Marine Aquaculture Research Lease Providence Bay, Port Stephens NSW

Environmental Impact Statement

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Cover Image: Yellowtail Kingfish in a research tank at PSFI (Source: NSW DPI, 2008).

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ENVIRONMENTAL IMPACT ASSESSMENT CERTIFICATION

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Proposed development

Under the *State Environmental Planning Policy* (State and Regional Development 2011) the proposal is classified as State Significant Infrastructure (c.14 (1)(b) and Schedule 3 (1)(1)) and requires approval from the Minister for Planning and Infrastructure under s.115W of the *Environmental and Planning Assessment Act 1979*.

Certification

We certify that we have prepared this EIS in accordance with the Director-General's Requirements and to the best of our knowledge the information contained in this EIS is neither false nor misleading.

Ian Lyall	Hester Bushell	Graeme Bowley
Project Director	*Project Manager*	*Project Manager*

EXECUTIVE SUMMARY

Overview

NSW Department of Primary Industries (NSW DPI) proposes to develop a 20 hectare Research Lease 4 km off Hawks Nest, NSW for a period of five years. Floating sea cages anchored to the seafloor would be used to research marine finfish aquaculture in an offshore sea cage trial. The research will allow the NSW Government to extend its successful marine hatchery research at Port Stephens Fisheries Institute (PSFI). Key outcomes of this research would include: proving species suitability, validating equipment and technology, and monitoring the marine environment.

The NSW Government recognises the need to look at opportunities for sustainable and viable aquaculture development that is built upon sound research. Aquaculture supports the regional economies of NSW and will be an increasingly important contributor to the future food security needs of the State.

Rationale

Global demand for seafood is rapidly expanding and seafood consumption per capita is increasing. In 2008, 46% of the seafood consumed worldwide was produced by aquaculture (FAO, 2010). In NSW the supply of locally caught fish is not expected to increase from current sustainable catch levels and approximately 87% of seafood purchased in NSW is imported (Wilkinson, 2004).

Sustainable seafood production is a key focus of the NSW Government's State Aquaculture Steering Committee to support future demands of food security for the state. The gap between capture fishery supply and the growing demand for seafood can only be supplied by aquaculture.

Aquaculture is a relatively new food production sector in NSW with a history of strong research and development support from NSW DPI (formerly NSW Fisheries). PSFI has been working in marine finfish research since the early 1990s and Snapper *(Pagrus auratus)* sea cage farming research commenced in the inshore waters of Botany Bay in 1993. Successful hatchery and nursery research for Mulloway (*Argyrosomus japonicus*), Yellowtail Kingfish (*Serioli lalandi*) and other marine finfish also needs to be extended and validated in sea cages trials.

The proposed site for the Marine Aquaculture Research Lease (Research Lease) off Port Stephens is in close proximity to PSFI which has suitable fish rearing and land based infrastructure. The proposed site also has suitable characteristics for cage based aquaculture (e.g. water quality, sandy bottom and moderate current flow), there is a history of finfish farming in the area and the harbour infrastructure of Nelson Bay is a suitable land-water interface for the project. Port Stephens is a key location in NSW for aquaculture research and the commercial production of oysters, barramundi, silver perch, freshwater crayfish and hatchery stock.

Approvals Pathway

Under *State Environmental Planning Policy (State and Regional Development 2011)* the proposal is classified as State Significant Infrastructure (Clause 14 (1)(b) and Schedule 3 (1)(1)) and requires approval from the Minister for Planning and Infrastructure under Section 115W of the *Environmental and Planning Assessment Act 1979.* An Environmental Impact Statement (EIS) has been prepared to accompany the application for approval. Crown Lands have provided land holders consent to NSW DPI to lodge the application. A lease is required under the Section 163 of the *Fisheries Management Act 1994* and a permit is required under the *Marine Parks Act 1997*. The proposed Research Lease is located in a Habitat Protection Zone of the Port Stephens Great Lakes Marine Park and is a permissible activity in this zone.

Strategic Framework

The promotion of sustainable aquaculture was prioritised at the NSW Executive Food Security Group in 2011. This group tasked the government's State Aquaculture Steering Committee to progress initiatives to further develop aquaculture. Under *State Environmental Planning Policy – 62 (Sustainable Aquaculture)*, two strategies have been prepared to guide the development of aquaculture in NSW and promote industry best practice. They include the NSW Oyster Industry and Land Based Sustainable Aquaculture Strategies. The investigations conducted on the Research Lease in Providence Bay will provide an evidence base for the development of policy for sustainable aquaculture in the marine waters of NSW.

The Proposal

The proposed Research Lease will provide an opportunity for NSW DPI and research partners to extend successful marine hatchery research to its next stage in an offshore sea cage trial. It is proposed that the trial will operate for five years (from the date that the aquaculture lease is granted) to validate the commercial potential of a number of marine finfish species that occur along the NSW coast, to trial the latest sea cage technologies and undertake environmental monitoring in the coastal waters of NSW.

The Research Lease would occupy an area of 20 hectares (approximately 370 x 530 m) in Providence Bay, Port Stephens (Figure 1). The main infrastructure will consist of an anchoring and bridle system to accommodate up to eight floating double collared sea cages. The cages may range in size (18-40 m diameter) depending on the number and size of the cultured fish. Also navigation buoys will be positioned on the corners of the lease area.

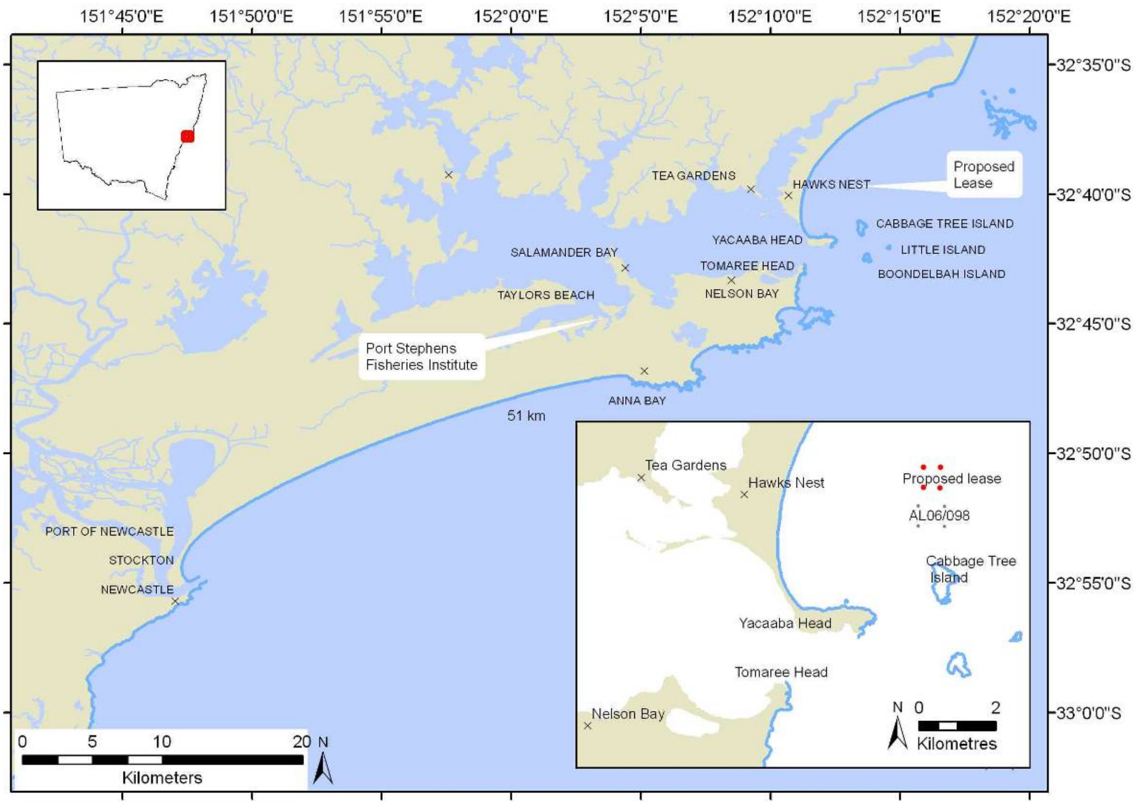

Figure 1: Location of the proposed Research Lease in Providence Bay, Port Stephens (Source: NSW DPI, 2012).

Risk Assessment and Mitigation

A risk assessment process based on the *National ESD Reporting Framework: The 'How To' Guide for Aquaculture* was used to identify and mitigate potential risks associated with the proposal. A total of 27 risk issues were identified and categorised that had potential to have an impact as a result of the proposal. These risks were identified in either the construction stage or the operational stage of the Research Lease.

Eleven issues were identified as representing a 'negligible' risk while 12 issues were assigned a 'low' risk ranking. No issues were identified as representing a 'high' or 'extreme' risk but four were classified as 'moderate', including: impacts on marine habitats - water quality, nutrient concentrations and sedimentation; chemical use;

disease and introduced pests; and impacts on migratory pathways, behavioural changes and predatory interactions. These classifications indicate that these issues require ongoing or further management and/or research. Table 1 provides a summary of the potential issues, risk rankings and the proposed mitigation measures.

Table 1: Summary of environmental, social and economic issues including risk ranking and proposed mitigation measures for the proposed Research Lease (modified from Fletcher *et al*., 2004).

Issue	Ranking	Mitigation
Site / Construction / Infrastructure (8.1)		
Significance of habitat loss and shading due to the installation of sea cage infrastructure **(8.1.1)**	*Negligible*	▪ Site selection (sand substratum, no environmentally sensitive or unique areas and extensive area of similar habitat in region) ▪ Open and streamlined sea cage design
Decommissioning **(8.1.2)**	*Low*	▪ Site selection (mobile sand, reasonable depth, high energy environment) ▪ Small scale short-term research operation ▪ Fish feeding practices
Impact on noise levels – construction and deployment stage **(8.1.3)**	*Low*	▪ Comply with *POEO (Noise Control) Reg. 2008* ▪ Comply with Industry Best Practice (Noise Management) ▪ Marine Fauna Interaction Management Plan (e.g. Observer Protocol and maximum approach distance for marine fauna)
Impacts on existing land based infrastructure **(8.1.4)**	*Negligible*	▪ Use of existing approved land based facilities
Structural integrity and stability of sea cage infrastructure **(8.1.5)**	*Low*	▪ Structural Integrity and Stability Monitoring Program (e.g. regular /post-storm /post-net cleaning inspections and maintenance) ▪ Sea cage design - use of existing and proven technologies ▪ Infrastructure modifications – qualified personnel ▪ Sea cage transport and deployment – overseen by qualified personnel ▪ Verification of structural integrity and stability by manufacturer for recorded wave climate maximums
Climate change and impact of sea cages on coastal processes and water flow **(8.1.6)**	*Negligible*	▪ Site selection (reasonable depth and distance from land /geomorphological formations) to minimise interactions with wave processes ▪ Sea cage design (streamlined, flexible and open) ▪ Regular cleaning of nets and mooring lines (i.e.

		biofouling removal) ▪ Five year research period ▪ Sea cage design – withstand recorded wave climate maximums ▪ Cultured species – broad temperature and salinity tolerances
Impact of sea cage infrastructure on navigation and other waterway users **(8.1.7)**	*Negligible*	▪ Site selection o Outside navigation channels and shipping port approaches o Does not obstruct vessel routes to Broughton Island or yacht courses o Not in significant recreational or commercial grounds ▪ Four navigational marks (corners of lease) ▪ Australian Hydrographic Office will be notified and a 'Notice to Mariners' will be issued and official charts amended. ▪ Traffic Management Plan ▪ Relevant publications and maps will be amended to include the Research Lease ▪ Staff will have relevant licences and qualifications, undergo regular training and abide by NSW Maritime regulations ▪ Target user groups will be informed about general boating rules in the vicinity of the Research Lease – keep safe distance and do not anchor near sea cages
Operation (8.2)		
Impacts on Communities **(8.2.1)**		
Impacts on visual amenity and odours **(8.2.1.1)**	*Low*	▪ Design features that minimise visibility (e.g. dark coloured materials, low profile, small scale, short-term and subsurface infrastructure) ▪ Waste Management Plan (e.g. demand feeding regime, use of dry pelletised feed, regular cleaning of nets and removal of injured/deceased stock) ▪ Vessels used will be similar to existing local commercial fleet
Impacts of marine vessel and vehicular transport **(8.2.1.2)**	*Negligible*	▪ Staff will have relevant licences and qualifications, undergo regular training and abide by NSW Roads and Maritime Services regulations ▪ NSW Roads and Maritime Services will be notified when cages are transported ▪ Vehicle loads will be safely secured and covered if possible ▪ Movements of vehicles will be limited to normal working hours ▪ Display of appropriate flags, symbols and signs

		▪ Traffic Management Plan
Impacts on Aboriginal and European heritage **(8.2.1.3)**	*Negligible*	▪ Consultation and seafloor survey support assessment that no items/areas of heritage significance within area proposed for Research Lease ▪ Significant buffer zone to prevent impact on heritage items in wider region (> 2 km)
Impacts on noise levels – operational stage **(8.2.1.4)**	*Negligible*	▪ Comply with *POEO (Noise Control) Reg. 2008* ▪ Comply with Industry Best Practice (Noise Management)
Impacts on adjacent aquaculture lease **(8.2.1.5)**	*Negligible*	▪ Buffer zone ▪ Navigation buoys ▪ Water Quality and Benthic Environment Monitoring Program ▪ Disease, Parasite and Pest Management Plan
Work health and safety issues **(8.2.1.6)**	*Low*	▪ Traffic Management Plan ▪ Waste Management Plan ▪ Structural Integrity and Stability Monitoring Program ▪ Marine Fauna Interaction Management Plan o Marine Fauna Entanglement Avoidance Protocol ▪ Disease, Parasite and Pest Management Plan
Impacts on the local economy **(8.2.1.7)**	*Negligible*	▪ No management required – positive benefits
Impacts on the Environment **(8.2.2)**		
Impacts on marine habitats – water quality, nutrients and sedimentation **(8.2.2.1)**	*Moderate*	▪ Site selection (high energy environment, reasonable depth, mobile sands) ▪ Small scale short-term research operation ▪ Water Quality and Benthic Environment Monitoring Program (regular sampling) ▪ Daily operational and maintenance practices – minimise nutrient and particulate loading ▪ Fallowing of sea cages
Fish feed - source, composition and sustainability issues **(8.2.2.2)**	*Low*	▪ Small scale short-term research operation ▪ Contribute to aquaculture sustainability – land based and offshore research (e.g. fish meal/oil replacements, improvements in FCR, diet development) ▪ Feed resources – sustainable suppliers ▪ Minimal feed wastage – demand feeding
Impacts of chemical use **(8.2.2.3)**	*Moderate*	▪ Chemicals administered in accordance with APVMA or via a prescription from licensed veterinarian ▪ Frequency and dose will be kept to a minimum

		▪ Liners will be used when therapeutics are administered ▪ Comply with *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research*
Genetic composition of cultured stock and impacts of escaped cultured stock on wild stock genetics and competition **(8.2.2.4)**	*Low*	▪ Broodstock will be sourced from local stocks or the same recognised genetic population ▪ First generation is cultured – no artificial selection ▪ Sufficient number of pairs used when breeding to maintain genetic integrity ▪ Daily operational and maintenance procedures to minimise predatory interactions ▪ Relocation of stock will occur when sea state conditions are calm ▪ Structural Integrity and Stability Monitoring Program ▪ Disease, Parasite and Pest Management Plan ▪ Sea cage infrastructure will be based on existing and proven technologies ▪ Structural integrity of sea cages will be verified based on recorded wave climate maximums
Disease transmission, cultured stock diseases and introduced pests **(8.2.2.5)**	*Moderate*	▪ Disease, Parasite and Pest Management Plan o Minimise stress (stocking density, water quality and predatory interactions) o Regular fish health monitoring (surveillance program) o Report 'declared diseases', unexplained mortalities, suspected marine pests and noxious species o Biofouling management o AQUAVETPLAN ▪ Hatchery Management Plan o NSW Hatchery Quality Assurance Scheme accreditation
Impacts of artificial lights on fauna species **(8.2.2.6)**	*Low*	▪ Site selection (> 2km from offshore islands; north of residential areas) ▪ Hours of operation – predominately daylight ▪ Vessel lights – shielded and concentrated downwards ▪ Marine Fauna Interaction Management Plan
Entanglement and ingestion of marine debris **(8.2.2.7)**	*Low*	▪ Maintenance and operational procedures – minimise attraction of predators ▪ Sea cage design features – entanglement avoidance ▪ Marine Fauna Interaction Management Plan o Marine Fauna Entanglement Avoidance Protocol ▪ Waste Management Plan

		▪ Structural Integrity and Stability Monitoring Program
Animal welfare issues **(8.2.2.8)**	*Negligible*	▪ All staff will be made aware of their obligations under the *Animal Research Act 1985* ▪ Research will be reviewed by an Animal Care and Ethics Committee ▪ Comply with *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* ▪ Comply with *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research* ▪ Comply with *Aquaculture Code of Conduct* ▪ Waste Management Plan ▪ Water Quality and Benthic Environment Monitoring Program ▪ Disease, Parasite and Pest Management Plan
Risk of vessel strike and acoustic pollution **(8.2.2.9)**	*Low*	▪ Observer Protocol ▪ Maintain appropriate distances from marine fauna ▪ Adhere to NSW Roads and Maritime Services speed limits ▪ Slow speeds will be used in sensitive areas ▪ Hours of operation – predominately daylight ▪ Vessel motors will be well maintained
Impacts on threatened / protected species and matters of NES **(8.2.2.10)**	*Low*	▪ Assessment of Significance - State ▪ Assessment of Significance - Commonwealth ▪ Environmental Management Plan
Impacts on migratory pathways, behavioural changes and predatory interactions (notably whales and sharks) **(8.2.2.11)**	*Moderate*	▪ Small scale short-term research operation ▪ Minimise marine fauna predatory attractions and interactions o Sea cage design features o Daily operational and maintenance procedures o Human activity o Structural Integrity and Stability Monitoring Program ▪ Marine Fauna Interaction Management Plan e.g. listening stations
Impacts on Areas of Conservation Significance - World Heritage, Ramsar Wetlands, MPA, national parks, critical habitat and natural reefs **(8.2.2.12)**	*Low*	▪ Site selection (high energy environment, buffer zone and mobile sands) ▪ Small scale short-term research operation ▪ Water Quality and Benthic Environment Monitoring Program (regular sampling) ▪ Daily operational and maintenance procedures – minimise waste inputs

Waste disposal - bio/general/equipment waste **(8.2.2.12)**	*Negligible*	▪ Waste Management Plan ▪ Water Quality and Benthic Environment Monitoring Program

Environmental Management

The Environmental Management Plan (EMP) will ensure that the commitments in the EIS, subsequent assessment reports and any approval or licence conditions are fully implemented. A preliminary draft of the EMP has been provided (Appendix 2), which consists of a series of the sub-management plans, monitoring programs and protocols that address the potential environmental impacts identified in Section 8 (Table 1).

The key objective of the EMP is to ensure that the Research Lease is sustainably managed and that its operation does not have a significant impact on the marine environment, surrounding communities or staff. The EMP will aim to ensure the following:

- Aquaculture best practices are employed during all stages of the Research Lease;
- Marine fauna interactions are minimised;
- Water quality is maintained and nutrient inputs are kept within safe levels for humans and marine communities;
- The structural integrity and stability of the sea cage infrastructure is maintained;
- The occurrence of disease, parasites, pests and escapees is minimised and if these events do occur, prompt management and/or remedial action will be implemented;
- The safety of staff and surrounding communities is maintained;
- Waste is appropriately managed;
- Navigational safety in Providence Bay, the Port of Newcastle and Port Stephens is maintained; and
- The performance of the Research Lease is regularly evaluated by reviewing environmental management reports and monitoring records.

Consultation

NSW DPI began the consultation process for this project with relevant stakeholders in August 2011. The aim of informing stakeholders early in the project was to provide as much information as possible about the aquaculture industry and then include issues of concern raised during consultation in this EIS. Information was also provided via local media and with a *Question and Answer* page on the NSW DPI website. Meetings were held with government, environmental and community groups, recreational and commercial fishers, the Worimi Knowledgeholders Aboriginal Corporation, marine tour operators and local associations. Some 49 key contacts and 23 face to face meetings were held.

Conclusion

This EIS has been prepared to accompany an application for a five year, 20 hectare Research Lease off Port Stephens. The EIS provides a thorough and transparent assessment of the potential risks associated with the proposed activity and proposes a number of measures to address the potential impacts of the Research Lease development and its activities. Through the employment of industry best practice and management strategies, it is concluded that the proposed research activity will not have a significant environmental, social or economic impact.

Comment on the Proposal

The Director-General of the NSW Department of Planning and Infrastructure (DoPI) is exhibiting this environmental assessment for a minimum of 30 days and inviting public comment. The environmental assessment is available for inspection during the exhibition period at the DoPI head office, local council offices as well as on the NSW DoPI and NSW DPI websites. Any person is able to make a written submission during the exhibition period to the Director-General regarding the project.

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Environmental Risk Analysis	7; 8; Appendix 2
Consolidated summary of all the proposed environmental management and monitoring measures, highlighting commitments in the EIS.	Ex. Summary (Table 1)
Consultation ▪ Consult with relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners.	5

LIST OF ABBREVIATIONS

ABARE	Australian Bureau of Agricultural and Resource Economics
AHIMS	Aboriginal Heritage Information Management System
AIMS	Australian Institute of Marine Science
APVMA	Australian Pesticides and Veterinary Medicines Authority
CMA	Catchment Management Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DEH	Department of Environment and Heritage
DGRs	Director-General's Requirements
DPIWE	Department of Primary Industries, Water and Environment (Tasmania)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ESD	Ecologically Sustainable Development
FAD	Fish Attracting (or Aggregating) Device
FAO	Food and Agriculture Organization
FCR	Feed Conversion Ratio
FRDC	Fisheries Research and Development Corporation
GIS	Geographic Information Systems
GNS	Grey Nurse Shark
HDPE	High Density Polyethylene
IALA	International Association of Lighthouse Authorities
JRA & DSA	Jenny Rand and Associates and Dain Simpson Associates

KTP	Key Threatening Process
LALC	Local Aboriginal Land Council
LGA	Local Government Area
METOC	Navy Meteorology and Oceanography
MMIC	Marine and Marine Industries Council
NES	National Environmental Significance
NPWS	National Parks and Wildlife Service
NSW DEC	New South Wales Department of Environment and Conservation
NSW DPI	New South Wales Department of Primary Industries
NSW DoPI	New South Wales Department of Planning and Infrastructure
NSW FM Act	New South Wales *Fisheries Management Act 1994*
NSW OEH	New South Wales Office of Environment and Heritage
NSW TSC Act	New South Wales *Threatened Species Conservation Act 1995*
POEO Act	*Protection of the Environment Operations Act 1997*
PSFI	Port Stephens Fisheries Institute
PSGLMP	Port Stephens – Great Lakes Marine Park
RMS	Roads and Maritime Services
SARDI	South Australian Research and Development Institute
SBT	Southern Bluefin Tuna
TO, HAG & PA Pty Ltd	Tassal Operations Pty Ltd, Huon Aquaculture Group Pty Ltd and Petuna Aquaculture Pty Ltd
TMP	Traffic Management Plan
TOC	Total Organic Carbon
WKHAC	Worimi Knowledgeholders Aboriginal Corporation

GLOSSARY OF TERMS

Acoustic Deterrent Device	An ADD is a device with a low intensity that emits middle to high frequency signals (2.5 – 10 kHz) with higher harmonic frequencies (up to 160 – 180 kHz). For example, pingers are designed to prevent by-catch of small cetaceans by emitting ultrasound frequencies to deter them from nets.
Ambient	Of or relating to the immediate surroundings.
Anchoring and Bridle System	The series of ropes, chains, weights and anchors used to keep the sea cages and nets in place in the ocean.
Anoxic	Absence of or low concentrations of oxygen.
Anti-predator Net	A net, which is suspended around the culture net to prevent predators from entering cages.
Aquaculture	**C**ultivating fish or marine vegetation for the purposes of harvesting the organisms or their progeny with a view to sell or keep the organisms in a confined area for commercial purposes (e.g. a fish-out pond).
Areas of Conservation Significance	For the purposes of the proposal, it refers to Marine Protected Areas, Ramsar wetlands and areas of critical habitat declared under the *Fisheries Management Act 1994* and the *Threatened Species Conservation Act 1995.*
Attenuation	To reduce in force, value, amount or degree.
Average Peak Wave Period (Tp)	The wave period associated with the most energetic waves in the total wave spectrum at a specific point.
Benthic	Living in or on the seabed.
Biofouling	The settlement, attachment and growth of organisms (e.g. microorganisms, plants, algae and animals) on submerged surfaces in aquatic environments.
Breaking Waves	Waves can break in three modes: spilling, surging and plunging. Waves break when the speed of the crest exceeds the speed of the advance of the wave as a whole i.e. as waves increase in height through the shoaling process, the crest of the wave tends to speed up relative to the rest of the wave.
Broodstock	The group of mature or parent fish used in aquaculture for breeding purposes i.e. to produce fry and fingerlings.
Cardinal Marks	A sea mark, usually a buoy or other floating or fixed structure, used to indicate the direction of safe water or the position of a hazard.
Caudal Peduncle	The narrow part of the fish's body to which the tail fin is attached.
Decommissioning	A general term for a formal process to dismantle or remove something from service i.e. removal of sea cage infrastructure.

Deepwater	Water that is sufficiently deep enough to avoid or minimise the effect of the ocean bottom on surface waves. Water deeper than one-half the surface wave length is generally considered deepwater.
Diffraction	A deviation in the direction of a wave at the edge of an obstacle in its path.
Ecologically Sustainable Development	For the purposes of the proposal, it refers to the principles outlined in s.6(2) of the *Protection of the Environment Administration Act 1991*.
Endemic	The ecological state of an organism being unique to a defined geographic region.
Environmental Impact Statement	A detailed study based on environmental assessment to determine the type and level of effects that a proposed project may have on the natural environment. Its objectives are to assess if the potential impacts are acceptable; to design appropriate monitoring, mitigation, and management measures and investigate acceptable alternatives.
Epifauna	Animals that live on or are attached to the surface of subtidal habitat or the seabed.
Eutrophication	Over enrichment of a water body with nutrients, resulting in depletion of oxygen concentration and excessive growth of organisms.
Fallowing	A good husbandry practice that involves moving cages over different seabed areas in order to minimise the build up of organic wastes in any one area, and to subsequently allow these areas enough time for natural marine processes and the environment to assimilate any wastes.
Fingerlings	A small or young fish.
Feed Conversion Ratio	The amount of food required to produce one unit of growth (e.g. kilogram) in an organism (e.g. fish).
Green Field Site	A piece of land that has not previously been built on.
Habitat Protection Zone	A marine park zone which aims to conserve marine biodiversity by protecting habitats and reducing high impact activities. Recreational fishing, some forms of commercial fishing and aquaculture, fishing competitions and tourist activities are permitted in Habitat Protection Zones.
High Density Polyethylene	A polyethylene thermoplastic made from petroleum.
Hmax (m)	Maximum wave height in a specified time period – the highest individual wave in a record.
Hsig (m)	The significant wave height of a record i.e. the average of the highest one third of waves in the record.
Infauna	Aquatic animals living in the sediment.
In situ	Situated in the original, natural or existing place or position.

Key Threatening Process A process that threatens or that could potentially threaten the survival or evolutionary development of species, populations or ecological communities.

Macrofauna Organisms retained in a sieve of 1.0 mm and associated with sediment environments.

Marine Protected Area An area of sea especially dedicated to the protection and maintenance of biological diversity and associated natural and cultural resources and is managed through legal means.

Matters of National Environmental Significance Matters of national environmental significance are protected under national environment law – the *Environment Protection and Biodiversity Conservation Act 1999*. These include listed threatened species and communities, listed migratory species, Ramsar wetlands of international importance, Commonwealth marine environment, world heritage properties, national heritage places, the Great Barrier Reef Marine Park and nuclear actions.

Microtidal A tidal range of less than two metres.

Nitrogen Cycling The biochemical cycle of nitrogen involving fixation, nitrification, decomposition and denitrification.

Offshore Zone Coastal waters to the seaward of the near-shore zone. In the offshore zone, swell waves are unbroken and their behaviour is not influenced by the presence of the seabed.

Oxic Designating an environment or process in which oxygen is involved or present.

Peak Energy Period (Tp) The period of the dominant waves in a record.

Precautionary Principle A principle of ESD which states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Pelagic Organisms that inhabit open water.

Plankton Organisms (< 0.5 mm) that drift with the ocean currents.

Ramsar Wetlands Refers to wetlands listed under the Ramsar Convention, which is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the sustainable use of all of the wetlands in their territories.

Recirculating Tank Systems Recirculating aquaculture systems are indoor, tank-based systems, in which fish are grown at high density under tightly controlled environmental conditions. Most of the water is reused or 'recirculated' rather than being lost from the system. The water in the system is continually cycled through the production tanks and through a series of water treatments to remove waste products.

Regular Monitoring Periodic recording of a set of parameters.

Risk	The likelihood of an undesired event (or impact) occurring as a result of some behaviour or action.
Risk Management	The culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.
Sanctuary Zone	A marine park zone which provides the highest level of protection to habitat, animals, plants and areas of cultural significance by prohibiting all forms of fishing and collecting activities, and anchoring on reefs. Only activities that do not harm plants, animals and habitats are permitted.
Sedimentation	The settling of particles (e.g. uneaten food and fish faeces) to settle out of the fluid in which they are suspended (e.g. out of the water column of the ocean onto the seabed).
Semidiurnal Tide	Two high tides and two low tides each day.
Shallow Water	The depth in which surface waves are noticeably affected by bottom topography. Generally, water depth less than one-half the surface wave length is considered shallow water.
Shoaling	The influence of the seabed on wave behaviour. Shoaling only becomes significant in water depths of 60 m or less which is manifested as a reduction in wave speed, a shortening in wave length and an increase in wave height.
Significant Impact	A significant impact is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted and upon the intensity, duration, magnitude and geographic extent of the impacts.
Stanchions	An upright bar, frame or post forming a support or barrier.
Standing Biomass	Is the maximum fish biomass that may be supported in a system on a continuing basis.
State Significant Infrastructure	A range of infrastructure types as designated under the State Environmental Planning Policy (State and Regional Development) 2011.
Storm or Severe Weather Event	A period of high wave activity. For the NSW coastline, a storm event is usually defined as the time when a significant wave height is recorded at greater than 3 m at an offshore wave recording station.
Subsurface	Below the water's surface.
Total Organic Carbon	The amount of carbon bound in an organic compound which is often used as a non-specific indicator of water quality.
Wave Climate	The average wave conditions at a place over a period of years, such as height, direction and period.
Wave Height	The vertical distance between a wave crest and preceding or succeeding wave trough.

Wave Length The distance between consecutive wave troughs or wave crests.

Wave Period (T) The time taken for consecutive wave crests or wave troughs to pass a given point.

Wave Reflection The seaward return of an incident wave when it impinges on a steep beach, barrier or other reflecting surface.

Wave Refraction The tendency of wave crests to become parallel to bottom contours as waves move into shallower waters. This effect – i.e. the slowing down of waves in shallower waters, is caused by the shoaling process.

Waverider Buoys A floating device that is used to measure water level variations caused by ocean waves. The wave data collected by the Waverider buoy network and by other project specific stations has been incorporated into an extensive long-term database which assists with design, construction and performance monitoring of coastal projects. Directional Waverider buoys measure ocean wave height, period and direction.

1 INTRODUCTION

NSW DPI is an office of the NSW Department of Trade and Investment, Regional Infrastructure and Services (known as NSW Trade and Investment) which aims to drive sustainable economic growth in NSW.

NSW DPI proposes to develop a 20 hectare Research Lease 3.5 km off Hawks Nest in Providence Bay near Port Stephens, NSW for a period of five years. Floating sea cages anchored to the seafloor would be used to research marine finfish aquaculture. The research will allow the NSW Government to extend its successful marine hatchery research at PSFI to an offshore sea cage trial. The research will assist to validate the commercial potential of a number of marine finfish species, trial the latest production technologies in the high energy coastal waters of NSW and conduct environmental monitoring. The principal objective of the proposed Research Lease is to contribute to the development of sustainable marine aquaculture in NSW.

The location, the structural design of the proposed sea cages, the cultured species, the research objectives and a preliminary draft of the EMP are outlined in this EIS but will be finalised subject to development approval. Potential locations for staging the construction of the sea cages and facilities associated with the operation of the Research Lease (e.g. moorings and wharfs) have been identified but will also be finalised post-approval.

