy and accompanying Implementation Plan in 2002. The strategy recognises that ‘fishing has been an integral part of the cultural and economic life of coastal and inland Aboriginal communities since they

have been in this land. (I&I NSW web site 2009)'. Most implementation activities were completed between 2002 and 2004 whilst others remain ongoing.

Several of the initiatives of the strategy are noted below because they influence the ongoing approach of DPI to the involvement of Aboriginal people in fisheries management. Some initiatives also relate to the proposed marine fish stocking program.

Key initiatives include:

- Acknowledge and address Aboriginal issues in preparing every fishery management strategy;
- Support and promote the employment of Aboriginal staff in NSW Fisheries, within natural resource management generally and in the aquaculture and commercial fishing industries;
- Employ and retain Aboriginal Fisheries Officers in regional locations, with an emphasis on having Aboriginal community involvement in fisheries management issues and promoting community commitment to regulations;
- Support a coordinated Aboriginal approach to natural resource management; and
- Negotiate with local communities on ways to achieve sustainable fisheries and where appropriate engage other agencies in joint strategies which contribute to sustainable resource management.

The importance of these initiatives has been highlighted by the issues Aboriginal community stakeholders raised during consultation for the marine fish stocking proposal (see **Section 3**).

2.3.3 Aboriginal cultural fishing

In April 2009, the Australian Government endorsed the United Nations Declaration of the Rights of Indigenous Peoples (2007). The principles of this Declaration relate to the rights of Indigenous people to maintain and teach cultural traditions, customs and ceremonies, but also to the rights and needs of Aboriginal Elders and other disadvantaged Aboriginal people.

In May 2009, DPI released a discussion paper on cultural fishing in NSW; it related principally to a definition of cultural fishing which at the time was being considered for inclusion in the *Fisheries Management Act 1994* (FM Act) and changes to the section 37 permit process for cultural fishing events.

The NSW Aboriginal Land Council (NSW ALC) published their submission to the Discussion Paper in July 2009. The proposal to stock fish into selected NSW estuaries is a different issue to the rights of Aboriginal cultural fishers in NSW. However, the debate about definitions of Aboriginal cultural and subsistence fishing does provide background to the responses from regional Aboriginal stakeholders to the proposed enhancement of fish stocks. Fish that are stocked into estuaries and lakes will be available to be caught for both cultural purposes (ceremonies and gatherings) and for day to day subsistence fishing (continuing the traditional and ongoing importance of fish and shellfish as part of the diet of extended Aboriginal families). NSW ALC presented a case that both cultural fishing and subsistence fishing should be recognised in the FM Act.

I&I NSW (2009) suggested a definition of cultural fishing:

'*Fishing activities and practices carried out by Aboriginal persons for the purpose of satisfying their personal, domestic or communal needs, or for the educational or ceremonial purposes or other traditional purposes and which do not have a commercial purpose*.'

NSW ALC supported this definition, but also requested a further definition of Aboriginal subsistence fisher:

'*The Aboriginal subsistence fisher would be afforded the freedom to gather fish for their family, Elders and guests consistent with traditional practices of everyday subsistence*.' (NSWALC 2009:8)

Both classes of fishing are separate to recreational or commercial fishing.

At the same time, NSW ALC reiterated its commitment to researching how Aboriginal people could be involved in the various aspects of fishery management in NSW, including habitat management and stock enhancement programs, capacity building and employment. These themes are widespread in the comments of stakeholders during consultation about fish stocking into estuaries (see **Section 3**).

3.0 Consultation with Aboriginal Community Stakeholders

Aboriginal communities along the NSW coast have a strong and continuing cultural, economic and social association with estuarine fishery resources.

In regional coastal communities, fishing continues to provide an important component of Aboriginal diet (Schnierer and Faulkner 2002, Faulkner 2000, Cozens 2003, Egloff 1981, English 2002). Traditional cultural knowledge and practices are also related to features of estuarine waterways. Some of these aspects of Aboriginal cultural heritage are reported in the literature, others are special knowledge held only within local communities where the cultural activities are practiced.

Aboriginal people along the NSW coast are actively involved in the delivery of natural resource management programs that help to look after sea and land country. Some of these programs are incorporated into the implementation of Catchment Action Plans. Other programs have been separately initiated by OEH in partnership with local Aboriginal communities; an example is the Land Alive program.

The aim of the current assessment is to evaluate the positive and negative impacts of marine fish stocking on Aboriginal cultural heritage values of estuarine waterways. Local Aboriginal communities have been provided with information about the proposed fish stocking program and have been given the opportunity to provide written and verbal feedback about the program.

Information resulting from consultation is included in the discussion of Aboriginal cultural heritage values in **Section 6.** Consultation with Aboriginals community groups has been conducted in three stages. The stages in the consultation process are described below.

Stage 1: Inform Aboriginal community groups about the proposal to stock marine waters with selected species.

- Letters were sent to 40 LALCs along the NSW coast (see **Appendix 1** for a copy of this letter and for a list of the LALCs). The letter was also sent to the NSW ALC. This letter advised the Land Councils about the proposal, which species are proposed to be stocked and the preparation of the Fishery Management Strategy and Environmental Impact Statement. The letter invited comment on the species and their relevance to Aboriginal fishing and Aboriginal cultural heritage. Land Councils were asked to provide initial feedback by phone, email or letter.

- Some Land Councils requested further information to assist Elders to discuss the proposal. For instance, Nambucca LALC requested more visual information (such as a PowerPoint presentation) to assist Elders. This was provided.

- Letters were also sent to the following organisations:

  - Native Title Services (NTSCORP)
  - NSW Registrar of Aboriginal Owners
  - Northern Rivers Catchment Management Authority (NRCMA)
  - Hunter Central Rivers Catchment Management Authority (HCRCMA)
  - Sydney Metropolitan Catchment Management Authority (SMCMA)
  - Southern Rivers Catchment Management Authority (SRCMA)

- OEH (NPWS) offices in coastal locations

These letters requested advice about other Aboriginal stakeholders and existing estuary habitat management or restoration programs (particularly those involving Aboriginal community stakeholders) that would be complemented by the fish stocking program.

Stage 2: Receive and analyse responses to written advice

Telephone or written responses were received from six Local Aboriginal Land Councils. HCRCMA Aboriginal Culture and Heritage Network also coordinated written responses from Aboriginal stakeholders in the Hunter Central Rivers CMA region.

Responses were also received from some CMAs and the Marine Parks Authority (in relation to Port Stephens).

A summary of all responses is included in **Appendix 1**. The main issues raised by the groups are set out below (**Section 3.1**).

Stage 3: Community meetings in regional areas

Four meetings were held with Aboriginal communities on the NSW north and central coast, to document comments and questions and to further explore issues of concern. Issues raised during the discussion at these meetings are noted in **Section 3.2**.

All individuals and groups who contributed information about cultural values are thanked for their time and for sharing their valuable knowledge.

3.1 Written Responses

Issues raised in written responses included the following matters, which fall into three main themes:

Cultural importance of the marine environment and resources

- The marine environment is very important to Aboriginal people and communities have maintained a strong connection to coastal land and the sea, over many generations.
- Elders in several areas commented on their observations of a decline in certain species, such as blue swimmer crab, whiting, school, prawn, bream, mud crab, flathead and mullet in coastal lakes, over the last 10 to 15 years.
- Fishing has always been part of Aboriginal coastal culture, but opportunities are disappearing as development and pressure on resources reduces the access of Aboriginal people to estuarine fish species.
- Fish stocking in estuarine waters has the potential to be of significant benefit to Aboriginal people along the NSW coast.
- Traditional owners in any area to be stocked should be consulted prior to the fish stocking being conducted.
- There are no particular areas that should not be stocked for cultural reasons.

- Aboriginal people have no concerns about the species that are proposed to be stocked (see also **Section 3.2** for suggestions from meetings about additional species that could be considered).

Involve Aboriginal people in the fish stocking activities, as part of sustainable management of sea country

- Aboriginal people in regional areas would be interested in being involved in the stocking process, particularly as an extension of existing environmental restoration and conservation work being managed by LALCs.

- Stocking to increase populations of non threatened species is very risky, and it's not how traditional Aboriginal people would have approached the management of the resource. They would have reduced pressure on the fishery resource by moving on to other areas or by reducing catch and using other food resources.

- Degraded habitats should not be stocked.

- Aboriginal people in regional areas would like access to training in relation to employment in fish stocking and fishery management, but community Elders could also offer valuable cultural experience and knowledge to assist with sustainable management.

- Aboriginal people should be consulted about any fish stocking activities at local scales (in relation to any specific estuary proposed to be stocked) and given opportunities to contribute to sustainable management of the fishery resources.

Fish stocking may not be the best way to maintain and enhance stocks of popular species – and there are significant risks

- Caution should be exercised when considering introducing species to waterways, which may have unintended consequences. Habitat protection and restoration programs are preferred as a long term strategy to maintain sustainable fishery resources. Stronger controls on commercial and recreational fish take could help protect the fishery resource better than adding hatchery bred stock.

- Natural areas such as Myall Lakes should not be stocked.

- Concern was expressed about quality control in hatcheries and the potential for poor genetic stock or diseases to be released into natural waterways.

- Concern was expressed about the survival of stocked fish in natural waterways and how the survival of stocked fish would be monitored.

3.2 Community Meetings

Meetings were held at the following locations:

- Yamba – Meeting with north coast LALCs at their regional forum (this group also included Aboriginal Owners).

- Nambucca – meeting with Nambucca LALC and elders.

- Coolongolook – Wang Wauk River – meeting with members of the Hunter Central Rivers Catchment Management Authority Aboriginal Culture and Environment Network. This

meeting included Land Council members, elders, Aboriginal Owners and Aboriginal staff of the CMA.

- Raymond Terrace – Meeting with Worimi Knowledge Holders, including Traditional Aboriginal Owners.

Notes from the discussion at each of these meetings are included in **Appendix 1**.

The schedule of meetings of Aboriginal groups on the NSW south coast did not permit a specific south coast meeting about the project, but some groups provided feedback by phone or email.

The discussion in each case was wide ranging. Many of the participants have lived around estuaries for all of their lives and shared experience and observations gained over many years.

However, several themes were consistent across all four of the meetings. These are noted below and more detail is in **Sections 3.2.1** to **3.2.5**. Each of these five common themes is based on the continuity of traditional and contemporary attachment of Aboriginal people to country and custodianship obligations. Aboriginal people want a say in how sea country is managed and they want to be partners in delivering works that will protect the health of sea country systems, such as estuaries.

Issues raised included the following:

- The cost benefit relationship for fish stocking and the role and effectiveness of fish stocking in a package of measures to enhance the health and productivity of estuarine waterways.

- The likely balance of benefit from any fish stocking activity – to commercial fishers, recreational and Aboriginal cultural fishers.

- How fish stocking could contribute to Aboriginal communities 'looking after sea country', including monitoring (see below) and actively communicating about sustainable management of estuarine waterways.

- How Aboriginal communities could be involved in the fish stocking activity, and particularly in monitoring fish stocks and estuary health.

- The importance of estuary fish species to Aboriginal diet and community health.

People attending the meetings also raised a variety of other issues. These are noted below, although some are not directly relevant to the proposal of fish stocking:

- Concern about the quality of hatchery bred fish stock, including genetic character, potential for disease and impacts on wild stock. The groups were interested in how hatchery bred stock would later be identified.

- Concern about other fishery management issues such as razor clams in Lake Macquarie and the potential for Aboriginal community groups to be involved in managing these species.

- The impact of commercial fishing on fish stocks (numbers of fish and size of fish) and fish habitats, together with a concern that commercial fisheries were not adequately regulated – in the sense of regular inspections and enforcement of management rules and protocols.

- Other aspects of Aboriginal fisheries management, such as licensing issues, and closures of parts of Marine Parks to Aboriginal cultural fishers.

3.2.1 Fish Stocking and Enhancing the Health of Estuarine Waterways

Although communities recognised that fish stocking was likely to provide more fish to catch, including species valuable for Aboriginal diet, they also questioned whether fish stocking is the best medium to long term approach to managing the health and productivity of estuaries. They thought that looking after fishery habitat would be a better long term investment. There was a strong view that fish stocking should only be practiced in healthy estuaries, and not in degraded estuaries. Works to improve habitat condition and diversity in degraded estuaries should precede any stocking activities.

Groups referred to projects such as fish ladders to restore fish access to all parts of the estuarine system, protection of seagrass and saltmarsh and protection of mangroves. They also spoke about the importance of sound catchment management to ensure that fresh water entering the upper reaches of estuaries is of good quality and that natural flows are maintained. Groups thought that more should be done to stop polluted discharges and to protect good water quality. Groups were interested in being involved in estuary health monitoring, including water quality.

Some groups felt that fish stocking, if not carefully managed, could actually be detrimental to estuary health, by overloading sensitive habitats, or by changing the predation balance in the waterway, or by changing the genetic character of the total stock (wild stock plus released stock). Groups thought that DPI should be very cautious about the fish stocking program, and pointed out some previous inadvertent translocation events in the past such as the introduction of carp and Pacific Oyster.

To address this issue, the groups made the following suggestions:

- Introduce fish stocking gradually, starting in healthy but robust estuary systems. Monitor what happens to the stocked fish and also to fish catches and estuary health after stocking and adapt the stocking strategy if necessary;

- Only stock estuaries in partnership with habitat enhancement programs; and

- Involve regional Aboriginal communities in stocking events – both in planning and in monitoring. Tie monitoring of fish stocking outcomes to other monitoring of estuary health. Groups did not specifically refer to the State-wide NRM targets or to estuary condition monitoring programs managed by OEH or CMAs, but their suggestions would align fish stocking with the management framework for natural resources in NSW.

3.2.2 Who Benefits from Fish Stocking?

DPI estimate from experience with trials of fish stocking in estuaries and coastal lakes, that catch rate is expected to increase generally in stocked estuaries for between 2-4 years following stocking and may increase by as much as 15 times in some cases (Taylor *et al.*2009).
There was a strong view expressed at Aboriginal community meetings that fish stocking activities in estuarine waterways should be managed primarily to provide benefits to recreational and Aboriginal cultural fishers only. This is partly due to the group's view that commercial fishers are part of the problem when it comes to declining fish stocks, catch rates, size and recruitment.

Groups reported their perception that the size of key estuary species (such as bream) has declined and that the number of fish (e.g. in the mullet run) has declined. They believed that

the lack of these fish contributes to imbalances in fish ecology. They blamed the trends that they perceived on commercial fishing activity, although they also believed strongly that habitat quality (such as water quality and presence of deep pools and in stream woody debris) has declined.

Groups felt that the benefits of fish stocking in terms of catch per unit effort should flow first to recreational and Aboriginal cultural fishers.

Groups were concerned that if fingerlings were to be stocked into commercially fished estuaries, that many would be lost as bycatch before they grew to a legal size for recreational and Aboriginal cultural fishers.

To address the issue of a perceived inequitable distribution of benefit, the groups made the following suggestions:

- Groups stated their preference that fish stocking should only occur in estuaries that are RFHs;
- Combine fish stocking with temporary closures of commercially fished estuaries, to give wild stocks time to recover and to allow stocked fish to grow to a legal size, without the risk of losing them as by catch; and
- Involve local Aboriginal communities in fish stocking activities.

3.2.3 Opportunities for Aboriginal Community Involvement in Managing Fish Stocking

In discussions with Land Council representatives, it was clear that Land Councils see environmental management work as an important training and employment opportunity for Aboriginal people that can contribute to community social and economic well-being.

They saw this as having two way benefits (see also **Section 3.2.4**). Groups stated that a lot more needs to be done to look after waterways, particularly improving habitat, whether or not stocking takes place. Groups stated that Land Councils are a strong existing network for Aboriginal people, with significant responsibilities to look after the well-being of Aboriginal people (health, education, employment, housing etc.) as well as to support culture. Land Councils could organise groups to work on restoring estuary health. Many Land Councils already have groups that are training young and old people and also providing an opportunity for transferring cultural knowledge about how to look after country.

Land Councils use local people to do local work. They thought that this would be more effective for managing estuary health and fish stocking activities, and would be better for a sense of community achievement and pride, than bringing in people from elsewhere to do the work.

3.2.4 Looking after Sea Country

Groups noted that estuaries are part of the traditional sea country of coastal Aboriginal people. They thought there was an important role for Aboriginal people, as custodians of sea country, to contribute to fishery management, for instance in monitoring programs and in communication about sustainable fishery management.

Groups suggested that Aboriginal people should be employed as field officers or ‘sea rangers’. As field officers they could help enforce the existing fishing rules about, and help to educate people about sustainable fishery management. They thought that investment in

more on ground/on water presence and information for anglers about sustainable management would reduce the need for stocking. Some of the rules and knowledge that groups would like to see become more widely understood are about managing fishing at critical times in the life cycle of fish.

3.2.5 Fish Stocking and Aboriginal Community Health

Groups noted that the availability of popular estuarine species had declined over the last twenty years. They thought that the size of fish (such as bream) has also declined. This means that Aboriginal people who fish to supplement their diet have to fish for longer to catch the same amount of fish.

Some groups also noted that past river 'clean-up' practices, which removed a lot of natural debris from rivers and estuaries had also removed important habitat for insects and worms – food for fish and also additional species targeted by Aboriginal people.

Groups noted that some of these clean-up activities and agricultural land uses on estuary floodplains also had the potential to pollute the waterways. They noted the toxins released from camphor laurel foliage and wood when these invasive trees fall into the river. People felt that these toxins would weaken the fish and also reduce their value as part of people's diet.

Some groups also noted the loss of mangrove habitat from some estuaries and how loss of this habitat had affected the access of Aboriginal people to healthy fish and shellfish (such as cockles). Some groups also referred to a decline in access to other species, such as pipi (principally on open beaches). They felt there were no longer enough of these species for Aboriginal cultural fishers to collect.

The groups suggested that these concerns could be addressed by improved collaboration between local Aboriginal groups, CMAs and DPI, to maintain and improve all estuary habitats and stocks of all estuary species, not just selected fish and crustacea. A healthy Aboriginal diet is not just based on a few species but on understanding how and when a wide range of species can be obtained.

4.0 Statutory Constraints

This section discusses how fish stocking activities relate to national, State and local regulations, policies and natural resource management plans.

4.1 National Heritage List

Several National Heritage List Places in NSW include estuarine landscapes. **Table 4.1** lists these places and notes the references to Aboriginal values in each listing.

References to Aboriginal values are restricted to midden sites along estuarine shorelines and to rock art sites which depict estuarine and marine species, including fish, whales and sharks. The shoreline at Kurnell, on Botany Bay is particularly significant because it is the first meeting place of Aboriginal people and arriving European settlers.

The activity of fish stocking would not impact on the Aboriginal values of these places.

Table 4.1 - Estuarine Landscapes included in National Heritage List

NHL listing	Reasons	Aboriginal issues constraint to fish stocking?
Ku-ring-gai Chase National Park, Lion, Long and Spectacle Island Nature Reserves ID 105817 The listed area has frontage to Broken Bay (southern shore) and Pittwater (western shore) estuaries and to estuarine tributaries such as Cowan Creek.	Listed for its Natural Values. Garrigal traditional owners. 800 Aboriginal sites are listed in the Park, with foreshore shell midden sites the most common. No information on fish species, but shellfish species use changed over time (mid to late Holocene). Rock engravings include depictions of marine species.	The listing would not preclude fish stocking on Indigenous issues grounds
Royal National Park and Garrawarra State Conservation Area. ID 105893 The listed area has frontage to the Hacking River and to the southern shore of Port Hacking.	Listed for its Natural Values. Traditional country of Dharawal people. Two Aboriginal Places under NPW Act (North Era Beach and Costens Point) – do not affect the estuary. Many midden sites along the estuary foreshore, including shellfish as well as fish bone and shellfish hooks. Rock art in the Park includes images of whales, marine and terrestrial animals.	The listing would not preclude fish stocking on Aboriginal issues grounds.
North Head ID 105759 The listed area includes foreshore of Port Jackson, from Little Manly Beach to Quarantine Headland	Listed for Historic Values. Midden sites are located on the harbour foreshore, particularly close to fresh water sources. Mostly rocky shore shellfish species in middens, with very little fish or marine species bone. Rock engravings on the	The listing would not preclude fish stocking on Indigenous issues grounds.

NHL listing	Reasons	Aboriginal issues constraint to fish stocking?
	headland and open rock platforms include images of fish, whale and shark.	
Kurnell Peninsula ID 105812 The listed area includes the shoreline of Kurnell/Solander Headland, at the mouth of Botany Bay	Listed for Historic Values. Traditional country of Gwegal people. 'Meeting Place' precinct is the first recorded contact between Aboriginal people and British people in eastern Australia. Records of crew are amongst earliest descriptions of Aboriginal people and their activities. Observations included a 'village' of 6-8 Aboriginal houses Midden sites and open campsites are located on the shoreline. Sites include shellfish, ocean and estuarine fish bone.	The listing would not preclude fish stocking on Aboriginal grounds

4.2 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act 1974) protects Aboriginal objects and certain gazetted Aboriginal Places. Aboriginal objects are the physical evidence of past Aboriginal occupation of the land. Aboriginal sites are places where objects occur.

Under Part 6 of the NPW Act 1974, it is an offence to knowingly move, damage, deface or destroy Aboriginal objects.

In the estuarine context, Aboriginal objects and Aboriginal sites include the following:

- Middens, which may include estuarine (and beach) shellfish species, fish bone, bird bone, flaked stone artefacts, spear barbs, grinding implements and fish hooks made of shell, bone or stone. Burials have also been recorded in some midden sites.
- Open campsites, comprising one or more stone artefacts, but no shell. Where the estuarine shoreline is affected by erosion, it is possible that midden shell and stone artefacts can be found in shallow nearshore waters, adjacent to the intact remnant of the site.
- Grinding grooves in sandstone rock outcrop, which may occur on the estuarine shoreline.
- Engravings in sandstone on the estuary shoreline or on outcrops overlooking the waterway.
- Rock art sites (paintings and drawings) in rock shelters adjacent to the waterway.
- Archaeological deposits in rock shelters adjacent to the waterway.
- Scarred trees that have been used as lookouts, or to obtain bark to make canoes or dishes.

Many Aboriginal sites on estuary shorelines are listed in the OEH AHIMS data base. Some sites have not been recorded or are only known to local Aboriginal communities and are not listed in AHIMS. Many sites that are listed have been damaged by ongoing natural surface processes and by 200 years of non Aboriginal land use.

Aboriginal archaeological sites provide evidence of the traditional attachment of Aboriginal people to the estuarine landscape, including evidence of economic activity, social and spiritual values. The archaeological evidence relating to species targeted, fish size and other aspects of traditional fishery management is discussed in **Section 5** of this report.

4.2.1 Risk of Disturbing Aboriginal Objects/Sites During Fish Stocking Activities

The activity of fish stocking into estuarine waters involves delivering fingerlings from fish hatcheries and placing them into the estuarine waterway. Fish would be placed in the water directly from boats or from existing structures (jetties) around the shoreline of the estuary. Fish stocking activities would use existing car parking areas and existing boat ramps to access estuarine waters. Fish stocking would involve only a few vehicle and boat movements at any estuary in any year.

DPI is aware of the types of Aboriginal sites that may occur around estuaries and of the general distribution of these sites in the landscape. DPI has consulted with Aboriginal communities about how fish stocking into estuaries could interact with the cultural heritage values of estuarine waterways and the presence of Aboriginal sites around estuarine shorelines (see also **Section 3**).

DPI have not obtained a full site search from AHIMS (the OEH Aboriginal sites data base) of all known Aboriginal sites on estuarine shorelines. This is not necessary from a due diligence perspective because the fish stocking activities would use only existing structures to access the waterways. These existing structures are well established waterway access points and are also used by recreational anglers and other stakeholders.

Some Aboriginal sites may occur in close proximity to estuarine access structures. These existing structures are located on Crown land (reserves) or on community land managed by local government. Plans of Management prepared under the *Crown Lands Act 1989* and the *Local Government Act 1994* require that the Aboriginal cultural heritage values of reserves are taken into account and protected.

The likelihood of the fish stocking activity impacting on an Aboriginal site is considered to be very low, but DPI recognises that Aboriginal communities are likely to view any impacts on cultural heritage objects as significant and unacceptable.

4.2.1.1 Protocols to Minimise Risks to Aboriginal Sites (Objects)

Although the likelihood of marine fish stocking impacting on Aboriginal sites is considered to be very low, DPI would implement a number of measures to ensure that Aboriginal sites are not damaged during the fish stocking activity. DPI proposes that:

- It would consult with representatives of the local Aboriginal community groups at each new estuary that would be stocked. Groups would be asked for advice about any place that should be avoided during fish stocking activities.