Statutory obligations under State and Commonwealth legislation, areas of responsibility for government departments and key considerations for the EIS were identified in the Preliminary Environment Assessment of the proposal carried out by NSW DPI in July 2011. Requirements to satisfy State legislation were subsequently issued to NSW DPI in March 2012.

Under the *State Environmental Planning Policy* (State and Regional Development 2011) the proposal is classified as State Significant Infrastructure (c.14 (1)(b) and Schedule 3 (1)(1)) and requires approval from the Minister for Planning and Infrastructure under s.115W of the *Environmental and Planning Assessment Act 1979*. Guidelines have been issued to meet the requirements of State legislation – the Director-General's Requirements. The assessment and approvals process is outlined in Figure 2. This EIS has been submitted to NSW DoPI in support of the development application for this proposal.

The main requirements of the EIS include the following:

- Provide a detailed description of the project proposal, including the need for the project, a justification for the development, staging of the development, interactions with other developments and plans of any proposed building works;

- Consider relevant environmental planning instruments, including statutory obligations, policies and guidelines relevant to a marine aquaculture lease in NSW waters;
- Undertake a risk assessment of potential environmental impacts associated with the project and identify key issues for further assessment;
- Provide a description of the existing environment using sufficient baseline data;
- Provide an assessment of the potential impacts of all stages of the development and a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development;
- Provide a consolidated summary of all the proposed environmental management and monitoring measures;
- Consult with relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners and present their views;
- Carry out a detailed impact assessment of key issues specified in the State guidelines and those identified in the risk analysis. This includes issues relating to:
    - *Biodiversity*
        - Baseline assessment (habitat types, species types/assemblages);
        - Assessment of impacts on critical habitats, threatened and protected species, populations, communities and their habitat;
        - Draw down effects from natural reef areas and aggregation of any native fauna;
        - Impacts on Great White Sharks;
        - Impacts on Gould's petrel;
        - Entanglement; and
        - Artificial lights, acoustic pollution and vessel strikes.
    - *Water Quality*
        - Background conditions;
        - Trigger values;
        - Impacts of increased nutrient concentrations and sedimentation; and
        - Biofouling.
    - *Disease Risks and Management*
        - Disease risks associated with hatchery fish;
        - Genetic integrity of wild stocks;
        - Disease and pest management protocols; and
        - Impacts of chemical use.

  - *Coastal Processes*
    - Coastal hazards, wave run up/reflection;
    - Adequacy of structure's stability and height of projected sea level rise; and
    - Changes of wave behaviour including wave dispersion and creation via amendments to orbital/oscillatory motions.
  - *Navigation and Safety*
    - Impacts on other boat traffic.
  - *Visual Amenity*
  - *Construction*
    - Measures to minimise potential noise, air quality, traffic, soil and water, and waste impacts.
  - *Decommissioning*
    - Process description and waste disposal measures.
  - *Cumulative Impacts*
- Outline project monitoring:
  - Integrity and effectiveness of cage structure and supporting lines;
  - Total organic carbon in sediments at the farm site relative to relevant reference locations;
  - Structure of benthic macrofaunal assemblages at the farm site relative to reference locations;
  - Any impacts on water quality, threatened/protected species and communities;
  - Changes to shark behaviour in the vicinity of the project site;
  - Any impacts on all water based traffic;
  - Escapees; and
  - Describe the measures that would be implemented to avoid, minimise, mitigate, rehabilitate/remediate, monitor and/or offset the potential impacts of the project.

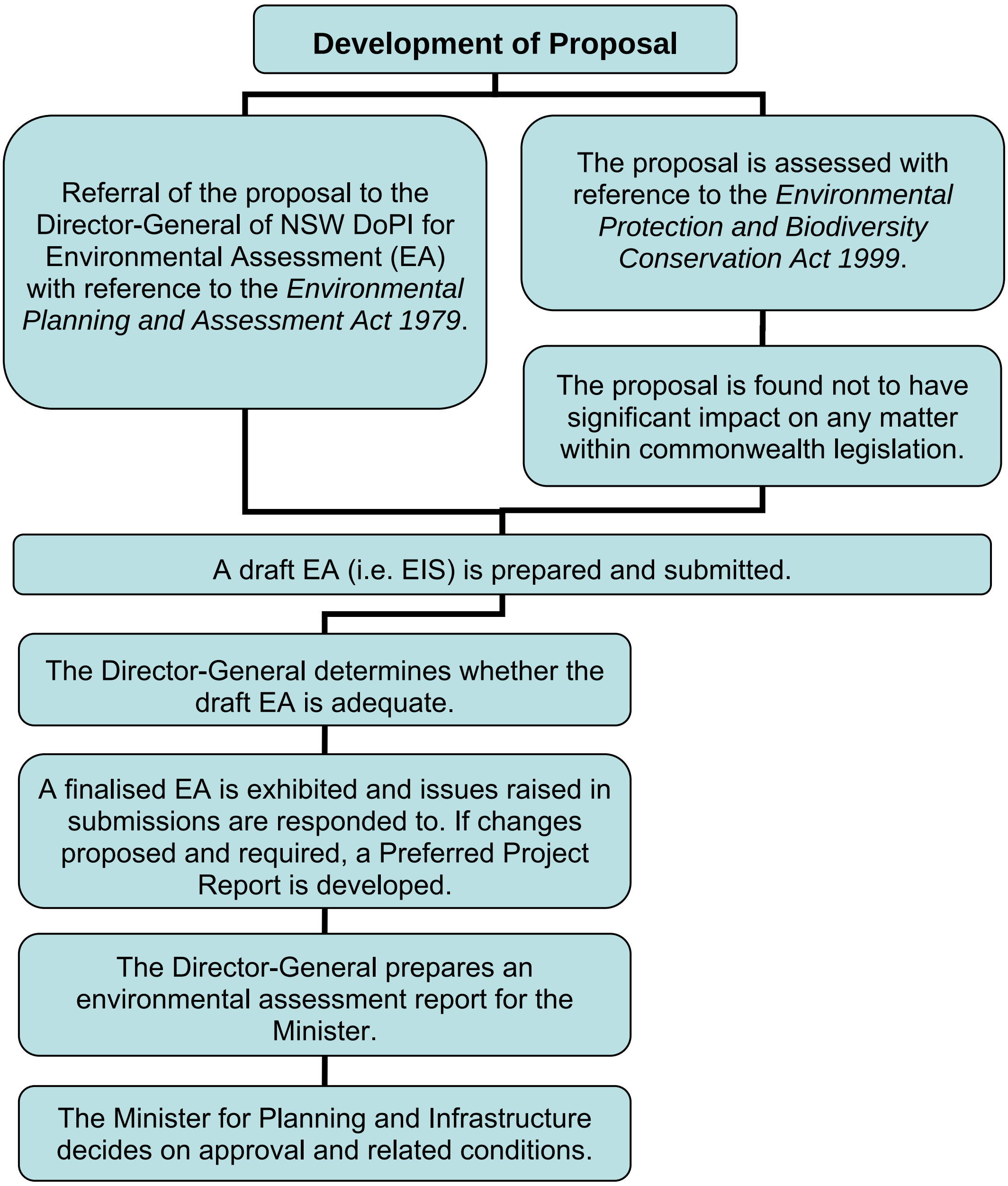

Figure 2: Steps in the assessment and approvals process.

Study Team

NSW DPI has coordinated a team of environmental practitioners with extensive experience in fisheries biology, marine ecology, aquaculture, environmental management, Geographic Information Systems (GIS), policy and NSW coastal processes.

Services and expertise of a range of personnel were engaged during the completion of this EIS including:

- Marine scientist/contractor, Hester Bushell, to provide an overview of the existing environment and conduct the risk analysis, assess potential impacts associated with the Research Lease, provide mitigation and management recommendations, and assist with the development of a draft EMP;

- NSW DPI Policy Officer Aquaculture, Graeme Bowley, to provide an overview of the proposed project, assist with the assessment of impacts and the development of a draft EMP;
- NSW DPI Manager Aquaculture, Ian Lyall, and NSW DPI Director Aquaculture, Conservation and Marine Parks, Bill Talbot, to conduct community consultation and correspondence with NSW DoPI, potential industry partners, manufacturers and research scientists, as well as assist with the development of the EIS;
- NSW DPI Senior Policy Officer Aquaculture, Tim Gippel, to review relevant State and Commonwealth legislative requirements and ensure compliance with relevant approvals, permits and notifications;
- PSFI research scientists, Mark Booth, Wayne O'Connor and Stewart Fielder, to provide expertise on finfish aquaculture such as disease and pest management, genetic integrity, chemical use, fish feeds and diet development, as well as assist with the development of research objectives;
- NSW DPI Aquaculture Officer, Columbine Waring, to provide GIS and mapping support, as well as assist with the review of the existing environment and threatened species assessments;
- NSW DPI Senior Conservation Manager Threatened Species, Peter Gallagher, to provide advice on the assessment of impacts on critical habitats and threatened and protected species, populations and ecological communities;
- NSW DPI Threatened Species Project Officer, Emma Mitchell, to provide assistance with State and Commonwealth threatened species assessments;
- NSW DPI Senior Research Scientist, Nick Otway; to provide advice about the potential issues associated with shark interactions;
- NSW DPI Aquaculture GIS Officer, Antonia Creese; to provide GIS support;
- NSW DPI Aquatic Biosecurity Officer, Brigid Krug, to provide advice about potential biosecurity issues; and
- NSW DPI Senior Conservation Manager, Scott Carter; to provide advice on the potential impacts on areas of conservation significance and threatened and protected species.

2 REVIEW OF EXISTING INFORMATION ON MARINE AQUACULTURE

2.1 Introduction

"Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants". Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated (FAO, 1988).

Aquaculture has been traditionally undertaken in a number of countries for centuries and has grown rapidly worldwide in the last 50 years. In Australia aquaculture has been practiced for approximately 40,000 years by Aboriginal communities who used sophisticated fish traps to capture and hold fish. The Aboriginal fish traps in the Brewarrina region of NSW still exist today and stand as a testament to Aboriginal knowledge of engineering and fish migration. In Victoria there are also remains and archaeological evidence in the Lake Condah region of a settled Aboriginal community farming eels for food and trade in what is considered to be the earliest and possibly largest ever land based aquaculture venture in Australia.

The NSW oyster industry has a history dating back to the 1870's in the Georges River and is now the State's largest aquaculture sector. In the 19th century Acclimatisation Societies undertook aquaculture to produce fish species for stocking rivers and streams. Trout and aquarium industries were key aquaculture industries in NSW until the 1980's saw the advent of tiger prawn farms on the north coast and native fish hatcheries in inland NSW. By the 1990's silver perch, yabbies, barramundi, Snapper and blue mussels were being cultivated.

There are a variety of aquaculture production systems used to culture finfish, crustaceans, molluscs and algae. The choice of systems depends upon the physiological requirements of the species (e.g. space, water quality and nutrition), the site (i.e. offshore, estuarine or land based) and operational criteria (e.g. proximity to services and markets).

Floating sea cages with suspended nets are typically used in inshore areas or in estuarine waters. Longlines (suspended cultivation) or post and rail infrastructure are also used for marine aquaculture. Land based facilities include earthen and lined ponds, tanks and aquaria. The fundamental aspect of any suitable aquaculture development is access to good quality water.

2.2 Marine Aquaculture Worldwide

Worldwide production from wild capture fisheries has levelled off (Figure 3) and it is unlikely that new fishing grounds will be found in the future. If the harvest of wild fisheries products remains at current levels there will not be enough supply to meet the growing worldwide demand for seafood products. Aquaculture has the potential to meet this gap.

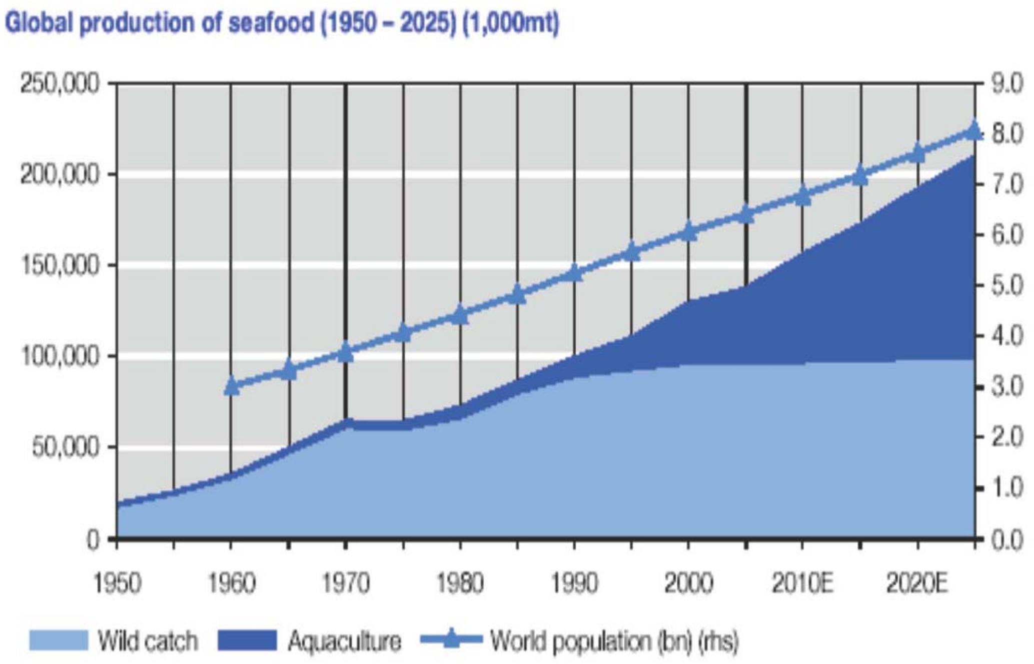

Figure 3: Global production of seafood and world population (1950 - 2025) (Source: A. Obach, 2012).

Aquaculture is developing and expanding in almost all regions of the world to meet the demand for seafood products. Aquaculture produces a wide variety of animal and plant species including finfish, crustaceans, molluscs, echinoderms, polychaetes, as well as seaweeds and other aquatic plants. These products are mainly used for human consumption, but can also be used for chemical extraction, pharmaceuticals, stock feed, jewellery and ornamental purposes.

FAO reports that world aquaculture production has increased substantially with less than 3 million tonnes produced in 1970 and increasing to 52.5 million tonnes in 2008 (Figure 4). This rate of increase is three times greater than that for world meat production. Projections by FAO estimate that in order to maintain the current level of per capita seafood consumption, worldwide aquaculture production will need to reach 82 million tonnes by 2050 (FAO, 2011a).

FAO estimates that marine based aquaculture production using seawater (in the sea and/or in ponds) accounts for 32.3% of world aquaculture production by quantity and 30.7% by value (FAO, 2011a). Aquaculture in seawater produces many high-value finfish, crustaceans and abalone species but also large quantities of oysters, mussels, clams, cockles and scallops. The cultured marine species are predominately of relatively high commercial value and for many of these species the aquaculture production is substantially higher than the past highest wild capture recorded catches.

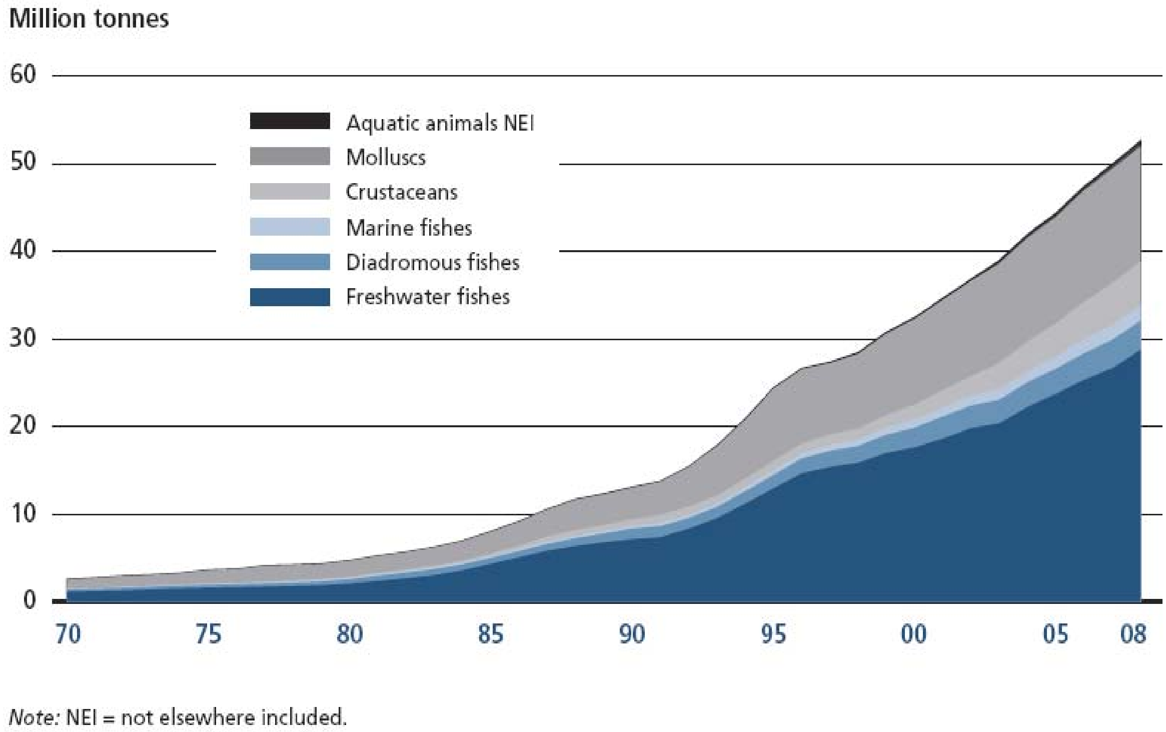

Figure 4: Trends in world aquaculture production – major species groups between 1970 and 2008 (Source: FAO, 2011a).

Aquaculture is making an important contribution to worldwide food security and is doing this through the responsible sustainable use of resources. Aquaculture relies upon high standards of water quality and environmental parameters. This focus has resulted in improved environmental management by the aquaculture industry and the adoption of best management practices.

2.3 Marine Aquaculture in Australia

The Australian aquaculture industry occurs in marine, estuarine and freshwater systems. The industry is predominantly based in regional Australia and makes a positive contribution to some regional economies (Figure 5).

Although the Australian aquaculture industry is a relatively new industry, it has grown in volume at an average rate of around 12% per annum since 1992–93. The gross value of aquaculture production in 2009-10 was $871 million and accounted for 40% of the gross value of fisheries production. The majority of this value came from marine production systems producing high value species such as salmonids, tuna, prawns and oysters.

NSW aquaculture production by value represents about 6% of the Australian industry. In comparison, those states with strong sea cage based industry sectors, such as South Australia and Tasmania, represent 22% and 45%, respectively of the Australian aquaculture industry (ABARES, 2011).

A key factor contributing to the rapid growth of aquaculture in recent years has been a strong focus on research and development. This has resulted in better species selection, improved feeding techniques and feeds; better fish health and disease management and the adoption of best practises to ensure the long-term environmental sustainability of aquaculture.

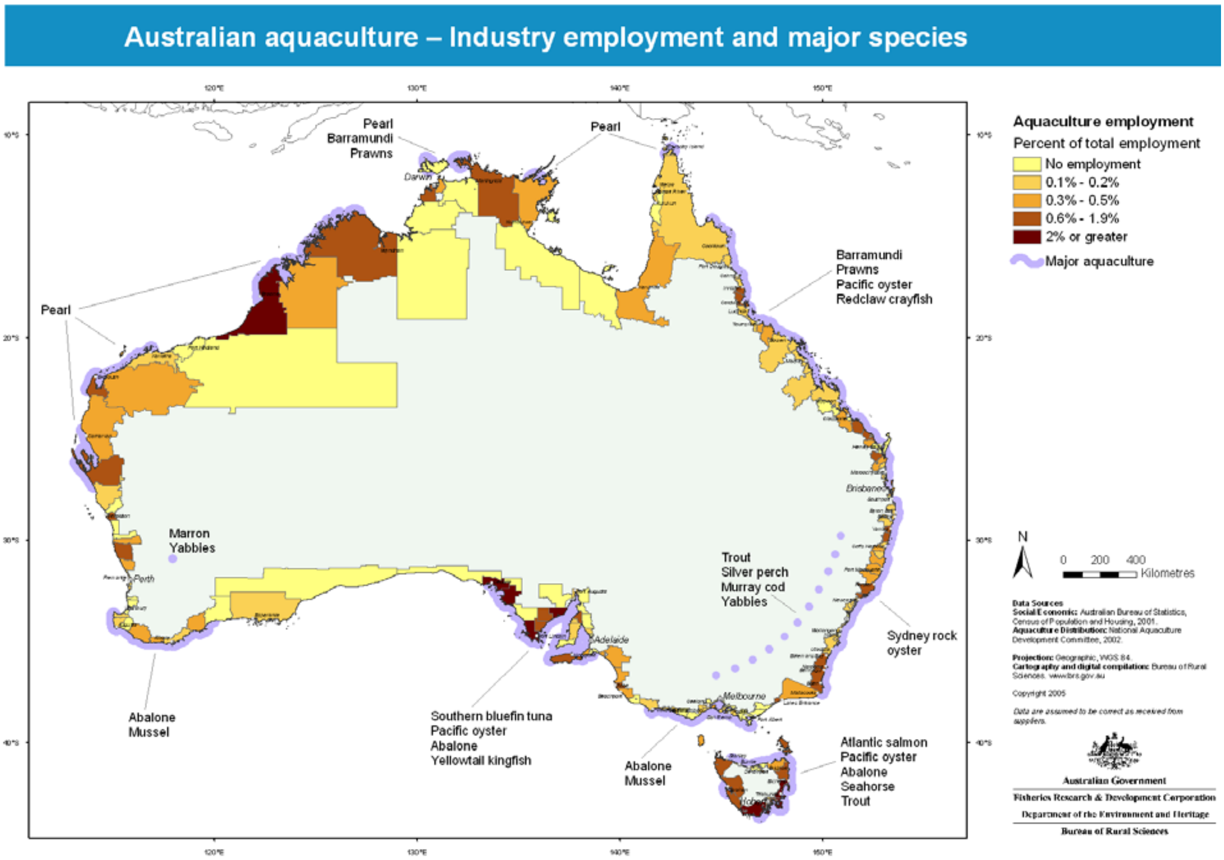

Figure 5: The percentage of employment in the aquaculture industry in Australia, including the major species (Source: Web Reference 27).

With an abundant supply of seawater, offshore aquaculture offers many biological and environmental benefits over other forms of aquaculture. Results of recent environmental monitoring from South Australian, Tasmanian and Queensland sea cages farms indicate limited environmental impacts on surrounding environments. Recent improvements in the engineering of infrastructure for offshore farming operations have also resulted in equipment that has the capability to operate in harsh environmental conditions.

The Atlantic Salmon and Yellowtail Kingfish industries are the fastest growing aquaculture sectors in Australia due to the demand for this seafood product and the economic advantages of marine based aquaculture.

NSW Aquaculture

In 2009–10 the gross value of NSW fisheries production was $132.9 million, of which the wild-catch sector accounted for $80.5 million or 61%. The aquaculture sector, which was valued at $52.4 million, accounted for 39% (ABARES, 2011).

Oyster aquaculture was worth $40 million and is conducted in 31 estuaries along the NSW coast utilising approximately 3,000 hectares of leases. Farmed Tiger Prawns (166 tonnes), Silver Perch (194 tonnes) and Rainbow Trout (149 tonnes) were also produced during 2009-10. By comparison the most valuable wild-caught fisheries product in NSW is prawns. The wild-catch also comprised a wide range of finfish species, including Mullet (3,182 tonnes), School Whiting (839 tonnes), Australian Salmon (541 tonnes), Snapper (260 tonnes) and Bream (231 tonnes) (ABARES, 2011).

The NSW Government has developed a whole of government approach to the development of the oyster and land based aquaculture industries in NSW to promote sustainable industry development. NSW Oyster Industry and Land Based Sustainable Aquaculture Strategies detail a streamlined approval process and advice on best aquaculture practice for species, site selection, design and operation. Research undertaken on aquaculture production in the marine environment will assist with the development of policy and management practices for any future marine aquaculture developments in NSW.

3 DESCRIPTION OF THE PROPOSAL

3.1 Description of the Proposal

Marine finfish aquaculture research has been carried out by scientists and staff at PSFI since the early 1990s (Figure 6). Snapper, Mulloway and more recently Yellowtail Kingfish and Southern Bluefin Tuna have been the focus of aquaculture research at the institute in conjunction with industry partners.

Figure 6: PSFI researchers inspecting fish and collecting data from brookstock tanks (Source: NSW DPI, 2008).

The proposed development of a Research Lease off the coast of Port Stephens will provide an opportunity for NSW DPI and research partners to extend successful marine hatchery research to its next stage in an offshore sea cage trial. It is proposed that the trial will operate for five years (from the date that the aquaculture lease is granted) to validate the commercial potential of a number of marine finfish species, to trial the latest sea cage technologies and undertake environmental monitoring in the coastal waters of NSW.

3.2 Principal Objective and Rationale of the Proposal

The principal objective of the proposed Research Lease is to conduct specific research relating to the sustainable development of sea cage aquaculture in NSW waters.

The Research Lease would provide the necessary research platform for the above objective to be undertaken. It would allow researchers from PSFI to expand their successful land based hatchery and nursery research into sea cages in the marine environment. This would support evidence based policy development for future sustainable seafood production in NSW.

Port Stephens is a key centre for aquaculture in NSW with a well established edible oyster industry, Barramundi, Silver Perch and freshwater crayfish production and marine and freshwater hatcheries.

Based on the results of preliminary environmental studies, NSW DPI considers that it is feasible to proceed to the development of a Research Lease off Port Stephens.

3.2.1 Research Objectives

The research objectives of the proposed Research Lease are primarily to provide the opportunity for NSW DPI and research partners to extend successful marine hatchery research to its next stage in an offshore sea cage trial.

The research objectives for the proposed Research Lease may include but will not be limited to:

- Evaluating suitable husbandry practices for aquaculture in the temperate marine environment of NSW. This will include evaluating and adapting existing husbandry practises employed in the cooler waters of South Australia and Tasmania.
- Evaluating and further developing the dietary development research undertaken in small controlled research tanks by extending the research to a commercial level. This will include the testing of feeding efficiency and growth performance models developed as part of the tank based research.

- Evaluating the use of terrestrial protein and energy sources such as legumes (e.g. lupins, field peas, faba beans), oilseeds (soybean meal and soy protein concentrates), cereals (wheat and gluten products) and by-products of the rendering industry such as meat and poultry meal as partial or complete replacement of fish meal and fish oil in aquaculture feeds.
- Evaluating and further developing the water temperature growth performance models for marine finfish. Data indicates that the prevailing sea surface water temperatures in NSW are conducive to rapid growth of the proposed research species. These models need to be fully tested on a commercial scale against the effects that seasonal changes in water temperature have on the production of these species in NSW. Included in this research is the evaluation of the biological and economic implications of growing species such as Yellowtail Kingfish in the warmer waters of NSW (Figure 7). All these factors need to be evaluated over 2 or 3 year production cycles in order to obtain the most reliable scientific information.
- Investigating water quality parameters in the area of the Research Lease.
- Evaluating the environmental impacts of a marine aquaculture farm in the NSW marine environment on a ‘green field’ site.
- Investigating novel methods for the assessment of ecosystem change.
- The environmental research may also include the evaluation of the effectiveness of employing mitigation measures such as bioremediation activities, fallowing, anti-predator netting, bird exclusion nets, controlled feeding strategies, management of deceased fish inside sea cages and entanglement avoidance strategies and protocols.
- Investigating economic aspects of marine aquaculture production in NSW. This includes supply chain issues such as the supply of fingerlings, feeds, equipment, services and sale of product.
- Investigating the structural integrity and stability of current sea cage infrastructure and their suitability in the high energy marine environment of NSW.
- Provision of a research platform for students from the University of Newcastle and/or any other research partners (e.g. CSIRO). The research would need to be consistent with the above research objectives or complement these objectives.

These objectives provide for a range of marine based aquaculture research to be undertaken provided it is consistent or complements the above research objectives. This research is still dependant on the provision of suitable resources and research partners before specific detailed project outlines can be developed. Once detailed research projects are identified they will be referred to NSW DoPI to ensure they are considered to be consistent with the above research objectives and any Development Application consent conditions.

The above research is important in informing the development of evidenced based policies and procedures to promote best practice for the sustainable development of sea cage aquaculture in NSW.

Figure 7: Researchers collecting data on Yellowtail Kingfish cultured in tanks at the PSFI (Source: NSW DPI, 2008).

3.3 Cultured Species

The marine finfish species to be cultured will be determined by the research requirements of the NSW DPI and its research partners. Currently the primary research species are Yellowtail Kingfish and Mulloway. Yellowtail Kingfish and Mulloway are ideal species for aquaculture in the temperate waters off Port Stephens. The endemic range of these species is from the warm tropical waters of Queensland through to the cool waters of southern Australia.

Other potential research species include Southern Bluefin Tuna, Yellowfin Tuna and Snapper which also inhabit the marine environments from the warm tropical waters of Queensland through to the cool waters of southern Australia.

3.3.1 Yellowtail Kingfish (Seriola lalandi)

Description

Yellowtail Kingfish have a long torpedo shaped body which is covered in small smooth scales (Figure 8). Yellowtail Kingfish have counter shaded bodies which are generally a blue or blue-green colour on their back, white-silver below with a yellowish coloured strip running along the middle of the fish from the eye to the tail. The fins and caudal fin are also yellow in colour (Web Reference 18).

Mature Yellowtail Kingfish can measure more than 2 m in length and reach a weight of over 70 kg. This schooling pelagic species feeds on a wide range of species including small fish, squid and crustaceans. Young fish up to 7 kg are known to form shoals of several hundred fish (Web Reference 18).

Figure 8: Yellowtail Kingfish (*Seriola lalandi*) (Source: NSW DPI, 2010).

Distribution

Yellowtail Kingfish are distributed globally in the cool temperate waters of the Pacific and Indian oceans. In Australia they are generally found close to the temperate waters along the coast, in ocean waters from Queensland south to Western Australia, off the east coast of Tasmania and around Lord Howe Island and Norfolk Island.

In general this species inhabits coastal waters including rocky reefs, sandy areas and occasionally estuaries, and are found from shallow water down to depths of around 50 m but have been caught from depths of over 300 m (Web Reference 18). Fielder *et al.* (2004) found that juvenile Yellowtail Kingfish were remarkably tolerant to variable salinity. No effect on growth or the feed conversion ratio (FCR) was observed when this species was cultured in seawater with a salinity ranging from 15 to 30%.

Harvesting

Although Yellowtail Kingfish are widely distributed around Australia the main commercial fishery occurs in NSW where 242 tonnes was landed in 2006/07. The species is taken using line methods and is often caught as bycatch to line methods for other species in states other than NSW (Web Reference 18).

In addition to the valuable commercial fishery, Yellowtail Kingfish are an important species for recreational anglers with most effort concentrated in the warmer months of the year. The annual recreational harvest of Yellowtail Kingfish in NSW is likely to be between 120 and 340 tonnes (Rowling *et al*., 2010).

Aquaculture

In Australia, Yellowtail Kingfish are predominantly cultured in sea cage farms in South Australian waters. Marine finfish researchers at PSFI have undertaken a range of research activities on juvenile Yellowtail Kingfish in developing broodstock maintenance, hatchery techniques and diets for this species.

Experimental work has also been undertaken to ascertain the optimal water temperature and feeding rates to obtain optimum feed conversions and growth rates for this species. Tank based research has shown that the prevailing sea surface water temperatures in NSW, particularly on the Mid North Coast, are conducive to the rapid growth of this species. Experimental modelling indicates that Yellowtail Kingfish could reach a body weight of 2 kg in about 230 days in marine waters off the Mid North Coast of NSW opposed to about 500 days in the cooler South Australian waters.

Port Stephens researchers propose to test their experimental results on a larger scale through the stocking of sea cages in the proposed Research Lease. Since Port Stephens is located in warmer waters than the South Australian farms, there is the potential benefit of rapid growth of this species but this has not yet been adequately trialled on a commercial scale in NSW.

Yellowtail Kingfish are native to the waters of Port Stephens. To ensure that the genetics of the stocked fish are the same as the local population, local broodstock will be used to produce fingerlings for stocking the proposed sea cages.

3.3.2 Mulloway (Argyrosomus japonicus)

Description

Mulloway are mostly silver with a blue/grey, green or bronze coloured back (Figure 9). This species possesses a line of silver/white spots that follow the lateral line and sometimes have a black mark at the pectoral fin base. The caudal fin varies from pointed in juveniles to concave dorsally in adults. Adult fish can reach a size of about 1.8 m with a weight of approximately 60 kg (Web Reference 20).

Figure 9: Mulloway (*Argyrosomus japonicus*) (Source: NSW DPI, 2010).

Mulloway have a relatively large mouth with caniniform teeth and sharp gill rakers. This species will feed throughout the water column targeting crustaceans, small fish and squid. Mulloway belong to the family (Sciaenidae) of fishes. (Web Reference 20).

Distribution

Mulloway are found in near-shore coastal and estuarine waters of the Pacific Ocean and Indian Ocean. In Australia, they occur from Rockhampton in Queensland down and around to North West Cape in Western Australia (excluding Tasmania). Mulloway are commonly found around offshore reefs but may also be encountered in shallow estuaries (Web Reference 20). Mulloway can tolerate variable salinities illustrated by their occupation of a range of habitats including marine waters and coastal river systems.

Harvesting

Mulloway are commercially targeted in the estuary general, ocean hauling and line fisheries in NSW where 44 tonnes was landed in 2006/07. This species is also considered to be a significant recreational fishing species where the annual recreational harvest of Mulloway in NSW is likely to be between 100 and 500 tonnes (Rowling *et al*., 2010).

Aquaculture

Mulloway are currently cultured in estuarine pond based aquaculture systems in NSW and in sea cage systems in South Australia. Researchers at PSFI have undertaken a range of research activities on Mulloway including: broodstock maintenance; and developing hatchery techniques and diets for this species. Experimental work has also been undertaken to ascertain the optimal water temperature, stocking density and feeding rates to obtain improved feed conversions and growth rates for this species.

Mulloway is native to the waters of Port Stephens. To ensure that the genetics of the stocked fish are the same as the local population, local broodstock will be used to produce fingerlings for stocking the proposed sea cages.

3.3.3 Other Species

NSW DPI and current research partners are primarily interested in extending the successful marine hatchery research of Yellowtail Kingfish and Mulloway to the next stage of an offshore sea cage trial. However, the Research Lease infrastructure provides an opportunity for a range of research to be undertaken on a variety of temperate marine species on the east coast of Australia.

Once the Research Lease infrastructure is established it will provide the only infrastructure of its type in NSW for other associated marine aquaculture research activities and investigations which may include:

- Establishing a better understanding of the aquaculture potential of a species;
- Investigating the use of a species for bioremediation;
- Investigating the use of a species as a bio-indicator; and
- Investigating the potential commercial viability of polyculture (multi-trophic) with other species.

Discussions with the University of Newcastle have highlighted the benefits that the Research Lease would provide to students as a research platform. It is difficult to specify all of the species that could potentially be involved in additional research but these species may include organisms such as finfish, molluscs, echinoderms or sea weeds.

CSIRO has expressed interest in the Research Lease to support their research programs. Any complimentary research would need to fit alongside the primary research objectives of the Research Lease without increasing environmental risk.

Southern Bluefin Tuna (Thunnus maccoyii)

Description

Southern Bluefin Tuna (SBT) are large, moderately long, streamlined, muscular bodied fish with a slender caudal peduncle and relatively short dorsal, pectoral and anal fins. This species is bluish black in colour along the back and silvery white below with small scales covering the skin (Figure 10). Keels are present near the tail and are coloured yellow in juveniles and black in adults. SBT tuna are reported to live for up to 40 years, measuring more than 2 m in length and can reach a weight of over 200 kg (Web Reference 19).

SBT are a pelagic species feeding on a wide range of species including other fish, crustaceans, squids and other marine animals. They have the ability to maintain their body core temperature up to 10 degrees above the ambient water temperature, which allows them to maintain high metabolic output for predation and for migrating large distances (Web Reference 19).

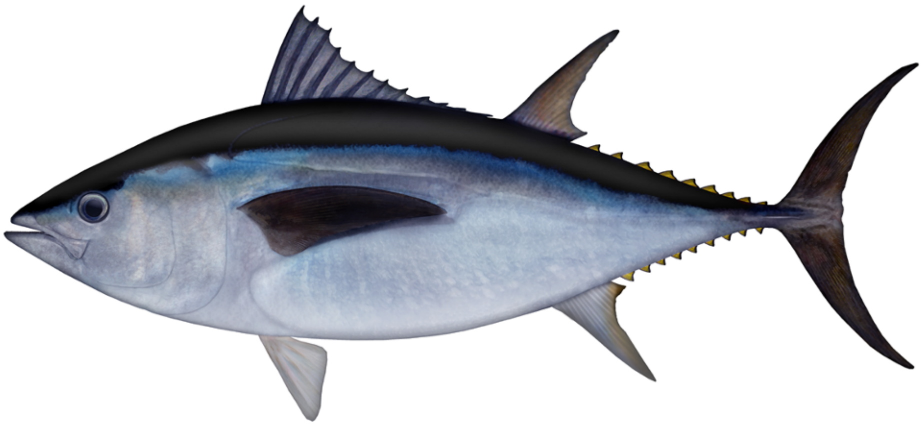

Figure 10: Southern Bluefin Tuna (*Thunnus maccoyii*) (Source: NSW DPI, 2010).

Distribution

SBT are found in open oceanic waters in the southern hemisphere, predominately between 30°S and 50°S but are only rarely seen in the eastern Pacific. In Australian waters, this species ranges from northern NSW around southern Australia to northern Western Australia (Web Reference 19).

The only known breeding area is in the Indian Ocean, south-east of Java, Indonesia, with breeding reported to take place from September to April. As there is only one identified breeding location, SBT are managed as a single genetic population (Web Reference 12).

Harvesting

The main harvesting methods for SBT in the past has included pole and line fishing, sea-surface set baited long lines and purse seine nets. In Australia purse seining is predominantly used where fishers operate under strict catch quota limits.

The catch is usually transported live in specially designed net cages back to areas off Port Lincoln in South Australia, where they are transferred into sea cages for grow out prior to sale (Web Reference 19). SBT flesh is in high demand as it is considered to be the best eating raw fish in the world for use in sashimi and sushi dishes (Web Reference 19).

Aquaculture

Juvenile SBT, with an average weight of 15 kg, are currently harvested from the waters of the Great Australian Bight and transported live to sea cages off Port Lincoln, South Australia for grow out until they reach market weight of about 40 kg.

In response to a declining population of SBT, this species is listed as 'endangered' under the *Fisheries Management Act 1994* and as 'conservation dependent' under the *Environment Protection and Biodiversity Conservation Act 1999*. Management quotas have been introduced which restrict the level of harvest for this highly sought after commercial fish species. The introduction of quotas and the increasing demand for its high quality flesh has resulted in research being undertaken to close its life cycle. By closing the life cycle of SBT and breeding stock for grow out in sea cages, there is a reduced reliance on wild caught stock to meet worldwide demand for this species.

A SBT hatchery facility has been established by Cleanseas Tuna Ltd in Arno Bay, South Australia. The hatchery research program is partly funded by the Australian Seafood Cooperative Research Centre in association with industry partners including NSW DPI. The aim of the program is to successfully produce SBT fingerlings in land based recirculating tank systems. Cleanseas Tuna Ltd has been successful in producing limited numbers of fingerlings. Further research is required to investigate dietary and grow out requirements of this species in sea cage systems. If SBT fingerlings were to become available during the five year research period they may be considered as a potential species and incorporated into the research trial. However, research on propagation of SBT is at a very early stage and a research partnership would need to be formed for this to occur.

SBT are native to the Port Stephens marine environment and the population is considered to be a single genetic population. Port Stephens is also located in waters warmer than Arno Bay or Port Lincoln in South Australia. The elevated water temperatures off Port Stephens are closer to the natural conditions to which wild tuna fingerlings are found.

Snapper (Pagrus auratus)

Description

Snapper (*Pagrus auratus*) have bright blue spots on their bodies that become less distinct with age and a background colour of pinkish silver to red. Large fish may have a large bony hump on the head and a fleshy bulge on the snout (Figure 11). Snapper are a popular angling species and are regarded as an excellent table fish.

Common names include: Cockney Bream, Reddies and Squire, which are the names of juvenile Snapper during different stages of their lifecycle (Web Reference 34). This species grows up to 1.3 m in length and at least 20 kg in weight (Web Reference 35). Snapper are serial spawners with the number of eggs increasing exponentially with length.

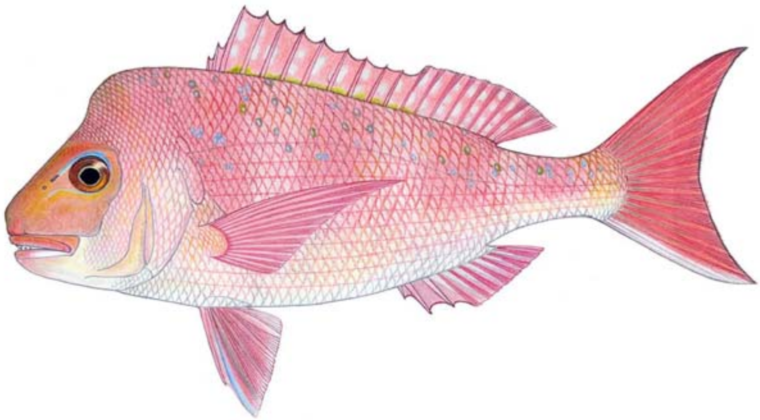

Figure 11: Snapper (*Pagrus auratus*) (Source: Bernard Yau).

Distribution

Snapper are distributed in the Indo-Pacific region from Japan and the Philippines to India, Indonesia and New Zealand. In Australia, Snapper occur in waters south from Hinchinbrook Island in Queensland to Barrow Island in Western Australia and are occasionally found off the north coast of Tasmania.

Juveniles can be found around inlets, bays and other shallow sheltered marine waters, including over mud and seagrass. Adults can be found near reefs, over mud and sand substrates and offshore to the edge of the continental shelf across a depth range of 5 to 200 m. Some level of genetic sub-structuring is thought to exist for Snapper in southern and Western Australia. However, Snapper on the east coast (NSW and Queensland) are thought to constitute one stock. (Web Reference 36)

Harvesting

Over 95% of Snapper harvested from the NSW commercial sector are taken by the Ocean Trap and Line Fishery. The NSW commercial harvest of Snapper is currently about 300 tonnes, which is considerably less than the 1970s and 1980s landings of between 600 to 800 tonnes (includes catches in Commonwealth waters).

The main harvest season for Snapper in the commercial sector is winter to spring. Significant quantities of Snapper are also taken by recreational fishers (Web Reference 36). The annual recreational harvest of Snapper in NSW is likely to be between 180 and 250 tonnes. This estimate is based upon the results of the offsite National Recreational and Indigenous Fishing Survey (Henry & Lyle, 2003) and onsite surveys undertaken by NSW DPI (Web Reference 36)

Aquaculture

Snapper species (sea bream) are cultured worldwide. The culture of Red Sea Bream in Japan commenced during the 1960s. The basic techniques described by Japanese scientists formed the basis for hatchery technology development in Australia. FAO reported that in 2009 Japan produced over 70,000 tonnes of Red Sea Bream (Web Reference 37).

Opportunistic Species

Opportunistic species, such as Slimy Mackerel (*Scomber australasicus*) and Yellowtail Scad (*Trachurus novaezelandiae*) may be inadvertently caught as bycatch in small numbers in the sea cages. Effort will be made to minimise potential impacts associated with these species during the proposed research trial.

3.4 Site Description

3.4.1 Research Lease Site

The proposed Research Lease would occupy an area of 20 hectares (approximately 370 x 530 m) in Providence Bay offshore of Port Stephens on the Mid North Coast of NSW (Figure 12).

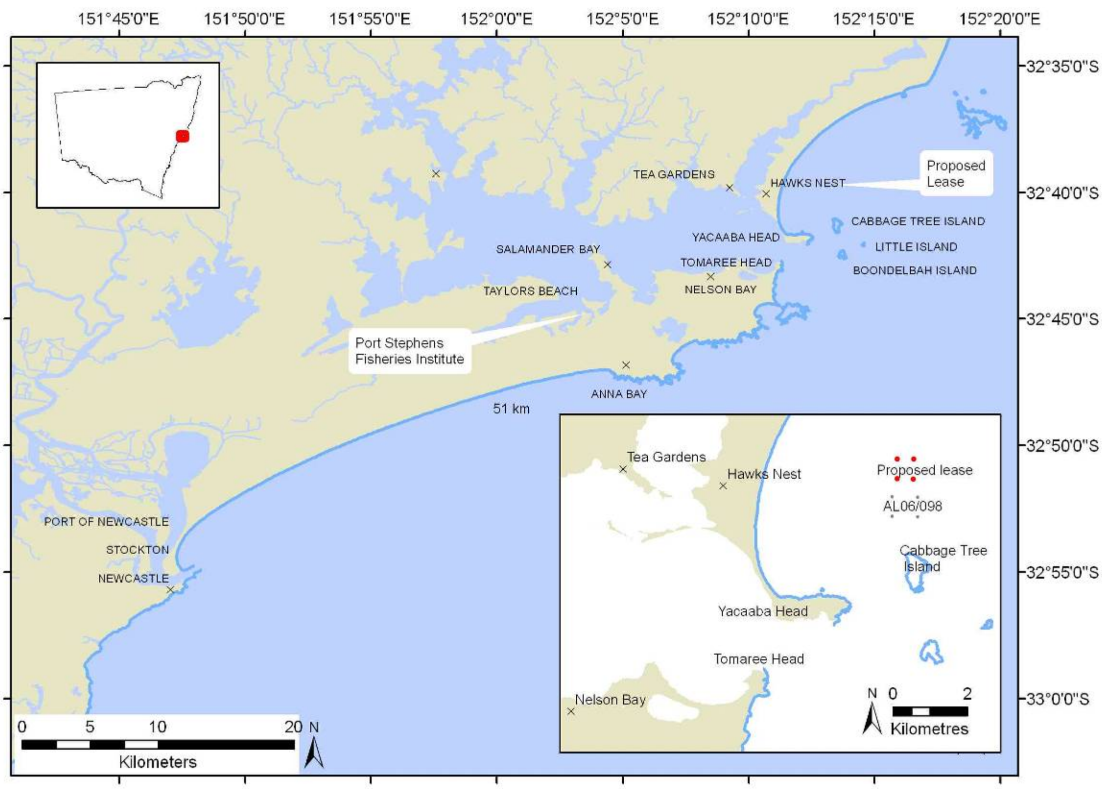

Figure 12: Location of the proposed Research Lease in Providence Bay (Source: NSW DPI, 2012).

The Research Lease is about 4 km east northeast of the township of Hawks Nest, 10 km northeast of Nelson Bay and 2 km north of Cabbage Tree Island (Figure 13). The approximate co-ordinates are 32.661 S, 152.22 E; 32.666 S, 152.22 E; 32.661 S, 152.224 E; 32.666 S, 152.224 E. The exact layout of the site in the proposed location will be finalised once a formal survey is undertaken by a registered surveyor during placement of the lease corner navigation buoys.

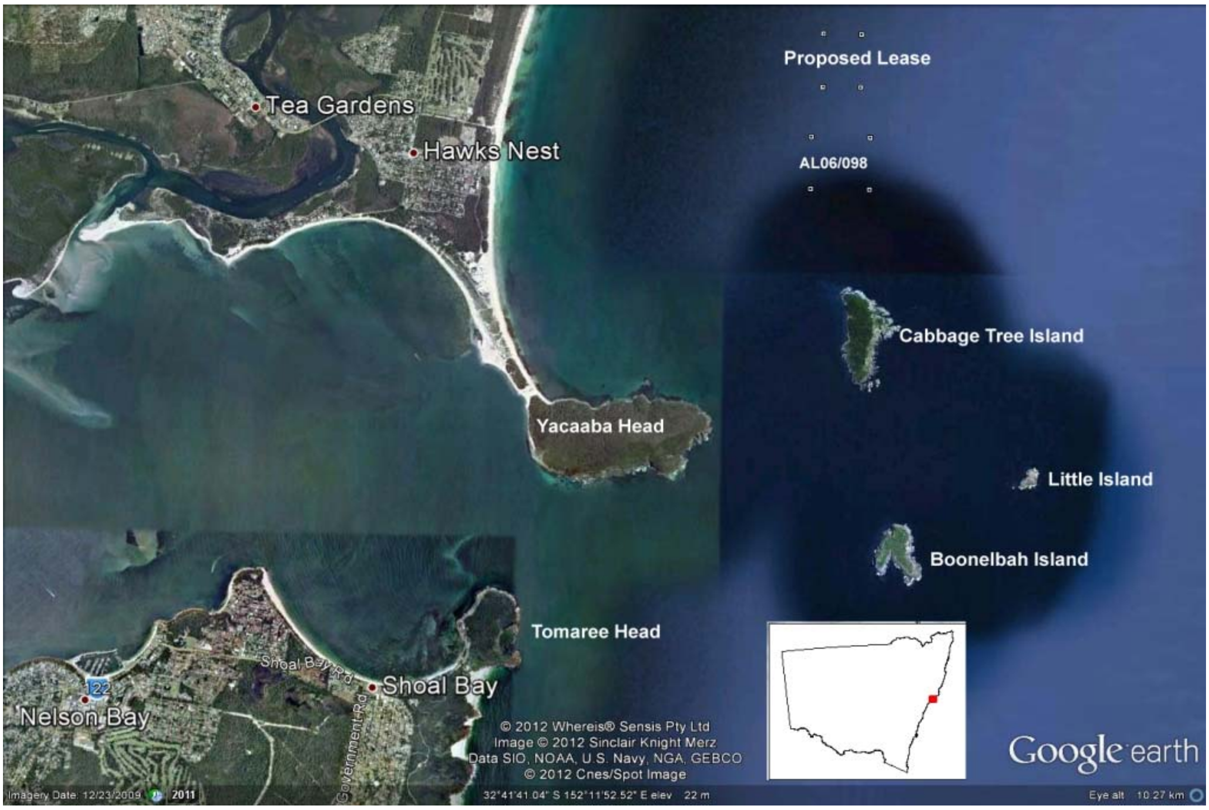

Figure 13: Aerial view of the location of the proposed Research Lease and the existing aquaculture lease (AL06/098) in Providence Bay (Source: Google Earth, 2012; NSW DPI, 2012).

The proposed Research Lease is located in a Habitat Protection Zone of the Port Stephens-Great Lakes Marine Park (PSGLMP) (Figure 14), which is a multiple use zone that caters for a wide range of sustainable activities. The proposed aquaculture research activity is permissible within this zone. The nearest Sanctuary Zone (highest protection) is located approximately 1.5 km to the south next to a zoned bait gathering site. The proposed Research Lease is located over an area of soft sediment habitat with a depth of 15 to 22 m. The site is afforded with some protection by Yacaaba Headland and the offshore islands of Cabbage Tree Island, Little Island and Boondelbah Island. The proposed site is to the north of an existing aquaculture lease (AL06/098).

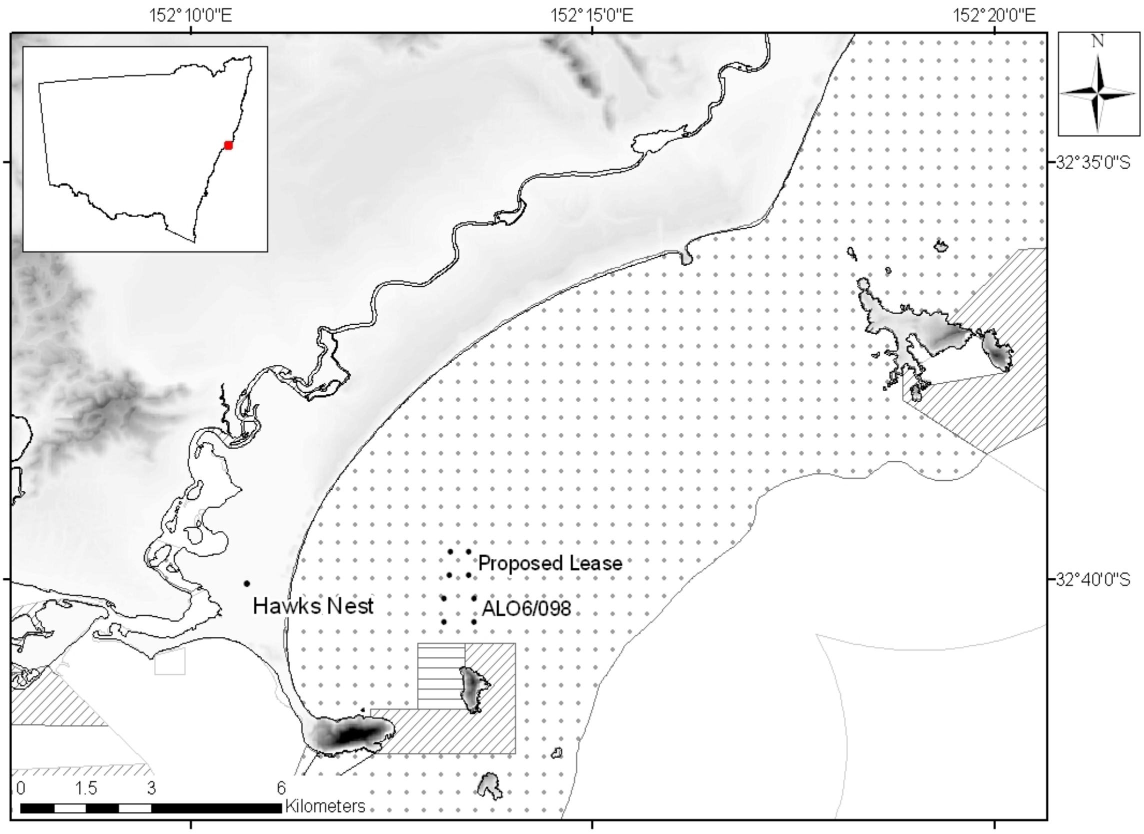

Figure 14: Port Stephens-Great Lakes Marine Park zones relative to the proposed Research Lease. Dots = Habitat Protection Zone; horizontal lines = Special Purpose Zone; diagonal lines = Sanctuary Zone (Source: NSW DPI, 2011).

3.4.2 Land Base Site

There are no new land base sites proposed for development as part of this research project. It is proposed that existing facilities at PSFI, the Port of Newcastle (commercial port facilities) and possibly the Nelson Bay Commercial Fishermen's Co-operative (shore base facilities) will be utilised for operational activities. Existing marina facilities in Port Stephens will be sought for mooring service vessels.

3.5 Structure Design

The Research Lease infrastructure will consist of an anchoring and bridle system to accommodate up to eight floating double collared sea cages (Figure 15). The cages may range in size (18-40 m diameter) depending on the number and size of the cultured fish. The sea cages will be constructed out of high density polyethylene (HDPE) pipes which will be bent and welded to form the circular floating collars (Figure 16). Floatation will be aided by air contained in the pipes or by filling the pipes with expanded polystyrene foam.

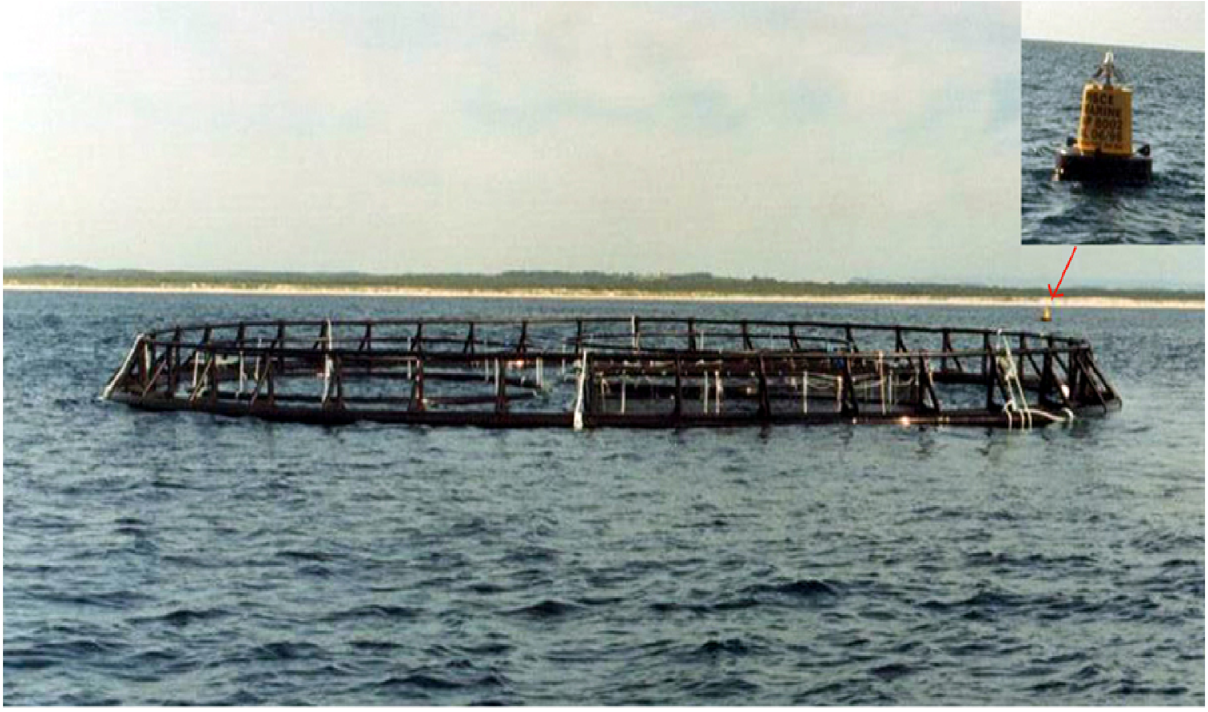

Figure 15: A double collar sea cage with two smaller fingerling cages contained within the existing aquaculture lease in Providence Bay. Insert - lease marker navigation buoy (Source: NSW DPI, 2000).

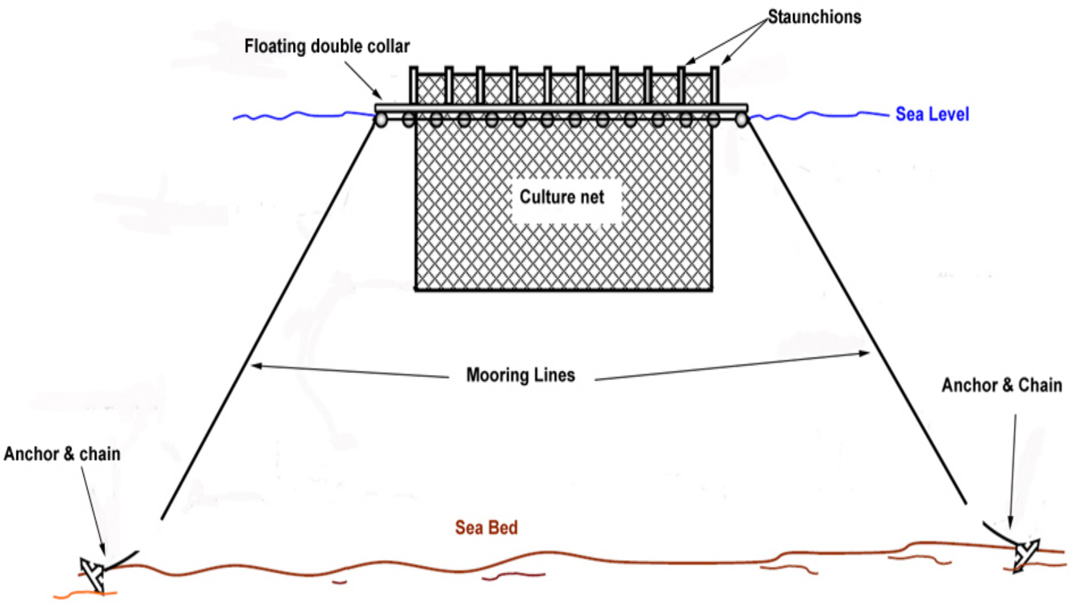

Figure 16: The basic components of the sea cage infrastructure (Source: NSW DPI, 2012).

During construction of the collars, a number of stanchions will be fed onto the pipes to strengthen the structure and to provide a mooring point when placed in the anchoring and bridle system (Figure 17). An additional pipe (with a smaller diameter) will be used to form a railing 1-2 m above the water's surface. Culture and anti-predator nets will be secured to this railing and the stanchions.

Figure 17: Stanchions fed onto two HDPE pipes to form the double collar sea cage system. A smaller diameter pipe will be placed into the loops where there is no pipe work forming a support rail for culture and anti-predator nets (Source: NSW DPI, 2012).

The culture nets used to contain the fish will be made from knotless polypropylene or nylon netting of a mesh size that is suitable for the size class of the fish being cultured. Nets will be suspended from the floating sea cage structures and a weighting system will be incorporated to ensure the nets maintain an appropriate shape and are secured at the appropriate depth (i.e. about 10 m from the water's surface).

Mooring of the floating double collared sea cages using an anchoring system may be through a bridle system in a grid array or another configuration that may be trialled to test its effectiveness as part of the experimental activities in the Research Lease area (Figure 18). Small buoys will be attached to the bridle/mooring system to assist with the mooring of the sea cages (Figure 19). This floatation, combined with the sea cages and chains will maintain taut ropes to prevent marine fauna entanglement.

The anchoring system consists of 1-5 tonne anchors connected to lengths of heavy chain (Figure 20) and polypropylene rope (e.g. 40 mm eight strand rope). The length of heavy chain not only assists in ensuring the floating double collared sea cages remain in their designated location but also acts as a ballast to make sure the anchor ropes are taut as the sea level changes with tidal, swell and waves.

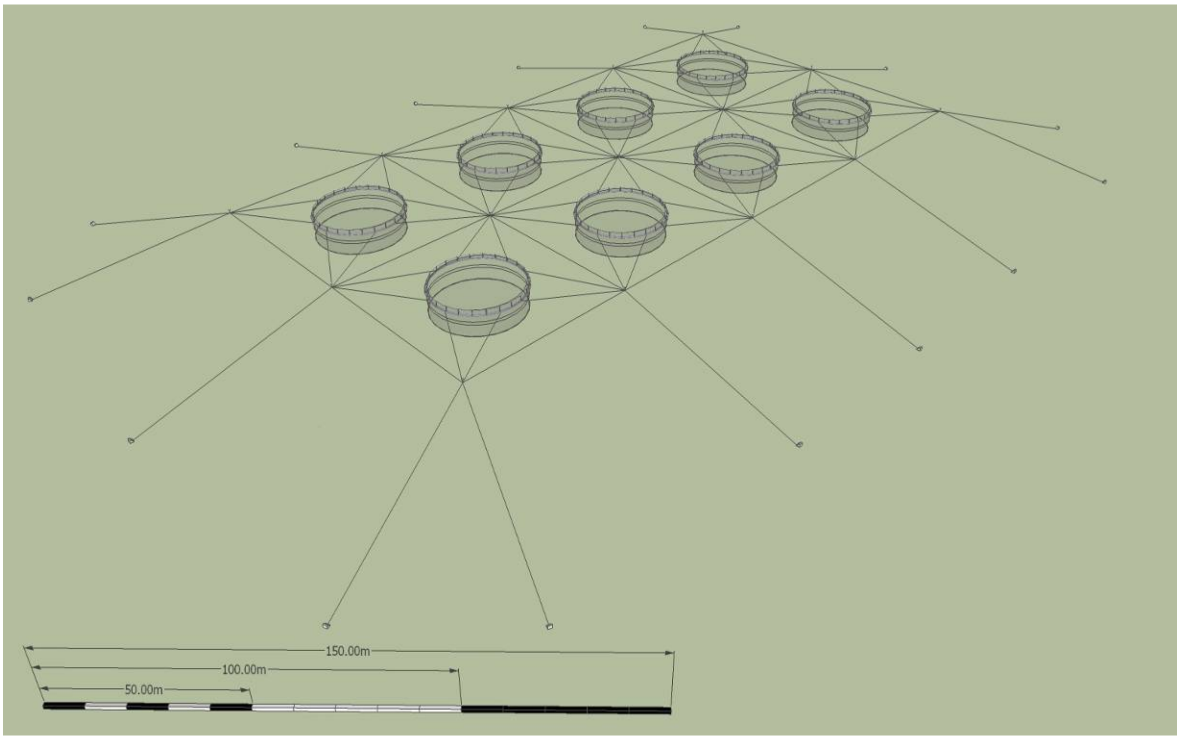

Figure 18: The proposed sea cage infrastructure including cages and anchoring and bridle systems (Source: NSW DPI, 2011).