- With some stockings, local Aboriginal communities may undertake parts of the fish stocking activity on behalf of DPI (see **Section 6**). Details of involvement would be developed in consultation with individual Aboriginal stakeholder groups.

4.2.2 Aboriginal Places

The term Aboriginal Place refers to any places declared by the Minister for the Environment by an order published in the Gazette. Section 84 of the NPW Act defines what constitutes Aboriginal Places. To declare an Aboriginal Place the Minister must be of the opinion that the place was, or is, of special significance to Aboriginal culture. Aboriginal Places do not need to contain Aboriginal objects, although some Places do. When a place has been declared an Aboriginal Place, the entire place has the same level of protection under the NPW Act 1974 as any individual object. This means that a s90 approval (AHIP) is required from OEH if any proposal would damage, deface or destroy an Aboriginal Place.

In general, Aboriginal Places are declared to protect traditional places associated with stories or legends. Some have also been declared to recognise post-contact sites such as Missions.

Aboriginal Places have been declared at several locations along the NSW coastline (e.g. Birubi Point in Port Stephens local government area, Goanna Headland at Evans Head on the north coast and Pulbah Island in Lake Macquarie local government area), but overall, few are associated with estuarine waterways.

English (2002) notes that no Aboriginal Places have been declared expressly to protect an area that has been or is used by Aboriginal people to obtain wild resources. However, English (2002) also points out that many Aboriginal Places declared for their spiritual values would also have been used for wild resource collection. He cites the Saltwater Aboriginal Place (an estuarine place near Foster) as a gazetted Place that has been used by local Aboriginal people for camping, fishing and teaching during the entire period of European settlement.

Separate to gazetted Aboriginal Places are a large number of localities which are associated with traditional Aboriginal stories, but have no formal statutory protection. For example, in the Lake Macquarie estuary, there are traditional stories associated with rock formations in the bed of Fennell Bay and with sea monsters which guarded the deeper waters between Pulbah Island and Wangi Point.

This assessment does not attempt to document the many local stories of traditional estuarine use or prohibition from along the NSW coast. This is a matter that would be discussed with relevant local Aboriginal community groups when DPI is identifying new estuaries or parts of estuaries to be stocked as part of the program.

4.2.2.1 Protocols to Minimise Risks to Aboriginal Places

As noted above in relation to Aboriginal sites/objects, marine fish stocking presents a low risk to the cultural value of Aboriginal Places. It should be noted however, that fish stocking is, in the words of Ben Cruise from Eden LALC, 'human aided biodiversity'. Aboriginal communities may have a preference that fish 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, reported at the Yamba community meeting).

Not all community stakeholders along the coast have chosen to participate in consultation about the fish stocking proposal. None of the Aboriginal stakeholder groups who have responded in writing and taken part in discussions about fish stocking so far have suggested that any places should be excluded from stocking because of cultural stories about them.

To ensure that fish stocking does not impact on the Aboriginal community's values of Aboriginal Places, DPI proposes to do the following:

- Consult with relevant local Aboriginal stakeholder groups before conducting stocking in any new estuarine sites.

- Fish stocking would not be conducted inside estuarine Aboriginal Places without the approval of the relevant local Aboriginal stakeholder groups and OEH. Aboriginal Places are protected by the NPW Act, which is administered by OEH.

- Fish 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. Fish stocking may still be conducted in other parts of these estuaries.

5.0 Aboriginal Communities and Estuarine Fishery Activities – Cultural Heritage Context

This section presents a review of literature about the ways in which Aboriginal people along the NSW coast value and relate to estuarine landscapes and estuarine species. The information comes from studies and reports prepared as part of academic research conducted for OEH and for DPI. Some of the research has focused on archaeological evidence and other projects have involved the stories of contemporary and historical Aboriginal communities.

There is extensive literature about the archaeology of estuarine landscapes in NSW and a growing literature drawn from oral histories of coastal Aboriginal people and from traditional stories about cultural and spiritual associations with coastal landscapes and coastal species. The Aboriginal cultural value of coastal landscapes is well established and DPI accepts the significance of Aboriginal attachment.

The scope of the literature review in this section is therefore intended to provide an indication of how this cultural and spiritual attachment influences Aboriginal attitudes to the concept of fish stocking and the level of involvement that Aboriginal people would like to have in the management of estuarine fisheries. It is not intended to be a comprehensive review of all available literature on Aboriginal fishing.

The literature review reinforces the significance of estuarine fisheries to the diet, culture and well being of coastal Aboriginal people. This significance extends from the distant past right up to the immediate period.

The information from the literature provides context for comments made by Aboriginal community stakeholders during face to face consultation about this project.

5.1 Aboriginal Cultural Traditions and Estuary Fisheries

The relationship of Aboriginal people to fishery resources in estuaries and other waterways was summarised by Cr Bev Manton (Chairperson the NSW ALC) in her speech to the Port Stephens Great Lakes Marine Park Advisory Council in July 2009.

> 'Aboriginal people have a spiritual, social and customary association with fisheries resources.
> Aboriginal people have continued their tradition of fishing consistent with our cultural beliefs.
> It is crucial to Aboriginal culture that this connection be maintained for the present and the future generations.
> Our fishing rights have provided us with a staple and healthy diet for thousands of years.
> Seafood kept us healthy and fit for generations but now we cannot fish in our traditional areas, or teach our kids, the next generation of our cultural fishing ways because we cannot fish in there.
> It has been a long standing concern of our people that cultural fishing has not been adequately recognised by NSW legislation.
> I hope to have this rectified during my last two years as Chairperson of NSW ALC.'

This section provides information about the various aspects of Aboriginal connection to estuary fisheries and how that connection is relevant to and affected by the proposal to stock selected fish species into some estuaries.

5.1.1 Aboriginal Estuarine Totems and Traditional Stories

The traditional social structure of Aboriginal communities includes familial or totemic relationships to natural features, plants and animals.

Rose, James and Watson (2003) describe totem systems in Aboriginal society and report conversations with the Yuin people of Wallaga Lake about what totems mean to them and their relationships to country.

Mutual caring between humans and non human kin (totems) and between the land and living things is at the core of Yuin culture. It is a two way dependent relationship.

Rose, James and Watson (2003) quote Yuin people who describe their totem as 'who you really are' and as 'friends, spirit guides and helpers'. They go on to say that the Yuin system of mutual caring

> '… consists of networks of people and groups of species kin, protect and assist each other. People's understanding of species is not isolated knowledge, but rather includes knowledge of the environment, habits, food and physical needs of the bird, animal, plant or tree involved.'

So when a person or family has a fish species as their totem, they have a deep interest in its full life cycle and the habitats in which it lives. This was also highlighted in a conversation with Ben Cruise from the Eden Local Aboriginal Land Council during this project. He commented on the cultural links of the black fish (black bream), which is both a food and a bush medicine for Aboriginal people. He commented that the blackfish eats a weed that needs nutrients supplied from the catchment; it also needs clean sand and logs in the water to lay its eggs; when these are available and the blackfish grows strong, it supports the needs of Aboriginal people. In turn, Aboriginal people have a responsibility to look after the habitats that the blackfish needs.

Yuin people also say that they believe that their totem species will help them by providing or conveying information. Rose, James and Watson 2003 provide examples such as:

> 'there was also collaboration with dolphins. The late Guboo Ted Thomas, on his tape The Dreamers, recounted an early memory of his grandfather singing songs, hitting the water with a stick and dancing on a beach down on the south coast, calling the dolphin to bring fish to shore for them to eat….. Guboo said that he could still sing the songs and described another time when a dolphin brought a big bream to shore for him.' (2003:48)
>
> 'Yuin women were also able to communicate with dolphins. There is a story that women from Brou Lake would hit on the water, and speak to the dolphins when they swam up, giving them messages to transmit to the men on Montague Island.' (2003:48)

One of the old Yuin women was still maintaining this practice in 1958.

There are similar stories about the relationship between Aboriginal people and dolphins elsewhere along the NSW coast. For instance, Faulkner 2000 refers to a documented tradition of dolphins assisting Aboriginal people to fish on the beaches in the Yaegl territory at Yamba. Faulkner refers to a similar relationship in the Moreton Bay region, at Bribie Island and North Stradbroke Island. Mick Leon (pers. comm. 2003) from the mid north coast, noted that dolphins are considered as 'brothers' on that part of the coast (but whales are not).

The Gumbaynggirr people on the mid north coast (English 2002) also tell of people calling to the dolphins from the headland at Corindi.

Yuin people also rely on communication from plants for important ecological information about totem species. For instance,

> 'Plants talk to you. They can tell you things. When the bark is peeling off the trees here, the fish are running. When you go up into the river country, bark peeling means the eels are getting fat. It's how our mother talks to us…. when it's time to go up the mountain for the bogong. Different flowers here tell you about diving for different things – abalone.' (2003:48)

> Faulkner (2000, p3) notes that a 'general characteristic of Aboriginal totemic relationships was the basic tenant of not consuming one's totem and taking some degree of responsibility for its survival.'

In some cases, the relationship was expressed in terms of ceremonies at particular sites (increase sites) to ensure the continuation of the species. For example, Schnierer and Faulkner (2002) report early twentieth century work by Radcliffe Brown, who recorded a bream increase site on the lower Clarence River for the Yeagal people.

How do these totem relationships interact with the proposal to stock selected fish and crustacean species into some estuarine waterways?

It is clear that estuarine species are totems or kin for coastal Aboriginal people, including dolphins, ducks, sea eagles and possibly bream; these traditional relationships continue today and for those with traditional knowledge, the concept of kinship with animal and plant species underpins Aboriginal community approaches to the management of land and sea country. However, there appears to be limited documentary information about kinship with particular fish species. Previous research projects such as those conducted under the OEH Biodiversity Program refer to people relying on even quite small coastal lakes and creeks (such as Corindi Lake for the Gumbaynggirr people) for a range of resources, such as oysters, prawns, crabs, turtles, fish and birds, and also wood worm. Fishing activities are highly valued by Aboriginal people. There is much less historical information about the species of fish that were targeted (see also **Section 5.3**) or whether any of these species were identified as having kinship relationships with local Aboriginal people.

The key principle of kinship to animal species is to look after them and their habitat. In this context, fish stocking using species that are generally valued by Aboriginal people (see **Sections 5.3** and **5.4**) can be seen as a positive thing. The value of fish stocking to Aboriginal people would increase significantly if Aboriginal people had an active role in the stocking activities or in monitoring how stocked fish interact with wild fish stocks (for instance, see the comments from Land Councils and Elders reported in **Section 3**).

Even when there were not specific totem or kinship relationships involved, there are many examples of cultural beliefs and cultural stories that influenced who could fish, when and for what species. DECCW (2010) summarises some examples:

DECCW 2010 refers to the work of Janet Mathews (1979) about restrictions on the diet of pregnant women, noting that

> 'in some areas, they could not eat snapper, bream or groper and could eat only rock cod, flat head and leather jacket.'

Becker (1989) in DECCW (2010) describes the experience of Aboriginal women from the Richmond River:

> There's a bend in the river, a lagoon, we cast out our lines and wasn't catching any fish, so I called out in our lingo and then we caught fish. But if I didn't call out, or get some of

> the old ones to call out, she would sit there all day and not catch a fish. It is strange but it is true, it is a spiritual thing with us.'
>
> 'When we go up to the lagoon, if we can't catch any fish, we talk to the spirits. That lagoon belongs to our people, so I can talk to them.'

5.2 The Archaeology of Aboriginal Estuarine Fisheries

Aboriginal archaeological sites along the NSW coast and estuarine shorelines provide evidence of the continuity of fishing over 6000 years or more. In excess of 1500 midden sites have been recorded along the NSW coast. Midden sites are identified by the presence of shell from edible species, but also often include remains of fish species. Also along the coast are open campsites, artefact scatters and rock shelter deposits, which do not contain shell, but may contain bones of fish, birds or other animals.

The largest middens in NSW are located in the Macleay Valley (Clybucca and Stuarts Point), and similar large sites are known along the Richmond and Clarence Rivers. Mounded middens are also known from Pambula, Wallaga Lake, Wagonga Inlet and Sussex Inlet (near Wreck Bay) on the south coast. The Clybucca middens are up to four metres high, and several kilometres in length; they are estimated to contain between 150,000 and 200,000 cubic metres of material.

Despite the large volume of material in estuarine midden sites, McBride (1982) estimated that the shell fish remains could only account for less than 1% of the total diet of Aboriginal people over the 2000 years that the middens accumulated. For these observations to be consistent with the ethnographic observations of Aboriginal cultural fishing and the account of Aboriginal people themselves of the significance of fishing activity for community well being, then much of the fish and shellfish must have been consumed elsewhere. For instance, there are many accounts (such as Threlkeld, in Gunson 1974) of Aboriginal people cooking and eating fish in their canoes.

There is a tendency towards an increasing variety of fish species and sizes in the upper layers of midden sites. Several authors suggest that this is due to the introduction of new fishing technologies (particularly line fishing) over time. Dates for fish hooks are all less than 1000 years. On the south coast, there is also an apparent change towards consumption of hairy mussel and edible mussel over the last 1000 years.

Common fish species in archaeological sites include snapper, southern bream, black bream, groper, red rock cod, leather jacket, dusky flathead, wrasse, luderick, morwong, wirrah, tailor, sand whiting, mullet, sea mullet and salmon (Poiner 1980).

There are frequent references in the literature highlighting the use of specific fishing technologies to target fish in particular habitats, of particular species and size. Technologies include fish traps or weirs (made of rock and plant material), hook and line, four pronged spears from land or canoe, butterfly style nets and combinations of these (see also **Section 5.3.1**).

5.3 The Historical Record – Estuarine Fishing and Cultural Survival

5.3.1 Ethnographic Records

There are many nineteenth century ethnographic references to Aboriginal people fishing in north and south coast estuaries, at estuary mouths and around headlands (see DECCW 2010 for a summary of ethnographic references to fishing by Aboriginal women). Although these descriptions would have been affected by the cultural values of the European sailors and settlers who made them, they do provide a clear indication of the ways in which coastal Aboriginal people accessed fishery resources and of the dependence of coastal Aboriginal people on fish and shellfish as key sources of nutrition.

This does not mean that coastal Aboriginal people only ate fish and shellfish, or that they relied on fish and shellfish as staples for the whole year – many of their other subsistence activities involving hunting and gathering in bushland would have been much less obvious to European observers.

The frequent references to Aboriginal people very quickly spearing or netting sufficient fish to feed substantial groups of people, does however, suggest that fish were abundant in estuaries. Aboriginal cultural fishers note that they always target what is seasonally available, increasing the impression of abundance (mullet, tailor, salmon etc.).

Another important observation from the ethnographic and historical records and in comments from contemporary Aboriginal cultural fishers is that Aboriginal people have targeted diverse species in estuarine waterways – from wood worms to eels to whales and a wide range of shell fish and water birds. They appreciated and drew on the complexity of estuarine ecology. These historical records are consistent with the attitudes expressed by people consulted about the proposed marine fish stocking, that looking after fish stocks should mean more than just adding fingerlings of finfish. In their view, looking after estuary health and fish stocks requires attention to all types of estuary habitat, and to a range of invertebrate species, not just fish.

Examples of the fishing activities of coastal Aboriginal people, of their affinity with estuary species and environments and with the effectiveness of their fishing techniques are noted below.

Ainsworth (pre 1922)

> 'the seasons were known to them by the foliage and flowers. They could tell by the natural signs of flowers and fruit when the salmon and mullet were due on the beaches and in the rivers and also when certain game was likely to be in evidence in particular localities'.

Hodgkinson (1845)

> 'fish formed a never failing article of food (for Aboriginal people)'
>
> 'the (Aboriginal people) at the Macleay and Nambucca Rivers spear in a few minutes sufficient fish for the whole tribe, on the shallow sand and mud flats of that part of the river which rises and falls with the tide.'

Henderson (1851) describes Aboriginal people diving for oysters, slowly working their way upstream in estuarine creeks.

Beaglehole (1955) (quoting from Captain James Cook)

> 'on the sand and mud banks are oysters, muscles (sic) cockles etc. which I believe are the chief support of the inhabitants, who go into the shoald (sic) water with the canoes

> and pick them out of the sand and mud with their hands and sometimes roast them and eat them in a canoe, having a fire for that purpose.'

Crown Lands Commissioner Fry (1843)

> 'the subsistence of the natives of this portion of the colony being determined in a great manner from fishing, the localities which they inhabit are consequently the immediate banks of the rivers Clarence and Richmond'. Of the coastal Aborigines, Fry says 'their diet is composed almost entirely of fish and honey.'

Ainsworth (1922) describes fishing methods used by Aboriginal people near Ballina:

> 'They were exceedingly expert hunters and fishermen and in these pursuits brought to their aid many ingenious weapons and contrivances. In catching fish they used what they called a 'tow-row' – that is a finely meshed net attached to a stick of bamboo bent in the shape of a bow about eight feet across between the two ends. This gave a bag effect to the net and with a tow-row in each hand the blacks could surround the fish schools in narrow and shallow waters and catch them by the hundreds.'

Ainsworth also describes Aboriginal people taking advantage of huge shoals of salmon in the surf in September.

Macfarlane hints at seasonal opportunities to catch eels when fish were less abundant in floodplain and estuarine wetlands:

> 'As the swamps reached the waterless stage an abundance of eels presented a plethora of the needful for the sustenance of the Aboriginal, as there was little trouble capturing the slimy wrigglers in the shallow water. Some of these attained a large size, but the average weight was considered best for eating. It was strange how the swamps produced so numerous a quantity of eel species, as in drought periods they were cleared of fish, but breeding was renewed when refilled from a flood.'

Threlkeld (in Gunson 1974) describes Aboriginal fishing in Lake Macquarie in the 1820s. He describes people fishing at night from canoes made of bark, tied at the ends and across the middle with vine. A fire was often kindled in the centre of the canoe – partly for warmth and partly to cook fish as soon as they were caught. Threlkeld (in Gunson 1974) also describes several different methods of fishing, tailored for different species and for different parts of estuarine habitats.

> 'Their mode of fishing is curious, sometime angling with hook and line thrown by the hand as they are seated in their bark canoe, sometimes diving for shell fish, sometimes standing in their frail bark darting their spears into the fish as they pass, or at other times using hand nets forming a circle in shallow waters and enclosing the fish; but the most curious method is that of planting sprigs of bushes in a zig-zag form across the streams leaving an interval at the point of every angle where the men stand with their nets and catch whatever others frighten towards them by splashing the water.'

Scott (1929), quoted in Brayshaw (1966) noted

> 'the schools used to travel from west to east close inshore on the northern side of the harbour, at high water….. The fishermen, generally about half a dozen at once, would rush into the water up to their middles…., then when the school was within striking distance, the spears would all be landed at once.'
>
> Scott (1929) also observed 'by some unerring instinct, the blacks knew within a day when the great shoals (of sea mullet) would appear through the heads.'

Scott's observations also provide a valuable record of the implements used for fishing in the Port Stephens estuary, for instance, in relation to fishing lines:

> 'the bark (of the kurrajongs) would be stripped carefully from the tree and soaked in water until the outer portions could be readily scraped off with a shell. This left a white, flax like

> fibre, very tough and strong. The women twisted this fibre to the required thickness and length by rolling it on the front part of the thigh with the hands.'

DECCW (2010) quotes Becker, biographer of Grace Roberts, an Aboriginal woman from the Richmond River, in relation to Aboriginal community awareness of the seasonality of species and the signs that individual species would be available in abundance:

> 'the river was and still is a happy place for these people and they have a rare knowledge of the fishing in the district. They watch the flowers: when the white ti tree is in full bloom the dog fish are bighting; it is the flowers that tell when the turtles are fat and plentiful; and when certain clouds appear in the sky it is time for bream.'

Another valuable early contact reference (Bennett 2007 (in DECCW 2010), citing convict West, from the Illawarra) to fishing highlights the importance of fishing as a source of food for families and for whole communities – not just for individuals. West referred to the construction of weirs made of sticks and bushes, to trap fish for large gatherings at Mullet Creek. This is reiterated by Aboriginal people in more recent interviews (see **Section 5.3.2**).

Table 5.1 provides a summary of references to Aboriginal use of fish and other aquatic species, drawing on a range of ethnographic references. The diversity of species reinforces the integrated use of estuarine resources by traditional Aboriginal people, an approach that continues where possible to the present (see **Sections 5.3.2** and **5.3.3**)

Table 5.1 - Summary of Ethnographic References to Use of Aquatic Species

Habitat	Species
Estuary and coastal lakes	• Fish including black bream, yellowfin bream, garfish, whiting, flathead, trevally and tailor • Prawns • Oysters (Sydney rock, mud or float oysters) • Cockles (Anadara and bimbula), mussel • Birds including swan, wild geese, wild duck, redbill and pelican
Tidal creeks and swamps	• Birds such as quail and brolga, as well as duck • Eels • Crabs and crayfish • Mussels, cockles, oyster • 'Cobra' worms • Tortoise • Food plants including rush (Typha), orchid, blechnum, water lily
Beach and coast – including estuary entrance areas	• Fish, such as sea mullet, groper, kingfish, leatherjacket, bullseye, salmon, snapper, stingray • Crabs and crayfish • Shellfish – pipi, rock platform species, Anadara, mussel • Whales and dolphins (e.g. Threlkeld refers to people feasting on both of these at Lake Macquarie) • Mutton birds

Scott (1929) and Attenbrow (2002) provide some examples of Aboriginal names for fish species in the local areas of the Worimi and the people of Port Jackson. Of relevance to the species proposed to be stocked into estuaries are the following:

Port Stephens

Beerah	crab
Coopere	bream
Kurrangcum	snapper
Peewah	mullet
Punnoong	shrimp
Tarrahwarng	flathead
Turrahwurah	jew-fish (mulloway)

Sydney Region

Cowerre	large flathead
Mullinagul	small flathead
Murraynaugul	flathead
Wallumai	snapper
Waradiel	large mullet

5.3.2 Historical Records

Although there are many accounts of Aboriginal subsistence in the twentieth century, the Aboriginal Women's Heritage series prepared by DECCW in 2004 provides a great insight into the life that coastal Aboriginal families lived in the earlier and middle parts of the twentieth century. For instance, the Port Stephens, Nowra and Nambucca Aboriginal Women's Heritage documents tell the stories of families who grew up in or around the missions and reserves at Karuah, Stuart Island (in the Nambucca Estuary) and Bowraville and at Roseby Park or Wreck Bay in the Shoalhaven. All of these women came from coastal families and the traditional fishing skills of their families have continued to support them all their lives. More than the other areas, the Shoalhaven families were also involved in seasonal vegetable picking and their stories reveal a more diverse diet, with farm produce supplementing fish and wild game.

The quotes below from the stories of these women highlight the importance of access to the estuary fishery to these women and their families. Although families fished for a variety of species, influenced seasonally, the women all refer to species included in the list considered suitable for stocking.