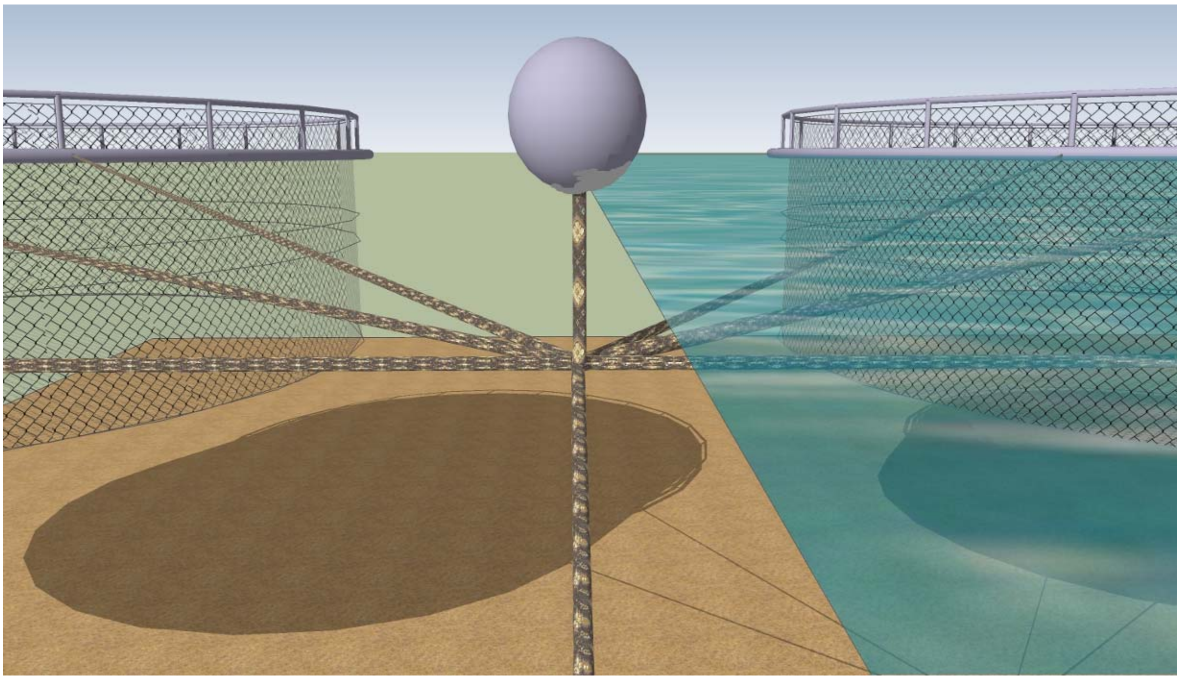

Figure 19: Small buoys that will assist with mooring the sea cages (Source: NSW DPI, 2011).

Anti-predator nets will be deployed both under and above the water to minimise and/or prevent potential predators, such as seabirds, fish and marine mammals, from gaining access to the stock. Subsurface anti-predator nets, if used, will be designed to specifically manage any identified/encountered predator. The nets are designed primarily to prevent access to the culture nets and are not designed to entangle predators.

Anti-predator nets may range from thick corded mesh nets through to finer mesh nets depending on the predator to be excluded. Highly visible surface anti-predator nets will be installed to deter and prevent access of diving seabirds. The surface anti-predator nets will be secured above the sea cages on poles, and will be particularly important for sea cages stocked with small fingerlings.

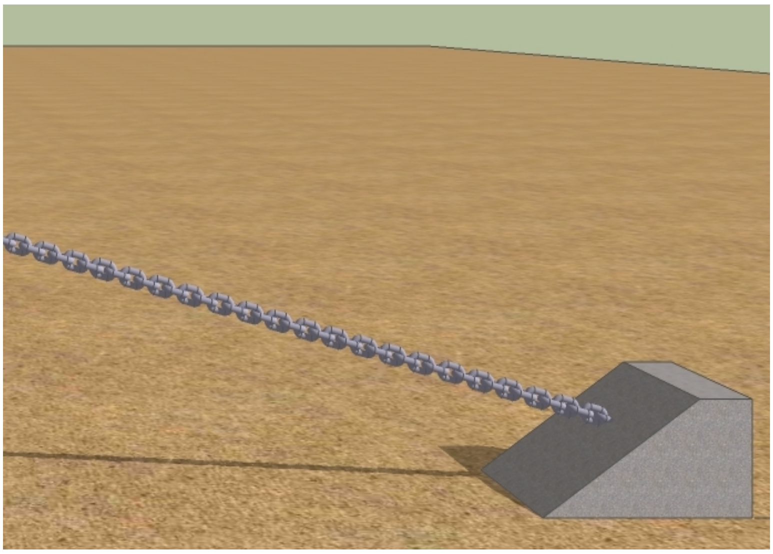

Figure 20: The anchors that may be used to secure the sea cages (Source: NSW DPI, 2011).

Navigation buoys will be positioned on the four corners of the proposed Research Lease in accordance with NSW Maritime and International Association of Lighthouse Authorities (IALA) requirements (Solar Technology Australia, n.d.; IALA, 2008) (Figure 21). These requirements generally require the following:

- Only cardinal marks to be used;
- Cardinal marks must have a day mark light and a radar reflector;
- The focal point of the light should be at least 1800 mm above the water level;
- The day mark may be mounted above or below the light. In the instance where the light is the highest point, the centre of the day mark must be at 1800 mm above water level;
- The light shall have a flash character to suit the type of cardinal mark;
- The range of the light must be at least 4 nautical miles in clear conditions (transmissivity of 0.74). This range will provide a safety factor for instances of poor visibility and choppy or rolling seas;
- The light must be white to suit cardinal characteristics and must have a minimum vertical divergence of 9 degrees;

- The buoy tower shall be coloured according to IALA recommendations; and
- The buoy shall be located so that it does not encroach within 10 m of the Research Lease structure.

Figure 21: Navigation markers commonly used to mark the boundaries of aquaculture leases (Source: NSW DPI, 2012).

3.6 Construction and Operation of the Project

3.6.1 Transportation

During the construction stage the movement of vessels between the Research Lease and wharf facilities may be as high as six return trips per day to install the proposed sea cage infrastructure. Once the infrastructure has been installed, vessel movements are expected to be in the range of one to three return trips per day to undertake feeding, net changing, repair and maintenance of infrastructure and net cleaning.

Vehicular movements to provide goods and services to the vessels are also expected to be the highest during the construction and deployment stage. Trucks will predominately be used to supply required components for construction and deployment of the sea cages, where the number of vehicle movements is likely to be in the range of three to six movements per day to the wharf facilities at PSFI, the Port of Newcastle and/or the Nelson Bay Commercial Fishermen's Co-operative.

Once the sea cages have been installed the number of vehicular movements between these localities is expected to be reduced to three to five trips per week. Staff vehicular movements are expected to be in the order of four to six per day to the mooring location of the service vessel.

3.6.2 Operation Hours

During the construction stage, the proposed hours of operation on the Research Lease will be between 7:00 am and 6:00 pm from Monday to Friday and between 8:00 am and 1:00 pm on Saturdays. This is in accordance with the standard hours of work recommended by NSW DECC (2009) in the *Interim Construction Noise Guideline*.

Operational and maintenance times are expected to vary from day to day depending on prevailing weather conditions and the day length at that time of year. During summer for example, main operational activities may commence early in the morning to avoid the strong north easterly winds that often prevail during the afternoons in this region.

3.7 Cultivation and Post-Cultivation Practices

Fingerlings will be produced at either PSFI or at an industry partner's hatchery facilities depending on the species. The fingerlings will originate from locally collected broodstock held at PSFI or if unavailable, broodstock will be sourced from other localities with the same genetic population. During the hatchery stage fingerlings will be monitored for diseases and parasites and quarantined and inspected prior to transportation to the proposed Research Lease. PSFI marine fish hatchery is accredited under the NSW Hatchery Quality Assurance Scheme.

The fingerlings will be managed in small sea cages ranging in size from 18–25 m until they reach an appropriate size (e.g. 5 to 40 g) and will then be stocked into larger sea cages (i.e. 40 m diameter) for grow out (Figure 22). Stock will be transferred between sea cages using proven techniques, such as the 'swim through' technique which involves securing nets at a point and allowing stock to swim from one net to another. Standing biomass will vary throughout the research activities but will be maintained below a maximum level of 12 kg per m^3 of cage capacity.

Stock will be fed a commercially manufactured feed which will be of a pellet size appropriate to the size and activity of the cultured stock. Feeding may vary from four times a day for younger stock to twice a day for older stock. Feed will be delivered to the stock by hand broadcasting or a mounted feed hopper attached to a blower that will dispense the feed onto the surface of the water in each cage from a vessel.

To prevent wastage and environmental impacts the amount of feed provided to the stock will be determined by the feeding response of the stock (i.e. 'demand feeding regime') or an appropriate feeding model. Automated feeding systems employing underwater cameras or remote sensors may also be used to assess feeding responses and validate feeding models.

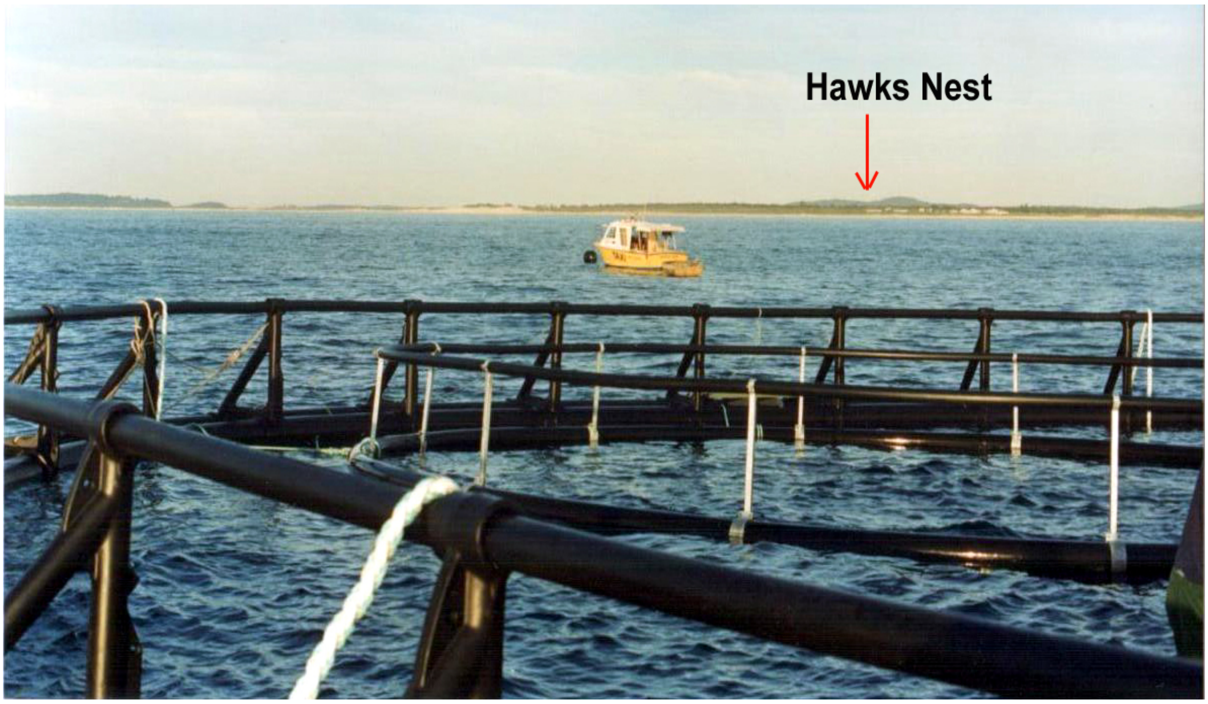

Figure 22: The existing aquaculture lease in operation in Providence Bay, including the view of a double collared sea cage, a smaller fingerling cage within the larger cage and the township of Hawks Nest in the background (approximately 3.5 km away) (Source: NSW DPI, 2000).

The health of the stock will be monitored on a regular basis (daily when weather permits) to identify any disease or parasite issues that may arise. Any unusual mortalities will be reported to enable appropriate investigation to identify causative agents. The sea cages and supporting infrastructure will be cleaned of biofouling on a regular basis to reduce the potential to attract wild fish or to harbour disease or parasites. The use of therapeutic substances will be kept to a minimum and only used in accordance with an approval from the Australian Pesticides and Veterinary Medicines Authority (APVMA) or a veterinarian.

On the completion of grow out trials, stock will either be harvested for transportation back to PSFI for evaluation or harvested and sold through commercial outlets. No processing, such as gutting or filleting of stock will occur at the Research Lease.

If harvested stock is required to be transported live for evaluation at PSFI, fish will be placed into specialised containers containing seawater, appropriate levels of anaesthetic to calm the fish and aeration to maintain dissolved oxygen levels. Otherwise stock will be harvested and placed on ice in containers on board the vessel for transportation to wharf facilities and then to commercial fish markets. Harvesting for human consumption will be in accordance with NSW Food Authority requirements.

3.8 Decommissioning

NSW DPI proposes to operate the Research Lease for a period of five years to enable the research objectives (See Section 3.2.1) to be achieved. Once the five year research trial has been completed NSW DPI would have no further use for the site and therefore its decommissioning would be required.

Decommissioning of the Research Lease would be undertaken in the year following the five year trial. The decommissioning process could commence earlier than this if research projects are completed prior to the end of the five year trial.

Decommissioning would involve the removal of all Research Lease infrastructure to an appropriate land base. It is likely that the Research Lease infrastructure would be disassembled in the following order:

- Sea cages, predator nets and any other equipment suspended or attached to the sea cages;
- Anchoring and bridle system, including mooring lines, chains and anchors; and
- Lease navigation markers, which will be the last items to be removed to ensure navigational safety throughout the decommissioning process.

As the substrate underneath the Research Lease area is composed of fine to coarse sand, no earth works will be required to rehabilitate the site. The only substrate disturbance will be the removal of the anchors which will only occupy an area of 31.5 m^2 out of the total 20 hectare area. As the sandy substrate is relatively mobile and there is a prevailing water current strength of approximately 0.1m/s through the Research Lease, it is expected that the sand will naturally redistribute over the disturbed area.

NSW Roads and Maritime Services would be notified once all infrastructure has been removed so that any required adjustments to navigation charts and/or 'Notices to Mariners' can be made.

3.9 Project Alternatives

3.9.1 Alternative Sites in the Region

The principal objective of the proposed Research Lease is to provide NSW DPI and research partners with the opportunity to extend successful marine hatchery research to its next stage in an offshore sea cage trial.

Investigations into suitable sites for the proposed Research Lease were guided by the above objective and the following criteria, which researchers identified as being critical for effective management of the proposed research:

- Close proximity to research and marine fish hatchery facilities at PSFI;
- Suitability of the site to support offshore sea cage culture;
- Suitability of the marine environment;

- Availability of maritime and other support services;
- Availability of port facilities;
- Availability of seafood processing and marketing facilities; and
- Availability of transport linkages.

It was identified that the proposed Research Lease needed to be on the Mid North Coast of NSW to minimise travelling distances and time for research personnel and fingerlings located at PSFI. This was identified as an important criterion to mitigate potential impacts on other research activities being undertaken at the institute and minimise transport shock to fingerlings and larger live animals.

The marine hatchery research undertaken at PSFI indicates that the temperate species proposed for investigation may obtain optimal growth in water temperatures that are commonly found off the Mid North Coast of NSW. This biological requirement of the species has focused investigations into suitable locations for sea cage farms in this region of the state.

Researchers also identified that a suitable site for the Research Lease must also possess the following features:

- Adequate water depth to accommodate the sea cage infrastructure and minimise effects on the benthic environment;
- Unconsolidated soft sediment seafloor;
- Sufficient distance from environmentally-sensitive and unique areas e.g. seagrass beds, mangroves and reefs;
- Sufficient current flow;
- Outside any recognised navigation channels or shipping port approaches;
- Outside any predominant vessel routes to nearby localities;
- Sufficient distance from significant recreational and commercial areas e.g. yacht courses, fishing grounds, diving sites and dolphin/whale watching areas;
- Sufficient distance from residential areas;
- Sufficient distance from other aquaculture activities;
- If located within a marine park, the zone must permit aquaculture i.e. Habitat Protection Zone or General Use Zone;
- Within the natural distribution range of the finfish species that are proposed for cultivation;
- Receives some shelter from prevailing weather conditions (preferably); and
- Limited visibility of the site from major land based vantage points (preferably).

These criteria eliminate the estuarine environments along the NSW coastline as these are generally high use areas and largely too shallow and narrow for sea cage infrastructure. Also, the key objective of the Research Lease is to conduct a sea cage trial in offshore marine waters.

Sites along the NSW coastline which are greater than 200 km from PSFI were also eliminated for the following reasons:

- The requirement for the research to be conducted in temperate waters, eliminated those areas on the south coast of NSW;
- Logistical and resource constraints in the transportation of fingerlings, staff, infrastructure and consumables from PSFI;
- Potential impacts on other research activities at PSFI as a result of research staff being away for long periods due to commitments associated with the Research Lease;
- The limitations of research staff at PSFI to promptly respond to on-site issues if the Research Lease is an considerable distance away; and
- The proximity to potential research partners (e.g. University of Newcastle).

The availability of port facilities and suitable maritime services within 200 km of the PSFI is important for the deployment and maintenance of the sea cage infrastructure, as well as for the mooring of service vessels. On the Mid North Coast there are a number of ports (with all weather access), including:

- Newcastle;
- Port Stephens;
- Forster/Tuncurry; and
- Port Macquarie.

Each of the above ports have seafood processing facilities as they are existing commercial fishing ports and have commercial fishing co-operative facilities, which would ensure that the stock harvested at the end of a experimental trial would be marketed through licensed seafood outlets. Transport services are also readily available at each of four ports listed above.

The offshore waters of Port Stephens is the only location that meets the criteria of being in close proximity to PSFI, possessing a soft sediment seafloor, moderate to high current flows and is not near a significant shipping/navigation port or channel. In addition, Broughton Island and Cabbage Tree Island combined with the Tomaree and Yacaaba headlands provides some protection to the waters of Providence Bay from prevailing weather conditions.

3.9.2 Alternative Sites in Providence Bay

Providence Bay is a large open bay and its southern end is partly sheltered by Boondelbah Island, Little Island and Cabbage Tree Island. The area that receives some shelter by these offshore islands has previously been identified as suitable for marine based aquaculture. As identified in Section 3.9.1, the Research Lease site should preferably receive some shelter from prevailing weather conditions.

There is an existing 30 hectare aquaculture lease located approximately 500 m south of the site proposed for the Research Lease in Providence Bay. Originally a trial Snapper farm operation was conducted within the lease area for two years. A commercial finfish farm operation was then approved for the lease area which included the construction and operation of nine sea cages.

The approved standing stock for the commercial finfish farm is 998 tonnes while the approved stocking density is 12 kg/m^3. The approved species are Snapper and Mulloway but there is also an allowance for a small number of bait fish if they become entrapped in the cages (i.e. Slimy Mackerel and Yellowtail Scad) (NSW DoPI, 2009). The approved development was modified in 2008 to include an additional nursery cage and additional species (i.e. Yellowtail Kingfish and Yellowtail Bream) (NSW DoPI, 2009).

The commercial finfish farm is currently not operating and the sea cage infrastructure has been removed from the lease site. See Section 6.14.1 for further details on the operation of the Snapper farm and the development approval conditions.

There are a number of reasons why the existing aquaculture lease is not suitable to use for NSW DPI's marine finfish research trial, including the following:

- The approval of the Development Application for the existing aquaculture lease was granted to a private entity for the purposes of commercial finfish production and not for research purposes;
- The existing aquaculture lease does not have approval for all the finfish species that are proposed for the Research Lease;
- NSW DPI would not have as much control over the operation of a commercial lease as opposed to a research lease. It could be difficult to effectively undertake the proposed research and to work around a business which usually have strict timelines and budgets to adhere to;
- NSW DPI would not be able to adequately validate its environmental monitoring research as the existing aquaculture lease is not a 'green field site' and may still exhibit signs of impact from previous aquaculture operations; and

- If the existing aquaculture lease was used for the five year research trial, there is no surety that the lease will not be impacted by commercial circumstances e.g. sale of the aquaculture lease.

3.9.3 No-Project Option

There are a range of consequences for the community of not proceeding with the proposed five year marine finfish research trial, including the following:

- If the research trial is not undertaken the opportunity to address research knowledge gaps in marine aquaculture will be lost.
- Not proceeding with the project and the development of evidence based policies and procedures to promote best practice for the sustainable development of marine aquaculture in NSW may result in non strategic, piecemeal and potentially inappropriate development.
- Valuable knowledge about sustainable marine aquaculture will not be able to be validated if NSW DPI and research partners are not able to extend their successful land based marine hatchery research to the next stage of an offshore sea cage trial. The PSFI does not have the facilities or the capability to expand existing facilities at Taylors Beach to conduct large scale land based experiments on marine finfish species with the aim of validating their commercial potential. The Research Lease objectives can only be achieved via an offshore trial - validation cannot be achieved using a land based system.
- There would be a loss of direct economic benefit to the local economy of Port Stephens and surrounding areas associated with employment positions, the purchase of goods, such as fuel and materials, and the use of services, such as vessel and vehicle servicing, as well as accommodation and food services for visiting researchers.
- The Research Lease provides an opportunity for tourist operators to diversify visitors' experiences by visiting the marine finfish aquaculture facility, it is likely to increase community awareness about sustainable seafood production and may encourage an interest in tourists to source fresh local seafood. The potential for these benefits will be lost if the research trial is not undertaken.
- Aquaculture is essential to achieving worldwide food security and meeting the demand for seafood products around the globe. In 2009–10 the gross value of NSW fisheries production was $132.9 million, of which the aquaculture sector accounted for $52.4 million or 39% (ABARES, 2011). As the gap between capture fishery supply and the growing demand for seafood can only be met by aquaculture, it is important

3.10 Justification of Preferred Option

Sustainable seafood production is a key focus of the NSW Government's State Aquaculture Steering Committee to support future demands of food security for the state. The gap between capture fishery supply and the growing demand for seafood can only be met by aquaculture. The NSW Government recognises the need to look at opportunities for sustainable and viable aquaculture development that is built upon sound research. Aquaculture supports the regional economies of NSW which will be an increasingly important contributor to the future food security needs of the state.

PSFI has been working in marine finfish research since the early 1990s and Snapper (*Pagrus auratus*) sea cage farming research commenced in the inshore waters of Botany Bay in 1993. Successful hatchery and nursery research for Mulloway (*Argyrosomus japonicus*), Yellowtail Kingfish (*Serioli lalandi*) and other marine finfish needs to be extended and validated in sea cages trials.

The Research Lease will allow the NSW Government to extend its successful marine hatchery research at PSFI with the principal objective to conduct specific research on the sustainable development of sea cage aquaculture in NSW waters. The Research Lease will provide an opportunity to prove species suitability, validate equipment and technology, and monitor the marine environment. The results of this research will in turn support evidence based policy development for future sustainable seafood production in NSW.

Providence Bay off Port Stephens has been selected as the locality for the proposed Research Lease as it best satisfies the necessary criteria (See Section 3.9.1) for NSW DPI and research partners to extend successful marine hatchery research to its next stage in an offshore sea cage trial in NSW state waters.

The proposed site is in close proximity to PSFI which has suitable fish rearing and land based infrastructure. The physical features of the marine environment in Providence Bay also meet the criteria required for the establishment of a research sea cage facility (e.g. good water quality, soft sediment seafloor, suitable depth, moderate current flow and receives some protection from prevailing weather conditions).

The proposed site is also located outside recognised navigation channels and shipping port approaches, outside any predominant vessel routes to nearby localities, is a sufficient distance from significant recreational or commercial areas (e.g. yacht courses, fishing grounds, diving sites and dolphin/whale watching areas), is a sufficient distance from residential areas, is a sufficient distance from other aquaculture activities, is located in a marine park zone which permits aquaculture and is within the natural distribution range of the finfish species that are proposed for cultivation. There is also limited visibility of the proposed site from major land based vantage points in the region.

There is a history of finfish farming in the area and the harbour infrastructure of Nelson Bay enables necessary logistical support to be easily provided. Port Stephens is a key location in NSW for aquaculture research and the commercial production of Oysters, Barramundi, Silver Perch, freshwater crayfish and hatchery stock.

The site would provide NSW DPI with the security and flexibility it needs to undertake research unencumbered from the constraints and limitations of a commercial lease such as that adjacent to the Research Lease. The proposed lease area is also a ‘green field’ site upon which important research can be undertaken to validate environmental monitoring and develop industry best practice.

The sea cages may be constructed on existing land base facilities in the Port of Newcastle and/or Port Stephens. The infrastructure can be easily towed to the proposed site for deployment. Service vessels for the research facility will be moored in Port Stephens which minimises the travel time for researchers required to access the site. The Port Stephens and Newcastle ports are also well serviced by maritime services, transport linkages and fisheries related services, including the provision of experienced maritime staff.

Strategically the proposed site can be easily managed from the PSFI which will reduce State resource requirements to manage the site. This includes:

- A number of vessels which are stationed at PSFI and can be utilised to service the Research Lease;
- Research and support staff which are available to manage the research and lease requirements;
- Research facilities and infrastructure e.g. scientific monitoring and analysis equipment;
- Established buildings for undertaking research analysis activities and storage e.g. infrastructure items and feeds; and
- The minimal distance between PSFI and the Research Lease will minimise costs associated with the transfer of resources e.g. staff, feed and infrastructure, as well as minimise stress to fingerlings when transferred from the hatchery to sea cages.

Potential impacts are not thought to be significant when considered in context with the small scale and short-term operation of the Research Lease, the low stocking density, the minor increases in vessel movements and vehicular traffic, the distance from key landmarks, the existing aquaculture lease, residential areas, critical habitat and reefs, as well as the use of design features that will minimise visual impacts. Noise generated will predominately be characteristic of the area and service vessels will be similar to existing vessels that use Providence Bay.

Potential impacts are also not thought to be significant when considered in context with the characteristics of the proposed site, including the high energy wave climate and the extensive area of similar habitat in the direct and wider area. The small area of habitat disturbed from the installation of the anchors is expected to return to pre-existing conditions relatively quickly after the removal of the sea cage infrastructure.

The proposed site is not a high use area, safe navigation will not be obstructed, the site is not of significant recreational or commercial importance and the lease will be clearly delineated with navigation buoys. Items and places of heritage significance in the region are located a sufficient distance away from the proposed site to ensure no direct or indirect impacts. Broodstock will be sourced locally or from the same genetic population, and hatchery protocols will ensure that genetic integrity is maintained, healthy fish are stocked into the cages and pest organisms are not introduced to the site.

The Research Lease may act as a catalyst for economic development as it will provide increased employment opportunities and use local goods and services, as well as provide the tourism industry with an opportunity to diversify experiences available to visitors. The Research Lease is also likely to improve the sustainability of aquaculture feeds by undertaking research to reduce reliance on fish meal and oil. Ultimately, the results from the monitoring programs and reviews of the effectiveness of the management plans, protocols and other mitigation measures will provide valuable information to support evidence based policy development for future sustainable seafood production in NSW.

Through the employment of industry best practice, management plans, protocols and monitoring programs identified in the EIS and EMP it is concluded that the proposed research activity will not have a significant environmental, social or economic impact.

4 STATUTORY FRAMEWORK

4.1 Relevant State Legislation

Environmental Planning and Assessment Act 1979 (EP&A Act)

The EP&A Act provides a framework for environmental planning in NSW and includes provisions to ensure that proposals with the potential to significantly affect the environment are subject to detailed assessment. The EP&A Act is administered by NSW Department of Planning and Infrastructure (NSW DoPI) and provides for various planning instruments including State Environmental Planning Policies and Local Environment Plans, as well as specifying which types of developments require development approval.

The objectives of the EP&A Act include:

- the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment;
- the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats; and
- promoting ecologically sustainable development.

Under the *State Environmental Planning Policy* (State and Regional Development 2011) the proposal is classified as State Significant Infrastructure (c.14 (1)(b) and Schedule 3 (1)(1)) and requires approval from the Minister for Planning and Infrastructure under s.115W of the EP&A Act. An EIS has been prepared to accompany the Research Lease application.

Threatened Species Conservation Act 1995 (TSC Act)

The TSC Act is administered by NSW Office of Environment and Heritage (NSW OEH) and includes provisions to declare and protect threatened species, populations and ecological communities. Species populations and ecological communities identified as ‘endangered’ ‘critically endangered’ and ‘vulnerable’ are listed in Schedules 1, 1A and 2 of the TSC Act, respectively.

The TSC Act also lists ‘key threatening processes’ that may threaten the survival of those species, populations and ecological communities. Marine birds, mammals and reptiles are included in schedules of the TSC Act. In addition, the TSC Act provides for the identification of habitat that is critical to the survival of an endangered species, population or ecological community.

An assessment of significance on all threatened species that may occur in the area of the proposed development is required.

Fisheries Management Act 1994 (FM Act)

Provisions for the protection of fish and marine vegetation are administered by NSW DPI under the FM Act. Threatened species populations and ecological communities identified as ‘endangered’ ‘critically endangered’ and ‘vulnerable’ are listed in Schedules 4, 4A and 5 of the FM Act, respectively.

The FM Act also lists ‘key threatening processes’ that may threaten the survival of those species, populations and ecological communities. Part 2 (19) of the FM Act allows for the declaration of ‘protected species’, which, though not currently declining, must be protected so they do not become threatened in future. Provisions for the protection of aquatic habitats and aquatic reserves are included under Part 7 of the FM Act. In addition, Division 3 Part 7A of the FM Act provides for the identification of habitat that is critical to the survival of an endangered species, population or ecological community.

An aquaculture lease issued under Section 163 of the FM Act is required for the proposed Research Lease. The activities will also be authorised under an aquaculture permit issued under Section 144(1) of the FM Act.

Aquaculture permit and leases are subject to conditions that regulate species, structures, farming activities, monitoring requirements and reporting declared diseases (listed Schedule 6B of the FM Act) or unexplained mortality events. Powers in the FM Act are available to quarantine an area to contain suspected or confirmed presence of declared diseases. There is also provision in the FM Act to report noxious fish and marine vegetation (listed Schedule 6C of the FM Act).

Animal Research Act 1985 (AR Act)

The AR Act, administered by NSW DPI, governs any research that involves vertebrates in NSW. It was introduced to protect the welfare of animals by ensuring that their use in research is humane, considerate, responsible and justified. All research must be covered by a current Animal Research Authority and issued by an accredited Animal Care and Ethics Committee. The research undertaken on the Research Lease will be reviewed by an Animal Care and Ethics Committee.

Marine Parks Act 1997 (MP Act)

Provisions for the protection of marine biological diversity, marine habitats and ecological processes in marine parks, as well as ecologically sustainable resource use are administered by NSW DPI under the MP Act.

Before determining a development application under the EP&A Act for a development within a marine park, an approval authority must take into consideration:

- the objects of this Act specified in Section 3;
- the objects of the zoning plan for the marine park zone;
- the permissible uses of the area concerned under the regulations; and
- any relevant marine park closures.

It is proposed that the Research Lease will be located in a Habitat Protection Zone within the Port Stephens-Great Lakes Marine Park (PSGLMP). The objects of this zone are:

- to provide a high level of protection for biological diversity, habitat, ecological processes, natural features and cultural features (both Aboriginal and non-Aboriginal) in the zone, and
- to provide opportunities for recreational and commercial activities (including fishing), scientific research, educational activities and other activities, so long as they are ecologically sustainable and do not have a significant impact on any fish populations or on any other animals, plants or habitats.

Aquaculture is a permissible use with the approval of the relevant Ministers in accordance with c 1.18 of the *Marine Parks (Zoning Plans) Regulation 1999*. A permit in accordance with Clause 12 of the *Marine Parks Regulation 2009* will be required to undertake the proposed activity.

National Parks and Wildlife Act 1974 (NPW Act) and the National Parks and Wildlife Regulation 2009 (NPWR)

Under the NPW Act, the Director-General of the NPWS is responsible for the care, control and management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas and State game reserves. State conservation areas, reserves and regional parks are also administered under the NPW Act. The Director-General is also responsible under this legislation for the protection and care of native fauna and flora, and Aboriginal places and objects throughout NSW. The NPW Act and the NPWR are administered by NSW OEH.

Crown Lands Act 1989

Submerged land is generally classified as a type of Crown land. Submerged land includes most coastal estuaries, many large riverbeds, many wetlands and the State's territorial waters, which extend 3 nautical miles (5.5 km) out to sea. The principles of Crown land management are that:

- environmental protection principles be observed in relation to the management and administration of Crown land;

- the natural resources of Crown land (including water, soil, flora, fauna and scenic quality) be conserved wherever possible;
- public use and enjoyment of appropriate Crown land be encouraged;
- where appropriate, multiple use of Crown land be encouraged;
- where appropriate, Crown land should be used and managed in such a way that both the land and its resources are sustained in perpetuity; and
- Crown land be occupied, used, sold, leased, licensed or otherwise dealt with in the best interests of the State consistent with the above principles.

The proposed area for the Research Lease is located on Crown land and therefore will require landowner's consent through NSW DPI Catchments and Lands (Crown Lands Division) to lodge this EIS.

Coastal Protection Act 1979 (CP Act)

The CP Act is administered by NSW OEH and its objectives include:

- to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality;
- to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development; and
- to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including:
- benefits to the environment; and
- benefits to urban communities, fisheries, industry and recreation.

Under the CP Act, the proposed Research Lease is in the coastal zone as defined by Section 4 of the Act. However, in accordance with Section 37B of the CP Act the area of the Research Lease does not require the concurrence of the Minister administering the CP Act.

Heritage Act 1977

Under the *Heritage Act 1977*, historic shipwrecks are the remains of any ship (including articles associated with the ship) that has been situated in State waters (within the 3 nautical mile limit) or otherwise within the limits of the State, for 75 years or more, or that is the subject of a historic shipwrecks protection order. Under Section 51 of the *Heritage Act 1977,* a permit is required to move, damage, or destroy any historic shipwreck. The *Heritage Act 1977* does not apply to State waters that are waters to which the *Commonwealths Historic*

Shipwrecks Act 1976 applies. There are also provisions in the *Heritage Act 1977* which allow for the declaration of an Interim Heritage Order. NSW OEH is responsible for administering this Act.

Maritime Services Act 1935 (MS Act)

The MS Act, administered by NSW Roads and Maritime Services, sets out a range of authorisations for a variety of works in and adjacent to navigable waters. A towing licence will be required for the transport/deployment and operational stages of the Research Lease. Notification under Section 13Z of the MS Act to grant an aquaculture lease under Part 6 of the FM Act is also required.

NSW Coastal Policy 1997 and *State Environmental Planning Policy No. 71 – Coastal Protection*

The *NSW Coastal Policy* 1997, administered by NSW DoPI, applies to Port Stephens Council and the proposal lies in the coastal zone as defined by the policy. *State Environmental Planning Policy No. 71 – Coastal Protection* gives legal force to certain elements of the coastal policy and provides a development assessment framework for new development in the coastal zone. More specifically, the policy aims to:

- protect and manage the natural, cultural, recreational and economic attributes of the NSW coast;
- protect and preserve the marine environment of NSW; and
- manage the coastal zone in accordance with the principles of ecologically sustainable development.

The policy applies to the coastal waters of the State and includes the seabed, subsoil and airspace in that zone. Clause 8 matters for consideration of *State Environmental Planning Policy No 71—Coastal Protection* apply to the proposed development.

Aboriginal Land Rights Act 1983 (ALR Act)

The ALR Act, administered by the Office of the Registrar, provides a mechanism for compensating Aboriginal people of NSW for loss of their land. The preamble of the ALR Act states that land was traditionally owned and occupied by Aboriginal people and accepts that as a result of past Government decisions, the amount of land set aside for Aboriginal people had been reduced without compensation.

To redress the loss of land Aboriginal Land Council's which are established under the Act can claim vacant crown land, which if granted, is transferred as freehold title. Vacant Crown land can include land below the mean high water mark and state waters (See *Crown Lands Act 1989*).

A Local Aboriginal Land Council has the following functions in relation to the acquisition of land and related matters:

- in accordance with the ALR Act and the regulations, to acquire land and to use, manage, control, hold or dispose of, or otherwise deal with, land vested in or acquired by the Council;
- functions relating to the acquisition of land and any other functions conferred on it by or under Part 4A of the NPW Act;
- to submit proposals for the listing in Schedule 14 to the NPW Act of lands of cultural significance to Aboriginal persons that are reserved under the NPW Act;
- to negotiate the lease by the Council or by the Council and one or more other Aboriginal Land Council's of lands to which Section 36A applies to the Minister administering the NPW Act;
- when exercising its functions with respect to land that is the subject of a lease, or proposed lease, under Part 4A of the NPW Act, to act in the best interests of the Aboriginal owners of the land concerned;
- to make written applications to the NSW Aboriginal Land Council for the acquisition by the NSW Aboriginal Land Council of land on behalf of, or to be vested in, the Local Aboriginal Land Council; and
- to make claims to Crown lands.

A Local Aboriginal Land Council has the following functions in relation to land use and management:

- to consider applications to prospect or mine for minerals on the Council's land and to make recommendations to the NSW Aboriginal Land Council in respect of such applications; and
- to protect the interests of Aboriginal persons in its area in relation to the acquisition, management, use, control and disposal of its land.

A Local Aboriginal Land Council has the following functions in relation to Aboriginal culture and heritage:

- to take action to protect the culture and heritage of Aboriginal persons in the Council's area, subject to any other law; and
- to promote awareness in the community of the culture and heritage of Aboriginal persons in the Council's area.

The proposed Research Lease does not grant exclusive use and does not extinguish native title.

Protection of Environment Operations Act 1997 (POEO Act)

The POEO Act, administered by NSW OEH, ultimately aims to protect, enhance and restore the quality of the environment in NSW, to reduce risk to human health and promote mechanisms that minimise environmental degradation through a strong set of provisions and offences.

A licence is required from NSW EPA if any of the activities associated with the proposal are determined to be a Scheduled Activity under Schedule 1 of the Act. Sea cage aquaculture is not considered to be a Scheduled Activity and a licence will not be required for the Research Lease.

Environmentally Hazardous Chemicals Act 1985 (EHC Act)

The EHC Act, administered by NSW OEH, governs the use and disposal of potentially hazardous chemicals and waste material. Any use and/or removal of hazardous chemicals and material defined under the EHC Act require licensing and must be appropriately declared. At this stage it is not expected that any hazardous chemicals will be used. Therapeutics may be needed intermittently (on an as needed basis) but will only be used in accordance with the Australian Pesticides and Veterinary Medicines Authority (APVMA) or when given veterinary approval.

Food Act 2003

The *Food Act 2003* is administered by the NSW Food Authority with the object of ensuring food for sale is both safe and suitable for human consumption. A Food Authority Licence under the *Food Regulation 2010* will be required for Research Lease stock destined for human consumption.

4.2 Relevant Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is administered by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and aims to:

- provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance (NES);
- promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
- promote the conservation of biodiversity; and
- provide for the protection and conservation of heritage.

In the aquatic environment, the Act lists the following matters of NES:

- nationally threatened species, ecological communities, critical habitats and key threatening processes (including marine species);
- migratory species;
- Ramsar wetlands of international importance; and
- Commonwealth marine areas (extends between 3-200 nautical miles from the coast).

Threatened fauna and flora are listed in any one of the following categories as defined in Section 179 of the EPBC Act as:

- extinct;
- extinct in the wild;
- critically endangered;
- endangered;
- vulnerable; or
- conservation dependent.

Species listed as 'extinct' or 'conservation dependent' are not considered matters of national environmental significance (protected matters).

The proposed development is required to be assessed according to the EPBC Act, the EPBC Act Policy Statement 1.1 (Significant Impacts Guideline: SIG 1.1) and the EPBC Act Policy Statement 2.2 (Offshore Aquaculture).

Historic Shipwrecks Act 1976 (HS Act)

The HS Act, administered by DSEWPaC, protects historic wrecks and relics in Commonwealth waters, extending from below the low water mark to the edge of the continental shelf. For the purposes of this study, any shipwrecks within the footprint of any proposed sea cage infrastructure would be under the jurisdiction of the HS Act. Under Section 4 of the HS Act, all shipwrecks 75 years of age and older are declared historic and afforded automatic protection. At the time of writing, vessels wrecked before 1933 are protected under the HS Act. Other shipwrecks can be declared historic and granted this protection on an individual basis according to their particular merits.

Under Section 13 of the HS Act, it is an offence to damage, interfere, remove or destroy an historic shipwreck or artefacts associated with it. A permit can be issued under special circumstances, with conditions, to carry out a specified action that would otherwise be prohibited under Section 13. For shipwrecks under threat, a protected zone can be declared that can prohibit certain activities within a specified radius around the wreck. Under Section 17 of the HS Act persons discovering a shipwreck are legally obligated to notify the appropriate authorities of the discovery.

Native Title Act 1993

Native Title is the name Australian law gives to the traditional ownership of land and waters that have always belonged to Aboriginal people according to their traditions, laws and customs. Native Title might continue to exist in areas such as beaches, oceans and other waters that are not privately owned. Registered native title claimants gain a right to be notified of, and to comment on, certain acts which government proposes doing ('future acts') which may affect land in their claim area. The Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA) administers this Act.

The proposed Research Lease does not grant exclusive use and does not extinguish native title.

Policy on Ecologically Sustainable Development (ESD)

Australia's National Strategy for Ecologically Sustainable Development 1992 (NSESD) defines ecologically sustainable development (ESD) as 'using, conserving and enhancing the community's resources so that ecological processes on which life depends are maintained and the total quality of life, now and in the future, can be increased'.

The main objectives of ESD are:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- to provide for equity in and between generations; and
- to protect biological diversity and maintain essential ecological processes and life-support systems.

The main principles of ESD state that:

- decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- the global dimension of environmental impacts of actions and policies should be recognised and considered;
- the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;

- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- decisions and actions should provide for broad community involvement on issues which affect them.

5 CONSULTATION

NSW DPI began the consultation process for the proposed Research Lease with relevant stakeholders in August 2011. The majority of consultation was undertaken with preliminary telephone calls which were followed by face to face meetings in the Port Stephens and Great Lakes regions. Stakeholders were provided with information about the Research Lease and emerging marine sea cage aquaculture industry and any issues raised during consultation were addressed in this EIS. Information was also provided via email and with a *Question and Answer* page on the NSW DPI website (Web Reference 32). Consultation carried out to–date includes:

- August 2011: Initial contact with government agencies and local government (Port Stephens and Great Lakes Councils);
- September 2011: Preliminary Project Outline provided to the NSW Department of Planning and Infrastructure;
- October 2011: Consultation commences with local government, environmental and community groups, recreational and commercial fishers, marine tour operators and local associations and local Aboriginal leaders.
    - *Question and Answer* page provided on NSW DPI website;
    - A media release from the Minister for Primary Industries was provided to the Port Stephens Examiner and the Myall Nota which resulted in local press;
    - Radio interviews were conducted with ABC Newcastle for the News and Drive segments of the program; and
    - Media in the Newcastle herald and Myall Nota newspapers
- November 2011 – September 2012: Stakeholder consultation continues with calls, emails and face to face meetings.

Consultation has included 49 key contacts calls and 23 face to face meetings. A list of all stakeholders engaged during the consultation stage of the project is provided below (Table 2).

Table 2: A list of all stakeholders that were consulted about the Research Lease.

Stakeholders	
Port Stephens MP	Newcastle & Port Stephens Game Fish Club
Mayor - Port Stephens Council	Lets Go Dive Charters
Port Stephens Councillors	Feet First Dive Charters
Port Stephens Council	Tamboi Queen Boat Charters

Mayor - Great Lakes Council	Moonshadow Boat Charters
Great Lakes Councillors	EcoNetwork
Great Lakes Council	Imagine Boat Charters
NSW Department of Premier & Cabinet	Bay FM
NSW Department of Planning and Infrastructure	CSIRO
NSW Office of Environment and Heritage	Port Stephens Yacht Club
NSW Food Authority	Corlette Point Sailing Club
NSW Marine Parks Authority	Nelson Bay & District Business Chamber
National Parks & Wildlife Service	Tea Gardens - Hawks Nest Surf Life Saving Club
NSW Roads and Maritime Services (Newcastle)	OceanWatch
NSW Roads and Maritime Services(Tea Gardens)	Fisheries Research Development Corporation
Land and Property Management Authority	Port Stephens PROAM
Newcastle Port Corporation	Tea Gardens Hawks Nest Progress Association
Catchment Management Authority	Karuah Motor Yacht Club
Water Police	Hawks Nest Golf Club Fishing Club
Mineral Resources	Broughton Island Hut Users
Worimi Local Aboriginal Land Council	Hawks Nest Sports Store
Worimi Knowledgeholders Aboriginal Corporation	Myall Waterways Chamber of Commerce and Tourism
Karuah Local Aboriginal Land Council	Tomaree Ratepayers & Residents Association
NSW Department of Primary Industries	Commercial Fishers & Fishermen's Co-operative
Marine Rescue	Port Stephens Tourism
Australian Seafood CRC	University of Newcastle
Recreational fishers	Pisces Marine Farms

5.1 Statutory Authorities

A Preliminary Project Outline for the Research Lease was provided to NSW Department of Planning and Infrastructure so the Director-General's Requirements for the EIS could be developed. The Preliminary Project Outline also assisted with informing government agencies about the project. The Director-General's Requirements advised that relevant local, State and Commonwealth government authorities, service providers, community groups and affected landowners should be consulted with about the project (Appendix 1). In particular, the Director-General's Requirements requested consultation with the following stakeholders:

- Environment Protection Authority;

- NSW Roads and Maritime Services;
- NSW Marine Parks Authority;
- NSW Food Authority;
- NSW Land and Property Management Authority;
- Great Lakes Council;
- Port Stephens Council;
- NSW Department of Primary Industries (Aquatic Habitat Protection);
- Myall Waterways Chamber of Commerce and Tourism; and
- The Hawks Nest Tea Gardens Progress Association.

Key issues raised during consultation with statutory authorities (excluding Director-General's Requirements) are listed in Table 3.

Table 3: Issues of concern raised during consultation with statutory authorities.

Issue	EIS Section
Diet protein content, excess feed impact	8.2.2.2
Genetics of stocked fish	8.2.2.4
Shark movements and interaction with cages	8.2.2.11, 8.2.2.7
New seal haul-out ground on Cabbage Tree Island	8.2.2.11, 8.2.2.7
Whale movements and interaction with cages	8.2.2.11, 8.2.2.7
Presence of rocky reefs	6.3, 6.7
Briefing for councils	5
Navigational safety	8.1.7, 8.2.1.2
Chemical use	8.2.2.3
Health management – diseases	8.2.2.5
Water quality and potential for pollution	8.2.2.1, 6.6
Sustainable aquaculture development	3.2, 8.2.2.2
Employment opportunities	8.2.1.7
Licence required from NSW Food Authority for sale	4.3
Permit required from Marine Parks Authority	4.3
Ensure consultation with Worimi and Karuah LALCs	5, 8.2.1.3
Visual impact	8.2.1.1
Alternative sites	3.9.1, 3.9.2
Use of Tea Gardens Fishermans Cooperative	8.2.1.7

Meetings were held with Port Stephens Councillors and a presentation was made to the Mayor, Councillors and Senior Council staff at a Committee meeting in November 2011. A meeting was also held with Great Lakes Mayor and Councillors in February 2012. There was extensive discussion with NSW Office of Environment and Heritage regarding the information required in the EIS. Several meetings were held with the Port Stephens-Great Lakes Marine Parks Authority with an invitation extended from them to attend a meeting with shark expert, Barry Bruce, from the CSIRO.

During consultation with the Harbour Master at the Newcastle Port Corporation, NSW DPI was advised that a management plan will need to be developed if the cages are to be constructed in the Port of Newcastle and then launched from Newcastle Harbour. Mineral Resources advised that there were no applications pending under the *Mining Act 1992* in the area proposed for the Research Lease.

5.2 Non-Statutory Authorities

Non-statutory groups were phoned, emailed and/or invited to meetings. Face to face meetings and tours of PSFI were held with EcoNetwork and Tomaree Ratepayers and Residents Association. Meetings were also conducted with recreational fishers John ‘Stinker’ Clarke and Graham Duffy and Port Stephens Professional/Amateur Fishermen (PROAM). Presentations were made to Port Stephens Tourism (which consists of a significant number of local businesses), the Tea Gardens Hawks Nest Progress Association, Australian Seafood Cooperative Research Centre, Pisces Marine Farms, University of Newcastle and CSIRO.

In addition, the Worimi and Karuah Local Aboriginal Land Councils were contacted and emailed information on the project. A meeting with the Worimi Knowledgeholders Aboriginal Corporation was held at PSFI in April 2012. As part of Port Stephens Council Summer Activities Series, presentations on the project were made to visitors during the two community tours of PSFI.

Key issues raised during consultation with non-statutory are listed in Table 4.

Table 4: Issues of concern raised during consultation with non-statutory authorities.

Issue	EIS Section
Fish meal content of diet, excess feed, feeding practices, sustainability	8.2.2.2
Genetics of stocked fish and impacts of escapees, survival prospects of escapees	8.2.2.4
Skeletal deformities	8.2.2.4
Shark movements, impact on migration and interaction with	8.2.2.11, 8.2.2.7

cages	
Trial farm - a shark attractant	8.2.2.11
Seal haul-out ground and interactions with cages	8.2.2.11, 8.2.2.7
Cages acting as a predator attractant	8.2.2.11
Whale movements, impact on migration and interaction with cages	8.2.2.11, 8.2.2.7
Navigational safety, boundary markers	8.1.7
Entanglement	8.2.2.7
Alternative sites	3.9.1, 3.9.2
Chemical use (e.g. antibiotics), residual impacts	8.2.2.3
Health management, impact on wild fish	8.2.2.5
Water quality pollution – nutrient release impact on sediment	8.2.2.1
Sustainable aquaculture – need to develop a management plan and consider ESD	2, 3.2, 4
Status of lease after five year period	3.8, 8.1.2
Employment opportunities	8.2.1.7
Potential for impact on tourism	6.13.2, 8.2.1.7
Food security	3.2
Import protocol for fish sourced from interstate	8.2.2.5
Construction of cages, avoiding breakages and equipment being lost, suitable for wave climate	8.1.5
Avoiding commercial fishing grounds	6.13.1, 8.2.1.7
Recreational fishing access to the site	8.2.1.6
Climate change, increased offshore lows, ocean acidification water temperature increases	6.1, 8.1.6
Use of existing lease	8.2.1.5, 3.9.2
Sailing windward mark	6.13.3
Justification for research fund expenditure	3.2.1, 3.10
Potential for using pilchards as feed	8.2.2.2
Impact of freshwater/sediment from Port Stephens	6.6
Why this site not another	3.9, 3.10
Choice of species and market acceptance	3.2.1
Impact of high water temperatures on fish survival, climate change	3.3, 8.1.6
Waste/equipment washing up on Hawks Nest Beach	8.1.5, 8.2.2.13
Volume of imported seafood product to NSW	2.3
Security of cages and experimental trials	8.1.7

Monitoring water quality	8.2.2.1, EMP (Section 3.2.2)
Impact on little penguins	8.2.2.7, 8.2.2.6, 8.2.2.11
Economics of production	3.2.1,
Other research options at site	3.2.3
Updates of progress of application/trial	5
Cumulative impacts	8.2.1.5, 8.2.2.1
Governance – compliance with approval and permit conditions, independent regulatory authorities	4.1, 4.3
Impacts from diesel spill	8.2.1.7

Issues raised during statutory and non-statutory consultation will also be addressed in the draft Environmental Management Plan (Appendix 2).

6 THE EXISTING COASTAL ENVIRONMENT

6.1 Coastal Climate

Port Stephens experiences a subtropical climate with mean maximum air temperatures ranging from 27.4˚C in January to 17.4˚C in July, while mean minimum air temperatures range from 18.6˚C in February and 8.6˚C in July. The highest average monthly rainfall for the region occurs from May to June (155.1-153.9 mm), while the lowest rainfall occurs from October to November (79.1-79.5 mm) (Figure 23).

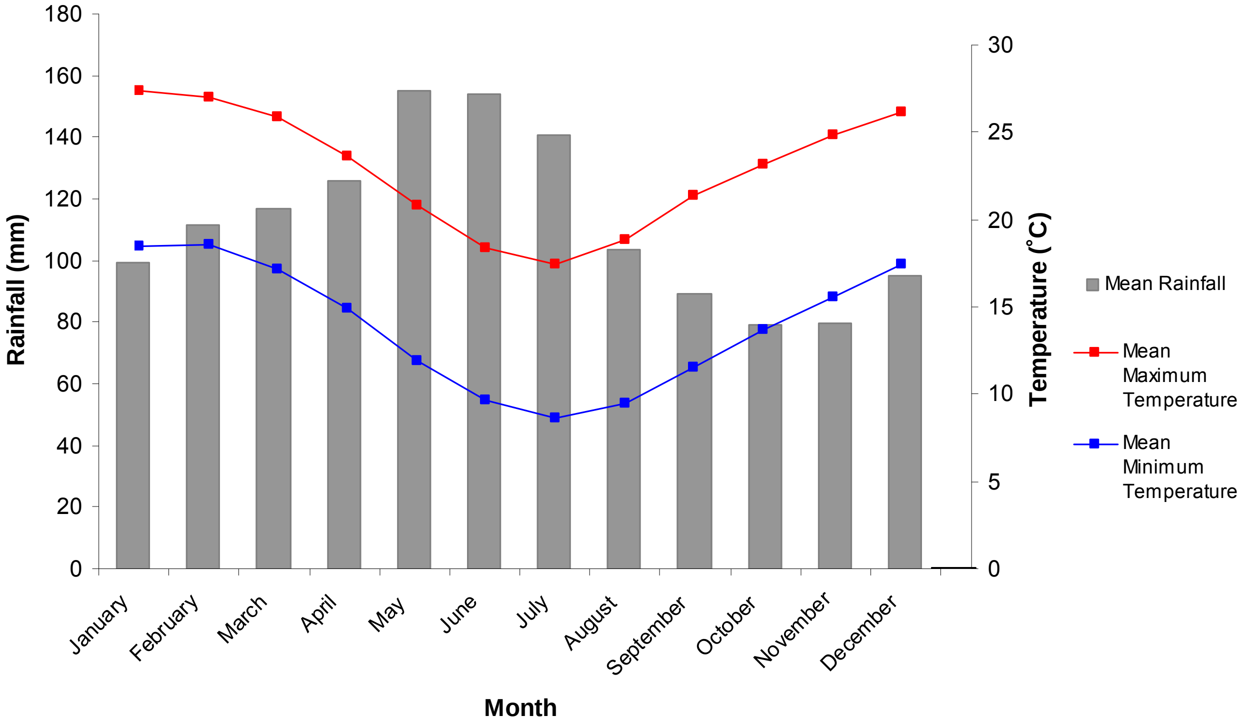

Figure 23: Mean monthly rainfall (1881-2011) and mean monthly maximum and minimum temperature (1914-2011) for Nelson Bay (32.71˚S 152.16˚E) (Source: Web Reference 15).

Wind speed and direction vary noticeably from the morning to the afternoon. During spring and summer westerly breezes dominate the morning wind pattern while afternoon winds are predominately from the east, southeast and south. During autumn and winter, westerly winds prevail both in the morning and afternoon. Mean morning wind speed varies across the year with the greatest speed experienced during late autumn and winter (maximum 15.9 km/h in June) (Figure 24). Average wind speeds in the afternoons are greatest during spring and summer (maximum 21.7 km/h in January) (Appendix 3).

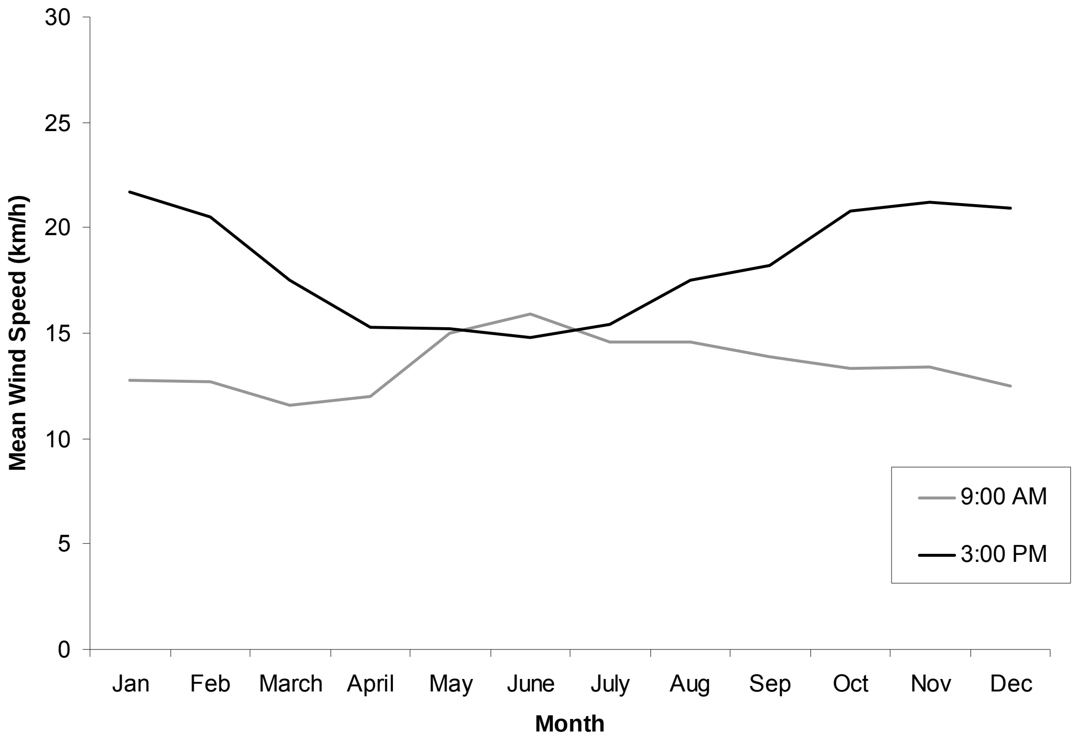

Figure 24: Mean monthly 9 am and 3 pm wind speed (1968-2010) for Nelson Bay (32.71˚S 152.16˚E) (Source: Web Reference 15).

Climate Change

Potential impacts of climate change include sea level rise, changes in seawater temperatures, increased frequency and severity of severe weather events and ocean acidification. Scenarios for NSW suggest that coastal temperatures may increase between 0.2 - 1.6° C by 2030 (Smith *et. al*., 2010) while sea level may rise by 0.18 – 0.91 m by 2090 – 2100 (NSW DECC, 2007b). A number of serious consequences for coastal human communities, infrastructure and the marine environment are expected in the long-term as a result of these changes (Smith *et. al*., 2010).

6.2 Bathymetry

Providence Bay is typically less than 40 m deep but depths of up to 80 m are found on the outer edge. The site proposed for the Research Lease is situated in an area with a depth ranging from 15 to 22 m (Figure 25).

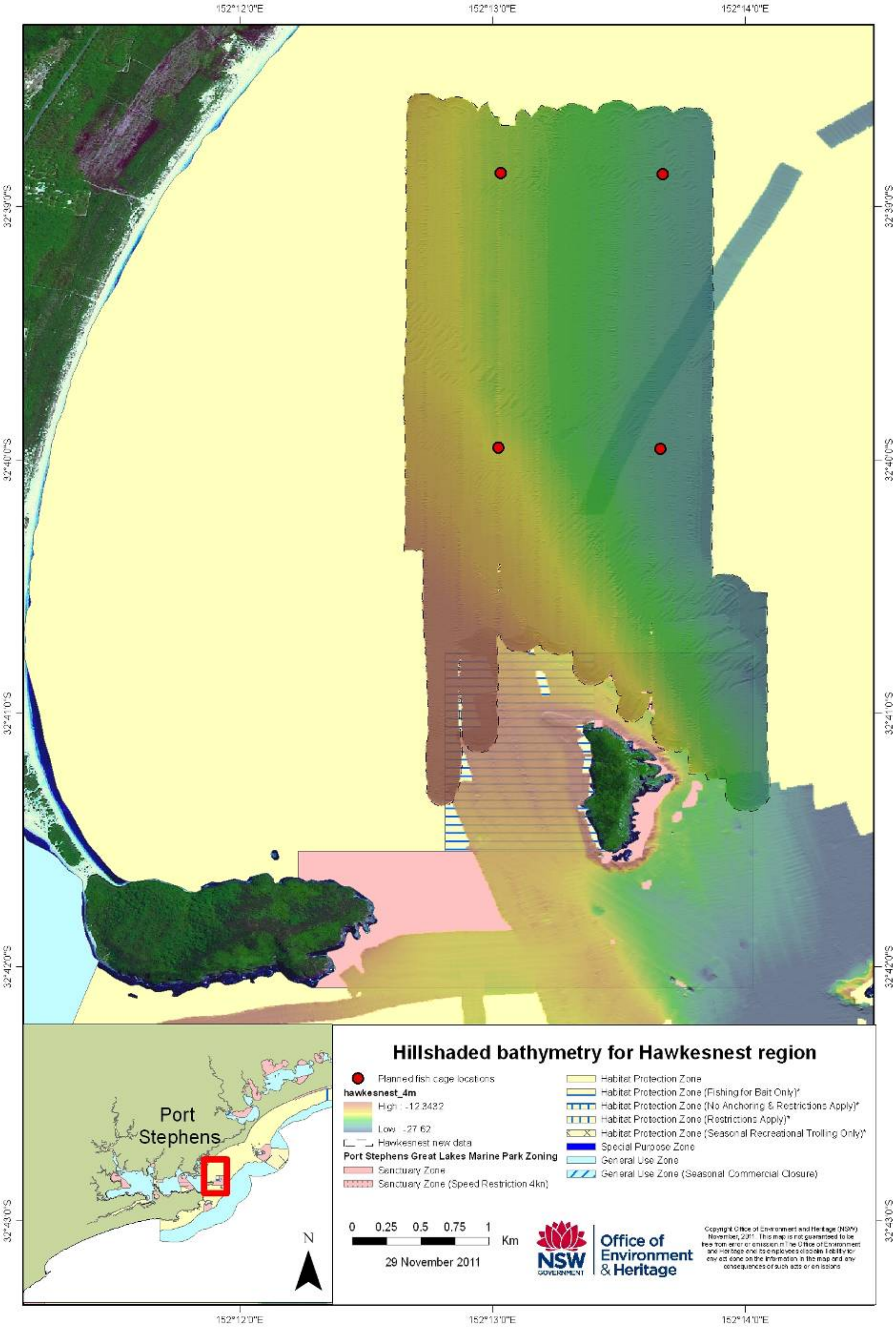

Figure 25: Bathymetry with hillshaded relief at the proposed Research Lease site (Source: NSW OEH, 2011b).

6.3 Substrate Characteristics

The Port Stephens region is characterised by subtidal reefs and offshore islands formed by Nerong Volcanics bedrock outcrops on the inner shelf (Jordan *et al*., 2010). The offshore islands, such as Broughton, Boondelbah and Cabbage Tree, are bordered by shallow, structurally complex fringing reefs that consist of boulders, continuous rock, cobbles, reef patches, overhangs, small caves and gutters which are surrounded by areas of sand and pebbles. The site proposed for the Research Lease is situated in an area with unconsolidated fine to medium sandy substrate.

6.4 Wave Climate

Waves travelling from deep water to the shallower areas may be transformed by the processes of refraction, shoaling, attenuation, reflection, breaking and diffraction (Demirbilek, 2002). At the depth of the proposed Research Lease (15 to 22 m), the main wave transformation processes are likely to be refraction, shoaling, diffraction and reflection. Orbital velocities and accelerations in the water column below are also generated by waves.

Previous studies of the wave climate of Port Stephens indicate that it is moderate with a mean significant wave height of 1.5 m and a mean wave period of 8 seconds (Short and Trenaman, 1992). The central coast of NSW has been found to receive a significant amount of high energy waves (i.e. 2-3 m for 21% of the time, 3-5 m for 5% of the time) and a lower percentage of low energy waves (< 1 m for 10% of the time) (Short and Trenaman, 1992). During summer wave direction is predominately from the northeast, while the prevalent wave direction for the rest of the year is east southeast. Storms with a southeast wave direction occur throughout the year in the region but are more frequent between April and September (Short and Trenaman, 1992).

According to data collected from the directional Waverider buoy off Sydney, which is considered to experience a similar wave climate to the Newcastle and Port Stephens region, storms with a significant wave height exceeding 4.5 m occurred less than one percent of the time between 1987 and 2004 (Kulmer *et al*., 2005). The average peak wave period was found to be 9.7 seconds with about 60% of the peak energy period between 8 seconds and 12 seconds and about 90% of the peak energy period values between 6 seconds and 14 seconds (Kulmar *et al*. 2005).

Further analysis of the region's wave climate will be undertaken and utilised by structural engineers and/or sea cage manufacturers to ensure structural integrity and stability of the infrastructure in all weather conditions.

6.5 Tides, Currents and Sea Surface Temperature

Tides in the Port Stephens region are semidiurnal and microtidal with a mean range of 1.6 m for spring tides and 1.3 m for neap tides (Short, 1985). It is estimated that tidal currents during ebb and flood flow are at around 0.1 m/s predominately in a north-south or south-north direction and during a spring tide the flow rate is not expected to exceed 0.3 m/s in Providence Bay.

Sea surface temperatures around the Port Stephens region are highest during March with a monthly average of 23.1˚C at Broughton Island while the lowest mean sea surface temperature is 18.3˚C which was recorded for August (Figure 26).