Nambucca

> I was born here on Stuart Island in 1936…….In the early days I'd go out fishing with Dad. We had a launch. Dad was catching mullets in those days and I would help him pull in the nets. Rosie and I would sit up the top of the headlands. We'd signal like mad when we saw the fish coming in the waves. When they got our signal, they'd go out in the boat, drop their nets and catch them. It was quite an experience.
>
> If you wanted to catch bait properly and there was too much of a tide, you had to wait until the afternoon. There were just certain times when you could catch worms on south Beach. We would catch about two or three thousand worms a day. (Valerie Cohen Smith)
>
> There was a lot of sharing on the mission when we went out and caught fish. We'd rent a boat and go over to south Beach to catch it. We'd catch a lot of fish over there. I used to live fishing. We'd get oysters too. (Fay Davis)
>
> My biggest thrill was when I was twelve, I would stay with me Auntie Bryan here and she's take me out worming. She taught me how to catch sea worms. I was frightened at first but when I caught my first one it was wow. After I went out a couple of times, I

caught hundreds. We'd go over to McQuires crossing and everywhere. The Goughs owned the bait shop then…… Uncle Benjie was the first Koorie around here to have a fishing licence. …. We'd go out fishing with him up the creek. As soon as we'd catch a feed, he'd make a fire, shove a stick through the mullet's mouth and shove it over the coals. He'd just put it on leaves or bark or just skin it. (Alma Jarrett)

Karuah and Port Stephens

It was idyllic in so many ways, if we wanted fish we just went down to the beach and threw our line in, and we had fish. If we wanted oysters, there were oysters, we just went down and collected them from the rocks. If we wanted crab, we'd put our crab traps down and we had crabs…… Most of our food consisted of fish oysters and crabs, mostly seafood – meat was a luxury, even minced meat would have been a luxury…….Aboriginal people have always looked after the fish – they would never have gone out and deliberately killed little fish. They know that the little fish were next year's food stock. They just didn't do it. …….we'd throw them back, but you see people come around here taking fish that should never be taken out of the water. They are just too small. And once you take those little fish there is not stock for next season. (Viola Brown)

We used to have to take crab sandwiches for school lunches when we had no money. Sometimes there just wasn't anything else to put on our bread. You see we were very poor. I mean these days crab sandwiches would be a luxury, but in those days it was a shame factor. …….so we'd have our crab sandwiches or oyster patties. Sometimes we'd have cold fish. (Bev Manton)

My dad fished with nets, both he and his dad. When I was a little girl, I'd go out in the boat with them, down towards Soldiers Point. They would go out with the tide, fishing along the way, and come back with the tide. They only had rowing boats in those days, no motor boats. We'd just pull into the bank of the river to have our lunch. Us kids used to help my grandfather and my dad with cleaning the nets and dying them too. We'd get the bark off the trees to dye (cure) them. My dad used to have a smoke hut – to smoke the fish, mainly mullet. And it was lovely too. My brothers and everyone helped with the smoking. We had to clean the fish and hang it up for so many days, then salt it down. That got us through the winter. (Val Merrick)

We used to do a lot of fishing. I remember when we'd walk from here right down to North Arm Cove……we'd take our lunch and spend the day down there, fishing all day off the rocks and especially on the big rocks out on the Point. We would catch some nice squire there (that's young snapper). Nice big bream and flathead and occasionally we'd catch some blue swimmer crabs. We'd walk back home in the afternoon. That was one of my favourite spots…….as kids we had our own special spots along the river bank. The day before we'd go out fishing, we'd go up to a big mud flat called Duck Swamp. It had a lot of small creeks running into it where the young mullet used to breed. We used old hessian bags and we'd catch a bucket full of them and bring them home for bait…….. If we didn't catch enough to go around, we'd make a curry up with what we had and sometimes we'd gather cockles and curry them up too. Cockles were plentiful then but you don't see them anymore. (Colleen Perry)

Well we used to row across to the Pig Station, which is up on the other side of Middle Island. There's a deep hole there. We'd catch things like lobsters and jew fish there, and just a few yards along from there is where the old fig tree used to be. And we always knew that if you went out fishing there we had to line our boat up with the fig tree – that's where all the whiting were. So we'd get a good feed of whiting from there. We used to fish all around the rocks around to the eastern side of the Point. You get things like flathead there…. (Carol Ridgeway Bisset)

Nowra

Dad made his living doing seasonal work and by fishing. He was a good fisherman. That was the main basis of our diet. He had lobster pots down at Crookhaven Heads, just

> there where the lighthouse is today. He'd catch plenty of lobster and mutton fish. When we went to Bodalla, we lived on ducks as the main thing and of course fresh vegies, there was always plenty of fruit and veggies down there. (Cheryl Carpenter)

> There was lots of seafood. We were taught how to fish from a really young age. We were always fishing. We'd go down after school for the oysters. But dad wouldn't let us go near the rocks, he did the rock fishing…….. we could only fish down at the front with a hand line…..but we learnt how to dig for nippers and we knew what bait to use……You can get them easy if you know where they are….. It's worth getting them because they make really good bait. We'd mix up dough for blackfish. (Lynette Simms)

5.4 Estuarine Fishing and the Wellbeing of Contemporary Aboriginal Communities

As was clearly stated during consultation about the fish stocking proposal (**Section 3**), the traditions of fishing carry on through the modern generations of coastal Aboriginal families, particularly those living in regional coastal areas. However, English (2002) also notes that traditions that were strong in the 1950s, 1960s and 1970s have declined over the last 30 years, partly because of reduced access to private land, pollution of waterways, land clearing and changes to social welfare access, natural resources legislation, availability of vehicle transport and changing work conditions for Aboriginal people. An example is the decline in reliance on fish resources from Corindi Lake, which became more polluted in the 1970s as the local town grew rapidly. In the 1970s the Gumbaingirr people still relied on Corindi Lake for fish, oysters, prawns, crabs, turtles, fish and birds.

> Oh I think they ruined that lake. All that murky water come down from that big drain near the shop there. All run into the swamp there, and from the swamp out into the lake. So we hardly don't take anything from the lake now, clouded up like that….. I don't know how the turtles are going to get into the swamp hole, where they go to, because it runs straight into the swamp and from there straight out into the lake. Big lake. All of its polluted. (Cecil Laurie, quoted in English 2002:18)

In the early and mid-twentieth century, many of the Aboriginal camps and missions were in relatively isolated places, with limited road access. The traditional cultural knowledge of people living in these coastal and estuarine places was essential for subsistence and to medicine and also 'cemented' attachment to country. In recent decades, Aboriginal people have not needed to hunt, fish and collect resources to the same extent as previously, but some traditions have been maintained – as much to continue connections to country and respect for Elders as for economic necessity (English 2002:16).

English (2002) suggests that the loss of access to land based resources since the 1960s and 70s may have been more dramatic than loss of sea resources. Many of the terrestrial places mapped by Gumbaingirr people in the English (2002) study had not been used for many years. So modern wild resource use along the coast has become more focused on sea resources such as fish and shellfish (and coastal plants).

On the south coast, Smyth (1997) reported that 90% of adult Aboriginal people in the community fished regularly, making fish a core component of the community's diet.

5.4.1 Species and Size Targeted

Chapman (1996) reports on the practices of Aboriginal commercial fishers on the NSW south coast. Many of these fishers worked seasonally both in vegetable picking and in beach or estuary hauling. Chapman refers to 'circular fishing':

> 'Aboriginal people employ a circular method of fishing where we fish for whatever is in season at the time. For example, there are specific times of the year when prawns are plentiful and at that time of the year we target prawns. It is the same with other species of fish such as mullet and so on. This method ensures sustainability of fish resources because by catching the species that are most plentiful at any given time, no species can become endangered.'

Whether or not this targeting of species when they are plentiful is ecologically sustainable, it is illustrative of the approach that Aboriginal cultural fishers have taken to fishing and is consistent with other ethnographic and historical descriptions of large gatherings when the mullet were running, or when oysters were fat.

Some Aboriginal people in NSW report that they have a clear cultural practice of returning small fish.

> 'We know when a fish is too small to eat, chuck him back grow up bigger.'

(Uncle Doug Pearce, Indigenous Fisheries Forum Group, Yamba).

However this view is not expressed uniformly across the community, as evidenced by this comment from the south coast:

> 'Aboriginal people do not go recreational fishing. When the Wallaga lads go fishing they go fishing to get a feed. Aboriginal people do not catch a fish and kiss them and then throw them back, they catch them to eat them.'

(Aboriginal Interviewee (south coast) quoted in Cozens 2003).

5.4.2 Indigenous Fisheries Surveys

Henry and Lyle (2003) conducted a survey of recreational fishing activity, in which data about Aboriginal fishing practices was analysed separately from the general population. Fishing households were first contacted by telephone (i.e. a phone survey) and encouraged to participate in a diary program where monthly information was collected about fish catches, fishing effort and fishing expenditure. Basic information collected about each household included household structure and demographic character (including ethnicity).

Of 10,300 households who were sampled by phone survey in NSW (containing 19,600 people over 5 years of age), 1.4% identified as Aboriginal people. Of 1836 households who participated in the diary program, 1.3% of households, with 1.7% of people were Aboriginal (63 people, including both coastal and inland fishers). This is a very small sample, given the Aboriginal population of NSW and the importance of fishing to Aboriginal communities.

The 63 Aboriginal fishers who participated in the survey reported going fishing on 266 separate occasions over a ten month period. They reported a very diverse catch an also reported a relatively high release rate.

The reported catch statistics for estuarine/marine species are shown in **Table 5.2**. Species corresponding to those proposed for stocking are highlighted. The three species most commonly reported as being caught by Aboriginal people in this survey (bream, flathead and whiting) are all species proposed to be stocked into estuaries.

Table 5.2 - Records of Recreational Fishing Survey, Aboriginal Households (2002)

Species common name	Kept	Released	Total
Bream (unspecified)	32	66	98
Cod – red rock/red scorpion/coral perch		2	2
Flathead unspecified	43	79	122
Flounder/sole/flatfish - unspecified		6	6
Garfish, unspecified	30		30
Gurnard	3		3
Leatherjacket	6		6
Lobster unspecified	12	11	23
Morwong - blue	0		0
Mullet, unspecified	4	7	11
Mulloway/jewfish/kingfish	3		3
Salmon – Australian east/west/kahawai		1	1
Shark, unspecified	1		1
Snapper – pink/southern/squire	2	13	15
Tailor/chopper/jumbo	9	7	15
Whiting, unspecified	10	39	49
Yabbies/nippers/bass yabbies	40		40
Fish – other		12	12

Although this was a recreational fishing survey, it should be noted that most Aboriginal fishers who participated would not have considered that they were fishing for recreational purposes. Rather, Aboriginal people consistently report that they are fishing for cultural purposes or for subsistence, or as part of how they look after country and country looks after them. Very often, those who are fishing do so to support an extended family or other kin (see also **Section 2.3.3** and **Section 6.3.1**).

The fishing effort by Aboriginal cultural fishers over the period of the survey is greater than the average across the State, hinting at both the subsistence value of catches and the broader community consumption of catches made by Aboriginal people.

A more detailed survey and consultation with Aboriginal people in coastal communities was conducted by Schnierer and Faulkner (2002). This research involved 150 questionnaires and multiple interviews with individuals, families and communities.

During this consultation, many different fish and invertebrate (shellfish, crabs, prawns, lobsters, squid and cobra worm) species were nominated by Aboriginal communities. Invertebrate species identified as being targeted by Aboriginal cultural fishers are listed in **Table 5.3**. Species that are also proposed as part of the marine fish stocking program are highlighted.

Responses to this survey and consultation reinforce the views expressed in other forums about the importance of fish and shellfish catches as a significant part of the diet of Aboriginal communities along the coast. The responses also highlighted the importance of sharing catches with extended family.

Table 5.3 - Invertebrates Targeted by Aboriginal Fishing Communities in NSW (Schnierer and Faulkner 2002)

Common name	Scientific name	Marine (M) or Estuarine (E)	Nominated for marine fish stocking into estuaries
Abalone	*Haliotis ruber*	M	
Beach worm	*various*	M	
Bearded mussel	*Trichomya hirsuta*	M	
Bimbula cockles	*Various*	E	
Blue swimmer crab	*Portunus pelagicus*	M, E	Yes
Cobra	*Teredo navilis*	E	
Eastern king prawn	*Penaeus plebejus*	E	Yes
Edible mussel	*Mytilus planulatus*	M, E	
Greasy back prawn	*Metapenaeus bennettae*	E	
Lobster	*Various*	M, (E)	
Mud crab	*Scylla serrata*	E	Yes
Mud oyster	*Ostrea angasi*	E	
Octopus	*Various*	M, E	
Pacific oyster	*Crassostrea gigas*	M, E	
Periwinkle	*Various*	M, E	
Pipi	*Donax deltoides*	M	
School prawn	*Metapenaeus macleayi*	E	
Sea urchin	*Various*	M, (E)	
Shrimp	*Macrobrachium sp*	E	
Squid	*Various*	M, E	
Sydney cockle	*Anadara trapezia*	E	
Sydney rock oyster	*Saccostrea commercialis*	M, E	
Tapestry cockle	*Tapes watlingi*	E	

5.5 Aboriginal Attitudes to Restoring Environmental Values and Landscapes

In 2007/2008, the Southern Rivers Catchment Management Authority (SRCMA) conducted a survey and consultation with Aboriginal people about caring for Country. The project involved people from different parts of the SRCMA, not just the coast, but the findings are consistent with comments made by coastal groups during consultation about fish stocking.

Key findings of the SRCMA consultation included the following:

- When asked to identify the most important factor affecting the health of the country in which they lived, the most nominated factor was a decline in the number of native animals. Pollution and poor water management (quantity) were the next most nominated issues.

- When asked to identify the most important ways to invest to improve the health of the environment, Aboriginal people nominated first land management activities (including bush regeneration and weed control) and second employment of Aboriginal people. The researchers noted that these two priorities were co-dependent. Aboriginal people saw

employment in programs that care for Country as a mechanism to improve both environmental well being and the well being of Aboriginal people. Respondents expressed a very strong view that healthy country and Aboriginal well being were interlinked. This view has been reiterated by a number of Aboriginal community groups during consultation about marine fish stocking.

- When asked to comment on which boundaries were appropriate to define units or managing country, Aboriginal people identified both Land Council boundaries and traditional owner boundaries as important. These boundaries were considered to be important by at least five times as many people as thought that regional NRM boundaries or local government boundaries were important.

- Similarly, Aboriginal people nominated better recognition of Aboriginal connections to country and more meaningful involvement of Aboriginal people in decision making as important improvements that should be made to make NRM programs more successful. Respondents thought that government agency staff did not properly understand cultural connections to country and also did not always follow through on information about cultural values that had been given to them by the community.

- Aboriginal people sought more training opportunities and more employment opportunities working on Country.

- Many people thought that sites and resources in their traditional country were not being properly looked after.

5.6 Natural Resource Management Targets for Aboriginal Cultural Landscapes

Each of the four coastal catchment management authorities in NSW has prepared a Catchment Action Plan (CAP) which sets out (amongst other things) how CMA programs will manage landscapes which have physical, cultural, or spiritual significance to Aboriginal communities. The intent of these CMA programs is to address intergenerational equity aspects of sustainability by ensuring that culturally valued aspects of the landscape remain available and accessible to Aboriginal people in perpetuity.

Implementation of the CAPs is also intended to contribute to achieving the NSW State-wide targets for natural resource management and for Aboriginal community well-being that is linked to healthy natural resources.

CMAs and Local Aboriginal Land Councils along the NSW coast have been building strong links over the last five years, enhancing opportunities for regional Aboriginal stakeholders to be involved in natural resource management planning, decisions and on ground works, including works in and around estuaries. Many of the issues raised by Aboriginal community representatives during consultation about the marine fish stocking proposal draw on these developing partnerships and are related to the broad themes of:

- Whether fish stocking is an effective and worthwhile component of natural resource management. Is it the best way to restore and maintain fish stocks in estuarine waterways? Is it consistent with Aboriginal and CMA priorities for habitat enhancement?

- Does the implementation of a marine fish stocking program provide opportunities to continue and build on the involvement, training and employment of Aboriginal stakeholders in natural resource management, building cultural, social and economic resilience in Aboriginal communities by looking after sea country?

This section notes the relevant regional scale natural resource management targets and programs and considers the extent to which fish stocking can address the issues raised by Aboriginal stakeholders. **Table 5.4** summarises the Catchment Targets from each CMA that promote Aboriginal involvement in the management of cultural landscape values, estuarine landscapes.

Each CMA has also developed multiple targets and actions for aspects of estuary health (protect estuarine biodiversity, rehabilitate estuaries), including riparian vegetation, floodplain wetlands, acid sulfate soils, bank erosion, environmental flows, entrance regimes, removal of blockages to fish passage, restoration of woody debris, research into fish breeding and constraints to population stability. All CAPs also have monitoring and reporting mechanisms.

Table 5.4 - Aboriginal Catchment Management Targets and Estuary Health Catchment Targets

CMA	Targets	Link between proposed marine fish stocking and this target
Northern Rivers	*By 2011, all regional and local planning instruments and decision making processes identify and adequately manage landscapes which have physical, cultural or spiritual significance to Aboriginal communities.* Relevant actions are identification and recording of cultural landscape values in consultation with Aboriginal stakeholders; facilitating the inclusion of these values into planning instruments. *By 2016 there is an improvement in the condition of coastal zone natural resources.* The intent of this target is to maintain those natural and cultural values of the coastline, major estuaries, small coastal creeks and coastal lakes that are in relatively good condition and improve the values of those that have been degraded. The focus of proposed catchment activities to deliver this target is communication and awareness raising, with improved partnerships with research organisations to enhance understanding of baseline condition and estuary processes. Priorities are linked to the NSW Comprehensive Coastal Assessment.	DPI recognises that estuaries and coastal lakes are important cultural landscapes for Aboriginal people. DPI has consulted with Aboriginal communities about the concept of fish stocking into estuaries and would consult with local Aboriginal stakeholder groups before any new fish stocking event in their area. Fish stocking activities would not impact on any known Aboriginal sites or Places. Fish stocking would increase the access of Aboriginal cultural fishers to species that have been important parts of their diet for generations. DPI would work with Aboriginal stakeholders to develop opportunities for regional Aboriginal people to be involved in stocking activities and monitoring of stocking outcomes. (see **Section 6**)
Hunter Central Rivers	*By 2016, manage an additional 52000 hectares of landscapes having physical, cultural or spiritual significance to Aboriginal people*. The intent is to safeguard the integrity of traditional interactions between people and nature. A high level of protection of Aboriginal cultural features and landscapes is intended. Relevant actions are access management for significant sites/places, maintaining natural landscape processes that support valued Aboriginal landscapes; clearing rubbish and removing invasive species, using traditional knowledge. The HCRCMA does not have an overarching	DPI recognises the importance of ongoing access of Aboriginal people to culturally significant places and resources, for well being, and for the continuation of a culture of caring for country. The fish stocking proposal would not alter Aboriginal access to sites or places. In selected estuaries, it would increase the number of popular dietary fish that are available to be caught by local Aboriginal people. DPI recognises that fish stocking should complement other habitat protection and enhancement

CMA	Targets	Link between proposed marine fish stocking and this target
	catchment management target specific to estuaries. Estuarine landscapes are included in targets relating to restoration of fish passage, riparian and foreshore vegetation, protection of wetlands and aquatic habitat, floodgate management, instream and foreshore stabilisation and urban stormwater and sewage management.	activities. Selection of estuaries for stocking each year would take the habitat enhancement program in each estuary into account. (See **Section 6**)
Sydney Metropolitan	*By 2016, Aboriginal cultural landscape values are identified, acknowledged and incorporated into all NRM activities and land use planning.* *By 2016, there is an improvement in the condition of estuaries and coastal lakes.* *By 2016, there is an improvement in the condition of coastal and marine ecosystems*	As for Northern Rivers and Hunter Central Rivers, DPI recognises the significance of estuarine cultural landscapes to Aboriginal people and the connection of these landscapes to a healthy diet, and to meeting cultural obligations to care for family and for country. By itself, fish stocking would not improve the condition of estuarine ecological communities or create healthy estuaries. It is a support action that would reduce pressure on wild stock in targeted estuaries.
Southern Rivers	*From 2006, Aboriginal communities will be better engaged in natural resource management planning and resources and opportunities to care for country are increased.* 'As custodians of the land (rivers and sea), Aboriginal people will be actively involved in natural resource planning and in land management on the ground. To participate as partners in planning, resourcing is needed to ensure that Aboriginal communities are properly equipped to take their custodian's role in natural resource management. We recognise Aboriginal spiritual and cultural connections to land and waters and call for a new relationship based on partnerships and a respect for traditional knowledge and perspectives.' *By 2016, the condition of coasts, estuaries and the marine environment is maintained or improved through active management, best management practice and strategic research*. • Through development and implementation of natural resource (estuary) management plans • Through development and adoption of best management practices by aquatic and marine industries • Through active management of key aquatic habitat areas (including threatened species and EECs) in partnership with relevant authorities and user groups • Through a targeted research strategy	An important message from consultation with regional Aboriginal stakeholders for this project is the desire of Aboriginal communities to be actively involved in managing the health of estuaries and coastal lakes in accordance with custodianship obligations. As above, DPI would work with Aboriginal stakeholders to develop opportunities for regional Aboriginal people to be involved in stocking activities and monitoring of stocking outcomes (see **Section 6**). DPI has heard feedback from Aboriginal stakeholder groups about the importance of protecting Aboriginal and recreational access to fishery resources in lakes and estuaries, and strong controls on commercial fishing practices and commercial fishing areas. When selecting estuaries and lakes to be stocked each year, DPI would ensure that recreational fishing havens in each region are included, to reduce competition between commercial, recreational and Aboriginal cultural fishers for access to fishery resources (see **Section 6**)

6.0 Analysis – How Fish Stocking Interacts with Aboriginal Cultural Heritage Values of Estuarine Waterways and Estuarine Landscapes

6.1 Summary of Aboriginal Perspectives

From the information presented in **Sections 3**, **4** and **5**, the following conclusions can be drawn about the values of estuarine wild fisheries to Aboriginal people in NSW:

- Aboriginal people have fished NSW estuarine waterways for all of the Holocene (approximately 6000 years) and probably also fished late Pleistocene estuarine systems, now under water off the coast, during the last glacial maximum. There is no doubt that estuary fishing has been part of the lifestyle and subsistence of coastal Aboriginal people for many generations.

- Species that are common in archaeological sites include mulloway, bream, whiting, mullet, blue swimmer crab, lobster, flat head, trevally, tailor, as well as shellfish.

- Species that early European explorers and settlers observed Aboriginal people catching in nets, spears and with hand lines include mullet, bream, whiting, tailor and crabs, as well as shell fish, birds and worms.

- Species that were part of the subsistence of mid twentieth century Aboriginal families, many of whom still relied on collecting wild foods to have enough to eat, include crab (poverty food in those days), whiting, mullet (a staple fresh and smoked), mulloway and bream. They also collected worms (from the sand/mud and from wood), oyster, cockles, pipi and mussel.

- In broad terms there is continuity of species favoured by Aboriginal cultural fishers, supported by and supporting intergenerational transfer of traditional cultural values, from 'prehistoric' traditional times to the present day. The favoured traditional species are consistent with the species that DPI proposes to stock into estuarine waterways.

- Some of the species proposed to be stocked are also totem species or are the subject of traditional stories.

- Aboriginal people have strong traditions of looking after estuarine systems and estuarine fish resources as part of their attachment and obligation to sea country and their dependence, until very recent times, on estuarine wild foods for subsistence. These traditions involve selective taking of bait fish and eating fish, not taking brood fish, use of very diverse species when necessary, a sound understanding of seasonal patterns and protecting wetlands and waterways. People who contributed information to this project stressed the importance of looking after river banks, estuarine and riparian vegetation (include logs and debris) and maintaining diverse habitats such as deep holes, sandy areas and mud flats.

- Some of the traditional knowledge of people who are now elders is being harnessed in land and waterway management projects such as Land Alive and in Coastcare and Landcare teams. In coastal areas, sea country may now be more accessible than land country for Aboriginal people, as tenure arrangements have changed and people become more mobile. But people remain very attached to the stories of how their parents and grandparents lived on fish.

- Special gatherings for Christmas, family events etc. still occur at estuary campsites along the coast. These are opportunities to transfer culture and traditional knowledge and would benefit from significant stocks of favoured fish species.

- Aboriginal people with traditional knowledge are very cautious about the role and merit of fish stocking in estuarine waterways. Everyone agreed that fish stocking would probably result in more fish to catch and eat in stocked waterways, provided Aboriginal access to those waterways is properly maintained. However, many people also questioned whether stocking with hatchery raised fish (even from the best hatcheries) was the best method of building up stocks of estuarine species. Concern was expressed that stocking would destabilise ecological balances in estuarine waterways, by changing predator- prey balances, or overcrowding some pools, or introducing different genetic strains. Note that the ecological components of the EIS address these real and important risks.

- There were multiple suggestions that habitat enhancement would be a more cost effective and sustainable investment in long term fish stocks. People also thought that stricter regulation of commercial fishing, particularly in small estuaries, would increase fish stocks for recreational and Aboriginal cultural fishers, by reducing competition for the resource.

- There was a strong view from all participating Aboriginal stakeholder groups that stocking should be carefully coordinated with habitat enhancement and catchment protection works. Waterways with poor habitat condition or diversity should not be stocked. Stocking should be used as a support tool where habitat enhancement works (such as fish ladders and bank protection) have already taken place.

- If stocking does take place as part of a package of estuary health and enhancement initiatives, then local Aboriginal communities should be consulted prior to any stocking event. Consultation should involve Local Aboriginal Land Councils and Aboriginal Owners as a minimum.

- Aboriginal communities are very keen to be involved in managing the health of estuarine waterways and this would extend to fish stocking if it were introduced. There were strongly expressed ambitions to be involved in the actual stocking process (collecting brood stock and releasing fingerlings) monitoring programs, in education programs for fishers, in regulatory activities and in on ground works. DPI should explore employment and training opportunities for Aboriginal people as fishery rangers in regional areas. These rangers could be part of the team managing fishery habitat and vulnerable populations of popular species. This concept could be explored with Aboriginal community leaders and with CMAs.

6.2 Fishery Management Risks Associated with Aboriginal Issues

A qualitative risk assessment of the ways in which the proposed fish stocking activity may impact on Aboriginal community values and activities has been completed. The risk assessment method and criteria are the same as have been applied to all other risks associated with the fish stocking proposal (see Chapter D of the EIS).