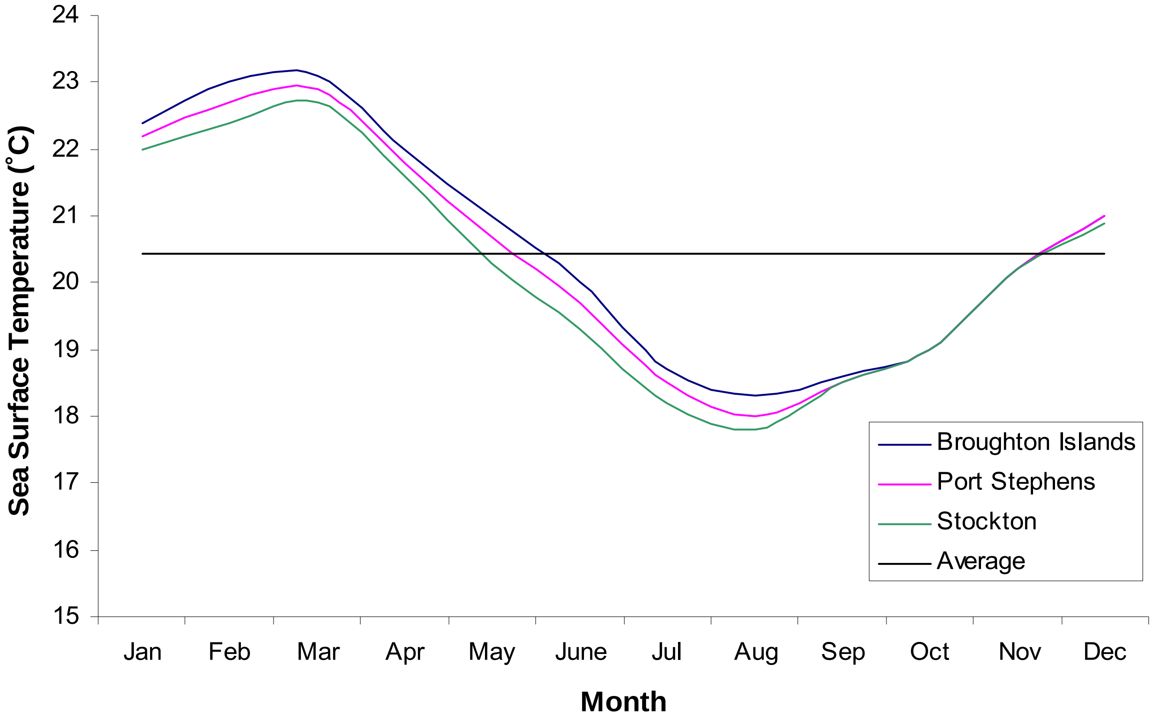

Figure 26: Monthly sea surface temperature averages for the Broughton Islands (32.37˚S 152.19˚E), Port Stephens (32.44˚S 152.09˚E), Stockton Beach (32.55˚S 151.46˚E) and the average of the three locations (Source: Web Reference 14).

6.6 Water Quality Characteristics

Prichard *et al*. (2003) found that the sea surface waters off the NSW coast typically have an oxidised nitrogen content of 10 µg/L and reactive phosphorus content of 8 µg/L. The deeper nutrient rich waters typically have an oxidised nitrogen content ranging from 70 to 140 µg/L and reactive phosphorus of content of 20 to 25µg/L. These nutrient rich deeper waters may occasionally reach the surface during upwelling events.

The Port Stephens estuary is adjacent to Providence Bay, which discharges flows from a number of creeks and two rivers out into the ocean between Yacaaba and Tomaree Head after circulating within the estuary. There are no large industrial or commercial operations in the immediate region impacting on water quality within Providence Bay. There is however, a deepwater ocean outfall discharging secondary treated water from Boulder Bay Wastewater Treatment Works at Fingal Bay. The outfall is 11 km south of the Research Lease and is situated in a high energy coastal zone so it is not considered to impact on the water quality in Providence Bay or conflict with required food safety standards for aquaculture.

The average salinity of the marine waters of Port Stephens is 35.63% (Figure 27). There are occasionally large discharges of low salinity water from the Port Stephens estuary during an ebb tide but the high energy environment of Providence Bay ensures that waters remain well mixed in the area proposed for the Research Lease which is about 3 km north of Yacaaba Head.

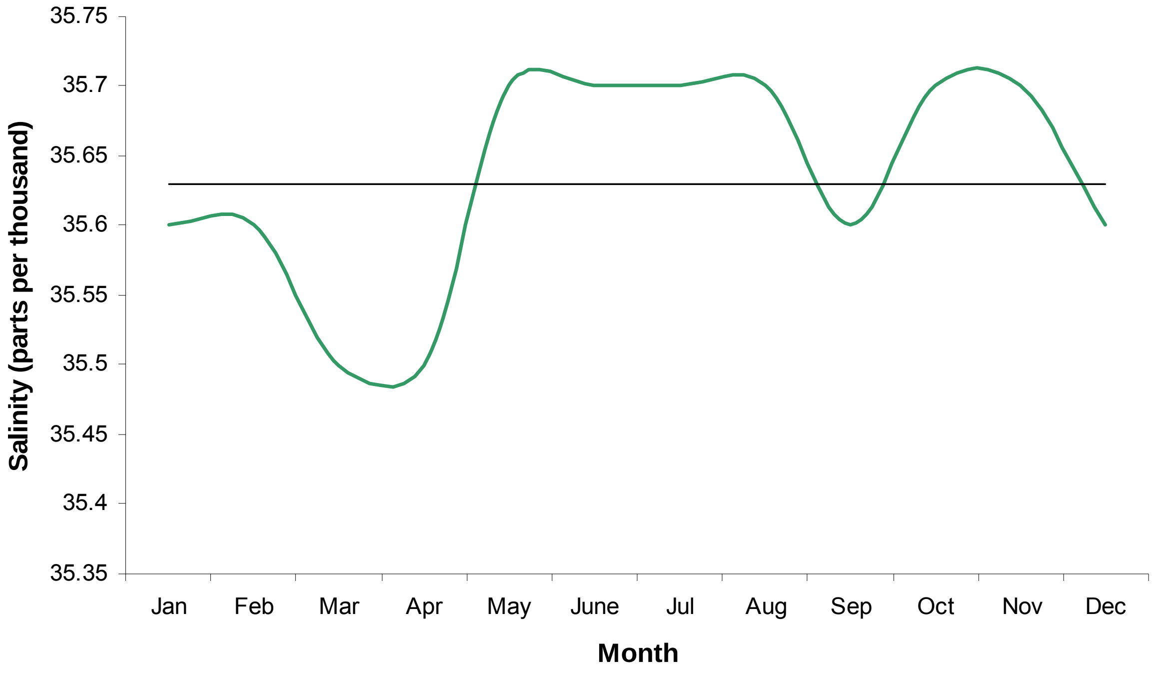

Figure 27: Monthly sea surface salinity averages for Port Stephens (32.44˚S 152.09˚E) (Source: Web Reference 14).

6.7 Benthic Habitats

The different habitat types present in Providence Bay include beaches, islands and rocks, reefs and shoals, subtidal sand, mud and muddy sands, seagrass and rocky intertidal areas (Figure 28). Habitat types, such as boulders, continuous rock, cobbles, overhangs, small caves and gutters and areas of unconsolidated pebbles, are also present but are generally associated with the offshore islands (Jordon *et al*., 2010).

A range of benthic organisms colonise the shallow rocky reef areas, including nudibranchs, bryozoans, hydroids, corals, anemones, worms, sea urchins, molluscs, crustaceans, octopuses, ascidians, sponges, macroalgae, coralline and turf algae. There are also a number of large barren reef areas off the coast of Port Stephens extending from the shoreline to a depth of 30 m. Fine-scale video mapping of reef habitats in the region revealed that barren habitat covered 13 to 69% of the shallow reefs areas and the greatest percentage occurred at depths of 10 to 15 m (Jordon *et al*., 2010).

The most extensive rocky reef habitat in Providence Bay is near Broughton Island, particularly to the southeast, where the reefs extend up to 5 km offshore (NSW OEH, 2011b). There is also a very narrow band of shallow fringing rocky reef that extends up to 170 m offshore of Yacaaba Headland (Jordon *et al*., 2010) and a maximum of 270 m from Tomaree Headland (NSW OEH, 2011b). The closest rocky reef to the proposed Research Lease is around 2 km to the south adjacent to Cabbage Tree Island (NSW OEH, 2011b).

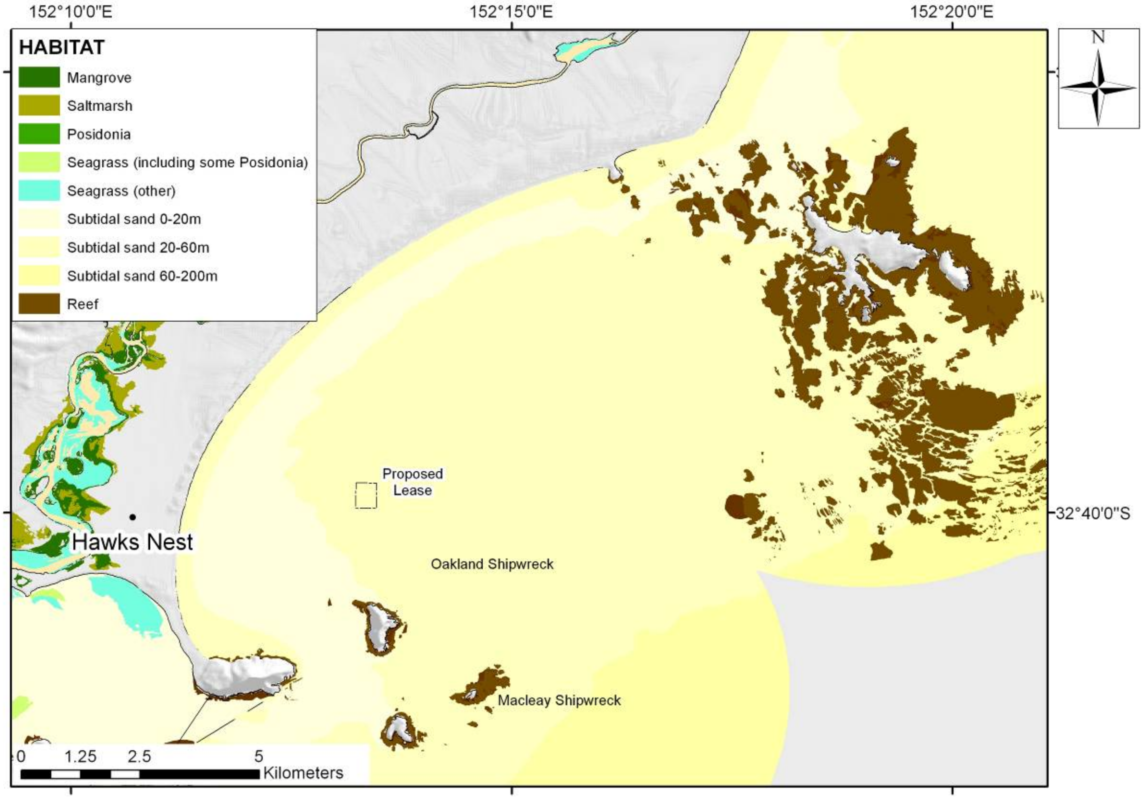

Figure 28: Habitat types present in the Providence Bay region (Source: NSW DPI, 2012).

NSW Office of Environment and Heritage was commissioned by NSW DPI to survey and map seafloor features using high resolution swath acoustics in the area proposed for the Research Lease in Providence Bay. Visual interpretation of acoustic backscatter and hillshaded bathymetry data indicated that the seafloor in the survey area consists of soft sediments only which is most likely dominated by sand and coarse sand with a depth ranging from 15 to 22 m (NSW OEH, 2011b) (Appendix 4). This is supported by the presence of distinct sand waves in much of the survey area, which are orientated to reflect the prevailing south easterly swell direction (NSW OEH, 2011b).

Some noticeable soft sediment features are highlighted by distinct boundaries between uniformly lighter and darker areas in the acoustic backscatter image (Figure 29). There is a distinct area of coarser sediment south and west of the proposed Research Lease area that is likely to be associated with coarser and harder shell material and/or pebbles and cobbles (NSW OEH, 2011b). The only evidence of this harder seabed material is in the southwest corner of the proposed Research Lease area. The soft sediment habitat appears to extend from the intertidal area of Bennetts Beach off Hawks Nest to depths of around 60 m at a distance of about 8 km offshore (NSW OEH, 2011b).

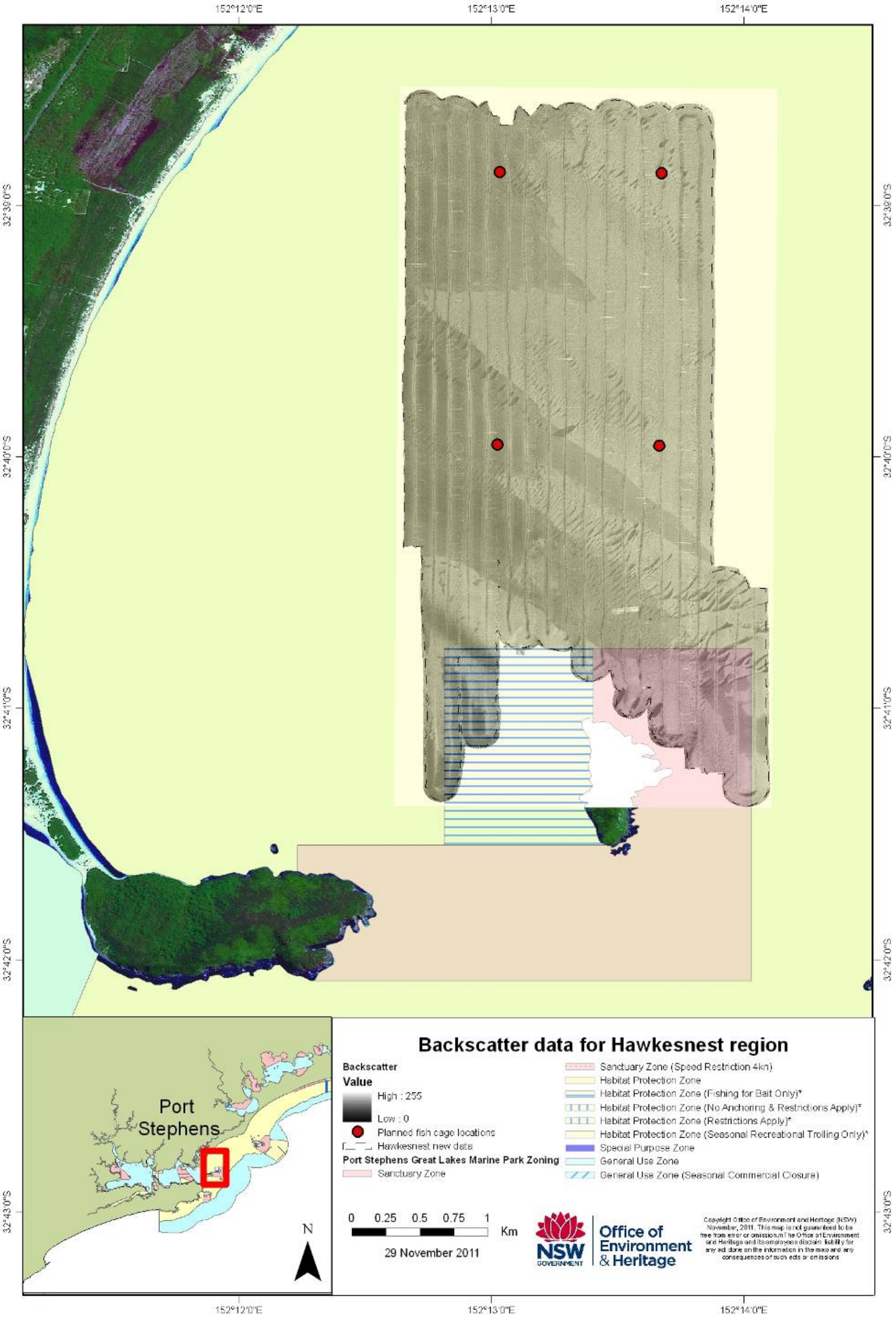

Figure 29: Acoustic backscatter at the proposed Research Lease site (Source: NSW OEH, 2011b).

There are no known seagrass beds, geomorphological formations (i.e. rocky reefs or bomboras) or any other substantial flora or fauna associations in the area proposed for the Research Lease except for phytoplankton in the water column. The closest marine communities are on the reefs surrounding Cabbage Tree Island which is 2 km south of the Research Lease.

The soft sediment benthic environment in Providence Bay was sampled in the area of the existing aquaculture lease before and after sea cages were stocked during the trial operation of the Snapper farm. During the first experiment in 1999, a total of 44 taxa representing nine invertebrate and one vertebrate phyla were found in the sediment samples (Underwood & Hoskin, 1999). During the second experiment in 2000, a total of 63 distinct types of animals from 11 invertebrate phyla and three types of animals from the Phylum Chordata were found in the samples (Hoskin & Underwood, 2001). Table 5 lists the different benthic taxa found in the sediment samples collected from within the aquaculture lease during both experiments.

Table 5: Taxa found in sediment samples collected from the existing aquaculture lease (Source: Underwood & Hoskin, 1999; Hoskin & Underwood, 2001).

Phylum	**Sub-phylum**	**Class (or sub class)**	**Order**	**Family**
Cnidaria		Anthozoa		
Nemertea				
Platyhelminthes				
Sipuncula				
Annelida		Oligochaeta Polychaeta		 Ampharetidae Arabellidae Capitellidae Cirratulidae Chaetopteridae Dorvilleidae Eunicidae Glyceridae Goniadidae Hesionidae Lumbrineridae Magelonidae Nephtyidae Nereididae Onuphidae Opheliidae Orbinliidae Oweniidae Paraonidae Phyllodoncidae Polynoidae Polyodontidae Sabellidae Scalibregmidae Serpulidae Sigalionidae Spionidae Spirorbidae Syllidae

				Terebellidae Trichobranchidae Trochochaetidae
Arthropoda	Pycnogonids Crustacea Uniramia	Mallacostraca Ostracoda Copepoda (s.c) Cirripedia (s.c) Insecta Pycnogonida	Amphipoda Isopoda Decapoda Tanaidacea Cumacea Mysidacea	
Mollusca		Bivalvia Gastropoda Opisthobranchia Scaphopoda		
Echinodermata		Echinoidea Holothuroidea Ophiuroidea		
Phoronida				
Ectoprocta				
Chordata	Cephaloochordata (*Amphioxus*) Vertebrata	Ascidiacea Osteichthyes		

In addition, there are a number of significant habitats in the wider Port Stephens region including 27 km² of mangrove forest (21% of NSW total), 14 km² of saltmarsh (13% of NSW total) and 8 km² of seagrass (5% of NSW total). Port Stephens is also connected to the Myall Lakes by the Myall River which contains the highest proportional cover of seagrass in the bioregion (Anon, 2006).

6.8 Flora and Fauna

NSW NPWS Wildlife Atlas

A total of 1690 flora species and 531 fauna species are listed in the NSW NPWS Wildlife Atlas records in the locality of Providence Bay. Of the listed flora species, one was a marine species - eelgrass *(Zostera capricorni*), two were estuarine species - river mangrove (*Aegiceras corniculatum*) and grey mangrove (*Avicennia marina subsp. australasica)* and the remaining 1687 species were terrestrial and/or freshwater.

Of the listed fauna species, there was 112 mammal species, 38 amphibian species (mainly frogs), one eel species, one species of insect, 57 reptile species and 322 bird species (Appendix 5). Of the 112 mammal species, 17 inhabit marine waters while the other 95 species inhabit terrestrial and/or freshwater environments.

Marine mammal sightings included the southern right whale (*Eubalaena australis*), Australian fur seal (*Arctocephalus pusillus doriferus*), dwarf minke whale (*Balaenoptera acutorostrata*), humpback whale (*Megaptera novaeangliae*), common dolphin *(Delphinus delphis)*, long-finned pilot whale (*Globicephala melas*), short-finned pilot whale (*Globicephala macrorhynchus*), melon-headed whale (*Peponocephala electra*), dugong (*Dugong dugon)*, bottlenose dolphin (*Tursiops truncates*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), leopard seal (*Hydrurga leptonyx*), pygmy sperm whale (*Kogia breviceps*) and the false killer whale (*Pseudorca crassidens).*

Of the 57 reptile species, 52 species were terrestrial and/or freshwater while the other five predominately inhabit the marine environment, including the green turtle (*Chelonia mydas)*, leatherback turtle (*Dermochelys coriacea)*, loggerhead turtle (*Caretta caretta*), hawkesbill turtle (*Eretmochelys imbricate*) and the yellow-bellied sea snake (*Pelamis platurus).* In addition, the flatback turtle (*Natator depressus*) was not listed in the NPWS Wildlife Atlas but has been sighted in Port Stephens waters.

In regards to the 311 bird species recorded, 32 inhabit intertidal, sandflats and/or shoreline environments while the other 232 species inhabit terrestrial and/or freshwater environments. Forty seven species are predominately marine and include storm petrels, terns, albatrosses, darters, the osprey, sea eagles, the Gould’s petrel (*Pterodroma leucoptera)*, little penguins (*Eudyptula minor)*, cormorants, shearwaters, Australasian gannets (*Morus serrator*), giant petrels and pelicans.

Based on the analysis of the NPWS Wildlife Atlas species list, seventy species could potentially be impacted by the proposed Research Lease in Providence Bay (i.e. marine species), including 17 species of mammals, six marine reptiles and 47 species of seabirds.

Other Record Sources

Additional finfish, shark and ray species sighted in Providence Bay include:

- Port Jackson Sharks (*Heterodontus portusjacksoni*);
- Wobbegongs (*Orectolobus sp*.);
- Blue-spotted Stingrays (*Dasyatis kuhlii*);
- Fiddler Rays (*Trygonorhina fasciata*);
- Sand Flatheads (*Platycephalis caeruleopunctatus*);

- Shovelnose Rays (*Aptychotrema vincentiana*);
- Small-toothed Flounders (*Pseudorhombus jenynsii*);
- Numb Rays (*Hypnos monopterygium*);
- Eastern Fortescues (*Centropogon australis*);
- Snapper (*Pagrus auratus*);
- Tailor (*Pomatomus saltatrix*); and
- Three-barred Porcupine Fish (*Dicotylichthys punctulatus*).

These species were observed foraging beneath the sea cages during the trial operation of the Snapper farm (D. Liszka 2011 *pers. comm*. cited in Worth & Joyce, 2001).

The risk of the Research Lease impacting on species that inhabit intertidal, sandflats, shoreline and/or terrestrial environments is considered to be low due to the distance of the proposed Research Lease from these environments and the highly localised impacts observed at other sea cage farms in Australian waters (McGhie *et al*., 2000; Hoskin & Underwood, 2001; DPIWE, 2004, Woods *et al*. 2004; Felsing *et al*., 2005; McKinnon *et al*., 2008; Edgar *et al*., 2010; Tanner & Fernandes, 2010).

6.9 Threatened and Protected Species, Populations and Communities (State Legislation)

State legislation relevant to threatened and protected species, populations and ecological communities includes the *Threatened Species Conservation Act 1995* (TSC Act), which protects all listed species except for fish, which are protected under the *Fisheries Management Act 1994* (FM Act).

The NSW Department of Environment and Conservation Threatened Species Database (Web Reference 1) and the Department of Primary Industries – Threatened and Protected Species Listing (Web Reference 2) were searched for threatened species, populations and communities listed under relevant Schedules of the TSC Act and FM Act that are likely or predicted to occur in the study region.

The search was carried out in 2011 and included species of marine fish, marine mammals, marine reptiles, marine algae/vegetation, marine invertebrates and seabirds. The threatened species search covered the Hunter/Central Rivers Catchment Management Authority marine zone subregion (Appendix 6). A precautionary approach was adopted where a broad-scale assessment of all threatened species that could potentially occur in the wider region was conducted to ensure all necessary species were considered. The results of the database search for the Hunter/Central Rivers - marine zone are listed in Table 6.

Species protected under the TSC Act and the FM Act potentially occurring in the Hunter/Central Rivers search area included:

- the ‘presumed extinct’ Green Sawfish (*Pristis zijsron);*
- the ‘critically endangered’ Grey Nurse Shark *Carcharias taurus);*
- the ‘endangered’ Scalloped Hammerhead (*Sphyrna lewini*);
- the ‘endangered’ blue whale (*Balaenoptera musculus);*
- the 'endangered' southern right whale (*Eubalaena australis*);
- the ‘endangered’ dugong (*Dugong dugon);*
- the ‘endangered’ Southern Bluefin Tuna (*Thunnus maccoyii);*
- the ‘endangered’ loggerhead turtle (*Caretta caretta*);
- the 'endangered' leatherback turtle (*Dermochelys coriacea);*
- the ‘critically endangered’ beach stone-curlew (*Esacus neglectus*);
- the ‘endangered’ little tern (*Sterna albifrons*);
- the ‘endangered’ pied oystercatcher (*Haematopus longirostris*);
- the ‘endangered’ southern giant petrel (*Macronectes giganteus*);
- the ‘endangered’ wandering albatross’ (*Diomedea exulans*);
- 30 species were listed as ‘vulnerable’ under the TSC Act, which were mainly seabirds but also included New Zealand fur seals (*Arctocephalus forsteri*), Australian fur seals (*Arctocephalus pusillus*), humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*) and green turtles (*Chelonia mydas*);
- 3 species were listed as 'vulnerable' under the FM Act, including the Black Cod (*Epinephelus daemelii*), the Great White Shark (Carcharodon carcharias) and the Great Hammerhead (*Sphyrna mokarran*); and
- 42 species were identified as ‘protected’ under the FM Act, including the Estuary Cod (*Epinephelus coioides*), Elegant Wrasse (*Anampses elegans)*, Giant Queensland Groper *Epinephelus lanceolatus),* Bluefish *(Girella cyanea*), Eastern Blue Devil Fish (*Paraplesiops bleekeri)* and 37 species of syngnathiforms (i.e. seahorses, pipefish, pipehorses, ghost pipefish, seamoths and seadragons).

Table 6: Threatened and protected species listed under the TSC Act, FM Act and EPBC Act that may occur in the coastal waters off Port Stephens.

Latin Name(s)	Common Name(s)	FM Act / TSC Listing	EPBC					Occurs in Wider Area
			# of listings	Status	Migratory Species	Listed Marine Species Category	Cetacean & Other	
Birds								
Albatrosses								
Diomedea (exulans) amsterdamensis	Amsterdam Albatross		3	E	✓	✓		✓
Diomedea antipodensis	Antipodean Albatross	V	2	V	✓	✓		✓
Diomedea dabbenena / exulans exulans	Tristan Albatross		3	E	✓	✓		✓
Diomedea exulans (sensu lato)	Wandering Albatross	E	3	V	✓	✓		✓
Diomedea exulans gibsoni	Gibson's Albatross	V	3	V	✓	✓		✓
Phoebetria fusca	Sooty Albatross	V						
Thalassarche (melanophris) impavida	Campbell Albatross		3	V	✓	✓		✓
Thalassarche bulleri	Buller's Albatross		3	V	✓	✓		✓
Thalassarche cauta (sensu stricto)	Shy Albatross, Tasmanian Shy Albatross	V	3	V	✓	✓		✓
Thalassarche cauta steadi	White-capped Albatross			V				✓
Thalassarche melanophris	Black-browed Albatross	V	3	V	✓	✓		✓
Thalassarche salvini	Salvin's Albatross		2	V	✓	✓		✓
Thalassarche steadi	White-capped Albatross		2		✓	✓		✓
Petrels and Shearwaters								
Calonectris leucomelas, Puffinus leucomelas	Streaked Shearwater		3		✓	✓		✓
Macronectes giganteus	Southern Giant-Petrel	E	3	E	✓	✓		✓
Macronectes halli	Northern Giant-Petrel	V	3	V	✓	✓		✓
Pterodroma leucoptera leucoptera	Gould's Petrel	V	2	E	✓			✓
Pterodroma neglecta neglecta	Kermadec Petrel (western)	V		V				✓
Pterodroma nigripennis	Black-winged Petrel	V				✓		
Pterodroma solandri	Providence Petrel	V			✓	✓		✓
Puffinus assimilis	Little Shearwater	V				✓		
Puffinus carneipes	Flesh-footed Shearwater	V			✓	✓		✓
Storm Petrels								
Fregetta grallaria	White-bellied Storm Petrel	V		V		✓		✓
Birds Of Prey								
Haliaeetus leucogaster	White-bellied Sea-Eagle		2		✓	✓		✓
Pandion haliaetus	Osprey	V			✓	✓		✓
Gulls and Turns								
Catharacta skua	Great Skua					✓		✓
Gygis alba	White Tern	V				✓		
Procelsterna cerulean	Grey Ternlet	V				✓		
Sterna albifrons	Little Tern	E			✓	✓		✓
Sterna fuscata	Sooty Tern	V				✓		✓
Intertidal and Wading Birds								
Calidris alba	Sanderling	V			✓	✓		
Calidris tenuirostris	Great Knot	V			✓	✓		
Charadrius leschenaultia	Greater Sand-plover	V			✓	✓		✓
Charadrius mongolus	Lesser Sand-plover	V			✓	✓		✓
Esacus neglectus	Beach Stone-curlew	C E				✓		
Haematopus fuliginosus	Sooty Oystercatcher	V						✓
Haematopus longirostris	Pied Oystercatcher	E						✓
Limicola falcinellus	Broad-billed Sandpiper	V			✓	✓		
Limosa limosa	Black-tailed Godwit	V			✓	✓		
Xenus cinereus	Terek Sandpiper	V			✓	✓		

Latin Name(s)	Common Name(s)	FM Act / TSC Listing	EPBC					Occurs in Wider Area
			# of listings	Status	Migratory Species	Listed Marine Species Category	Cetacean & Other	
Terrestrial Birds								
Myiagra cyanoleuca	Satin Flycatcher				✓	✓		✓
Monarcha trivirgatus	Spectacled Monarch				✓	✓		✓
Fish								
Anampses elegans	Elegant Wrasse	P						✓
Epinephelus coioides	Estuary cod	P						✓
Epinephelus daemelii	Black Cod	V						✓
Epinephelus lanceolatus	Giant Queensland groper	P						✓
Girella cyanea	Bluefish	P						✓
Paraplesiops bleekeri	Eastern Blue Devil Fish	P						✓
All Syngnathiformes								
6 Seahorses including								
Hippocampus abdominalis	Bigbelly, Eastern or New Zealand Potbelly Seahorse	P				✓		✓
Hippocampus whitei	White's, Crowned or Sydney Seahorse	P				✓		✓
19 Pipefish including								
Festucalex cinctus	Girdled Pipefish	P				✓		✓
Filicampus tigris	Tiger Pipefish	P				✓		✓
Heraldia nocturna	Upside-down Pipefish	P				✓		✓
Hippichthys penicillus	Beady Pipefish, Steep-nosed Pipefish	P				✓		✓
Histiogamphelus briggsii	Crested Pipefish, Briggs' Crested Pipefish, Briggs'	P				✓		✓
Lissocampus runa	Javelin Pipefish	P				✓		✓
Maroubra perserrata	Sawtooth Pipefish	P				✓		✓
Notiocampus ruber	Red Pipefish	P				✓		✓
Stigmatopora argus	Spotted Pipefish, Gulf Pipefish	P				✓		✓
Stigmatopora nigra	Widebody, Wide-bodied or Black Pipefish	P				✓		✓
Syngnathoides biaculeatus	Double-end(ed) or Alligator Pipefish	P				✓		✓
Trachyrhamphus bicoarctatus	Bentstick, Bend Stick or, Short-tailed Pipefish	P				✓		✓
Urocampus carinirostris	Hairy Pipefish	P				✓		✓
Vanacampus margaritifer	Mother-of-pearl Pipefish	P				✓		✓
4 Ghost pipefish including								
Solenostomus cyanopterus	Robust or Blue-finned Ghost Pipefish	P				✓		✓
Solenostomus paegnius	Rough-snout Ghost Pipefish	P				✓		✓
Solenostomus paradoxus	Ornate, Harlequin or Ornate Ghost Pipefish	P				✓		✓
5 Pipehorses including								
Acentronura tentaculata	Shortpouch Pygmy Pipehorse	P				✓		✓
Solegnathus spinosissimus	Spiny or Australian Spiny Pipehorse	P				✓		✓
1 Seadragon								
Phyllopteryx taeniolatus	Common Seadragon, Weedy	P				✓		✓
2 Seamoths								
Eurypegasus draconis	Short-bodied little dragon fish	P						✓
Pegasus volitans	Slender Seamoth	P						✓
Sharks								
Carcharias taurus	Grey Nurse Shark	C E		C E				✓
Carcharodon carcharias	Great White Shark	V	2	V	✓			✓
Pristis zijsron	Green Sawfish, Dindagubba or Narrowsnout Sawfish	Extinct		V				✓

Latin Name(s)	Common Name(s)	FM / TSC Act Listing	EPBC Act					Occurs in Wider Area
			# of listings	Status	Migratory Species	Listed Marine Species Category	Cetacean & Other	
Sharks								
Sphyrna mokarran	Great Hammerhead	V						✓
Sphyrna lewini	Scalloped Hammerhead	E						✓
Rhincodon typus	Whale Shark		2	V	✓			✓
Lamna nasus	Mackerel Shark				✓			✓
Marine Mammals								
Fur Seals								
Arctocephalus forsteri	New Zealand Fur Seal	V				✓		✓
Arctocephalus pusillus	Australo-African Fur Seal	V				✓		✓
Whales and Dolphins								
Balaenoptera acutorostrata	Minke Whale		1				✓	✓
Balaenoptera edeni	Bryde's Whale		2		✓		✓	✓
Balaenoptera musculus	Blue Whale	E	3	E	✓		✓	✓
Caperea marginata	Pygmy Right Whale		2		✓		✓	✓
Delphinus delphis	Common Dolphin or Short-beaked Common Dolphin						✓	✓
Eubalaena australis	Southern Right Whale	E	3	E	✓		✓	✓
Grampus griseus	Risso's Dolphin, Grampus						✓	✓
Lagenorhynchus obscurus	Dusky Dolphin		2		✓		✓	✓
Megaptera novaeangliae	Humpback Whale	V	3	V	✓		✓	✓
Orcinus orca	Killer Whale, Orca		2		✓		✓	✓
Physeter macrocephalus	Sperm Whale	V						✓
Stenella attenuata	Spotted Dolphin, Pantropical Spotted Dolphin						✓	✓
Tursiops aduncus	Indian Ocean or Spotted Bottlenose Dolphin						✓	✓
Tursiops truncatus s. str.	Bottlenose Dolphin						✓	✓
Sirenians								
Dugong dugon	Dugong	E			✓	✓		✓
Reptiles								
Caretta caretta	Loggerhead Turtle	E	3	E	✓	✓		✓
Chelonia mydas	Green Turtle	V	3	V	✓	✓		✓
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle	E	3	E	✓	✓		✓
Eretmochelys imbricata	Hawksbill Turtle		3	V	✓	✓		✓
Natator depressus	Flatback Turtle		3	V	✓	✓		✓
Pelamis platurus	Yellow-bellied Sea Snake					✓		✓

Note: V = vulnerable, E = endangered, CE = critically endangered and P = protected

6.10 Matters of National Environmental Significance (Commonwealth Legislation)

The proposed Research Lease was assessed with reference to the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) and according to the EPBC Act Policy Statement 1.1 (Significant Impacts Guideline 1.1) in conjunction with EPBC Act Policy Statement 2.2 (Offshore Aquaculture).

The EPBC Act Protected Matters Search Tool (Web Reference 3) generated a summary of matters of National Environmental Significance (NES) which may relate to or occur in the area of the proposed Research Lease (Appendix 6). The Search Tool was consulted on 30th March 2012 and included a range of fish, bird, marine mammal, marine reptile and shark species which are listed under the following classifications:

30 Listed Threatened Species

- 1 'critically endangered';
- 8 'endangered'; and
- 21 'vulnerable'

35 Migratory Species

- 16 marine birds;
- 3 terrestrial birds;
- 8 marine mammals;
- 3 sharks; and
- 5 reptiles.

49 Listed Marine Species

- 6 marine reptiles;
- 2 fur seals;
- 1 dugong;
- 18 birds; and
- 22 syngnathiforms.

13 Whales and Other Cetaceans

- 6 dolphins and
- 7 whales.

Ramsar Wetlands

The Myall Lakes is listed under the Ramsar Convention as a Wetland of International Importance and is located within 10 km of the Research Lease.

No Commonwealth Marine Area, World Heritage Property, National Heritage Place or Threatened Ecological Community occur in close proximity to or in the area proposed for the Research Lease.

The Search Tool also highlighted that the Port Stephens-Great Lakes Marine Park contains sites which are protected as critical habitat under the FM Act and the TSC Act, as well as Marine Protected Areas including marine parks, aquatic reserves and nature reserves. Further detail with respect to this marine park is found in Section 6.11 and 8.2.2.12 - Areas of Conservation Significance.

6.11 Areas of Conservation Significance

For the purpose of this EIS, areas of conservation significance include Marine Protected Areas, Ramsar wetlands, national parks, nature reserves and areas of critical habitat declared under the TSC Act and FM Act. Marine parks are areas of marine waters and lands permanently set aside to protect the biological diversity of our marine animals and plants, and to provide protection for unique and representative areas. Marine parks are zoned for multiple uses such as recreation, fishing and tourism (Web Reference 5).

Aquatic reserves have been established to provide representative samples of marine life and habitats, and protect biodiversity. Aquatic reserves are generally small compared with marine parks but play a significant role by protecting vulnerable and threatened species, important habitat and nursery areas and have research and educational roles (Web Reference 5).

National parks and nature reserves are areas of predominantly untouched land in a natural condition and are considered to have high conservation value. The primary purpose is to protect and conserve unique, outstanding or representative ecosystems, native animal and plant species or natural phenomena (Web Reference 5). National parks and nature reserves are generally terrestrial but there are some with associated marine components.

The Port Stephens-Great Lakes Marine Park (PSGLMP) extends south from Cape Hawke Surf Life Saving Club (Forster) to Birubi Beach Surf Life Saving Club (north end of Stockton Beach) from the mean high water mark to 3 nautical miles offshore. The park covers an area of approximately 98,000 hectares which is managed via a zoning plan consisting of Sanctuary, Habitat Protection, Special Purpose and General Use Zones. The proposed Research Lease is located in the PSGLMP. The types and approximate distances to areas of conservation significance near and/or within Providence Bay are summarised in Figure 30 and Table 7.

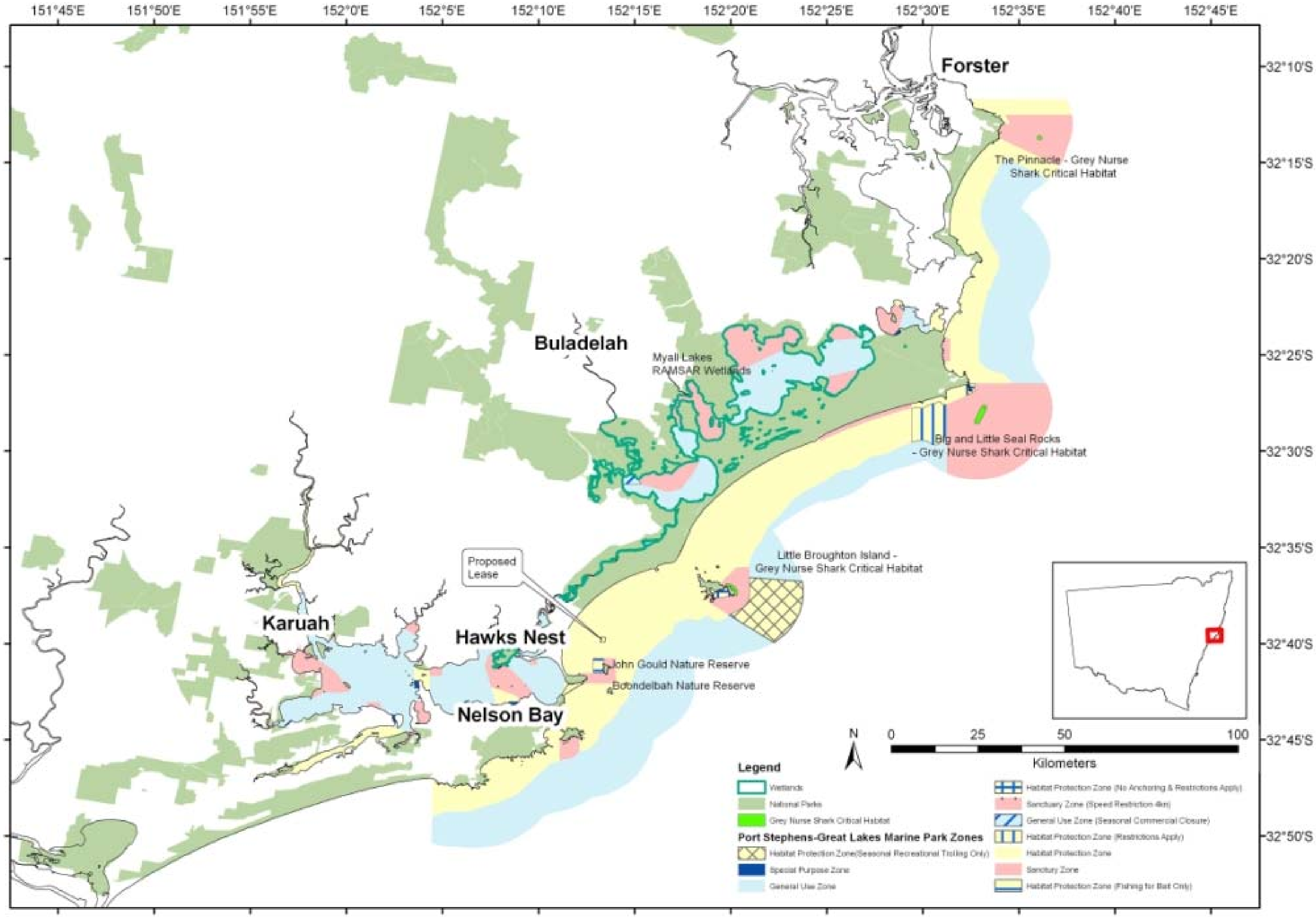

Figure 30: Areas of conservation significance near and/or within Providence Bay (Source: NSW DPI, 2012).

Table 7: Distance of the proposed Research Lease to areas of conservation significance.

Area of Conservation Significance	Designation	Distance to Research Lease (km)
Port Stephens-Great Lakes	Marine Park	0
Sanctuary Zone (Cabbage Tree Island)	Marine Park	1.5
Sanctuary Zone (Broughton Island)	Marine Park	9.5
Cabbage Tree Island	Gould's petrel Critical Habitat / John Gould Nature Reserve	2
Little Broughton	GNS Critical Habitat	10
Big and Little Seals Rocks	GNS Critical Habitat	40
The Pinnacle	GNS Critical Habitat	60
Myall Lakes	Ramsar Wetland	10
Myall Lakes (inc. Broughton Island, Yacaaba Headland)	National Park	>4
Boondelbah Island	Nature Reserve	4

6.12 Commercial and Recreational Activities

6.12.1 Commercial Fishing

Commercial fisheries potentially affected by the proposed Research Lease are those that can currently operate in the Port Stephens-Great Lakes Marine Park. The PSGLMP was zoned in April 2007 resulting in a reduction of fishing effort in the area. As a result of a commercial fishing license buyout implemented by NSW DPI, only 2-3 boats operate out of Nelson Bay, which was around 20 prior to the buyout (W. Bennett 2011, *pers. comm.*). In addition to this reduction in fishers, fishing effort and distribution have changed.

Commercial fisheries catch in NSW is reported to two bodies depending on whether the catch is from Commonwealth or State waters or fisheries. State commercial catch in NSW is reported to NSW DPI in 123 km² grid areas. The proposed Research Lease constitutes approximately 0.1% of one of these grid areas.

Five NSW fishing businesses reported catch from the grid containing the proposed Research Lease using four fishing methods: garfish net hauling, otter trawling, hand lining and fish trapping. Catch caught using beach based methods has been excluded from this overview. All four fishing methods are conducted from boats and fishers will be able to continue to utilise Providence Bay as a fishing ground but will have to keep a safe distance from the Research Lease infrastructure that includes a mooring and bridle anchoring system with sea cages which is contained within a 20 hectare area (370 x 530 m).

Consultation with commercial fishers indicated that the proposed site for the Research Lease would not significantly impact on activities. Ocean Trawling (Prawn Trawl) for example, is a fishery which was previously conducted in the Providence Bay region but is not permitted as a result of zoning changes associated with the PSGLMP. This change in area fished is reflected in the commercial catch data held by NSW DPI which shows no prawn catch recorded from the grid containing the proposed Research Lease since 2008 (Pers. Obs.).

Commonwealth managed fisheries generally operate outside of the study area (3 nautical miles or greater offshore) but these fishers may obtain bait from a 130 hectare area on the western side of Cabbage Tree Island which is designated for this activity (See Figure 11 - Section 3.5.1).

6.12.2 Marine Tourism Operations

Tourism is one of the main industries in Port Stephens LGA and the main economic activity on the Tomaree Peninsula (Port Stephens Council, 2008). The area attracts in the order of 27,000 international and 617,000 domestic overnight visitors, while the number of domestic day-trippers is about 612,000 per year. It is estimated that approximately $377 million per annum is spent in Port Stephens by these visitors and 1,574 people are directly employed in the tourism sector (Port Stephens Council, 2008).

There are a number of marine tourism operators in the PSGLMP which offer a range of activities including charter fishing, wildlife observations (e.g. dolphin and whale watching and swimming with dolphins), dive charters, jet boat rides, passenger transfers, jet ski and boat hire, non-motorised water sports, houseboats, parasailing, swimming, snorkelling and a variety of cruises. These operations occur in Port Stephens, Myall Lakes and offshore. The offshore operators include charter fishing, dive charters and wildlife observation vessels. The fishing and dive charters predominately operate around the offshore islands and reef areas. The closest dive site, the *SS Oakland* shipwreck, is located 1.7 km from the Research Lease.

Vessel movements are greatest during the summer months. Dolphin and whale watching operators for example, may undertake up to three return trips per vessel per day in summer and there are currently at least seven vessels operating in Port Stephens. Hence, dolphin and whale watching vessel movements in Port Stephens are estimated to be at least 21 trips during the peak summer period. During winter, dolphin and whale watching operators are estimated to undertake between 1-2 return trips per vessel per day.

6.12.3 Recreational Boating and Fishing

A number of resources were used to gather information on vessel traffic in the direct and wider region as no single information source details recreational boat use in the study area. NSW Marine Parks Authority, NSW Roads and Maritime Services, Marine Rescue NSW and local yacht clubs were consulted.

Recreational boating accounts for 90% of the recreational and competitive activities that occur in the Port Stephens LGA (JRA & DSA, 2010). Boat users often choose to visit Port Stephens for its embayment and surrounding waters which are part of the PSGLMP. This Marine Park consists of 98,000 hectares of waterways which are explored by vessels undertaking activities such as fishing, spear fishing, self directed dolphin and whale watching and water sports including motor cruising, sailing, jet skiing, water skiing, scuba diving, free diving and snorkelling.

Recreational boating activity is more intensive during the summer season, particularly around Christmas and New Year, and decreases substantially during winter. A number of recreational fishing and diving competitions are held during the warmer months. The Club Marine Trailer Boat Fishing Tournament for example, was held during March 2012 involving about 440 vessels. Similarly, the NSW Interclub Game Fish Tournament and the Nelson Bay Spearfishing Challenge held in February 2012 involved about 170 and 20-40 vessels, respectively.

Marine Rescue NSW offers a vessel monitoring service where vessels can ‘log in’ while they are on the water. Marine Rescue NSW (Port Stephens) service estimates that about 25% of all vessel traffic ‘log in’ with an estimated 200 plus vessels using the Port Stephens waterways during summer each day and as few as 20 vessels during winter. The ‘log in’ service monitors vessels which remain inshore as well as those which travel offshore but destinations and the purpose of trips are unknown.

The NSW Roads and Maritime Services Regional Boating Safety Officer for Port Stephens commented that during summer the number of boats on the water is substantially more than in winter (T. Woodfield 2011, *pers. comm.*). It has been estimated that there is up 200 recreational vessel movements in and around Port Stephens waters during summer. A few of these vessels venture offshore and navigate around the waters north of Cabbage Tree Island mostly to gather bait fish (T. Woodfield 2011, *pers. comm.*). The bait fish fishing zone adjacent to Cabbage Tree Island is 1.3 km^2 and about 1.5 km south of the proposed Research Lease.

The local sailing club - Corlette Point Sailing Club, holds a yacht race ‘Sail Port Stephens’ around April each year and competitors navigate around the three coastal islands adjacent to the Port Stephens embayment, including Cabbage Tree Island. One leg of the race runs north of Cabbage Tree Island between the island and the existing aquaculture lease in an area 1.5 km south of the proposed Research Lease. Discussions were held with the Club and the location of their windward race mark in relation to the Research Lease.

6.13 Navigation and Safety

As of the time of writing no navigation markers or buoys were located in Providence Bay or around Cabbage Tree Island (T. Woodfield 2011, *pers. comm*.). Current NSW Roads and Maritime Services maps for the Port Stephens region (2009) note that fish farms may occur in the area north of Cabbage Tree Island, which reflects that there is an existing 30 hectare aquaculture lease in the area which is not currently used and for which the buoys have been removed. Vessels which access Providence Bay are often launched or moored at local facilities or travel into the area via the waterways.

6.14 Infrastructure

Existing boating access infrastructure in Port Stephens includes a number of jetties, marinas, boat ramps and public wharves. Tomaree Peninsula has nine ramps – three are ocean ramps and six are bay ramps (JRA & DSA, 2010). There is currently no infrastructure in Providence Bay but a 30 hectare aquaculture lease (*Pisces Aquaculture Holdings Pty. Ltd*.) is registered with NSW DPI.

6.14.1 Existing Aquaculture Lease

The existing 30 hectare aquaculture lease is located approximately 500 m from the site proposed for the Research Lease in Providence Bay (Figure 31). The commercial fish farm is currently not operating and the infrastructure has been removed from the lease site.

Pisces Marine Aquaculture Pty. Ltd. carried out a trial operation of a Snapper farm from early 1999 to early 2001 under the provision of Schedule 3 of the *EP&A Regulation 1994* which allowed for the undertaking of trial commercial aquaculture projects in natural water bodies involving species indigenous to NSW for a period of two years (NSW DoPI, 2009).

The commercial fish farm, including the marine based site in Providence Bay and a land based site at Oyster Cove, was approved in 2001 (NSW DoPI, 2009). The approved water based development included the construction and operation of a fish farm 3 km offshore of Bennetts Beach which consisted of nine sea cages within a 30 hectare area. The approved standing stock was 998 tonnes and the stocking density was 12 kg/m^3 (NSW DoPI, 2009).

The authorised species for culture on the lease are Snapper and Mulloway but there is also an allowance for a small number of bait fish if they become entrapped in the cages (i.e. Slimy Mackerel and Yellowtail Scad) (NSW DoPI, 2009). The use of a pelletised feed was also approved and administered using an operator controlled blow feeder. Fingerlings were estimated to take 18 months to grow to harvest size with manual feeding occurring up to four times per day (NSW DoPI, 2009).

In March 2004 the aquaculture venture went into voluntary receivership and the aquaculture lease was purchased later that month by the current owner of *Pisces Aquaculture Holdings Pty Ltd* (NSW DoPI, 2009). An application was lodged in 2008 by *Pisces Aquaculture Holdings Pty Ltd* to modify the approved commercial aquaculture development. Approved modifications included an additional sea cage and additional species (i.e. Yellowtail Kingfish and Yellowfin Bream).

The current planning approval for the existing lease - *Pisces Aquaculture Holdings Pty Ltd*, is for commercial aquaculture activities.

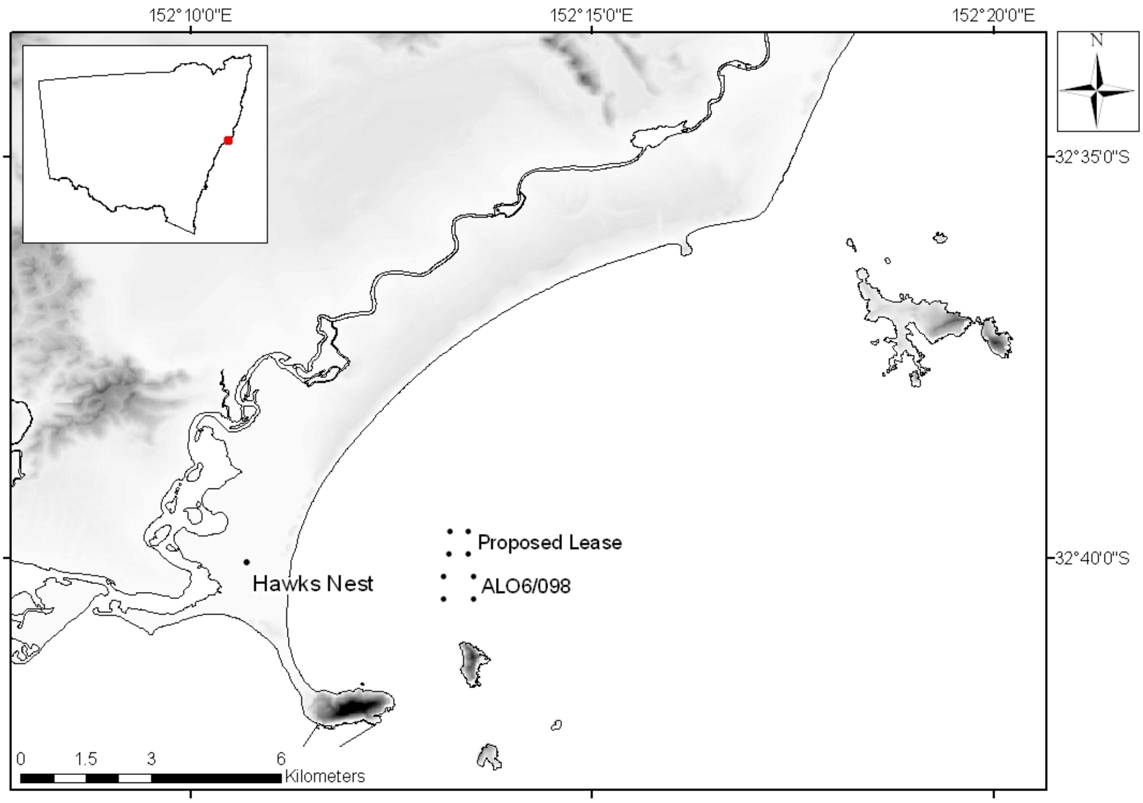

Figure 31: Location of the existing aquaculture lease (AL06/098) and the proposed Research Lease in Providence Bay (Source: NSW DPI, 2011).

6.15 Heritage

6.15.1 Aboriginal Heritage

Aboriginal people from the Worimi and Wonnarua Tribes are the original inhabitants of Port Stephens and the surrounding regions. The tribal relationships between the Aboriginal clans (*nurras*) in the area are inconclusive but it is believed that there was a definite relationship between clans from Gloucester and the Williams River through to Port Stephens (Roberts, 2000). Many clans were observed having a well developed kinship structure and extended family groups (Walsh, 1999 cited in Roberts, 2000). All clans on the southern side of Port Stephens (i.e. Nelson Bay area) were of the Worimi Tribe but relationships between clans were apparently not as distinct as they were in the north.

The Stockton Bight area, which extends from the Hunter River to Tomaree Peninsula, was believed to be inhabited by the *Malangal nurra* while the *Garugal nurra* was thought to inhabit the Tilligerry and Karuah region. The Aboriginal people were hunters and gatherers and there are records describing their healthy appearance, large numbers and the abundance of food (Roberts, 2000).

There are records of fishing in Port Stephens, including canoe trips out to Cabbage Tree and other offshore islands (Roberts, 2000). There is a paucity of archaeological surveys in the Port Stephens region but investigations conducted for the Port Stephens Council in 1992 revealed that Aboriginal occupation was predominately confined to the coastal strip and rarely extended beyond 2 km inland (Roberts, 2000).

As part of an EIS for a trial Snapper farm in Providence Bay, Roberts (2000) investigated the Aboriginal archaeological significance of the Port Stephens region. This site is located 500 m from the proposed Research Lease. After examining literature reviews and previous reports, it was concluded that the likelihood of finding sites of significance or artefacts, such as ceremonial grounds, natural sacred sites or occupation sites, on the trial Snapper farm site would be extremely remote. It was also concluded that it was unlikely that there was significant heritage value of a local or regional context (Roberts, 2000).

6.15.2 European Heritage

European settlement in the Port Stephens region dates back from 1812 when cedar getters arrived and farms became established, such as the Australian Agricultural Company which established sheep farms (Port Stephens Council, 2008). Between the 1820s to the 1860s gradual growth took place which was aided by agricultural activity and sending imports and exports through Port Stephens by ship. In the late 1800s and early 1900s growth continued, which was aided by the subdivision of many farms, fishing and oyster industries, timber getting and ship building. The most significant development in the Port Stephens region occurred during the post-war years.

Recently the population has increased from approximately 44,000 in 1991 to 60,000 in 2006. The majority of this growth occurred on the Tomaree Peninsula which was followed by Medowie (Port Stephens Council, 2008).

6.15.2.1 Historic Shipwrecks

A desktop review of shipwrecks known or potentially occurring in the direct study area was carried out in July 2011. Information was sourced from the NSW Historic Shipwrecks

Database (Web Reference 6), NSW Wrecks (Web Reference 7), the Australian Hydrographic Service (Web Reference 8), the Australian National Shipwreck Database (Web Reference 9) and a SCUBA Diving website (Web Reference 10).

Shipwrecks are found along the entire NSW coastline. Around Port Stephens 128 vessels were identified by the NSW Historic Shipwrecks Database, 59 were identified by the Australian National Shipwreck Database as being wrecked in the region and only three vessels were wrecked within 2 nautical miles (3.6 km) of the proposed Research Lease. Two of these vessels were wrecked onshore while the third, *SS Oakland*, is 1.7 km from the proposed Research Lease and is a popular dive site (Figure 32). The *SS Macleay* is another shipwreck in Providence Bay (also a dive site), which is located southeast of Cabbage Tree Island close to Little Island and approximately 5 km from the proposed Research Lease (Web Reference 10).

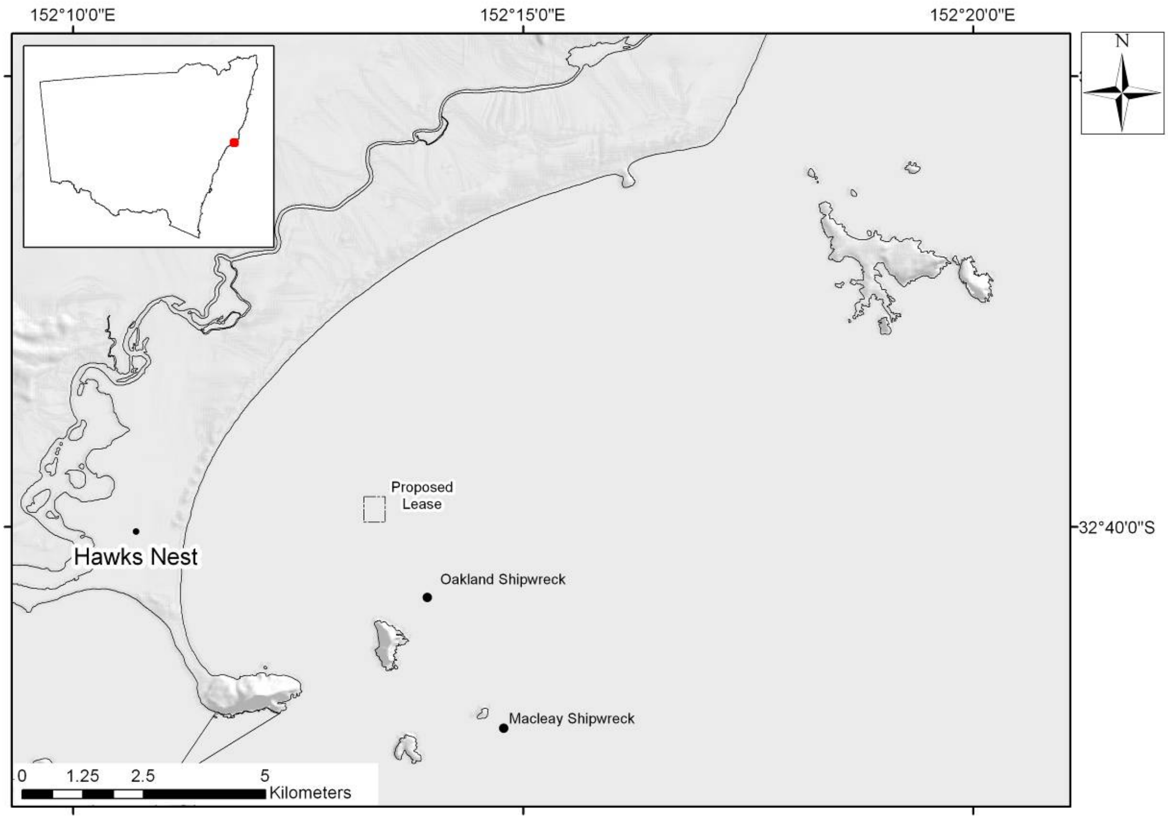

Figure 32: The location of the SS *Oakland* and SS *Macleay* shipwrecks with Providence Bay (Source: NSW DPI, 2012).

6.15.2.2 Historic Plane Wrecks

A desktop review of plane wrecks known or potentially occurring in the direct study area was carried out in 2011. Information was sourced from the Office of Environment and Heritage (Web Reference 11), the Department of Sustainability, Environment, Water, Population and Communities (Web Reference 12) and Maritime Archaeologist, Tim Smith (Smith, 2004). No evidence of plane wrecks was found from these sources. The most proximal plane wreck known to PSGLMP is 7.5 km south of the proposed Research Lease which crashed in 2006 (D. Harasti 2011, *pers. comm*.).

A survey of the seafloor beneath the area proposed for the Research Lease was also undertaken by NSW OEH in November 2011. No items that may be considered to be of submerged European heritage were observed during the swath acoustic survey.

6.16 Social and Economic Description

6.16.1 Demographics

The Port Stephens LGA has a population of approximately 68,000 and has experienced a growth rate of 1.5% between 2005 and 2010 (Table 8). The population of Port Stephens is growing and is expected to increase to 117,746 by 2031 (Port Stephens Council, 2008). This growth is predicted to be concentrated in Raymond Terrace and Tomaree Peninsula, which are currently the most populated areas.

Table 8: Estimated resident population of the LGA of Port Stephens, Newcastle and Great Lakes from 2005 to 2010 and the percentage increase over this period.

	Estimated Resident Population						% Change
LGA	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2005-2010**
Port Stephens	62,952	63,272	64,719	65,752	66,686	67,825	1.5
Newcastle	147,880	149,313	150,969	153,331	154,619	156,112	1.1
Great Lakes	33,922	34,192	34,656	35,006	35,451	35,924	1.2

The age structure of the Port Stephens LGA and the Hunter Statistical Division in 2006 is illustrated in Figure 33.

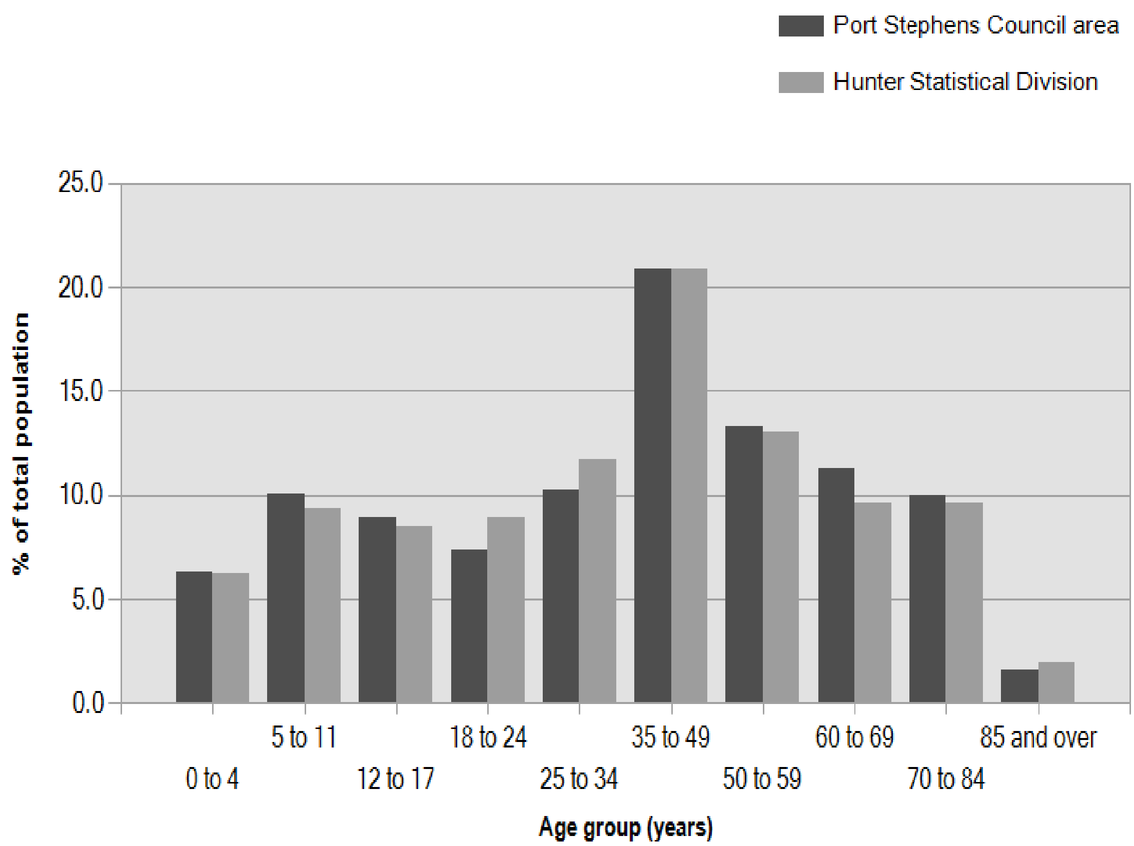

Figure 33: Age structure of Port Stephens LGA and Hunter Statistical Division in 2006 (Source: Australian Bureau of Statistics, 2006).