The likelihood and consequence measures are noted in **Tables 6.1** and **6.2**, and standard risk descriptors are noted in **Table 6.3**. In addition to the negative consequences associated with risk, there is potential with fish stocking that the impact for local Aboriginal communities would be positive.

Table 6.1 - Qualitative Measures of Likelihood

Level	Descriptor	Description
A	Almost certain	Is expected to occur as a result of the project under most circumstances.
B	Likely	Will probably occur as a result of the project in most circumstances.
C	Possible	Could occur and has occurred in similar circumstances.
D	Unlikely	Could occur as a result of the project but is not expected.
E	Rare	Could occur only in exceptional circumstances.

Table 6.2 - Qualitative Measures of Consequence

Level	Descriptor	Description
1	Catastrophic	Irreparable damage to highly valued structures/items/locations of cultural importance and/or infringement of cultural values.
2	Major	Significant damage to structures/items of cultural significance or infringement of cultural values.
3	Moderate	Moderate repairable damage to structures/items of cultural significance or infringement of cultural values.
4	Minor	Minor repairable damage to structures/items of cultural significance or infringement of cultural values.
5	Insignificant	No impact to structures/items of cultural significance or cultural values.

Table 6.3 - Risk Descriptions

Level	Risk	Description
E	Extreme	Risk is intolerable and cannot be justified under any circumstances. Measures to reduce risk to a lower level are required.
H	High	Risk is significant and requires cost effective measures for risk reduction.
M	Moderate	Routine and cost effective measures required to reduce risk.
L	Low	Risk can be managed by routine procedures and no further measures to manage risk are required.

Table 6.4 summarises the application of this risk framework to Aboriginal issues

Table 6.4 - Risks Associated with Fish Stocking: Aboriginal Culture Aspects

Risk description	Risk severity before treatment			Fishery Management strategy	Treatment type	Risk severity after treatment		
	L	C	Level			L	C	Level
Impingement on areas of Aboriginal cultural importance (sites and Places/objects)	D	3	Moderate	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. Consultation with Aboriginal community groups at each new estuary that would be stocked.	Reduce likelihood	E	3	Moderate
Fish stocking not seen as an adequate, 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. Monitoring of stocking success.	Accept Risk Level	D	3	Moderate – Could become positive if the programs are clearly well integrated and producing good results.

Risk description	Risk severity before treatment			Fishery Management strategy	Treatment type	Risk severity after treatment		
	L	C	Level			L	C	Level
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
Lack of involvement of Aboriginal stakeholders in fisheries management and stocking activities	D	4	Low	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 - Could be positive if stakeholders can see their issues and concerns are fully integrated into the project and they can be involved in monitoring and communicating.

6.3 Fishery Management Actions

This section elaborates on the information in **Table 6.4** and reviews the actions that can be put in place to minimise the risk of negative outcomes for Aboriginal communities where fish stocking occurs along the NSW coast. Potential actions are noted in relation to each aspect of risk.

6.3.1 Fish Stocking Impinges on Sites/Places or objects of Aboriginal Cultural Importance

Many places that are Aboriginal sites or gazetted places are listed in the AHIMS system maintained by OEH and are also known to local Aboriginal stakeholders.

DPI proposes to use existing ramps and jetties when collecting brood stock or releasing fingerlings into waterways. This minimises the risk that vehicles or boats involved in stocking activities will impact on Aboriginal sites or Places.

DPI would consult with relevant Aboriginal groups within the vicinity of any new stocking location prior to the stocking event proceeding. A protocol would be established in consultation with representatives of Aboriginal stakeholders and would be similar to the protocol already in place for consulting with Aboriginal stakeholders prior to stocking fish fingerlings into inland waters.

If consultation reveals that a valued Aboriginal Place is located in an estuary which is proposed for stocking, 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.

For instance, there is a bream increase site in the lower Clarence River estuary, which is important to the Yaegl people. In Lake Macquarie, Pulbah Island is a gazetted Aboriginal Place and there are traditional stories about monsters which inhabit the waters to the west of the Island. The deep waters of this area are widely used for recreational fishing and boating. If fish stocking is proposed in the Clarence River estuary, DPI would consult with the Yaegl stakeholders to make sure stocking does not affect the cultural values of the place. If stocking were proposed for Lake Macquarie, then DPI would consult with local Aboriginal stakeholders about whether the stocking activity should avoid this part of the lake system.

Goal 2 of the draft FMS aims 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. To meet this goal, and ensure stocking does not impinge on sites, Places or objects of Aboriginal cultural significance, DPI propose the following:

- Provide opportunities for Aboriginal communities to participate in stocking activities and to support cultural fishing practices.
- Ensure that new information about areas or objects of cultural significance is taken into account in the stocking review framework.
- Consult with relevant Aboriginal groups in the assessment of any new sites proposed to be stocked.

With the above measures in place, the risk of fish stocking impacting on culturally important sites, Places or objects is moderate.

6.3.2 Fish Stocking not seen by Aboriginal Stakeholders as an Adequate, Good Value or Sustainable Approach to Looking after Sea Country

Over the last five years, Aboriginal communities have engaged strongly with a range of catchment management initiatives, sponsored by CMAs. The coastal CMAs all employ Aboriginal community support and catchment officers, and generally also have an Aboriginal stakeholder reference group which provides feedback on proposed activities and opens links into the community. Programs of actions being implemented by these groups draw on local connections and commitment to look after land and sea country. Participants are proud of the achievements in habitat enhancement and see these programs as important steps towards culturally relevant and sustainable natural resource management.

Goals 1 and 2 of the draft FMS relate to improved access to fishery resources and protection of ecological and biodiversity values.

To meet these goals and to minimise risks that Aboriginal communities will not support fish stocking as an activity which has habitat and ecological benefits which outweigh ecological risks and is a valid part of looking after sea country, DPI proposes to do the following:

- 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

- Continue to run long-term habitat restoration and protection programs that would complement fish stocking.

- Monitor stockings to ensure success in line with appropriate management objectives. Monitoring programs would align fish stocking and estuary health indicators, potentially providing a link to CAPs and the ecosystem health targets of the NSW State Plan as well as the recreational activity target.

- Manage the activity having regard to cross-jurisdictional and DPI management arrangements (including programs designed to protect aquatic environments and biodiversity).

With all of these measures in place, the risk that fish stocking will be seen as poor value for money in terms of estuary health and estuary values will be reduced to low. The risk should continue to decrease over time, as partnerships between natural resource management organisations, Aboriginal stakeholders and DPI strengthen.

6.3.3 Competition from other Fishing Sectors Reduces Aboriginal Access to Stocked Fish for a Healthy Diet

There is a risk that competition between commercial, recreational and Aboriginal cultural fishers will lead to no real improvement in Aboriginal community access to fishery resources and a healthy based diet. This is the diet that many current Elders who grew up in coastal areas say they experienced as children and has great social significance in the community. To reduce this risk, DPI proposes the following:

- DPI would ensure that there is a balance between the number of RFHs stocked and the number of estuaries open to commercial fishing.

- 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 stakeholders are informed of relevant outcomes of stocking activities.

Monitoring of stocks and fishing effort would also help to clarify the extent of benefit that can be achieved for Aboriginal cultural fishers.

It should, however, be noted that fish stocking, especially a modest program, may not be sufficient by itself to make a significant difference to Aboriginal access to fish resources and to improved diet.

6.3.4 Lack of Involvement of Aboriginal Stakeholders in Fishery Management and Stocking Activities

Aboriginal stakeholders have strong views about what contributes to a healthy and productive estuarine system and are uncertain that fish stocking will be cost effective in delivering improved outcomes for estuaries and estuary fishers. The consequence of lack of certainty about impact on fish stocks and estuary health, combined with concerns about lack of equity in access to the resource, is an area of potential dispute and may contribute to developing a poor relationship between Aboriginal stakeholders and DPI.

To reduce the potential for these risks, under Goal 2 of the draft FMS DPI would:

- Consult 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. At the same time, DPI may seek feedback from Aboriginal stakeholders using stocked estuaries about their observations of the activity.

With these measures in place, the risk associated with insufficient information would remain as low.

6.4 Fishery Management and Monitoring

An issue of concern to Aboriginal stakeholders is limited access to information about fish stocks in estuaries and the relative importance of various factors that impact on the health and productivity of estuary systems.

DPI proposes to introduce fish stocking gradually. This period provides an opportunity to improve information about how stocking affects stocks of the selected species, how it affects other species and how it affects access to the resource by different stakeholder groups.

DPI would provide opportunities for involving regional Aboriginal stakeholders in these detailed monitoring and evaluation programs wherever feasible.

Proposed performance indicators, which are relevant to the issues raised by Aboriginal stakeholders for the activity, are set out below.

GOAL 1: To manage the activity in a manner that minimise impacts on aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates.

How will progress towards this goal be measured?

Estimates should be available through research and other programs designed to define and examine the effectiveness of stocking.

Monitoring activities could include:

- Tracking the survival of all species of fish stocked into each estuary.
- Monitoring numbers of key predators of the stocked fish (where relevant).
- Link to modelling and monitoring of estuary health (see OEH 'CERAT' estuary tools).

DPI would work with Aboriginal stakeholder groups to develop opportunities for Aboriginal involvement in these monitoring activities.

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 priorities of the NSW State Plan

How will progress towards this goal be measured?

Effective responses to Aboriginal or other cultural heritage issues would be indicated by the involvement of Aboriginal fishers in stocking activities

Monitoring/data gathering could include the following:

- Surveys of fish catch by recreational, Aboriginal and commercial fishers in stocked estuaries (requires pre stocking baseline information). Local Aboriginal people could be involved in the implementation of these surveys.
- Consult and provide information to Aboriginal communities during all stages of fish stocking. Maintain a data base of indigenous community consultation for each fish stocking event (from collection of brood stock through to stocking and then provision of information of stocking outcomes.
- Involve Aboriginal stakeholders in surveys of how fish stocking affects catch per fishing effort. This could involve targeted interviews with stakeholders around stocked estuaries or could involve broader surveys of recreational, commercial and Aboriginal cultural fishers (as above).

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Specialist Report B

Economic Feasibility Assessment

Cardno
Shaping the Future

Marine Fish Stocking in NSW

Economic Feasibility Assessment

EL0809106/R2646v4

Prepared for NSW Department of Primary Industries

4 November 2011

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Cover photograph: Pambula Lake (Cardno, 2010).

Document Control

Version	Status	Date	Author		Reviewer	
2	Draft	19 May 2010	Leo Drynan	LDD	Rhys Thomson	RST
3	Final	25 Feb 2011	Leo Drynan	LDD	Rhys Thomson	RST
4	Revised Final	25 March 2011	Leo Drynan	LDD	Rhys Thomson Louise Collier	RST LCC
5	Revised Final	11 August 2011	Leo Drynan	LDD	Rhys Thomson Louise Collier	RST LCC
5	Final	4 November			Peggy O'Donnell	POD

Executive Summary

NSW Department of Primary Industries (DPI) is proposing to institute a marine fish-stocking program within New South Wales (NSW) estuaries to enhance recreational fishing opportunities within the State. This Economic Feasibility Assessment (EFA) investigates the viability of such a program for the seven species selected and across ten estuarine regions in NSW.

The impact and viability of a fish stocking program, as determined by a comparison of costs and benefits, is seen to be dependent upon both:

- Fisher characteristics, including:
  - The number and location of fishers within the State;
  - The motivation of fishers;
  - The fishing effort expended within the State;
- Species characteristics, including:
  - The current species stock status;
  - The ease with which a fish (both finfish and crustaceans) may be caught (its 'catchability'); and
  - The biological ability of the species to survive and reproduce.

This EFA describes the methodology utilised to evaluate each of these aspects (both qualitatively and quantitatively).

Following analysis of both quantitative and non-quantitative data conclusions are drawn as to:

- the feasibility of stocking each of the selected species; and
- the optimal fish-stocking locations.

Feasibility of Stocking Individual Species

The data available in regards to fishing effort and success of capture within NSW is insufficient to undertake a standard quantitative cost-benefit analysis which would typically be reported as part of an Environmental Impact Statement (EIS). Consequently, both a qualitative discussion of the associated costs and benefits as well as three distinct non-standard quantitative cost-benefit analyses (CBA) are undertaken within the EFA to determine the feasibility of stocking each of the seven selected species.

The three cost benefit analyses are:

- Market value feasibility;
- Expenditure value feasibility; and
- Effort value feasibility.

Benefits associated with fish stocking programs include:

- Direct increased expenditure;
- Economic multiplier impacts;
- Enhancement of fish populations; and

- Enhancement of recreational fishing quality.

Costs associated with fish stocking programs include:

- Research and monitoring costs;
- Production costs;
- Negative perception costs;
- Administration costs; and
- Capital costs.

The quantitative assessments undertaken adopted a series of simplifying and conservative assumptions to account for the lack of available data while still providing indicative results as to the positive economic outcome associated with a fish stocking program.

An overview of the three quantitative feasibility assessments undertaken is provided in Figure ES.1.

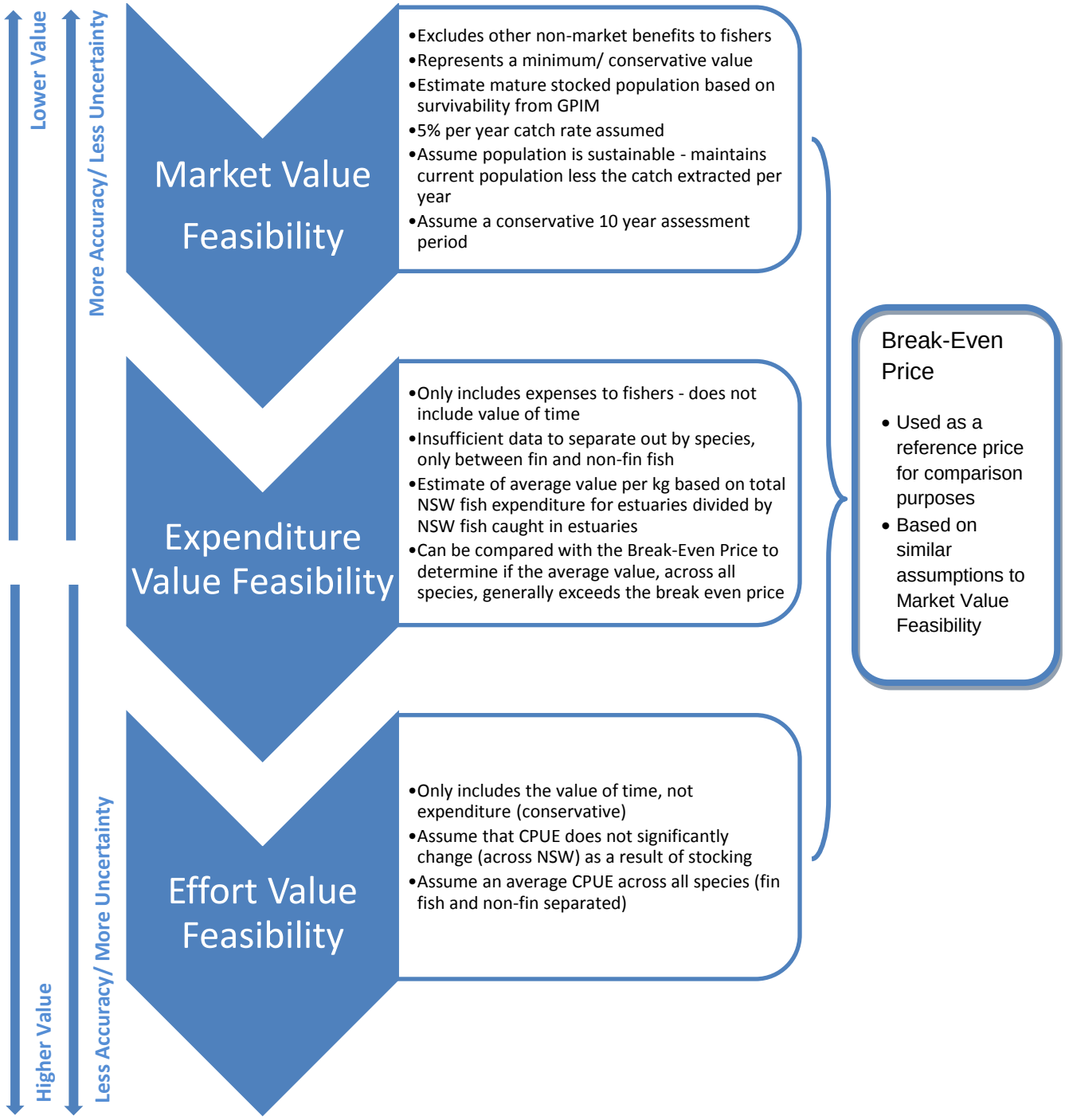

Figure ES.1 Quantitative Economic Feasibility Assessment Overview

The key finding of the EFA, for both the qualitative and quantitative assessments, in regards to feasibility 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 crab and prawn species are seen as more likely to be viable.

However, it is noted that the motivations behind non-finfish (e.g. crabs and prawns) capture and finfish (the other five species assessed) capture may be significantly different. Furthermore, non-finfish capture generally requires specialist equipment and is generally

undertaken by a lower proportion of the fisher population. Therefore, 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.

Further details are provided in **Section 9**.

Optimal Fish-Stocking Locations

An attempt was made to provide economic input to the optimal allocation of fish stocking amongst the 10 regions. Utilising fishing licence holder data and survey data held by DPI, the EFA identifies where fishers live, how often they are likely to fish and how far they are willing to travel. Using this information, an estimate of the fishing effort is quantified for 10 identified estuarine regions in NSW. Preferred regions for fish-stocking are considered to be those with a high fishing effort (i.e. popular regions) yet low fish populations.

Fish population estimates for NSW do not exist. Consequently, the EFA creates a population 'index' as a proxy population estimate based on calculated stocking potential of each of the estuarine regions.

With these popularity and population estimates the EFA identifies the Lower South Coast and Upper North Coast regions of NSW to be the most preferred areas for implementing fish stocking programs.

Further details are provided in **Section 9**.

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Glossary

Avidity	The keenness with which recreational fishing is pursued by an individual.
Catch	The harvest of fish obtained over the course of a fishing event.
Catchability	The ease with which one species is caught per unit of effort.
Commercial Fishing	Fishing undertaken with the sole purpose of selling catch.
CPUE	Catch per Unit Effort. The known harvest divided by the known effort expended to generate that harvest.
Discount Rate	The rate at which future values must be reduced to account for the time value of money (assumed to be 7 %).
Effort	The amount of time spent fishing.
Finfish	Selection of marketable fish that is neither shellfish nor molluscs.
Fish	Generally refers to both finfish and crustaceans.
Fishing Event	The undertaking of a fishing activity for a user defined period of time.
Fishing Mortality	The proportion of an existing fish population caught and removed by recreational fishers per year.
Fishing Quality	The characteristic of an area in which fishing may occur. This predominantly relates to the size of existing fish populations but also relates to environmental and social amenity.
GPIM	Generalised Predatory Impact Model
Harvest	The number of fish caught. Expressed in either kg or number of fish.
Inflation Rate	The rate at which the price of goods increases (assumed to be 3 % per annum).
Net Present Value	The overall current value of an income stream taking into account both future costs and benefits where future income is discounted at a given discount rate.
Population	A collection of inter-breeding organisms of a particular species occupying a defined area during a specific time.
Recreational Fishing	Fishing undertaken on a purely voluntary basis where any catch is not purposed to be sold on to others.
Utility	The amount of satisfaction received by an individual through obtaining a commodity or undertaking an action.

1 Introduction

The economic assessment of fisheries represents a significant school of natural resource economics. Primarily this is driven by the need to sustainably manage the commercial fisheries which represent an important primary industry within both New South Wales (NSW) and across the globe. In comparison, the proportion of academic effort directed towards recreational fishing economic analysis is relatively low. Further contributing to this imbalance is the difficulty associated with obtaining data in regards to recreational fishing. Unlike commercial fisheries, recreational fishers are not required to report their catch. Recreational fishing can be highly site specific in terms of its economic costs and benefits (e.g. population distribution and development is a significant factor which will influence the extent of costs and benefits received).

Within NSW the number of estuarine recreational fishing economic studies previously conducted is quite low (approximately 30 recreational fishing surveys, economic and non-economic, have been conducted within New South Wales (Henry and Lyle 2003)). Most of these available studies do not focus on economic aspects and are restricted in terms of geographic and temporal range, limiting their applicability to broader proposals such as the Environmental Impact Statement (EIS) that this economic feasibility assessment (EFA) has been prepared for.

1.1 Aim of Economic Assessment

This economic assessment aims to qualitatively describe the economic factors involved in fish-stocking programs and as well as provide a preliminary indication of the likely feasibility of an estuarine fish stocking program through a quantitative analysis.

Although the proposed program has the potential to affect all fishing sectors (i.e. commercial, Aboriginal and recreational), the main objective of the program is to improve the quality of recreational fishing. As such, the economic assessment focuses largely on the economic effects on recreational fishing.

In assessing the proposal, this study evaluates economic impacts of a stocking event in one year (i.e. stocking of $300,000 of fingerlings, crabs or prawns). It assumes that the scale of the program will not impact upon largely inelastic fishing effort at the scales at which the costs and benefits of the fish stocking program will be evaluated (i.e. at a State-wide scale, as well as at a regional scale) (see in Sections C.4.3.2.4 and D5.2.2.6) of the EIS.

This study does not aim to provide an economically rigorous valuation of the cost and benefits associated with a fish stocking program as would typically be undertaken for an Environmental Impact Statement (e.g. development of a quantitative demand models or scenario analysis). Similarly, the study does not attempt to quantitatively evaluate environmental and social impacts (environmental impacts and social impacts are addressed independently in Sections H.2 and G.2.2 of the EIS respectively). Such a study was not undertaken due to:

- The lack of available data in regards to recreation estuarine fishing utilisation;
- The lack of available data in regards to the fish populations within estuaries; and

- The cost and benefits associated with stocking are highly site specific and individual estuarine economic evaluation was considered to be beyond the scope of this State-wide EIS.

Further justification for the approach adopted is provided in **Sections 2** and **3**.

Although defined in broad terms due to the data limitation, the findings of this cost benefit analysis will reflect the nature of likely impact of fish stocking and can be utilised as a decision making tool to guide which species are economically feasible to stock and in which location the stocking will generate the greatest net benefits.

2 Literature Review

2.1 Valuation of Fisheries

In general, fisheries management is based on predictions of population growth based upon the existing level of stock (e.g. Gordon-Scott Model: Gordon (1954), Scott (1995)). Under such a system, the change in stock over time is equal to the difference between the fish populations' growth rate and the realised harvest rate as a result of fishery practices. The proportion harvested usually represents a small proportion of the entire stock (as opposed to the whole stock) at any one time (Hilborn and Walters 1992).

Actively managed fisheries are typically managed to restrict the level of fishing catch (predominantly through regulating fishing behaviour and effort) to ultimately obtain the maximum economic yield. Ideally, this requires the adoption of optimal control paths of increased and reduced harvests to adjust fish population sizes (Scrimgeour *et al*. 2001).

Theoretically, the need for, and benefits flowing from, a fish stocking program (increasing the base population of fish stock), would be relatively simple to assess based upon the current fish population levels in relation to the maximum economic yield quantities and known quantities of stocked fish, effects on growth rates, and subsequent predicted increases in yield and changes in effort.

However, this type of analysis is impractical in regard to most recreational fisheries as there is not adequate data available for many of the relevant parameters required to conduct such an assessment.

2.2 Recreational Fishery Economics

Recreational fisheries economics is typically based around the interaction between *fishers* and their environment. This differs from commercial fisheries in which it is the interaction between *fish* and their environment which is of primary concern (Cooke and Cowx 2006). In commercial fisheries, costs are associated with harvesting the fish (the fishing effort) and benefits represent the value of the harvest acquired at the market floor. For recreational fisheries there are a significant number of additional direct and indirect costs and benefits to those incurred within commercial fisheries.

2.2.1 Recreational Fishing Behaviour in New South Wales

A major factor to be considered in an economic analysis of recreational fishing is the diverse nature of fishers participating within the fishery. Henry and Lyle (2003) indicate that 30 % of the fishing effort across NSW is provided by just 10 % of the fishing population. Dominion (2003) focused on the Sydney region in particular and estimates that up to 39 % of fishing effort may be provided by just 10 % of the fishing population. This suggests that there is a small minority of fishers who undertake a large proportion of the fishing and hence receive a larger proportion of the direct benefit from fishing, while there is a large majority who receive a smaller direct benefit from fishing. On average within NSW the number of days spent fishing by fishers is approximately 6 days per year, although some people have been recorded undertake over 150 fishing events (Henry and Lyle 2003). When considering a potential fish stocking program designed to encourage recreational fishing, the impacts of

stocking between those who obtain high and low benefit from fishing will be significantly different. Such differences would need to be captured within consumer surplus estimates.

These differences are largely due to the variations in the motivations associated with recreational fishing. Fundamentally, most recreational fishing will be undertaken for enjoyment purposes (otherwise it would not be recreational). Other forms of non-commercial fishing (e.g. Aboriginal fishing practices) have not been assessed within this economic appraisal. The way in which this enjoyment is received or the form it takes will vary between individuals. For example some people may fish for the enjoyment of catching a fish, whereas others may fish for the enjoyment of tranquil surrounds. As shown in **Table 2.1** at least 73 % of fishers within NSW are estimated to be fishing for reasons that are largely independent of the quantity of the fish available to be caught.

Table 2.1: Motivations for Recreational Fishing (Source Henry and Lyle, 2003)*

	% respondents								
Motivation	**NSW**	**VIC**	**QLD**	**SA**	**WA**	**TAS**	**NT**	**ACT**	**Total**
Relax and Unwind	40	43	39	32	28	31	29	41	37
To be Outdoors	15	15	9	10	11	13	32	15	13
For Solitude	1	1	3	3	3	2	4	2	2
To be with Family	13	12	16	17	20	19	11	9	15
To be with Friends	4	7	3	9	6	3	10	2	5
Competitions	0	0	0	0	0	0	0	0	0
Fish for Sport	21	15	18	15	18	16	9	27	18
Fish for Food	5	6	9	12	11	8	2	3	8
Unsure	2	1	4	2	3	7	4	1	3

*it should be noted that these data are not estuarine specific.

Subsequently, measuring both the existing value of recreational fishing and the impacts of stocking is considerably challenging as it is frequently the activity rather than the outcome of the activity (the catch) that is valued by fishers. Valuing the harvest caught by recreational fisheries, as done in commercial fisheries, would considerably underestimate the value attributed to the activity by those fishers who are likely to fish for reasons independent of numbers or species caught.

Furthermore, the potential to utilise market values of individual fish and harvests as an attempt to value catch by fishers is also difficult as many fish caught are released. This received benefit is often ascribed to the "sport" aspect (the enjoyment received through the challenge and activity) rather than obtaining fish for food (under the food motivation the harvest price of fish may be an appropriate value estimate).

2.2.2 Recreational Fishing Valuation Techniques

Generally, most attempts to estimate the value of recreational fisheries have been done based around three broad methodological approaches (Rolfe and Prayaga 2007):

- **Single-site demand models**: expenditure and other revealed preferences are utilised to estimate the economic value through a travel cost method and estimate the fisher's willingness to pay for undertaking fishing (e.g. DAFF 2005, Raybould 2009).
- **Site choice models**: a random utility model is developed to identify how fishers make choices between sites (i.e. Choice experiments, econometric estimations) and thus identify the relative value of fishing locations (e.g. Lawrence 2005, Prayaga *et al*. 2010).
- **Stated preference techniques**: valuation based of trade-offs between items of worth and fishing (i.e. contingent valuation methods) (e.g. Wheeler and Damania 2001, Blamey and Driml 1998).

Given the scope of the EIS, the wide variation in estuary fishing locations, and the wide variation in fishing motivations, the single-site demand model using the travel cost method, although coarse, perhaps represents the best approach for assessing the value of NSW recreational fisheries as a whole. Travel cost studies typically provide a minimum estimate, as they only include the expenditure on fishing and the value of the time spent fishing. They do not include values for additional benefits of fishing (e.g. enjoyment value from participating in the activity).

The DAFF (2005) economic report on the National Recreational Fishing Survey (2000/2001) estimated expenditure by fishers on a range of fishing related items (e.g. accommodation, boats, car travel, bait and tackle) as a total of $554 million. This value represents the minimum value (in 2001 dollars) of fishing activity undertaken by NSW recreational fishers. It should be noted that this does not include the value of the time spent fishing.

The National Recreational Fishing Survey (Henry and Lyle 2003) also indicates that approximately 47 % of fishing effort is estuarine in nature within NSW, leading to an estuarine recreational fishing expenditure of $260.38 million (2003 dollars). The National Recreational Fishing Survey (Henry and Lyle 2003) did not contain more detailed information as to where this expenditure was spent, where the associated fishing occurred, or what species (if any) were targeted during the associated fishing. This limits the usefulness of this State-wide data in valuing particular estuaries or species in terms of recreational value.

The Henry and Lyle (2003) data represents the most comprehensive data available in regards to valuation of existing recreational fisheries and is adopted as the base point of comparison for the evaluation of the benefit of undertaking a fish-stocking program for this study.

2.3 Economic Impact of Fish Stocking Programs

While an estimate of the existing value of recreational fisheries can be established through the adoption of single-site demand models using a travel cost method (see Section 2.2.2), the estimation of benefit / costs associated with a proposed fish stocking program typically

requires the adoption of more detailed site choice models or stated preference techniques (Cantrell *et al*. 2004, Prayaga *et al.* 2010). This is because the single-site demand models using a travel cost method provide only the existing value of a fishery, and do not provide sufficient information to derive a demand curve, or the change in fisher behaviour with changing fish stocks.

2.3.1 Costs of Fish Stocking

The costs typically associated with fish stocking programs are outlined below:

- **Research and Monitoring Costs** – the complexity and diversity of ecological systems and fisher behaviour means that there are substantial research costs in identifying appropriate species and locations which minimise other costs (e.g. ecosystem, life cycle, and genetic costs). Similarly on-going monitoring is necessary to assess the effectiveness of the stocking program against its stated goals and objectives. This may include research to fill knowledge gaps relating to biology and ecology, genetics, optimal stocking rates in terms of minimal ecological impacts and socio-economic impacts.
- **Production Costs** – Increased production of fish at hatcheries incurs significant costs (e.g. extra staff, feeds, power, transport and equipment.)
- **Negative Perception Costs** - Potential loss of economic activity in unstocked regions as fishing effort shifts to stocked regions (this will significantly depend on the population distribution of fishers and potential changes in fishing effort). It is noted that this is a localised impact of the stocking (i.e. at the estuary level). Across the state as a whole this would not result in a cost as it is merely transferring the cost.
- **Administration Costs** – Increased administration and management costs of regulatory bodies for research, hatcheries and fishers.
- **Capital Costs** – Capital costs associated with the construction of hatcheries or public infrastructure to allow fishers to utilise fish stocking enhanced populations.
- **Environmental & Social Costs** - it is considered that these are likely to be minimal Section H.2 of the EIS demonstrates that despite several risks to biophysical components of the environment (e.g. ecological processes, threatened and protected species, areas of conservation significance, population genetics, disease, parasites and fish health), these would be mitigated by the various Goals and Objectives that would be implemented through the draft FMS. These measures 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. In terms of social costs, the case studies presented in Appendix 5 of the EIS together with the assessment of impacts in Chapter G, Section 2.2 conclude that although there are some low to moderate risks relating to social issues, these would be effectively managed through the FMS and that overall the marine stocking program would benefit recreational, Aboriginal and commercial fishers.

The majority of these costs are either readily identifiable market based costs (e.g. wages) or quantifiable off-market costs (e.g. pollution and loss of vegetation). As noted above, the expected environmental and social costs are likely to be low, due to the mitigating measures

of the EIS. It is also noted that these values are difficult to assign a dollar value without localised studies to determine an appropriate market value. With regard to the potential for fish stocking within NSW there is a significant lack of data preventing accurate quantitative evaluation of the economic costs relating to marine fish stocking. For example, the shift of fishing effort due to the establishment of better fishing sites in previously under-utilised areas would require site-specific surveys to determine the origin of expenditure and loss in expenditure. It is highly likely that such values would be negligible in comparison to other costs as a whole across the State, although it should be noted that specific local costs may be high. An analysis of the likely costs and the respective magnitude of these costs with respect to the potential for estuarine stocking within NSW are discussed in qualitative terms in **Section 6**.

2.3.2 Benefits of Stocking

The benefits typically associated with fish stocking programs are outlined below:

- **Increase in Direct Expenditure** – Should a fish stocking program be of sufficient magnitude to generate an increased catch rate, fishers will typically receive greater utility from their fishing. As such, following stocking, fishers may be willing to increase their fishing effort and subsequently their monetary expenditure on fishing related items. This increase in fishing utility can be measured through the associated increase in direct expenditure by recreational fishers and fishing tourists in pursuit of their leisure needs (e.g. transport, purchase of items such as fishing gear, fishing guides and tours, and accommodation).
- **Economic Multiplier Impact –** The expenditure associated with recreational fishing generates flow-on effects within other areas of the economy. For example: increased in production, consumption and employment within directly (e.g. hatcheries) and indirectly related industries (e.g. a manufacturer of fishing equipment). These flow-on effects are typically captured within an economic multiplier (typically given in the form of a ratio) and can be applied at State, regional, or local levels. In general the multipliers applicable at a State level will be greater than those at a local or regional level due to the greater diversity of industries available to capture the flow–on effects. It is noted that the presence of taxes and fees (e.g. fishing licence fees) will offset these multiplier benefits.
- **Enhancement of Fish Populations –** Fish stocking, in recruitment limited conditions, can improve the local or regional populations of fish threatened via over-fishing or general development related habitat disturbance. A fish-stocking program can also provide ecosystem conservation and protection benefits, i.e. through dedicated ‘conservation stocking’.
- **Enhancement of Recreational Fishing Quality –** The majority of benefit received by recreational fishers is obtained through participating in the action of fishing itself and catching fish (i.e. the joy of fishing). By improving the quality of fishing through fish-stocking, the overall benefit to recreational fishers will also increase.

For fish stocking programs not focussed on conservation, the benefits received from stocking is primarily driven by increases in fisher satisfaction (Prayaga *et al*. 2010). As the utility associated with fishing is a combination of both the activity (and associated activities/expenditures) and the quantity of fish caught, the increase in satisfaction received is both through increased harvests to fishers and the increased enjoyment associated with

fishing in an enhanced fishing environment. Both of these aspects will influence the amount of fishing effort any one individual fisher is willing to expend on the activity. Thus, when estimating the benefits resulting from fish stocking it is necessary to look at both the value of increased catch and the potential effects this will have on fishing effort (both the overall level of effort and its distribution).

Scrimgeour *et al*. (2001) argues that fishing effort is primarily determined by the probability of catching a fish and the cost of fishing. Thus, in order to have a significant impact on effort levels, the degree of stocking must be such that it changes the probability and ease associated with catching a fish (the quality of a fishing area). However, when this is considered in light of the Henry and Lyle (2003) data indicating that primary motivations for fishing are not associated with the catching of fish (**Section 2.2**), it is apparent that any stocking program must not only increase the chance of catching a fish (as identified by Scrimgeour *et al*. 2001) but increase it to such an extent that the perceived value associated with increased catch rates is worth the costs of conducting another or longer fishing trip, regardless of the motivation behind the fishing trip. Thus the potential benefits of a fish stocking program is highly dependent on the public perception of the efficacy of the program in making fishing trips more attractive to individuals.

The impact of changed perceptions to catch rate will vary between individuals. As an increase in the potential to catch an extra fish may be more of value to someone who fishes regularly than to someone who rarely goes fishing, individuals will have unique utility functions. However, sufficient data on utility functions is not currently available to generate the overall recreational fishing utility function (its "demand curve") for NSW and the situation is further complicated in that fishing events for individuals can vary greatly (e.g. an overnight camping trip would have distinct costs that would be much larger than a local fishing off a jetty. Thus an increase in the number/value of fish caught (even under stocking) may only represent a fraction of the trip costs and would require a significant increase in catch to stimulate further trips. Again this will vary on the value ascribed to the fish caught relative to the value ascribed to the fishing activity as well as the cost involved in a fishing event. This is likely to generate a "lumpy" demand curve for recreational fishing.

Further, public perception of the relative merits of conducting fish stocking in one area over another is also variable and a function of the avidity of fishers and the communication strategy of the responsible authority. For example, in regards to the creation of Recreational Fishing Havens (RFHs) in 2002 (areas largely free from commercial fishing and specifically designed to provide better angling opportunities for recreational fishers) Dominion (2003) estimated that 77 % of fishers were aware of the RFHs with 26 % of fishers utilising them, 34 % of fishers very likely to visit them and a further 30 % likely to visit them. This suggests that upon becoming aware of RFHs there is a strong likelihood that fishers will utilise them, highlighting the importance of the communication strategy in making fishers aware of relevant programs.

Most studies minimise these lumpy demand and public perception issues by focussing on specific locations and on fishers who are primarily interested in catching fish either for sport or food; those who would be considered to have elastic preferences in relation to fishing quality of an area (e.g. Lawrence 2005). Contingent Valuation Methods (CVM) assesses the willingness of fishers to pay for either increased catch (i.e. an extra fish), improved

conditions (i.e. environmental amenity), or control of fisher numbers (e.g. Sutton *et al*. 2009, Cantrell *et al*. 2004). By conducting surveys as to fishers preferred choices it is possible to estimate the marginal value associated with catching one or more extra fish. From this it is possible to estimate the value of a fish-stocking program through its impact on catch rate.

Cantrell *et al*. (2004) describe a typical CVM survey, where fishers in Hawaii for Pacific Threadfin (*Polydactylus sexfilis*) were seen to be willing to pay US$10.05 to increase their average catch by one fish per trip, with the marginal amount decreasing per additional fish. This was then able to be extrapolated across the fishery to represent the value of the stocking programs enabling the catch of at least one extra fish per fishing trip. Cantrell *et al*. (2004) also note, however, that current catch level, employment status, occupation, education, and gross income are also important determinants of willingness to pay.

Lawrence (2005) describes a similar relationship of a relatively high willingness to pay for an increase in one additional fish caught per day, but estimates that fishers tend to be satiated by seven fish. Lawrence also suggests that the size of the fish caught is of more importance (people are prepared to offer a higher willingness to pay) than the number of fish caught, and that the quality of the surrounding environment is somewhat irrelevant. However, it is noted that these surveys obtained data from fishers considered to have high avidity (e.g. fishing for food and or sport) and as such may not capture the full range of fishers and willingness to pay.

Wheeler and Damania (2001) support this variability of marginal value by suggesting that the recreational value of a species depends primarily on the reason for which it is pursued. They showed that the marginal value for fish pursued for food tend to reflect market prices (the opportunity cost) where as other fish recreationally targeted increase in marginal value pending upon the rarity and catchability of the species as well as the size of the fish. In the NSW scenario in which the majority of fishing is undertaken without targeting any one particular species (i.e. fishing undertaken for the purpose of relaxation) it would follow that the marginal value associated with additional fish catch is likely to be limited.

Prayaga *et al*. (2010) go further than this, in a study of recreational fishers upon the Great Barrier Reef, demonstrating that the change in frequency of fishing by fishers is inelastic to changes (positive or negative) in catch rates. They go on to suggest that this is a consequence of a range of factors determining the choice to go fishing aside from the possibility of catching a fish. This trend has been observed in other studies focussed on understanding the motivations behind recreational fishing (Ditton *et al*. 1992).

An analysis of the likely benefits and the respective magnitude of these benefits with respect to the potential for estuarine stocking within NSW is discussed in **Section 7**.

2.3.3 Summary

The majority of potential benefits stemming from a fish stocking program relate to the value associated with changes to fishing effort (time and frequency) rather than the benefits associated with increased yields. However, the existing literature within this area, while suggesting some form of diminishing marginal return relationship is likely in terms of fishing effort following fish stocking, also indicates that the elasticity of fishing effort varies over a range of factors (e.g. fish size, fisher demographic, fishing motivation).

It is considered that fishers who are motivated to go fishing primarily for non-catch related reasons are likely to be highly inelastic to increased catch rates (Prayaga *et al*. 2010, Ditton *et al.* 1992). Very little data exists within NSW as to fisher's willingness to pay or motivations. The most comprehensive data available is contained within the National Recreational Fishing Survey (Henry and Lyle 2003) and Economic Report (DAFF 2005). Both these reports highlight the diversity in fisher motivation (**Table 2.1** indicates at least 73 % of fishers within NSW fish for reasons that are largely independent of the quantity of the fish available to be caught) and the "lumpy" demand for recreational fishing dependent upon fishing avidity and location.

If it is assumed that fishing effort will be largely inelastic to changes in existing fish populations as a result of stocking, then the majority of the benefit received through stocking will be as a result of increased catch (and the value of this catch). Similarly, if fishing effort is inelastic to changes in fish population size and environmental costs are limited (as addressed Section 2.3.1), then the costs of stocking will be limited to those related to the construction/operation of hatcheries.

In light of the available literature (Section 2.3.2) it is possible that a more detailed survey of NSW fishers would identify some level of elasticity of recreational fishing effort with diminishing marginal returns. As such, any fish stocking program which increases the likelihood of catching a fish may generate changes to fishing effort and subsequently generate economic benefits. However, the paucity of available data prohibits a justifiable economic analysis of any such effort increase.

The available data does permit an analysis of the benefits associated with increased catch. Consequently, given the diverse nature of fishers within NSW and the available data, it is considered that an economic assessment assuming effort inelasticity, and focussing upon increased catch volume benefits, would provide a highly conservative estimation of the economic benefits associated with a fish stocking program. This approach was adopted for the purposes of this study (**Section 3**).

It is acknowledged that a proportion of NSW fishers are highly likely to fish more as a result of increased catch rates, thus any estimates of costs / benefits resulting from a system under which fishing effort is viewed as inelastic to fish population levels will represent a conservative minimum benefit as the result of a stocking program. The data presented within this report is intended to represent preliminary minimum benefit estimates as to potential benefits.

As such the economic study undertaken, based on these conservative assumptions, provides an indication of the nature of the associated cost / benefits but does not attempt to accurately quantify the magnitude of the benefits. A detailed survey assessment or model of the change in fishing effort as a result of a stocking program would be required to accurately capture the fishing effort related costs and benefits. Such a study is considered beyond the scope of this assessment and would require 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 etc. Such detail is unavailable at a State or regional level assessment. However, it is recommended that site specific models and surveys be undertaken to more

adequately assess the economic costs and benefits of fish-stocking at a local, estuary specific level.

3 Overview of Methodology

To conduct the economic analysis, costs and benefits were derived from a variety of sources:

- Cost information was provided by DPI as to the average costs associated per fish stocked (**Section 6**).
- Benefit information utilised estimates of fishing effort across the State, estimates of existing "fishing quality" (**Section 7.4**) per species across the State, and estimates of likely harvest rates resulting from the stocking program (**Section 7**).

The geographic scale at which the assessment was conducted is discussed in **Section 4**, while **Section 5** outlines the species assessed within the analysis.

Both the costs and benefits identified were assessed qualitatively. Where possible, depending upon the quality of the available data, quantitative assessments were undertaken to support the findings of the qualitative assessment. The methodology and results of the qualitative assessment are provided in **Sections 6** and **7**. The methodology adopted and results of the quantitative assessment are provided in **Sections 8** and **9**.

4 Analysis Regions

The analysis was conducted at both a State-wide and regional level. The paucity of data prevented the analysis being conducted at an estuarine or local level (i.e. fishing effort data from Henry and Lyle 2003) does not record the specific estuary at which the effort was applied but can be estimated for the broader area in general). To help overcome this issue, the State was divided up into 10 latitudinal regions (**Figure 4.1**). These divisions were estimated based upon the existing DPI Estuary General Bioregions, Regions and Zones (DPI 2010), as well as the number of estuaries, and population centres.

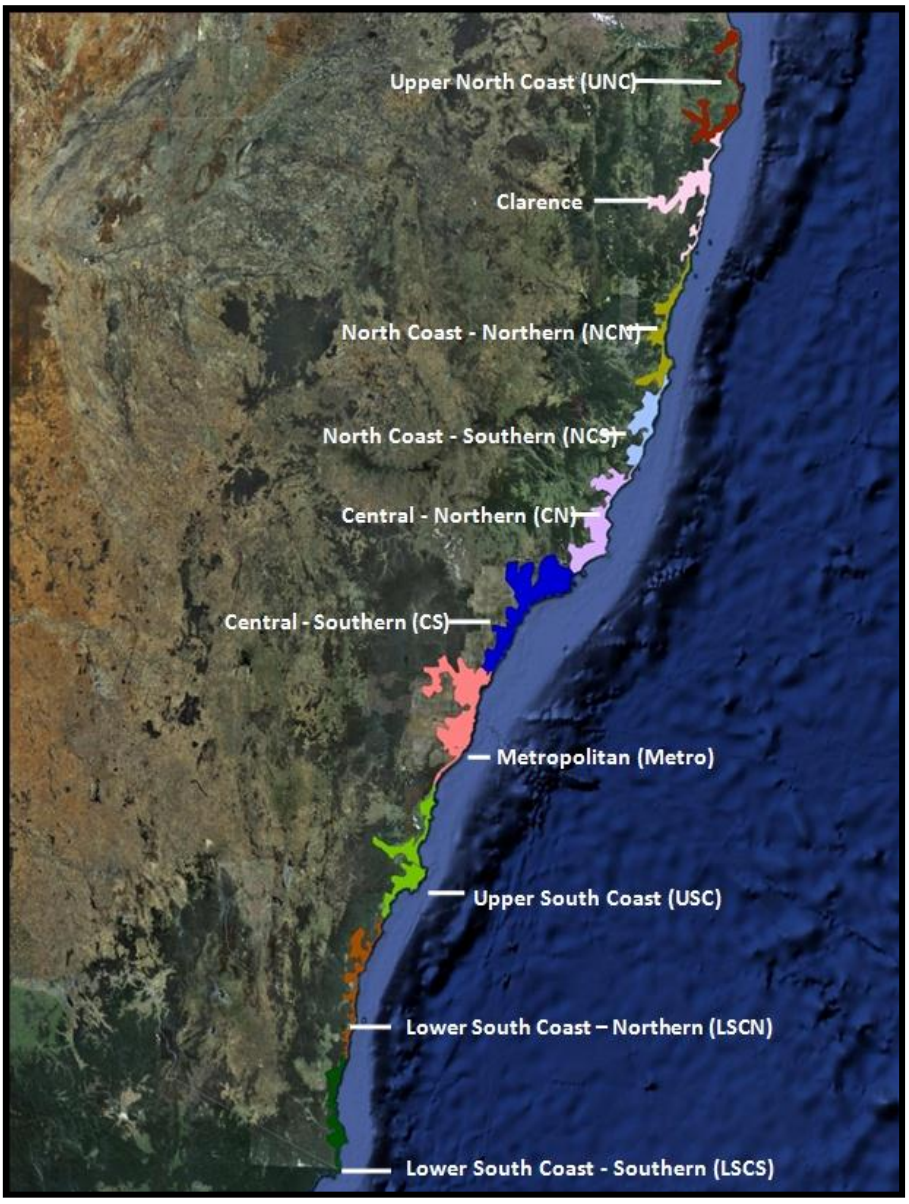

Figure 4.1: NSW Economic Estuarine Fishing Regions (Aerial source: Google Earth).

The delineation of the regions for the assessment were designed to be of comparative scale to each other; large enough to encompass a number of estuaries in close proximity to each other (as the available effort data cannot distinguish between individual estuary utilisation), yet small enough to identify variations in regional popularity in regards to recreational fishing and suitability for a fish stocking program. It was considered that the estuary regions (Northern, Central, Southern) adopted in the Multicriteria analysis (MCA) elsewhere within this EIS were too vast to be of significant value to the economic assessment.

The actual land area associated with the latitudinal estuarine regions was estimated based off a 2 km buffer around the edge of the riparian estuarine limit of all estuaries within a region. It was considered that this represented a reasonable distance range from the estuary to capture fishers and expenditure locations which relate to that specific estuary.

The land areas and estuaries defined from the MCA analysis utilised within the EIS for each of the estuarine regions are detailed in **Table 4.1**.

Table 4.1: Regional Estuarine Areas and Estuaries Identified as Potential Stocking Estuaries

Region	Area (sq. km)	Estuaries
Upper North Coast	1106	Tweed River Cudgen Creek Cudgera Creek Mooball Creek Richmond River
Clarence	1399	Evans River Jerusalem Creek Clarence River Cakora Lagoon
North Coast (Northern)	1017	Boambee Creek Bonville Creek Bellinger River Oyster Creek Deep Creek Nambucca River* Macleay River South West Rocks Creek Saltwater Creek
North Coast (Southern)	928.9	Korogoro Creek Killick Creek Hastings River Lake Innes / Lake Cathie Camden Haven River
Central (Northern)	1594	Manning River Khappinghat Creek Wallis Lake
Central (Southern)	2520	Hunter River Lake Macquarie Tuggerah Lake
Metropolitan	2430	Wamberal Lagoon Terrigal Lagoon Avoca Lake Brisbane Water Broken Bay Hawkesbury River Pittwater Narrabeen Lagoon Middle Harbour Creek Port Jackson Lane Cove River Parramatta River Cooks River Botany Bay Georges River Port Hacking
Upper South Coast	1409	Allans Creek* Lake Illawarra Killalea Lagoon

Region	Area (sq. km)	Estuaries
		Minnamurra River Crooked River Shoalhaven River Lake Wollumboola Carama Creek# St Georges Basin Swan Lake Berrara Creek Lake Conjola Narrawallee Inlet Ulladulla Estuary Burrill Lake
Lower South Coast (Northern)	954.3	Tabourie Lake Termeil Lake Meroo Lake Willinga Lake Bermagui River Barragoot Lake Cuttagee Lake Murrah Lake Bunga Lagoon
Lower South Coast (Southern)	820.6	Wapengo Lake Nelson Creek Bega River Wallagoot Lake Back Lagoon Merimbula Lake Pambula Lake Curalo Lagoon Twofold Bay Nullica River Towamba River Wonboyn River Merrica River# Nadgee River# Nadgee Lake#

* Estuary added to EIS after economic assessment completed
# Estuary removed from EIS after economic assessment completed.

5 Species of Interest

A total of seven species (and species groups) were evaluated for their potential for stocking in this assessment. These species included:

- Yellowfin Bream;
- Mulloway;
- Dusky Flathead;
- Sand Whiting;
- Eastern king prawn;
- Giant mud crab; and
- Blue swimmer crab

Data from Henry and Lyle (2003) was used as the primary source of recreational catch information. Data for the individual species proposed for marine stocking were used where available, but it should be noted that Henry and Lyle (2003) does not distinguish between some fish types (e.g. there is no distinction between dusky flathead and other flathead species and all are collectively referred to as flathead). This is the same for bream and whiting which may include more than one species.

6 Estimation of Costs

6.1 Qualitative assessment

As noted in **Section 2.3.1**, there are a number of costs associated with fish stocking programs including:

- Research and Monitoring Costs;
- Production Costs;
- Negative Perception Costs;
- Administration Costs;
- Capital Costs; and
- Environmental & Social Costs.

The research and monitoring costs associated with an estuarine fish stocking program are likely to be high due the complexity of the systems in question and the lack of existing research in this area. Stocking has occurred extensively within freshwater systems within NSW (NSW Fisheries 2003) and DPI operates the Effectiveness of Fish Stocking - Research Program (Baumgartner and Cameron 2007) monitoring program to assess the efficacy of such programs. In these studies, stocking rates and effectiveness have been assessed through assessment of historically successful levels of stocking by hatcheries, anticipated levels of fishing effort in the fisheries, and reported returns to anglers. None of this data currently exists for estuarine fisheries and would be required to be obtained. Further, the requirement to ensure ecologically sustainable development principles are applied to this project would further increase the cost associated with research and monitoring, given the poor knowledge of complex trophic interactions within the estuaries.

In comparison to research and monitoring costs, the production costs and negative perception costs are likely to be minimal. For the purposes of this assessment an indicative expenditure value was provided to Cardno ($300 000 worth of stocking) by DPI. A stocking program of such value was not considered likely to significantly alter hatchery related production and transport costs (Chapter C, Section 11.3 identifies that there are 62 hatcheries that are currently accredited or that will potentially become accredited under the marine Hatchery Quality Assurance Scheme (HQAS), and as such it was assumed that there would be sufficient capacity within these hatcheries for the proposed species). Similarly, given the scale of stocking any negative economic impacts associated with shift in fishing effort due to changes in fisher perception is likely to be minimal. Further, it is likely that the economic impacts of any such negative impact in one area would be balanced out on average across positive impacts in others.

Administration costs are likely to be moderate in the short term. The scale of stocking is such that the increased regulation by authorities of hatcheries will be relatively low (assuming existing hatcheries are used). Similarly, the low volume of stocking is such that the increase in number of fishers (i.e. new fishers requiring licensing) would also be low. However, as this program would be the first estuarine stocking program in the State the initial start-up costs are likely to be relatively high.

As discussed in Section 2.3.1, both the environmental costs and social costs are expected to be low.

As discussed above, it is not anticipated that significant capital expenditure will be required for the proposed volume of stocking to proceed as it is expected that there would be sufficient capacity within the existing hatcheries. Should larger stocking programs be undertaken in the future, likely to significantly alter local demand for an estuary then capital works (both for hatchery development as well as the provision of public infrastructure (e.g. boat ramps) may be required.

Table 6.1 summarises the perceived qualitative costs associated with the fish stocking program.

Table 6.1: Qualitative costs of fish stocking

Cost	Magnitude of Cost
Research and Monitoring Costs	High
Production Costs (assuming hatcheries exist)	Low
Negative Perception Costs	Low
Administration Costs	Medium
Capital Costs	Low
Environmental & Social Costs	Low

6.2 Quantitative assessment

There is limited quantitative data available in regards to the cost of establishing an estuarine fish stocking program. Marine hatchery operators in NSW were consulted in regards to the potential cost of producing fingerlings, crablets or post-larval prawns. Advice was given that prices will vary according to the scale of production and size of the fingerlings, crablets or post-larval prawns ordered. For the purposes of this economic assessment an indicative price of $1 per fingerling or crablet was used and $0.02 per post-larval prawn. For the purposes of this study it has been assumed that these costs take into consideration the cost of hatcheries, physical infrastructure, and any increased administration and management costs.

A budget of $300,000 was assumed as per the discussion in Section 6.1. Based on this, the maximum number and expenditure on any one type of fingerling is provided in **Table 6.2**.

Table 6.2: Species Maximum Stocking Quantities and Costs

	Cost per Fingerling ($)	Maximum Stockable Quantity (Fingerlings)	Maximum Cost per Species ($)
Yellowfin Bream	1.00	300,000.00	300,000.00
Mulloway	1.00	300,000.00	300,000.00
Dusky Flathead	1.00	300,000.00	300,000.00
Sand Whiting	1.00	300,000.00	300,000.00
Eastern King Prawn	0.02	15,000,000.00	300,000.00
Giant Mud Crab	1.00	300,000.00	300,000.00
Blue Swimmer Crab	1.00	300,000.00	300,000.00

7 Estimation of Benefits

7.1 Qualitative assessment

As noted in **Section 2.3.2**, there are a number of benefits associated with fish stocking programs including:

- Increase in Direct Expenditure;
- Economic Multiplier Impacts;
- Enhancement of Fish Populations; and
- Enhancement of Recreational Fishing Quality.

It is likely that the largest benefit from increase fisher utility as a result of stocking would be seen if there was an increase in fishing effort and the associated increased direct expenditure. This would include, among other items, increased expenditure on:

- Fuel and transport;
- Food and commodities;
- Bait and fishing gear; and
- Accommodation and hospitality services.

It is reasonable to assume that if a stocking program were to increase fisher effort (**Section 7.6**), would result in increased expenditure, and generate a benefit in this regard.

Henry and Lyle (2003) estimate the value of recreational fisheries within NSW at $723,105,230 (2010 dollars, 3 % inflation). Expenditure data represents the minimum value fishers are willing to spend to participate in fishing and therefore represents a minimum value of the fishery. Henry and Lyle (2003) also indicate that on average estuarine fishing within NSW accounts for 47 % of fishing trips made within NSW. As such the value of estuarine recreational fisheries within NSW could be estimated to be approximately $340 million per year. In contrast to the scale of this industry, the impacts of the proposed stocking program would be minimal.

For example, should the fish stocking be successful enough to recapture costs of production (assumed to be $300,000) through increased expenditure alone, then this would represent a 0.1 % increase in fishing expenditure. This is considered to be a negligible impact. It should be noted that the Henry and Lyle (2003) estimates do not account for the value of time expended during fishing (i.e. opportunity cost of fishing), which is considered likely to represent a significant proportion of the total expenditure value. Nevertheless, the magnitude of direct increased expenditure associated with the proposed stocking program is expected to be low in comparison terms of State-wide impact.

However, NSW Fisheries (2003) estimate that a freshwater fisheries stocking investment (on historic cost basis) of $33 million has generated an annual expenditure of $50 - $60 million. This indicates that while the impact of this proposal may be negligible as a proportion of State-wide values, in and of itself it is reasonable to expect that, if the program is large enough to alter fishing effort at a local (regional scale), the subsequent benefit in direct expenditure would be evident. It considered that, given the magnitude of the stocking proposed (assumed to be $300,000 for the purpose of this EIS) in comparison to the existing

stock available across the state, it is unlikely that the program would generate any significant net increase in effort at a state wide level. Rather, it is more likely that any changes to effort levels would be at a local/regional scale following redistributions/shifts of fishing effort by existing local fishers seeking to optimise their behaviour. Given there is some uncertainty as to how fishing effort will be affected within this, the magnitude of this benefit is considered to be moderate.

The economic multipliers triggered by the stocking program pick up the direct impacts as well as production-induced and consumption-induced impacts. Production induced impacts relate to purchases by individuals within the recreational fishing industry from companies from non-fishery industries (e.g. a bait and tackle shop buying goods from a manufacturer). Consumption induced impacts relate to the spending of income earned through recreational fishing. Within recreational fishing the production-induced elements of the multiplier would be greater than those of consumption.

NSW Fisheries (2003) estimate State-wide production induced recreational freshwater fishing to have an expenditure multiplier of between 1.5 and 1.8. There is no reason to expect these multipliers would significantly differ for estuarine fisheries. Additionally, other multipliers (e.g. tourism and employment specific multipliers) would also be triggered by a stocking program of sufficient scale to lead to increased fishing effort.

The enhancement of fish populations is a less tangible benefit. Throughout NSW the fish populations present vary in condition and composition. Some estuaries are heavily fished whereas other estuaries are not significantly affected by fishing. The provision of appropriate stocking has the potential to help develop an ecologically sustainable recreational fishing industry. This depends heavily upon the selection of the appropriate species mix and location. It should be noted that the proposed fish stocking program is not specifically conservatory in nature and does not target threatened or vulnerable species. Given this focus, it is considered the benefits associated with this would be low.

The enhancement of recreational fishing quality is a significant benefit associated with the project. Perceived improved fishing satisfaction is the base driver behind increased fishing effort and the expenditure based benefits. However, it is possible that, even if the scale of fish stocking is insufficient to significantly alter fishing effort (given its lumpy demand), it is possible that the stocking will result in increased harvest levels and an associated increased satisfaction in fishing. The value of any such increased harvest is considered to be small in comparison to benefits resulting from increased fishing effort stimulated by a stocking program (i.e. if these increases were large enough they would lead to an increase in effort).

Table 7.1 Summarises of perceived qualitative benefits associated with the fish stocking program.

Table 7.1: Qualitative Benefits of Fish Stocking

Benefit	Magnitude of Benefit
Increase in Direct Expenditure	Moderate (local/regional scale) Low (State-wide scale)
Economic Multipliers	High
Enhancement of Fish Populations	Low
Enhancement of Recreational Fishing Quality	Low

An increase in fishing effort from the program would result in a larger increase in benefits. As discussed in **Section 2.2 and Chapter C, Section C.4.2.2.4** of the EIS, there is limited data regarding the relationship between fish stocking and fishing effort, with a high probability of this relationship being inelastic, particularly at a State-wide level.

As increased fishing effort is a substantial driver behind the identified benefits in this Section, larger stocking programs (i.e. with sufficient magnitude to alter public perception as to the quality of fishing in an area) would generate larger increases in direct expenditure. There is a risk in being so small that the proposed program will miss out on the majority of available benefits due to the inelastic and lumpy demand characteristics. The conservative quantitative assessment undertaken addresses this issue by assuming that there is no increase in fishing effort, due to the fact that the stocking program is small in comparison to the overall existing supply.

In the wider context of the EIS any economic benefits that are a direct result of increased fishing effort need to be balanced with the associated ecological risks discussed in Chapter D, Section D.4.1 of the EIS. For example if not appropriately monitored, increased fishing effort could result in overfishing and hence the abundance of wild conspecifics and alteration to the distribution, abundance or structure of other populations through changes in competitive interactions.

7.2 Quantitative Assessment - Overview

There is limited quantitative data available in regards to the benefits of establishing an estuarine fish stocking program. The following sections provide an analysis of the available information and the associated limitations with estimating benefits associated with the proposed stocking program in support of the qualitative assessment undertaken (**Section 7.1**).

In order to estimate the benefits from a fish stocking program it is necessary to know the existing value of the fishery. Both the size of the benefit from the stocking program and

initial value are dependent upon the value of the existing fishing quality and fishing effort in any estuary or region.

The value of recreational fishing, as discussed in **Section 2.2.2**, can commonly be assessed through a travel cost method. This conservative economic measure incorporates two key aspects:

- Fishing Effort - fishing effort simply refers to the number of effort units (days) spent fishing. The value of the activity can be measured through the value of the time spent fishing. This does not include time spent travelling to or from fishing locations.
- Expenses incurred as a result of the activity. This includes the cost of travel and equipment required for the fishing activity.

The method for the estimation of the fishing effort and the expenses incurred is discussed in **Section 7.3** – **Section 7.6**.

The impact of a fish stocking program can be assessed by the likely increase in harvest of fish from existing levels. This can be estimated by either a measure of the direct increase in the harvest, or indirectly if the existing fish population is known. However, there is limited data on either of these for the NSW coast, with most data available at a State-wide level only. As such, the following sections discuss the method in which these were estimated.

7.3 The Harvest Relationship

The fishing quality of a region was defined as being the combination of two factors:

- Existing Fish Population - The number of fish of a species available to be caught.
- Catchability – The probability of catching a fish with a single unit of effort.

The existing population of fish within estuarine waters within Australia is unknown. Typically to estimate the population of an area, studies utilise known harvest and catch rates (catch per unit effort (CPUE)) (such as Puertas and Bodmer, 2004). However, these catch rates are typically determined by localised *in-situ* studies as they are also dependent upon species catchabilities which are also typically unknown.

Catchability represents the ease with which an individual fish is able to be caught, the interaction between the fishing (and the technology used in fishing) and the fish behaviour (described in numerous publications, e.g. Arreguin-Sanchez 1996). Typically the catchability of a species is assumed to be constant to allow ease of analysis (Ward, 2007). However, this assumption does not hold and proves problematic for studies conducted across large ranges and fisher populations as fishing technology will vary considerably between fishers (particularly recreational fishers) and the behaviour of species will vary according to population size, age of fish and aquatic habitat (i.e. the presence or absence of habitat structures / characteristics may raise or lower the probability of catching a fish with a unit of effort). Given the limited data available for the purposes of this study it has been necessary to assume that the catchability of each species does not vary between regions (e.g. the probability of catching a single yellowfin bream per unit effort in the Clarence region is equivalent to that in the Metropolitan region).

The relationship between population levels, catchability and harvest is commonly expressed as:

$$H_i = q_i N_t E_i \quad \text{(Baranov 1918)}$$

Equation 1: Catch Equation

Where: *H* = Harvest or catch
q = Catchability coefficient
N = Existing Population
E = Fishing Effort
i = a specific fishing operation
t = time

The following sections investigate the derivation of the Harvest, Fish Population, Fishing Effort and Catchability components of the above equation in light of the available data for NSW.

7.4 Estimation of Harvest

The National Recreational Fishing Survey (Henry and Lyle, 2003) reports total catch figures for recreational fishers within NSW for the year 2000 – 2001. Based on the recorded effort expended on estuarine fishing by fishers across Australia for the individual species, and total NSW catch numbers it was possible to estimate the NSW estuarine harvest (kg) (**Table 7.2**)

Table 7.2: Estimated Estuarine Catch per Species

Species	Australian Harvest (kg)[1]	NSW Harvest[1] (kg)	Estuarine Proportion of Harvest (%)	Estimated NSW Estuarine Harvest (kg)
Bream spp.	1,706,319	728,752	55	402,895
Mulloway	975,370	273,704	26	70,702
Flathead spp.	2,326,409	886,824	57	509,778
Whiting spp.	1,171,661	394,081	35	137,196
EKP	194,394	110,742	83	91,970
GMC	815,886	30,000	75	22,364
BSC	1,084,499	154,831	52	80,536

[1] Data taken from Table 5.8 in Henry and Lyle (2003).

The harvest of these species comprises approximately 70 % of all estuarine finfish harvest and 74 % of estuarine non-finfish harvest (Henry and Lyle 2003). This indicates that the species assessed represent some of the most commonly fished species.

It is important to note that this data is not available at local estuarine level, only at the NSW State-wide level.

7.5 Estimation of Existing Fish Population

Equation 1 can be applied at both a local population level and generalised to the entire stock of the fishery (Ward 2007). The only data available for this equation is the Fishing Effort and Harvest data (Henry and Lyle 2003), available at a NSW State level only. Consequently,

there are still two unknowns in this equation, preventing either the measure of Catchability or Population level.

To overcome this data gap a number of potential courses of actions were examined. These are discussed in **Sections 7.5.1** and **7.5.2**.

7.5.1 Methods for Estimating Fish Population

There are a number of methods for estimating fish populations, including:

- Estimation of population data through catch rates over time (i.e. Leslie Method (Leslie and Davis 1939), DeLury Method (DeLury 1947));
- Estimation of minimum catch rates through known recreational and commercial harvests (such as Hillborn & Walters 1992); and
- Estimation of catchability utilising "known" minimum catchabilities derived off harvest data (such as Hillborn & Walters 1992).

However, both the lack of NSW State-wide data over several time periods (necessary for developing catch rates over time) as well as the lack of harvest data for regional areas prevented realistic population/catchability estimates being made. In particular, in situations where catchabilities and existing populations are unknown, economic studies often utilise a Catch per Unit Effort (CPUE) catch rate (i.e. the harvest (H) divided by the effort (E)) as an index of relative abundance (such as Puertas and Bodmer, 2004). If we were to assume the catchabilities to be constant across all regions then the only variable in the equation left would be the existing population within each region. However, the ability to utilise CPUE as an index of relative abundance between economic regions was hampered by the absence of region specific harvest data and species specific effort data. The only CPUE able to be estimated was a non-species specific CPUE for State-wide catch and effort.

As such, it was decided that the adoption of realistic CPUE per region/species, population estimates, or catchabilities was impractical to obtain. Rather, it was proposed to utilise alternative estimates of abundances and regional population indices were derived (see Section 7.5.2 below). Regional population indices were used as proxies for the existing populations. Rather than providing strict economic values at the regional level, these would allow for indications and comparisons between the different regions.

7.5.2 Regional Population Indices

The regional fish population indices rely on the estimated maximum harvest rates as determined by the Generalised Predatory Impact Model (GPIM).

The GPIM was developed as a guide for fisheries managers so that overstocking and its associated impacts are prevented. The GPIM was 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 main downstream input for the model was an estimate of primary productivity within the estuary to be stocked, which is based up on the area of structural/physical habitat within the estuary that would be utilised. The estimated harvest rates for each of the estuaries proposed for

stocking (and further explanation of the GPIM and its limitations) are provided in Chapter E, Appendix E.5.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. 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 implemented through the draft FMS).

The key assumption in estimating the regional fish population indices was that the relative maximum stockable quantities broadly reflect or are proportional to existing populations of fish, crabs or prawns within estuaries. That is, estuaries capable of holding larger quantities of additional stocked fish would have larger existing populations and vice-versa. Maximum harvest rates from the GPIM provide a base proxy measure of abundance for the estuaries and by summing the predicted harvest rates for estuaries within each Economic Region (**Section 4**) it a population index for each Region was obtained for each stocked species (**Table 7.3**).

Table 7.3: Population Indices of Economic Regions

	Population Index						
Region	**Bream spp.**	**Mulloway**	**Flathead spp.**	**Whiting spp.**	**Eastern King Prawn**	**Giant Mud Crab**	**Blue Swimmer Crab**
UNC	38,664	60,904	40,300	65,509	30,986	11,033	58,488
Clarence	51,859	59,195	53,906	272,685	147,619	14,814	278,166
NCN	33,957	33,369	35,364	46,634	21,339	9,693	40,246
NCS	70,090	30,395	72,978	91,059	47,392	20,010	89,364
CN	17,688	163,515	153,532	141,806	77,505	42,019	146,057
CS	0	406,132	217,314	380,602	194,843	59,437	366,947
Metro	0	363,252	191,993	425,256	226,710	52,664	427,448
USC	0	52,929	128,184	214,548	116,703	35,078	219,810
LSCN	0	0	16,127	12,740	6,348	1,167	11,955
LSCS	0	3,664	33,021	44,434	24,273	0	45,735
State Total Index	**212,257**	**1,173,357**	**942,721**	**1,695,274**	**893,719**	**245,916**	**1,684,218**

Table 7.3 indicates that whiting and blue swimmer crab are considered to be the most widely occurring population (in terms of abundance) relative to the other species assessed. Most of the remaining species that are found across the State are expected to occur in relatively similar proportions.

Based on the proportion of harvest comprised by these species (i.e. finfish: 70 %, non finfish: 74 % (Henry and Lyle 2003) (**Section 3.2**) it was also possible to apply the index to the State-wide populations of both finfish (5,748,012) and non-finfish (3,816,017).

7.6 Estimation of Existing Fishing Effort

In order to estimate the benefits of a fish stocking program it is necessary to know the existing value of the fishery. Both the size of the benefit from the stocking program and initial value are dependent upon the amount of fishing effort applied. As noted previously (**Section 2.3.3**), it has been assumed that fishing effort is unlikely to vary as a result of the stocking program at a State-wide level (i.e. will be inelastic) but may do so at a local/regional level. However, the existing fishing effort can provide guidance upon both the distribution and extent of any stocking benefits.

Fishing effort data was estimated primarily from the data described in Henry and Lyle (2003) and Dominion (2003), being the two data sources providing greatest numerical data in regards to estuarine fishing effort currently within NSW. It should be noted that even these studies are considered limited in scope and the lack of detailed geographically linked data (i.e. linking effort to location of effort expenditure, species of expenditure, origin of effort) limits the accuracy of this analysis.

DPI provided data detailing the suburb location of fish licence holders (provided by DPI in 2008 as sourced from the DPI Licencing database (DPI Licences Lodged between 01/07/2007 and 30/06/2008 Group by Licensee's Primary Address Postcode)). This was based on on-line fishing licence subscriptions and therefore excludes licences which were obtained at fishing shops and similar venues. It is assumed that this licence data provides a reasonable indication of the proportion of licence holders at different suburbs. The on-line data identifies 164,096 licence holders within New South Wales. This information was mapped in GIS (**Figure 7.1**) to allow the formation of spatial relationships between the home residence of fishers and potential fishing locations.

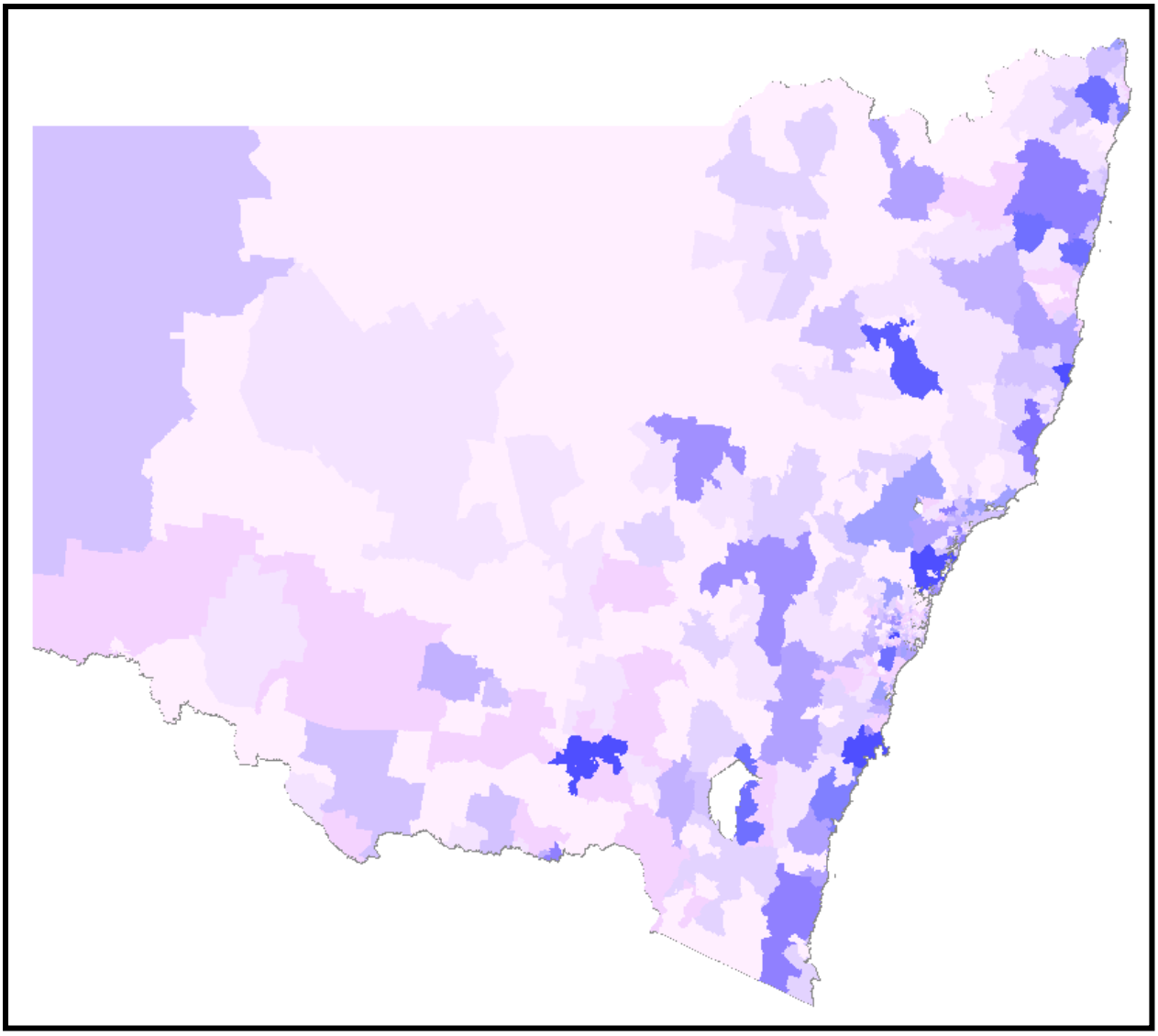

Figure 7.1: Location of Fishing Licence Holders within NSW (darker areas indicate a greater fisher population)

On average, the fishing population (based on the on-line licence holders) represents 3 % of total population within any postcode region of NSW (ABS 2006). From **Figure 7.1** it can be seen that in general fishing populations reflect population centres, although there are pockets of higher (e.g. Tamworth region) and lower (e.g. Newcastle) fisher residences than may be expected based off population alone and proximity to the coast.

Utilising the Economic Regions defined, it was possible to determine the number of fishers within a series of distance ranges from each of the regions. As the exact location of Fish Licence holder residents was not available, the centroid of each suburb area and as well as the centroid of the Economic Regions were utilised to calculate the number of fishers within a region and their proximity to NSW estuaries. The results of this analysis are described in **Table 7.4**.

Table 7.4: Number of Licence Holders within Specified Distances

	Number of Licence Holders within Range (km)						
Region	**0-50**	**50-100**	**100-200**	**200-300**	**300-400**	**>400**	**Total**
UNC	5,468	1,440	1,501	1,804	4,511	43,010	**57,733**
Clarence	1,386	5,076	5,156	3,224	4,666	40,728	**60,236**
NCN	2,453	2,845	6,420	11,944	13,772	25,371	**62,804**
NCS	3,440	3,271	5,514	19,571	36,693	6,819	**75,308**
CN	3,225	5,282	16,854	39,177	16,070	4,680	**85,288**
CS	22,148	14,147	37,972	8,039	11,193	4,056	**97,554**
Metro	64,358	16,839	11,849	11,061	10,433	4,112	**118,652**
USC	8,800	10,583	40,695	15,041	5,323	6,517	**86,958**
LSCN	2,819	3,408	10,077	36,956	20,464	9,117	**82,840**
LSCS	2,144	906	3,722	8,376	33,929	19,686	**68,764**

It should be noted that **Table 7.4** does not represent the total fisher numbers within NSW, but only those who held licences between 2007 and 2008 (as per the license data above) and the distance to each of the Economic Regions from their listed residence (i.e. a fisher may also be within 50 km of both UNC and Clarence). It does not include fishers from out of other States or international locations, licence holders who obtain licences through fishing shops or similar venues nor does it include fishers who actively fish without a licence.

Both the Dominion (2003) study and Henry and Lyle (2003) studies provide an assessment of the average distance travelled by fishers (one way) during a fishing event. **Table 7.5** displays the proportion of fishing trips undertaken by fishers of different lengths, calculated as an average of the Dominion (2003) and Henry and Lyle (2003) studies.

Table 7.5: Proportion of Fishing Trips of a Given Travel Distance

Trip length (km)	Proportion of Trips (%)
0-10	18.25
10-20	11
20-50	16.25
50-100	10
100-200	14.25
200-300	9.5
300-400	8
>400*	12.75

Source: based on Dominion (2003) and Henry and Lyle (2003).

*this category includes 2 % of trips of which length was unknown. The >400 km category was selected as providing the most equal distribution of fishing effort for these unknown trip lengths.

Table 7.5 clearly indicates that a significant proportion (45.5 %) of trips were undertaken within 50 km from the point of origin. These local trips are considered to be generally comprised of single day length events (i.e. not requiring overnight accommodation) and represent the most common fishing effort expenditure. The motivations for fishing are

expected to vary with the distance (and associated travel costs) to the fishing location. In general, it would be expected that the relative importance and effort spent on fishing in comparison to other potential recreational activities will decrease as travel costs increase (Rolfe and Prayaba 2007). However, as noted previously this will vary according to the avidity of the individual fisher. This is significant in any attempt to estimate the value of recreational fisheries in that while the travel costs for long distance trips may be significantly higher than the costs associated with the more numerous local trips, the expenditure associated with such trips is diluted amongst a variety of recreational activities. Any such analysis would need to apportion costs to reflect this.

Henry and Lyle (2003) data indicates that on average estuarine fishing within NSW accounts for 47 % of fishing trips made within NSW by the estimated 1 million fishers; a total of 3 million trips (based on 2001 data). Subsequently it can be seen that each fisher in NSW would be expected to make three estuarine fishing trips per year. Utilising, the proportionate breakdown of fishing trip travel distances (**Table 7.5**) and the distance to the various Economic Regions (**Table 7.4**), it was possible to estimate the number of trips made to each of the regions. Where one or more regions were within equal distance to the residence of the fisher, effort was equally divided between the regions. **Table 7.6** details the results of this analysis.

Table 7.6: Representative Fishing Effort for Each Economic Region

	Representative Fishing Effort for Estuarine Fishing of Set Distances						
Region	**0-50 (km)**	**50-100 (km)**	**100-200 (km)**	**200-300 (km)**	**300-400 (km)**	**>400 (km)**	**Total**
UNC	7,336	425	631	505	1,064	16,169	**26,129**
Clarence	1,859	1,497	2,166	903	1,101	15,311	**22,837**
NCN	3,290	839	2,697	3,346	3,249	9,538	**22,959**
NCS	4,615	964	2,317	5,482	8,655	2,564	**24,597**
CN	4,326	1,557	7,082	10,974	3,791	1,760	**29,489**
CS	29,713	4,171	15,955	2,252	2,640	1,525	**56,256**
Metro	86,342	4,965	4,978	3,098	2,461	1,546	**103,390**
USC	11,806	3,120	17,099	4,213	1,256	2,450	**39,944**
LSCN	3,782	1,005	4,234	10,352	4,827	3,427	**27,627**
LSCS	2,876	267	1,564	2,346	8,003	7,401	**22,458**
Total	**155,946**	**18,810**	**58,722**	**43,471**	**37,046**	**61,690**	**375,686**

These figures do not represent actual estimates of numbers of trips but are more of a representative proportion of fishing effort. They represent the minimum number of trips that may be expected in any one region, as they are based on the on-line fishing licence information as stated above. As the distribution is based off average travel distances, the analysis assumes that all Economic Regions are of equal value as a fishing location. Depending on the motivation behind individual fishing events (**Table 2.1**) this assumption may or may not be valid.

Based on this assumption, **Table 7.6** indicates that the largest proportion of trips occurs within the Metropolitan region of NSW (27 % of fishing events). This is approximately equal to the proportion of NSW fishers that live within the Metropolitan region (29 % of registered

fishers). This is due to the propensity for fishers to undertake trips less than 50 km distance and large resident fisher population within and just around the Metropolitan region (**Table 7.4**) It is also a product of the State geography as, being located geographically centrally means there are a higher number of fishers within shorter travel distances (which form the majority of fishing trips) than regions at the edges of the State. Alternatively, regions located on the northern and southern boundaries of the State receive higher quantities of long distance trips.

These numbers of trips can be converted to an estimate of fishing effort in terms of days spent fishing. Henry and Lyle (2003) data indicated that on average NSW Fishers spend 3.2 days on estuarine fishing per year over an average of 2.9 estuarine fishing trips. Consequently, the average estuarine trip length within NSW is seen to be approximately 1.1 days in length. Applying this factor to the calculated trip data reveals the relative value of fishing effort expended within each of the Economic Regions (**Table 7.7, Figure 7.2**).

Table 7.7: Fishing Effort for the Economic Regions

Region	Fishing Effort (days)	Proportion of Total Effort (%)
UNC	28,692	7
Clarence	25,077	6
NCN	25,211	6
NCS	27,010	7
CN	32,382	8
CS	61,775	15
Metro	113,533	28
USC	43,863	10
LSCN	30,337	7
LSCS	24,661	6
Total	**412,541**	**100**

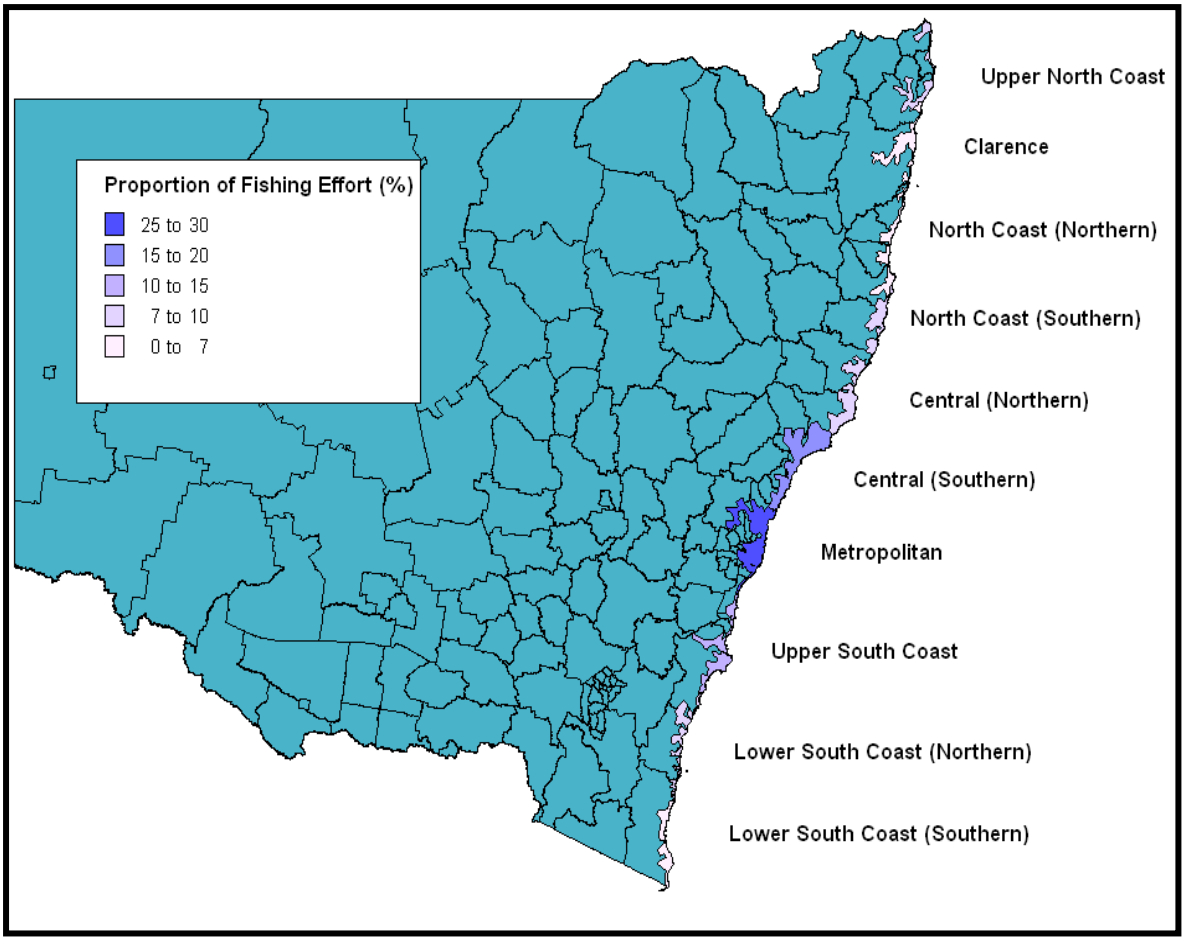

Figure 7.2: Distribution of Fishing Effort across NSW

This total estimated effort data (**Table 7.7**) is significantly lower than the level of effort described in the Henry and Lyle (2003) (3,232,942 estuarine fishing days). This is to be expected due to the difference in assessment methodology adopted. Henry and Lyle (2003) utilised public survey and estimated that there were 998,501 fishers within NSW. The assessment in this report utilised DPI licensing data as discussed above which utilised a base NSW fisher population of just 164,096 fishers based on on-line licence sales. Scaling the estimated total effort (412,541 days) to reflect the number of fishers estimated by Henry and Lyle (2003) provides a total adjusted estimated effort of 2,565,017 fishing days. This is comparable in magnitude to the Henry and Lyle (2003) figure as well as effort estimates based of Dominion (2003) data (2,983,666 days). This allows confidence to be ascribed to the methodology adopted in determining fishing effort and the relative proportions of that effort between the Economic Regions.

This estimate represents the fishing effort across all species. The potential to determine the effort applied per species is discussed in the following section.

7.7 Catchabilities

Utilising harvest data (Section 7.4), representative effort data (Section 7.6) and proxy values for the population data (Section 7.5.2), estimates were made on the State-wide catchabilities (**Table 7.8**).

Table 7.8: State-wide Fishing Characteristics

Finfish	
Harvest	1,603,574.83
Effort	2,754,466.18
State Population	5,748,012
Catchability	1.01E-07
Non-Finfish	
Harvest	262,463
Effort	426,748
State Population	3,816,017
Catchability	1.61E-07

These catchabilities are not true catchabilities as they are based on proxy population indices.

The potential to determine species specific catchabilities was seen to be dependent upon the availability of species specific effort data. Henry and Lyle (2003) provide an estimate of the total recreational fishing effort expended within NSW (6,878,599 days). Of these, approximately 47 % was expended on estuarine fishing (3,232,941 days). Further to this, Henry and Lyle (2003) suggests that approximately 85 % of this effort (2,745,466 days) is spent angling for finfish and a further 13 % (426,748 days) spent fishing for prawns, crabs and other species which require non-line based capture. However, the data does not indicate on which specific species the effort was expended.

This is problematic as making assumptions as to the amount of effort spent on each species will impact upon both the species catchabilities and the Catch per Unit Effort (CPUE) of the species which is a critical measure in determining the value associated with a fish stocking program. Further, the majority of fishers are considered unlikely to target a specific species as the majority of fishers are fishing for reasons other than catching a fish (refer Section 2.2.1). Therefore, it is difficult to ascribe effort to any particular species.

To get around this issue, two approaches were assessed:

1. Calculate effort based on Existing Population Estimates; and
2. Assume effort is not species specific.

7.7.1 Effort Based on Existing Population Estimates

The calculation of effort based of existing population estimates is a useful, although severely limited approach. Based on the State-wide average catchabilities (**Table 7.8**), species specific population levels (**Table 7.3**) and harvest levels (**Table 7.2**) it is possible to estimate the effort required to catch each of the individual species. However, when this calculation is done and the individual efforts are summed, the total effort across all species (25.5 million days) considerably exceeds the known actual effort (3.1 million days). This reflects the fact that proxy population estimates and average catchabilities were utilised in the calculations, and should not be taken as representative of total effort data. However, it does allow for

representative estimates of the proportionate effort per species to be observed. These proportions were then applied to the known total effort to estimate the per species effort (**Table 7.9**).

Table 7.9: Estimated Proportionate Effort Expended on Each Species

Finfish	Proportion of Effort (%)	Estimated Effort
Bream spp.	33	934,153
Mulloway	15	418,260
Flathead spp.	9	257,721
Whiting spp.	26	736,672
Non-Finfish		
Eastern King Prawn	48	206,607
Giant Mud Crab	6	29,459
Blue Swimmer Crab	22	96,374

While this data is useful in providing a method for apportioning species effort (particularly in light of the lack of data) it is significantly hampered by its lack of accurate population estimates and catchabilities.

7.7.2 Non-Species Specific Effort

Subsequently, it was decided to adopt the assumption that fishing effort is not species specific. This is considered to be a viable assumption in light of the range of motivations for fishing as well as the predominance of a large body of non-avid fishers who are unlikely to fish for specific species (Section 2.2.1).

For the non-avid fisher, each individual fishing effort is not species specific. Thus whether particular species are present or not is irrelevant as all fishing effort is effort applied to all species in all locations. Thus the total fishing effort can be utilised as a common factor for any calculations requiring a species specific effort. This approach was subsequently adopted for all calculations involving effort for this study.

It was considered that fishing effort could be distinguished between finfish and non-finfish effort due to the difference in fishing techniques required and availability of data in regards to this division. Under this assumption of fishing effort, it was not necessary to develop species specific catchabilities. Given the broad nature of this analysis, it is unlikely to significantly affect the results, particularly given the outcomes of Section 8.

8 Estimation of Impact of Stocking

A cost benefit analysis of a fish stocking operation requires an estimate of the existing harvest, and the potential increase in harvest as a result of the stocking. Given the inability to readily observe species specific catchabilities and efforts, it is impossible to accurately predict the resultant harvest in accordance with Equation 1 from an increase in existing population as would occur under a fish stocking program.

Subsequently, it was decided that rather than quantify harvest and identify the allocation of fish stocking resources to provide the optimum harvest, a two stage approach would be adopted:

1. Economic Feasibility Analysis – at a State-wide level, estimate the economic viability of each of the proposed species.

2. Regional Allocation Analysis – using the available information, provide guidance on the regions which would likely result in the highest potential economic returns.

8.1 Economic Feasibility Analysis

The feasibility analysis was undertaken based on the cost and benefit data described in Section 6 and 7, and utilising three different valuation methods:

- Valuation based on market rates for fish species;
- Valuations based on recreational fishing expenditure; and
- Valuation based on the time value of fishing effort expenditure.

These results are described in **Section 9.1.1– 9.1.4**.

One way to determine the economic benefits would be to undertake a standard travel cost / expenditure methodology. However, the lack of available data (refer to discussions in Section 2, 6 and 7) prevented a straight application of this or other techniques. Subsequently, a range of conservative assumptions and varying methodologies were undertaken to allow comparison against each other and the qualitative impact assessment. **Figure 8.1** outlines the structure and logic of this multipart assessment.

It is important to note that the economic analysis is based on a one-off stocking event that occurs over a 1-year period. After the completion of the economic analysis, it was determined that some of the species may be stocked over a longer period of time or there may be a number of stocking events. This should be kept in mind in reviewing this analysis.

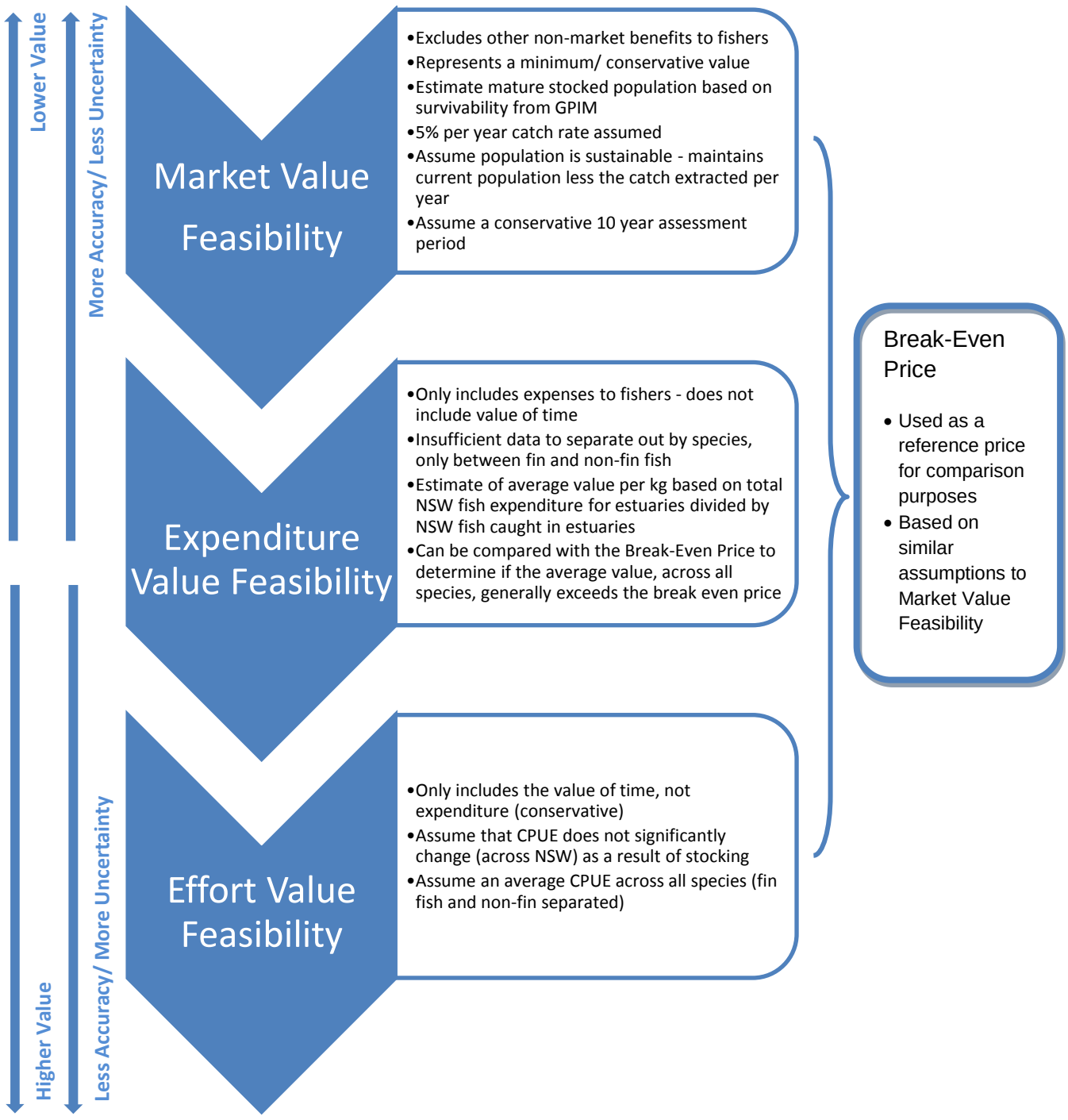

Figure 8.1: Quantitative economic analysis undertaken

8.2 Regional Allocation Analysis

Following from the assessment of economic feasibility at both an overall and species specific level, the optimum locations to be stocked were evaluated based on the ratio of existing fish population within a region to the amount of fishing effort expended within the region (the Q/E ratio).

Those regions seen to have high Q/E ratios (i.e. high existing populations and low fisher effort) are seen to be areas where existing fish populations are unlikely to limit the amount of

fishing effort within a region. Subsequently, increasing the existing fish population levels is unlikely to generate significant benefit to existing fishers or attract new fishers to the region.

In contrast, regions with low Q/E ratios are seen to be areas in which relative demand for fish is high and likely placing stress upon existing populations, potentially leading to over-fishing and degradation of populations. Stocking in these areas assists in meeting the consumer demand as well as minimising the ecological risk and problems associated with unsustainable recreational fishing. The results of the stocking selection are described in **Section 9.2**.

9 Results – Feasibility and Regional Allocation

9.1 Economic Feasibility Assessment

9.1.1 Feasibility: Market Value

Utilisation of current market prices per fish, coupled with the expected increase in harvest associated with fish stocking, represents a minimum value of the benefits. Such a measure, reflecting the value of fish in terms of market rates, does not reflect the other benefits associated with fishing (i.e. relaxation, sport, and appreciation of the outdoors).

The average market prices for each of the species proposed for stocking are summarised in **Table 9.1**. Market Price data was obtained from the Sydney Fish Market's 2009 annual report (SFM 2009) unless otherwise indicated.

Table 9.1: Market Prices for Fish Species (SFM, 2009)

Species	Price per Kilogram (2010 $)
Yellowfin Bream	10.54
Mulloway[1]	9.16
Flathead spp.	6.98
Sand Whiting	14.05
Eastern King Prawn (EKP)	18.75
Giant Mud Crab (GMC)	24.92
Blue Swimmer Crab (BSC)	12.10

[1] Data obtained from Schirmer *et al*. (2004)

If we assume an investment (and therefore total cost) of $300,000 into fish stocking (i.e. a maximum stocked amount of 300,000 fingerlings for all species other than eastern king prawns (**Section 6**)) then taking into account predicted survival rates or conversion to harvestable size (from the GPIM (refer Section 7.5.2) and Chapter E, Appendix E.5 of the EIS) the maximum per species value added to the fisheries are as described in **Table 9.2**.

Table 9.2: Maximum Value Added to Fisheries

Species	Stocked Amount (no. of fingerlings)	Average Conversion*	Predicted Adult Population of Stocked Fish (kg)	Value Added ($)
Bream spp.	300,000	0.1414	42,419	$ 447,319
Mulloway	300,000	0.1260	37,801	$ 346,357
Flathead spp.	300,000	0.1680	50,418	$ 351,953
Whiting spp.	300,000	0.0194	5,819	$ 81,794
EKP	15,000,000	0.0058	87,094	$1,632,679
GMC	300,000	0.1883	56,501	$1,408,027
BSC	300,000	0.1313	39,392	$ 476,832

*'average conversion' measure includes conversion of the number of individuals surviving to harvestable size to biomass, based on modelling done in Chapter E, Appendix E.5 of the EIS.

It can be seen that all species would provide a benefit to cost ratio of greater than one with the exception of whiting (BCR = 0.27). However, for this value to be realised it would require all surviving fish from the stocked quantities to be caught. This is an unrealistic assumption as based on catchability it would not be possible to extract all stocked fish one year.

Equation 1 (**Section 7**) outlines that harvest (H) is dependent upon catchability (q), the existing (whole) population level (N) and effort applied (E).

Consequently, it can be seen that the multiplication of "q" and "E" is really equivalent to the proportion of the existing population that would be expected to be converted into harvest.

As discussed in **Section 7** it was possible to develop proxy variables representing the relative proportions of State-wide finfish and non-finfish populations (N) and effort (E). However, the catchability estimates able to be generated from this data would significantly overestimate the proportion of catch caught each year due to significant underestimation of existing population through the adopted methodology. Estimates of fishing mortality are highly variable within and between species and locations and depend heavily on the catchability of the species (Arreguin-Sanchez 1996, Cooke and Beddington 1984, McPhee *et al*. 2002).

The estimation of both natural (i.e. natural death through age, predation, competition etc.) and fishing mortalities of species is still poorly defined within NSW, particularly in regards to wild harvest fisheries, and is critical to management of the recreational fisheries (Scandol and Rowling, 2007). Fishing mortality estimates vary significantly between species and are location/population specific. Subsequently although some species specific fishing mortalities are available (e.g. Farmer *et al*. (2005) identify mulloway as having a fishing mortality of 0.1 to 0.15, Montgomery *et al*. (2010) estimate school prawn fishing mortality to be less than 4 % for prawn species) a more general approach was adopted to account for the variety of species and breadth of study area. The natural mortality of fish species is commonly assumed to be 20 % for fisheries assessments (Siegfried and Sansó, 2009). Within NSW,

fish populations are regularly classified according to the degree of fishing undertaken (Scandol and Rowling, 2007). For example, populations of fish which are classified as "overfished" are typically classified by fishing mortalities being more than double the natural mortality rate, where as "lightly fished" populations typically have fishing mortalities at about 25 % of the natural mortalities. For the purpose of this assessment it was conservatively assumed that the populations of all estuaries were "lightly fished" and had a fishing mortality of 5 % per year (i.e. 5 % of the existing local populations is removed each year through recreational fishing). This is a conservative assumption because if the estuary is lightly fished, then the rate of extraction of fish that are stocked will be lower than an estuary that is over-fished. Therefore, as you have a lower rate of extraction, the benefits will be spread over a number of years, and therefore the PV of the benefits will be lower

It is considered that this assumption is likely to underestimate the extent of recreational fishing impact and as such is likely to minimise the benefits associated with a fish stocking program. It is also acknowledged that the value added of the stocked fish (**Table 9.3**) may be reduced under this assumption as stocking a population may generate a higher fishing mortality due to increased stock density.

Table 9.3: Value Added to Fisheries Assuming a one off 5 % Catch following Stocking

Species	Stocked Amount (no. of fingerlings)	Predicted Catch (kg)	Value Added ($)
Bream	300,000	2,120	22,366
Mulloway	300,000	1,890	17,318
Flathead	300,000	2,521	17,598
Whiting	300,000	291	4,090
EKP	15,000,000	4,355	81,634
GMC	300,000	2,825	70,401
BSC	300,000	1,970	23,842

Given the wide range of variables affecting survival of populations which vary between species and location a series of assumptions were adopted to allow estimation of the present value of the benefit. These assumptions included:

- the stocked populations do not breed either with the extant population or with themselves other than to maintain the natural population level in any given year (i.e. stocked population levels decrease at the rate of fishing extraction alone, population growth is not incorporated);
- a discount rate of 7 % per year is applied ;
- a ten year timeframe is applied;
- 5 % of the stocked population is caught each year from the third year from stocking; and
- costs incurred are restricted to the initial stocking phase in the first year.

These assumptions are not intended to be highly realistic but rather are utilised in order to provide indicative minimum values associated with stocking, given the lack of available data preventing more rigorous analysis being undertaken.

The assumptions allow for the removal of 5 % of the stocked population per year and allow for the remaining 95 % of the individuals will persist and be available for capture in the following year. Thus the value added benefit from the stocking program is more appropriately represented as the present value of the harvest into the future. The resultant present value of these potential maximum stocking benefit streams are displayed in **Table 9.4**.

Table 9.4: Present Value of Maximum Harvest Stocking

Species	Stocked Amount (no. of fingerlings)	Predicted Adult Population (kg)	PV*	BCR
Bream	300,000	42,419	$129,654	0.33
Mulloway	300,000	37,801	$100,390	0.26
Flathead	300,000	50,418	$102,012	0.26
Whiting	300,000	5,819	$23,708	0.06
EKP	15,000,000	87,094	$473,227	1.22
GMC	300,000	56,501	$408,112	1.05
BSC	300,000	39,392	$138,208	0.36

**determined using SFM (2009) market rates and discounting into present value dollars over the period of assessment*

Table 9.4 suggests that based on the adopted cost of stocking, estimated adult population and survivability assumptions, and utilising the market prices only Eastern king prawns and giant mud crabs are more likely to be economically viable than the other species. Given that all the relationships involved in the determination of these estimates are direct first order equations these feasibilities will hold regardless of the quantity of fingerlings stocked / amount of expenditure outlay. It is considered that these potential benefits, assessing only market value (i.e. the commercial value of fish to consumers) of harvest, would significantly under-estimate the realised benefits associated with fish stocking (**Section 7**).

9.1.2 Break Even Price

The value of a recreational fish caught is likely to be considerably greater than the market value of commercial catch due to the range of motivations, and hence generation of value, involved in recreational fishing. Based on the predicted per year harvest levels it is possible to determine the minimum value per recreational fish caught required to generate a stocking BCR greater than one (i.e. a net present value of zero, representing a Break-Even Price). This breakeven price and the market price are contrasted in **Table 9.5**.

Table 9.5: Break Even Price of Species

Species	Market Price* (kg)	BCR (Market Price)	Price per Kilogram ($) (BCR =1)
Bream	10.54	0.33	31.66
Mulloway	9.16	0.26	35.52
Flathead	6.98	0.26	26.63
Whiting	14.05	0.06	230.77
EKP	18.75	1.22	15.42
GMC	24.92	1.05	23.77
BSC	12.10	0.36	34.09

**Market price as determined from SFM (2009)*

In accordance with the BCRs observed, all species other than eastern king prawns and giant mud crabs have feasibility prices above that of the current market prices (SFM 2009). In particular, the required price of whiting is considerably greater than the market value (**Table 9.1**). The biology of these species appears to be such that in comparison to the other species, and taking into account the commercial value of these species, they are the weakest economic options for fish stocking. However, as noted previously these benefits only assess the associated market value of harvest, and must be placed in the context of wider benefits.

9.1.3 Feasibility: Expenditure Value

Henry and Lyle (2003) estimate the value of recreational fisheries within NSW at $723,105,230 (2010 dollars, 3 % inflation). These figures are based off the expenditure associated with fishing effort, and do not include the actual value of the time spent fishing. Expenditure data represents the minimum value fishers are willing to spend to participate in fishing and therefore represents a minimum value of the fishery.

In contrast to market value estimations, expenditure theoretically captures a wider range of values than solely market value of harvest. In particular, as the costs are generally incurred prior to the commencement of fishing the expenditure value method captures all expense devoted towards fishing regardless of the motivation for fishing. Market price valuation only captures the value of a fishery in terms of its harvest for consumption.

Henry and Lyle (2003) also indicate that 47 % of fishing effort is attributable to estuarine fishing. Therefore, if it is assumed that this also equates to 47 % of the expenditure, then the value of estuarine recreational fishing with NSW is estimated to be $340,000,000 (2010 dollars). These are approximate values only and based on the limited data contained in Henry and Lyle (2003) **Table 9.6** indicates the estimated estuarine recreational harvest within NSW.

Table 9.6: Estimation of NSW Estuarine Harvest (based on Henry and Lyle, 2003)

Characteristic	Finfish	Non-Finfish
Total Australian Catch (number of fish)	52,428,816	54,997,042
Total Australian Estuarine Catch (number of fish)	16,825,188	31,600,689
Total NSW Catch (number of fish)	11,408,204	1,673,116
Estimated Total NSW Estuarine Catch (number of fish)	3,661,062	9,613,513
Proportion of National Catch that is from NSW (%)	22	30
Proportion of NSW Catch that is Estuarine (%)	32	57
Total NSW Catch (kg)	4,996,885	456,784
Estimated Total NSW Estuarine Catch (kg)	1,603,574	262,463
Combined Total (kg)	**1,866,037**	

A simple average cost per kilogram across all species can be determined from this harvest data and expenditure incurred in obtaining the harvest data. This provides an average value of $182.13 per kilogram.

From the market data (**Table 9.1**), we know that the seven species of interest have an average market value of $13.79 per kilogram. This suggests that there is at least an additional $168.80 per fish kilogram caught associated with the activity of fishing over the market value of the fish caught. In fact, the market value of fish caught represents just 7 % of the expenditure estimated average value.

When compared to the Break Even Price (**Table 9.5**), it is seen that in all cases that average cost per kilogram across all species exceeds the Break Even Price of each species. In all species, with the exception of whiting, this average expenditure value is approximately four times the required feasibility price for each species.

The expenditure value indicates that stocking of the fish species may be feasible whiting was seen to be relatively the least feasible option.

Based on Dominion (2003) and the estuarine fishing effort statistics of Henry and Lyle (2003) it was also possible to estimate the number of fishing trips undertaken per year (3,028,200) and the average cost per trip ($112) from the expenditure data. This value roughly represents the minimum average utility value for going on a fishing trip. For the proposed fish stocking to increase the number of trips taken to an estuary it would need to create additional utility value in excess of $112. As these are based on average expenditure costs, fishers in close proximity to a stocked area would suffer lower expenditure and hence require less additional utility value. However, there is currently insufficient data available defining relationships between catch rates and the number of fishing trips undertaken. A rough calculation utilising the calculated average cost per kilogram ($182.13) would suggest that the ability to harvest an additional 0.61 kg may justify an additional trip.

9.1.4 Feasibility: Effort Value

A significant proportion of value associated with fishing (not captured under the market price valuation or the expenditure valuation) relates to the time value of money associated with the effort expended.

The Catch per Unit Effort ratio describes the harvest received per unit (days) of effort applied (as discussed in Section 7.3). Taking the inverse of this ratio forms the Effort per Catch ratio; the average effort (days) required to obtain a unit (1kg) of catch.

The Henry and Lyle (2003) study provides State-wide per species catch data, from which estimates of estuarine catch (**Table 7.2**) can be determined. However, as described in **Section 7**, it was seen to be difficult, based on existing data, to estimate the species specific effort. Subsequently, it was decided to utilise State-wide effort and catch data to provide an average Effort per Catch to be applied for each species (**Table 9.7**).

Table 9.7: Expected Harvest as a Proportion of Existing Population

Finfish	
Effort (days)	2,754,466.18
Harvest (kg)	1,603,574
Effort per Catch (days/kg)	1.72
Non-Finfish	
Effort (days)	426,748
Harvest (kg)	262,436
Effort per Catch (days/kg)	1.63

A recreational time value of $11.89 was adopted based on RTA (2009). This value was adopted as it represents the value of time to an individual when travelling for private use. As such, it provides a usual reference for the value of recreational time.

Using the recreational time value and the expected catch per year (**Section 9.1.1**) it was possible to estimate from the Effort per Catch rates the amount of effort required to generate the predicted catch and subsequently the associated value of this time. The present value (discount rate of 7 %) of this time value over the 10 year period of assessment was able to be compared against the known $300,000 cost to generate Benefit Cost Ratios (**Table 9.8**).

It is noted that this assumes the catch rates would not vary despite an increased fish density, and that fishers would continue to fish until the harvest is achieved. While artificial, this does provide an alternative estimate of the value of fishing associated with the predicted harvest resulting from the proposed fish stocking program.

Table 9.8: Feasibility of Fish Stocking Utilizing Average Effort per Catch*

Species	Stocked Amount (no. of fingerlings)	Predicted Catch over 10 years (kg)	PV of time expenditure in generating catch	BCR
Bream	300,000	14,277.23	$1,548,400.79	5.16
Mulloway	300,000	12,723.15	$1,379,856.36	4.60
Flathead	300,000	16,969.60	$1,840,394.46	6.13
Whiting	300,000	1,958.48	$212,401.73	0.71
EKP	15,000,000	29,314.16	$3,009,346.79	10.03
GMC	300,000	19,016.96	$1,952,252.17	6.51
BSC	300,000	13,258.47	$1,361,093.81	4.54

**Note the BCR does not include research and monitoring costs and no sensitivity analysis has been conducted on the BCRs.*

Under this approach it is seen that all species, with the exception of whiting, could be considered viable stocking options. For whiting the benefits are only approximately equal to the costs. This conclusion does also assume that all species are average in terms of the effort required per catch (e.g. should whiting be harder to catch than average species the effort required to generate the predicted catch, and hence BCR, would increase).

This data is consistent with the Expenditure data valuation and its comparison with the minimum Feasibility price required (**Section 9.1.3**).

9.1.5 Summary of Economic Feasibility Analysis

The data analysis strongly indicates that the stocking of estuaries for the majority of selected species is likely to be an economically feasible action. The conservative estimates utilised in this study are considered likely to significantly underestimate the true benefits associated with stocking. With the exception of whiting all species are seen to have strongly positive net present values and benefit cost ratios of greater than one.

The benefits associated with whiting stocking are seen to be very similar to the estimated costs. However, given the conservative nature of this study it is likely even this species will provide net positive benefits. However, the alternative species for stocking represent a better outcome on economic terms.

A ranking of the fish species in terms of the associated net present values (**Table 9.8**) is provided in **Table 9.9**.

Table 9.9: Ranking of Species Economic Feasibility*

Rank	Species	NPV
1	Eastern King Prawn	$2,709,346
2	Giant Mud Crab	$1,652,252
3	Dusky Flathead	$1,540,394
4	Yellowfin Bream	$1,248,400
5	Blue Swimmer Crab	$1,079,856
6	Mulloway	$1,061,093
7	Sand Whiting	-$87,598

**based on effort value method, the NPV does not include costs associated with research and monitoring and no sensitivity testing has been conducted on the NPVs.*

9.2 Regional Allocation Analysis

The benefits described in **Section 7** do not take into account the distribution of existing species populations and fishing effort, but rather represent feasibilities for NSW as a whole. The specific local distribution of fishing effort and existing populations will significantly influence whether these benefits are received or not.

Given the lack of specific species effort data available it is not possible to accurately quantify the regional breakdown of these benefits. Subsequently, the Q/E ratio (**Section 8**) was developed to be used as a proxy for regional stockability. Regions with lower Q/E ratios were considered to be more likely to generate greater benefits than those with higher ratios. Benefits will be greater in these areas as the expenditure value per existing fish is higher than in areas with higher ratios (i.e. the value of extant fish is greater). Thus, the value of each additional fish resultant from stocking is greater in these regions than in others.

Based off the estimated regional populations (**Table 7.3**), the proportion of regional effort (**Table 7.7**) and the total finfish and non-finfish State-wide efforts (**Table 7.8**) the Q/E ratio was able to be determined for each species within each region (**Table 9.10**). It should be noted that the data utilised for this analysis is limited, and that even breaking the State up into regions does not account for potential local biases (e.g. the potential concentration of effort to a single estuary within a region).

Table 9.10: Existing Population to Effort Ratios

Region	Ratio									
	Yellowfin Bream	Mulloway	Dusky Flathead	Sand Whiting	Finfish	EKP	GMC	BSC	Non-Finfish	Total
Upper North Coast	0.2	0.32	0.21	0.34	1.07	1.04	0.37	1.97	3.34	1.38
Clarence	0.31	0.35	0.32	1.63	2.61	5.69	0.57	10.72	16.99	4.54
North Coast Northern	0.20	0.20	0.21	0.28	0.89	0.82	0.37	1.54	2.73	1.13
North Coast Southern	0.39	0.17	0.4	0.50	1.47	1.70	0.72	3.20	5.61	2.02
Central Northern	0.08	0.79	0.71	0.66	2.20	2.31	1.25	4.36	7.92	2.97
Central Southern	-	0.98	0.53	0.92	2.43	3.05	0.93	5.74	9.72	3.41
Metropolitan	-	0.48	0.25	0.56	1.29	1.93	0.45	3.64	6.02	1.93
Upper South Coast	-	0.18	0.44	0.73	1.35	2.57	0.77	4.85	8.19	2.27
Lower South Coast Northern	-	-	0.08	0.06	0.14	0.20	0.04	0.38	0.62	0.21
Lower South Coast Southern	-	0.02	0.20	0.27	0.49	0.95	-	1.79	2.74	0.79

The region specific rankings within each species as well as the total region rankings are shown in **Table 9.11**. The shading present highlights the regions with lowest Q/E ratio for each species.

Table 9.11: Ranking of Regions within Species

Region	Rankings									
	Yellowfin Bream	Mulloway	Dusky Flathead	Sand Whiting	EKP	GMC	BSC	Finfish	Non-Finfish	Total
Upper North Coast	3	5	4	4	4	3	4	4	4	4
Clarence	4	6	6	10	10	5	10	10	10	10
North Coast Northern	2	4	3	3	2	2	2	3	2	3
North Coast Southern	5	2	7	5	5	6	5	7	5	6
Central Northern	1	8	10	7	7	9	7	8	7	8
Central Southern	-	9	9	9	9	8	9	9	9	9
Metropolitan	-	7	5	6	6	4	6	5	6	5
Upper South Coast	-	3	8	8	8	7	8	6	8	7
Lower South Coast Northern	-	-	1	1	1	1	1	1	1	1
Lower South Coast Southern	-	1	2	2	3	-	3	2	3	2

Table 9.10 and **Table 9.11** indicate that in terms of overall regional populations and current effort levels the optimum regions (based on ranks across all species and total ranking) for stocking across all species include:

- Lower South Coast Northern;
- North Coast Northern; and
- Lower South Coast Southern.

This predominantly reflects the proxy standards utilised to estimate the existing population within each of the regions (i.e. harvest data incorporated recreational fishing data from all estuaries across the State whereas the regional population indices utilised a variable number of estuaries within each region). It is considered likely that these figures underestimate the existing populations in some of the extreme northern and southern regions. Under-estimation of existing population levels results in lower Q/E ratio values, and hence a higher ranking in terms of stocking potential. If this assumption were practically verified it would be expected that, due to the higher fisher effort expended in mid-coast regions (i.e. metropolitan), the optimum regions may shift.

It is considered that these regional rankings act as a useful guide to identifying potential fish stocking areas most likely to generate the highest net benefit. However, it should be noted that a detailed economic quantification of specific species populations and fishing effort would be required to verify these findings.

10 Discussion and Conclusions

10.1 Species Recommendation

Although the data is limited, the various Cost Benefit analyses utilised collectively indicate that a fish stocking program based on any combinations of the identified species within NSW is potentially economically beneficial. This is consistent with the results of the qualitative assessment which suggest that given the relatively small scale of the program, the costs will be generally low and likely to be offset by direct expenditure benefits. The three species identified as being most viable relative to each other included:

- Eastern king prawn;
- Giant mud crab; and
- Flathead spp.

The prominence of non-finfish species in this listing is likely to be slightly misrepresentative due to the methodological assumptions necessarily undertaken as part of this analysis. The adopted approach assumes an equal time expense on fishing for finfish as for non-finfish. This is unlikely to be the case, as the techniques associated with non-finfish capture differ markedly to that of angling and typically place a lower active demand on fisher time. Similarly, it is considered that the motivations associated with non-finfish capture may differ significantly from the motivations typically associated with angling. In particular it would be expected that those fishers specifically targeting non-finfish species are likely to do so for food based motivations rather than recreational enjoyment, and are likely to be typically more avid in their pursuit than most recreational fishers. These differences in effort and motivation are not distinguished within the analysis and are considered likely to have over-estimated the benefits associated with stocking non-finfish species. Further studies analysing the differences between these fishing activities would need to be undertaken to validate this assessment.

It should also be noted that in general the number of fishers involved in angling as opposed to non-finfish capture is markedly the higher. It is considered that this reflects more the social preference for angling than any distribution of effort based upon availability or occurrence of non-finfish species limiting effort. Subsequently, it can be seen that should a fish stocking program engender growth in either effort per fisher or the total number of fishers, the maximum benefit would be received stocking finfish as opposed to non-finfish species. The three finfish species identified as being the most economically viable include:

- Flathead;
- Bream; and
- Mulloway.

Whiting were also considered to be potentially economically viable, although to a significantly lesser extent. The quantitative assessment undertaken indicates the program as likely to be viable even in the advent of no change in fishing effort and any increase in effort that does occur would significantly increase the economic benefits (and costs to a smaller degree). As such it is the conclusion of this analysis that the proposed fish stocking program is highly likely to be viable.

10.2 Location of Stocking

What is more difficult is determining the optimum location at which stocking should occur. It is important to note that there may be unique site factors which would prevent the generalised benefits described in this report from being received at each site. Given the basis of the decision the selected area and species will vary. For example, if the only concern is whether stocking will be feasible or not, then it does not matter which species are stocked (as all are feasible) or in which region they are stocked.

However, if the aim is to maximise the economic return from stocking, then it would be necessary to select the species that provide the greatest economic value from stocking (i.e. eastern king prawn, giant mud crab and 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 sensible.

However, while the data is sufficient to identify regions which would benefit the most from stocking, as well as identify at a State-wide level the most economically viable species to stock, it is insufficient to identify the optimum allocation of stocking. This is due to the lack of species specific effort data and existing population data. The Q/E ratio, while effective in comparing species and regions, does not directly relate to received benefit (i.e. two species/regions may have the same Q/E ratio yet the impact of stocking within those species/regions is likely to differ significantly based upon a large range of factors (e.g. geography, fishing conditions, relative existing population levels, the demand for fishing in the area and the existing extent to which it is satiated).

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 (**Section 7**)) would need to be obtained.

10.3 Recommendations for Further Research

It is considered that this assessment indicates fish 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 areas in which the greatest benefit will be received. Given these findings, it is recommended that following identification of preferred stocking areas, a more detailed economic assessment be conducted as to which of the species should be stocked and to what extent within each of the identified stocking areas.

Particularly, it is acknowledged that the amount of data available is extremely limited with respect to the depth and certainty of the economic analyses undertaken. While the qualitative and quantitative assessments align, there is a need for a robust cost benefit analysis to be undertaken. Such an analysis would require specific data in regards fish population levels, fisher behaviour, and environmental constraints. 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.

A substantial quantity of work within New South Wales recreational fishing could be done to make fisheries management more efficient. The existing data levels are low, and limit the

management decision making process. Data collated into the future which would benefit this includes:

- Fisher survey data identifying species preference;
- Fisher survey data indicating fishing location utilised;
- Fisher survey data ranking fishing motivations;
- Fish data regarding existing populations; and
- Catchability estimates along the New South Wales coast.

Under the marine fish stocking Fisheries Management Strategy (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 fish 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 fish stocking. These catch and effort surveys (initially focussed on regional areas) will contribute to measuring the benefits of the activity of fish stocking and include collation or collection of the information listed above. Procedures for monitoring fishing catch and effort would be established following the development of the stocking plan.

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