6.16.2 Economic Description

The Port Stephens Council LGA spans an area of nearly 1,000 km^2, of which a large proportion is national park, State Forest, farming land and nature reserves (JRA and DSA, 2010). It has expanding urban areas but is predominately rural with some commercial, industrial and military land uses.

The local economy is made up of tourism, retail trade, construction, agriculture, fishing, aquaculture and oyster farming, manufacturing, defence-government, public administration and safety, health care and social assistance and accommodation and food services (Port Stephens Council, 2008).

The three largest industry sectors are retail trade (12.7%), manufacturing (10.6%) and public administration and safety (10.5%) (Port Stephens Council, 2008). The three most popular occupations are technicians and trade workers (18.6%), clerical and administrative workers (13.6%) and professionals (13.2%) (Port Stephens Council, 2008). The largest single employers are the Tomago Aluminium Smelter and the RAAF Base (JRA and DSA, 2010). Over 100 personnel are employed at PSFI.

7 RISK ASSESSMENT METHOD

The perceived risks associated with marine sea cage aquaculture need to be addressed to ensure Ecologically Sustainable Development (ESD) of this industry (de Jong & Tanner, 2004). A risk assessment was conducted on the potential impacts associated with the Research Lease using the *National ESD Reporting Framework: The 'How To' Guide for Aquaculture* (Fletcher *et al.,* 2004) which is based on Standards Australia and Standards New Zealand (1999; 2000) risk management methods which are used by a variety of industries to conduct risk assessments.

Risk refers to "the chance of something happening that will have an impact on objectives" (Standards Australia and Standards New Zealand, 1999). The main objectives of the risk assessment was to assist with the separation of minor acceptable risks from major unacceptable risks and assist with the development of mitigation measures to avoid undesirable outcomes (Fletcher *et al.,* 2004). A variety of sources were used to ensure all risk sources associated with the Research Lease were identified, including consultation meetings to discover stakeholder opinions and perceptions, expert panels, literature reviews, examination of historical records and government guidelines.

The risk assessment identified knowledge gaps and areas that need further research, which in turn assisted with the development of the Research Lease research objectives. The focus of the risk assessment was environmental impacts but consideration was also given to social and economic issues. The generic component trees outlined in the National ESD Reporting Framework were modified so they were appropriate and applicable to the Research Lease.

Each issue was examined in terms of current knowledge and the proposed mitigation, management and monitoring measures, and then assigned a risk ranking. Two factors were used to analyse the risks - the potential consequences arising from activities on the marine environment (Table 9) and the community (Table 10) and the likelihood that this consequence will occur (Table 11) (Fletcher *et al.,* 2004). Table 12 depicts the risk matrix which is based on arithmetical calculation of the Consequence x Likelihood (0-30) that is used to separate the risk values into five risk ranking categories from 'negligible' to 'extreme'.

Any issues that were assigned with negligible risk were eliminated from subsequent assessments and a short justification is provided to support this classification (Table 13). Full management reports are recommended for issues that have been identified as having sufficient risk or priority (i.e. 'moderate, 'high' or 'extreme' risk) (Fletcher et al., 2004). A management report requires the establishment of operational objectives, indicator levels, acceptable levels and management responses for a particular issue. Management reports will form a component of the EMP and will be finalised upon development approval.

Table 9: Consequence levels for the impact of the Research Lease on ecosystems, habitats and populations (modified from Fletcher *et al*., 2004).

Level	Descriptor
Negligible (0)	Very insignificant impacts to habitats or populations. Unlikely to be even measurable at the scale of the stock/ecosystem/community against natural background variability. Activity only occurs in very small areas of the habitat, or if larger area is used, the impact on the habitats from the activity is unlikely to be measurable against background variability.
Minor (1)	Possibly detectable but minimal impact on structure/function or dynamics. None of the affected species play a keystone role – only minor changes in relative abundance of other constituents. Measurable impacts on habitat(s) but these are very localised compared to total habitat area.
Moderate (2)	Maximum appropriate/acceptable level of impact (e.g. full assimilation rate for nutrients) Measurable changes to the ecosystem components without there being a major change in function. (i.e. no loss of components). There are likely to be more widespread impacts on the habitat but the levels are still considerable acceptable given the percentage of area affected, the types of impact occurring and the recovery capacity of the habitat.
Severe (3)	This level will result in wider and longer term impacts. Ecosystem function altered measurably and some function or components are locally missing/declining/increasing outside of historical range &/or allowed/facilitated new species to appear. The level of impact on habitats may be larger than is sensible to ensure that the habitat will not be able to recover adequately, or it will cause strong downstream effects from loss of function.
Major (4)	Very serious impacts with a relatively long time frame and are likely to be needed to restore to an acceptable level. A major change to ecosystem structure and function (different dynamics now occur with different species/groups now the major components of the region). Substantially too much of the habitat is being affected, which may endanger its long-term survival and result in severe changes to ecosystem function.
Catastrophic (5)	Widespread and permanent/irreversible damage or loss will occur – unlikely to ever be fixed (e.g. extinctions). Total collapse of ecosystem processes. Long-term recovery period may be greater than decades. Effectively the entire habitat is in danger of being affected in a major way/removed.

Table 10: Consequence levels for the impact of the Research Lease on the community, including potential social, economic and political issues (modified from Fletcher *et al*., 2004).

Level	Descriptor
Negligible (0)	Very insignificant impacts – would not have any flow-on impacts to the local community, particularly other waterway users.
Minor (1)	May have minor impacts on the community (e.g. small loss of amenity, minor increase in road and vessel traffic, minor increase in noise levels, minor economic losses and minor WH&S risks) but these impacts would be easily absorbed.
Moderate (2)	Some loss of amenity, increase in noise levels, increased road and vessel traffic, impacts on heritage values, negative interactions with other waterway users, income loss, navigation and WH&S issues - to which the community will adjust to over time. Some community concern about impacts which may translate to some political action or other forms of protest.

Severe (3)	Significant loss of amenity, significant impacts on traffic levels, heritage items, noise levels, navigation safety and interactions with other waterway users, as well significant reductions in income and significant WH&S risks. Significant levels of community concern over the future of the community, which may translate to political action or protest.
Major (4)	High level of community impacts which the community could not successfully adapt to without external assistance. Significant level of protest and political lobbying likely. Significant loss of amenity, significant increase in noise levels, road and vessel traffic, WH&S risks and navigation issues. Significant impacts on other waterway users, heritage values and the local economy.
Catastrophic (5)	Large-scale impacts well beyond the capacity of the community to absorb and adjust to. Large scale loss of amenity, major increases in noise levels, road and vessel traffic, WH&S risks and navigation issues. Major impacts on other waterway users, heritage values and the local economy. Total change in the nature of the community.

Table 11: Likelihood definitions (modified from Fletcher *et al*., 2004).

Level	Descriptor
Remote (1)	Never heard of, but not impossible
Rare (2)	May occur in exceptional circumstances
Unlikely (3)	Uncommon, but has been known to occur elsewhere
Possible (4)	Some evidence to suggest this is possible here
Occasional (5)	May occur
Likely (6)	It is expected to occur

Table 12: Risk matrix – risk value is indicated by number in cells and the risk rankings are indicated by the different shades (modified from Fletcher *et al*., 2004).

		Consequence					
		Negligible	**Minor**	**Moderate**	**Severe**	**Major**	**Catastrophic**
Likelihood		0	1	2	3	4	5
Remote	1	0	1	2	3	4	5
Rare	2	0	2	4	6	8	10
Unlikely	3	0	3	6	9	12	15
Possible	4	0	4	8	12	16	20
Occasional	5	0	5	10	15	20	25
Likely	6	0	6	12	18	24	30

Table 13: Risk rankings and outcomes (modified from Fletcher *et al.*, 2004).

Risk Rankings	Risk Values	Proposed Mitigation / Management	Reporting Requirements
Negligible	0	No additional management measures needed to achieve acceptable performance.	Short justification only
Low	1 - 6	No additional management measures needed to achieve acceptable performance.	Full justification needed
Moderate	7 -12	Possible increases to management measures.	Full management report
High	13 -18	Possible increases to management measures.	Full management report
Extreme	>19	Additional management measures are likely.	Full management report

Risk mitigation is achieved by the implementation and evaluation of regulatory and/or voluntary management responses which are detailed in the EMP. The EMP states the goals and objectives for the Research Lease and provides a detailed overview of the proposed management initiatives that have been designed to mitigate the risk of the undesirable events. Risk monitoring aims to collect information to assess whether the management initiatives (i.e. the EMP consisting of monitoring programs and protocols), are effective at minimising the risk of the undesirable event. Monitoring programs will also be implemented to enable validation of management efforts, as well as highlight areas that need additional or alternative management responses if current initiatives prove to be ineffective.

Consultation with the various stakeholders, including aquaculture managers, research scientists, manufacturers, recreational and commercial fishers, Aboriginal leaders and marine tourism operators have also been conducted to provide information and feedback for decision-making. This approach aims to address any issues that require additional management actions and/or research to ensure ecological sustainability and that stakeholders are not significantly impacted by the Research Lease.

The assigned risk ranking was based on scientific literature and expert opinion, and is intended to reflect what is considered to be likely over the next five years (Fletcher *et al.,* 2004). Where there was little or no information available on the issue in NSW, a broader literature search was conducted to find any relevant information from other states or overseas (de Jong & Tanner, 2004). Representatives from the aquaculture industry, government, research and development, conservation groups and community groups provided input about issues of concern which were considered in the risk assessment.

Justification - Risk Assessment Method

A range of risk assessment processes were reviewed, including the multi-stage risk assessment process developed by NSW DPI for commercial fisheries management (Astles *et al*., 2006) but the National ESD Reporting Framework was considered the most appropriate risk assessment process for the Research Lease.

The National ESD method is specific to aquaculture and has been designed to be used nationally by the aquaculture industry. The method enables a range of environmental and socio-economic issues to be reviewed in a succinct manner and in a relatively short time frame when compared with other risk assessment methods. It has proven effective in identifying and prioritising issues and ensuring appropriate allocation of management effort. The method also encourages effective management by establishing predetermined outcomes that must be achieved for issues that are identified as potentially representing a substantial risk to the environment and/or community (Fletcher *et al.,* 2004).

Furthermore, the proposed Research Lease is a small scale short-term research trial of a short duration in a high energy locality in which no significant impacts were detected during a similar sea cage trial that was previously conducted in Providence Bay. Consequently, the National ESD method was considered to be the most appropriate method to achieve the overall goal of the risk assessment - to identify and prioritise environmental and socio-economic risks and ensure appropriate management efforts are allocated to each issue to prevent adverse impacts.

Uncertainty

To assist in assigning the correct risk level to the potential issues identified for the Research Lease, the risk assessment was reviewed and critiqued by a broad range of people with experience and expertise in a range of areas in NSW DPI (e.g. research scientists, aquaculture managers, conservation and threatened species managers).

An extensive range of stakeholders were also consulted to identify issues of concern, state their opinions and make enquiries. Stakeholders and the community also have the opportunity to provide feedback and make a submission about the risk assessment or any other component of the EIS when it goes on exhibition for public comment. This will also assist with ensuring that risk rankings are correct and adequate management attention is given to each potential impact.

8 ASSESSMENT OF IMPACTS

A total of 27 issues were identified and categorised in either the construction stage or the operational stage of the Research Lease (Figure 34). The construction stage includes issues related to site selection, construction and the installation of the sea cage infrastructure. The 20 issues associated with the operational stage were then divided into impacts on the community or impacts on the environment.

Eleven issues were identified as representing a ‘negligible’ risk while 12 issues were assigned a ‘low’ risk ranking. No issues were identified as representing a ‘high’ or ‘extreme’ risk but four were classified as ‘moderate’, including: (1) impacts on marine habitats - water quality, nutrient concentrations and sedimentation; (2) chemical use; (3) disease and introduced pests; and (4) impacts on migratory pathways, behavioural changes and predatory interactions.

The ‘moderate’ classifications indicate that these issues require further management and/or research. However, management responses to ‘moderate’ issues are unlikely to need to be immediate or drastic (de Jong & Tanner, 2004). Management responses will generally be in the nature of continuous improvements over the next 5 to 10 years to reduce the risk level to ‘low’ or ‘negligible’ (de Jong & Tanner, 2004). Hence, the Research Lease provides an opportunity to research the issues of concern in a controlled and small scale setting, which will assist with gaining a greater understanding about the impacts of marine sea cage aquaculture and achieving sustainability without adversely impacting on the environment or local communities.

Table 14 provides a summary of the potential environmental, social and economic issues associated with the proposed Research Lease, as well as the consequence, likelihood and risk ranking values recorded for each issue during the risk assessment.

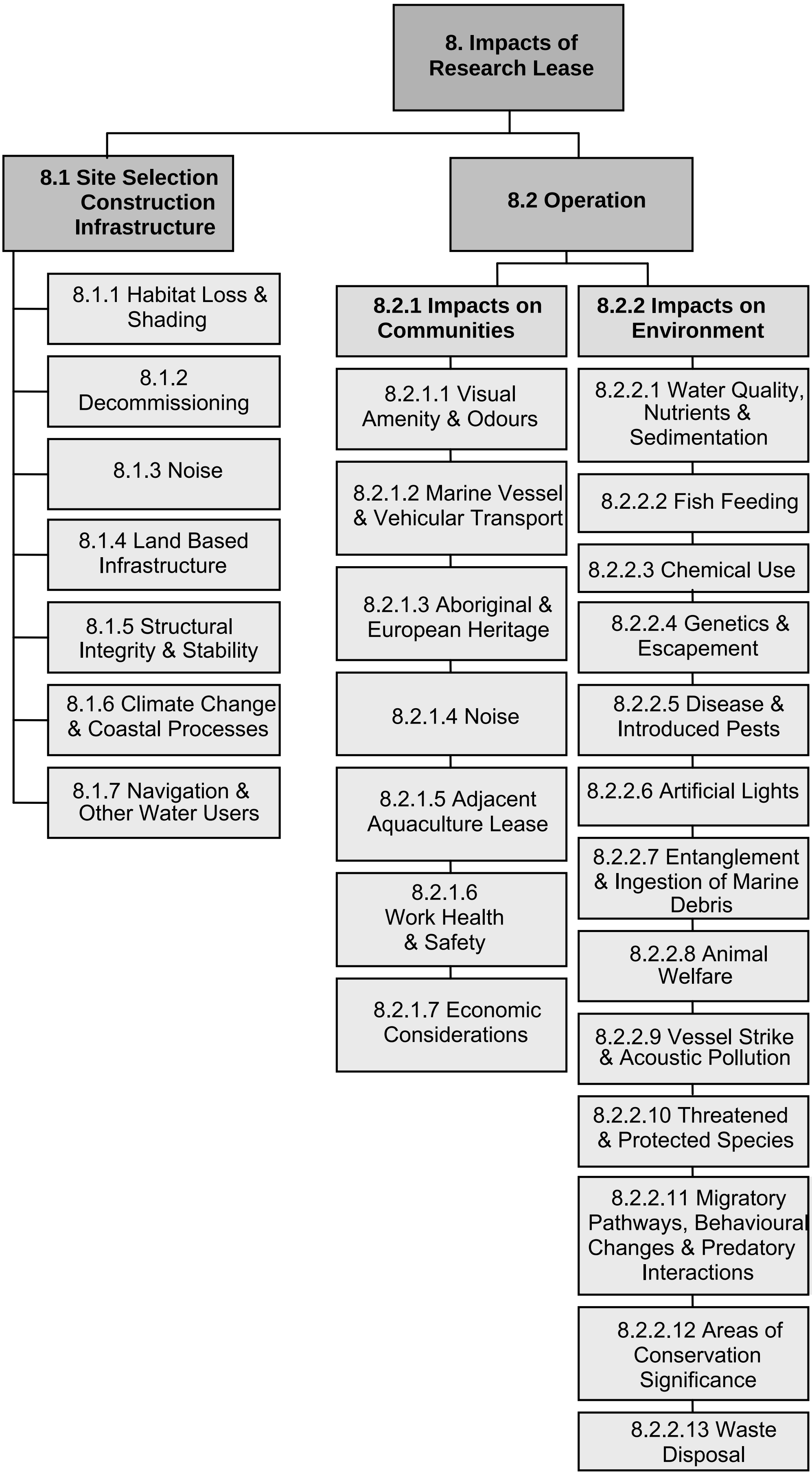

Figure 34: Component Tree – Environmental and socio-economic impacts of the proposed Research Lease (modified from Fletcher *et al*., 2004).

Table 14: Summary of environmental, social and economic issues including consequence, likelihood, risk ranking values for the proposed Research Lease (modified from Fletcher *et al*., 2004).

Issue	Consequence	Likelihood	Risk Ranking	Ranking
Site Selection / Construction / Infrastructure (8.1)				
Significance of habitat loss and shading due to the installation of sea cage infrastructure **(8.1.1)**	0	6	0	Negligible
Decommissioning **(8.1.2)**	1	6	6	Low
Impact on noise levels – construction and deployment stage **(8.1.3)**	1	6	6	Low
Impacts on existing land based infrastructure **(8.1.4)**	0	6	0	Negligible
Structural integrity and stability of sea cage infrastructure **(8.1.5)**	1	6	6	Low
Climate change and impact of sea cages on coastal processes/water flow **(8.1.6)**	0	6	0	Negligible
Impact of sea cage infrastructure on navigation and other waterway users **(8.1.7)**	0	6	0	Negligible
Operation (8.2)				
Impacts on the Community (8.2.1)				
Impacts on visual amenity and odours **(8.2.1.1)**	1	6	6	Low
Impacts of marine vessel and vehicular transport **(8.2.1.2)**	0	6	0	Negligible
Impacts on Aboriginal and European heritage **(8.2.1.3)**	0	6	0	Negligible
Impacts on noise levels – operational stage **(8.2.1.4)**	0	6	0	Negligible
Impacts on adjacent aquaculture lease **(8.2.1.5)**	0	6	0	Negligible
Work health and safety issues **(8.2.1.6)**	1	6	6	Low
Impacts on the local economy **(8.2.1.7)**	0	6	0	Negligible
Impacts on the Environment (8.2.2)				
Impacts on marine habitats – water quality, nutrients and sedimentation **(8.2.2.1)**	2	5	10	Moderate
Fish feed - source, composition and sustainability issues **(8.2.2.2)**	1	6	6	Low
Impacts of chemical use **(8.2.2.3)**	2	5	10	Moderate
Genetic composition of cultured stock and impacts of escaped cultured stock on wild stock genetics and competition **(8.2.2.4)**	1	6	6	Low
Disease transmission, cultured stock diseases & introduced pests **(8.2.2.5)**	3	3	9	Moderate

Impacts of artificial lights on fauna species **(8.2.2.6)**	1	6	6	Low
Entanglement and ingestion of marine debris **(8.2.2.7)**	1	6	6	Low
Animal welfare issues **(8.2.2.8)**	0	6	0	Negligible
Risk of vessel strike and acoustic pollution **(8.2.2.9)**	1	6	6	Low
Impacts on threatened and protected species **(8.2.2.10)**	1	6	6	Low
Impacts on migratory pathways (notably whales and sharks), behavioural changes and predatory interactions **(8.2.2.11)**	2	5	10	Moderate
Impacts on areas of conservation significance - World Heritage, Ramsar wetlands, MPA, national parks and critical habitat **(8.2.2.12)**	1	6	6	Low
Waste disposal - bio/general/equipment waste **(8.2.2.13)**	0	6	0	Negligible

8.1 Site Selection / Construction / Infrastructure Risks

This section investigates issues relating to site selection and the construction and deployment stage of the proposed Research Lease.

8.1.1 Habitat Loss and Shading

Table 15: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue of habitat loss and shading caused by the installation of the sea cage infrastructure (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the installation of the sea cages and associated infrastructure result in significant shading of the marine benthic environment or significant loss of marine habitat through modification, isolation, disturbance or fragmentation?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ What habitat will be modified, removed, isolated and/or fragmented by the installation of the sea cages and anchor/bridle systems?
▪ How much habitat will be disturbed?
▪ Will the sea cage infrastructure cause shading of the seabed or water column?
▪ Is this area of habitat critical to the survival of any resident or vagrant species in the direct or wider area?
▪ Is this habitat unique, under threat and/or restricted in extent/scale?
▪ Is similar habitat available in the direct and wider area?
▪ Are environmentally-sensitive areas (e.g. seagrass, mangroves and corals) present in or in close proximity to the Research Lease?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Total lease area = 20 ha (exclusion will only occur in the vicinity of the sea cages)
▪ Total seabed area beneath sea cages = 1 ha
▪ Total area of water column occupied by sea cages = 100,571 m^3
▪ Total seabed area occupied by anchors = 31.5 m^2</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Site selection
o No environmentally-sensitive or unique areas
o Habitat type beneath sea cages = unconsolidated sand
o An extensive area of similar habitat is available in the direct and wider area
▪ Open streamlined sea cage design</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification for Ranking

Visual interpretation of acoustic backscatter and hillshaded bathymetry data from seafloor surveys indicate that the substratum in the area proposed for the Research Lease in Providence Bay consists of soft sediments only, which are dominated by sand and coarse sand with a depth ranging from 15 to 22 m (NSW OEH, 2011b) (Appendix 4).

The seabed is inhabited by a range of organisms such as worms, crustaceans, molluscs, echinoderms, meifauna, microalgae and bacteria but there is no evidence of seagrasses, macroalgae or corals (Underwood and Hoskin, 1999; Hoskin and Underwood, 2001).The soft sediment habitat appears to extend from the intertidal area of Bennetts Beach off Hawks Nest to depths of around 60 m at a distance of about 8 km offshore (NSW OEH, 2011b).

The installation of the sea cages and associated infrastructure will impact on a relatively small area of soft sediment habitat beneath the sea cages and anchor blocks via smothering and/or exclusion. Based on the proposed design of eight 40 m floating double collared sea cages, the total seabed area directly underneath the sea cages is about one hectare or 1257 m^2 for each individual sea cage. In addition, there will be 14 anchors occupying a total seabed area of 31.5 m^2 or 2.25 m^2 for each individual anchor.

The installation of the sea cage infrastructure will result in loss of a relatively small area of pelagic habitat contained in the sea cages where the mesh nets extend from the floating HDPE collars on the water's surface down to a depth of about 10 m. The total area of the water column that will be occupied by an individual mesh net and the enclosed fish stock will be approximately 12,571 m^3 or a total of 100,571 m^3 for the eight sea cages.

Conclusion

The area of soft sediment and pelagic habitat that is expected to be impacted by the Research Lease (i.e. habitat loss and shading) is thought to be ‘negligible’ when considered in context with the extensive areas of similar habitat in the direct and wider study area. The installation of the sea cages will not isolate any habitat area which is considered unique in the direct or wider region and adjacent soft sediment and pelagic habitat is likely to support very similar fauna and flora assemblages to those in the immediate vicinity of the sea cages.

8.1.2 Decommissioning

Table 16: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the decommissioning of the Research Lease (modified from Fletcher *et al.*, 2004; Vom Berg, 2008).

Issue	Will the Research Lease area be significantly degraded that rehabilitation will be required to restore its pre-existing state after the five year trial?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Will the lease area need rehabilitation at the end of the trial period?* ▪ *Will the pre-existing state of the environment return after aquaculture activities cease?* ▪ *How long will it take for the environment to return to its pre-existing state, notably the benthic environment?*			
Description	▪ Proposed duration for Research Lease = five years ▪ Decommissioning proposed for the year after the trial is completed ▪ All infrastructure will be removed i.e. sea cages and anchoring/bridle system			
Proposed Management – Mitigation and Monitoring	▪ Site Selection o High energy environment o Reasonable depth (i.e. 15-22 m) o Unconsolidated fine to medium grained sand ▪ Small scale short-term research operation ▪ Fish feeding practices that aim to minimise impact o High quality feed o Pellet size appropriate to fish size (avoid small pellets) o Demand feeding regime i.e. avoid overfeeding ▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2) o Regular sampling – before, during and after trial			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

<u>*Justification of Ranking*</u>

Many studies have been conducted on the impacts of marine finfish sea cage farms on the benthic environment in Australian waters and in most cases the impacts have been found to be highly localised and restricted to the area beneath or in the immediate vicinity of sea cages (McGhie *et al*., 2000; Hoskin & Underwood, 2001; DPIWE, 2004; Woods *et. al.*, 2004; Felsing *et al*., 2005; McKinnon *et al*., 2008; Edgar *et al*., 2010; Tanner & Fernandes, 2010).

Several studies have investigated the effect of fallowing on the recovery of the benthic environment beneath fish cages and the results indicated that any anoxic sediments returned to oxic conditions within 12 to 24 months (Butler *et al*., 2000; McGhie *et al*., 2000; MacLeod *et al*., 2002).

MacLeod *et al*. (2002) for example, investigated the recovery of highly impacted sediment (i.e. high sulphide levels and a community structure indicative of hypoxic and polluted conditions) beneath the sea cages in North West Bay in Tasmania. The extent and severity of the impact rapidly diminished with both time and distance from the cages. Impacts were generally not detected at 35 m from the cages and after 24 months sulphide levels returned to control site levels. The benthic community directly below and within 10 m of the cages appeared to undergo a marked recovery after four months, although community composition was still different to the control stations.

Similarly, MacLeod *et al.* (2004) evaluated the sediment condition at an Atlantic Salmon farm in southeast Tasmania to assess the rate and extent of recovering after the stock was removed. The sediment beneath the cages was initially markedly degraded but the impact rapidly diminished with both time and distance where conditions had noticeably improved after two months. Chemical measures were shown to recover at a faster rate than the macrobenthos. After 36 months the sediment measures had recovered but benthic community structure was still different from the reference conditions.

McGhie *et al*. (2000) also investigated the composition and rate of degradation of organic waste deposited beneath and adjacent to fish cages in the Huon Estuary in Tasmania. The results indicated that organic waste was largely restricted to the area beneath the sea cages where only small amounts dispersed to the 20 m perimeter. After a 12 month fallowing period any anoxic surface sediments returned to normal oxic conditions, although a portion of organic waste still remained in the sediment.

A study conducted by the Australian Institute of Marine Science (AIMS) on the environmental impacts of the Bluewater Barramundi farm in the Hinchinbrook Channel in Queensland found that there was no evidence of organic waste accumulation in sediments beneath the cages and that the footprint of the farm on the benthos (assessed by analysis of sediment chemistry) appeared to be restricted to the lease area (McKinnon *et al*., 2008). Findings indicate that despite the farm's operation for more than 20 years, it has not had a significant impact on the adjacent marine environment (McKinnon *et al*., 2008).

MacLeod *et al*. (2008) also investigated the recovery of soft sediment benthic invertebrate communities which had been subjected to high levels of organic enrichment on an Atlantic Salmon farm site in southeast Tasmania. During the first few months after the removal of stock, there was limited evidence of recovery and the community was dominated by species characteristic of impacted conditions. The system had markedly improved after 12 months where there was a diverse range of species with functional roles similar to those at the reference sites. However, subsequent changes in community structure became relatively minor once the ecological function of the sediment was restored.

The installation of the sea cages in the high energy environment of Providence Bay at a reasonable depth (i.e. 15-22 m) where waters are well mixed by wave action and tidal currents (See Section 6.4 and 6.5) will greatly assist in mitigating impacts on the soft sediment environment. These conditions will assist with the dilution and dispersal of suspended and dissolved wastes from the sea cages by providing rapid water exchange and a large bottom area over which wastes can disperse before settling (Alston *et al*., 2006).

As the substrate within the boundaries of the Research Lease is composed of soft sediment no earth works will be required during decommissioning. The only substrate disturbance will be the removal of the anchors which will occupy an area of 31.5 m^2. The sandy substrate is relatively mobile and with a prevailing water current strength of approximately 0.1m/s through the site, the sands will naturally redistribute over the disturbed area.

In addition, efficient fish feeding practices will aid in minimising the impact of the sea cage trial on the soft sediment environment. The use of feed pellets that are a size that is appropriate to the fish, the use of high quality feed, avoiding the use of small feed particles and monitoring the behaviour of fish while feeding to avoid overfeeding i.e. demand feeding regime (Alston *et al*., 2006) will assist to minimise any impacts on water quality and the benthic environment.

Conclusion

The risk of the Research Lease area becoming significantly degraded and requiring rehabilitation after the five year trial is thought to be ‘low’ when considered in context with the findings of other sea cage farms in Australia, the high energy environment of Providence Bay, the feeding practices that will be adopted, the type of substrate present and the small scale, short-term, low intensity operation of the Research Lease. All of which indicate that it is highly likely that the soft sediment environment within the boundaries of the Research Lease will not be significantly impacted and any minor impacts will return to pre-existing conditions relatively quickly after the removal of the sea cage infrastructure.

8.1.3 Noise

Table 17: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue of noise during the construction and deployment stage (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will uncharacteristic noise levels be generated during the construction and deployment stage (i.e. in level, type and/or duration) and is it likely to have a significant impact on adjacent communities and/or marine fauna?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *What types of machinery will be employed during the construction and deployment stage?* ▪ *Will there be a significant increase in noise levels during the construction stage of the project?* ▪ *Is the noise uncharacteristic for the construction site and likely to exceed acceptable levels?* ▪ *Will the noise generated during the transport and deployment of the sea cage infrastructure disturb marine fauna, notably cetaceans, seals and turtles?* ▪ *What is the duration of the construction and deployment stage?* ▪ *What mitigation and management measures are available to minimise the level of noise generated?*			
Description	▪ Proposed construction site = Port of Newcastle o Noise generated will not be uncharacteristic for area. ▪ Construction stage = short-term duration (i.e. several months) ▪ Deployment stage = short-term duration (i.e. several weeks) ▪ Types of machinery = diesel generator, mobile crane, truck, handheld welder, other hand and small power tools			
Proposed Management – Mitigation and Monitoring	▪ Comply with *Protection of the Environment Operations (Noise Control) Regulation 2008* ▪ Comply with industry best practice for noise management ▪ Marine Fauna Interaction Management Plan & Observer Protocol (Appendix 2) o Employ observers when transporting and deploying sea cage infrastructure o Comply with the NPWS maximum approach distance for marine mammals			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

<u>*Justification of Ranking*</u>

(a) Impact on the Community

Noise will be generated in conjunction with the construction, transport and deployment of the sea cage infrastructure. When assessing the impact of noise generated during the construction stage, it is recommended that consideration is given to ambient noise levels, existing land uses, noise source level, duration of operation and deployment activities, presence of noise softening measures (e.g. buildings or topography variations) and the sensitivity of the receiving environment (Cardno Ecology Lab, 2010).

NSW OEH is responsible for the regulation of noise from activities scheduled under the *Protection of the Environment Operations Act 1997* (POEO Act). The *POEO (Noise Control) Regulation 2008* also sets certain limits on noise emissions from vessels, motor vehicles and domestic use of certain types of equipment (Web Reference 16). Similarly, the *Interim Construction Noise Guideline* outlines how impacts from construction related noise are managed (NSW DECC, 2009). These regulations and guidelines will be referred to during the construction and deployment stage of the project to ensure compliance with all relevant provisions (Web Reference 16).

Industry best practices for noise management will be employed during the construction and deployment of the sea cages to minimise the impacts of noise. Some examples of industry best practices include:

- Use of well-maintained sound suppression devices (e.g. barriers, baffles and mufflers) when operating equipment;
- Acknowledging concerns and complaints and aiming to resolve them cooperatively;
- Use courteous language in the vicinity of other waterway users;
- Ensure truck drivers are informed of designated vehicle routes, parking locations, acceptable delivery hours and other relevant practices e.g. no extended periods of engine idling and minimising the use of engine brakes;
- Maintaining good communication between the community and project staff; and
- Due to the potential for surrounding communities to be impacted by the noise generated during the construction stage, hours of operation are recommended as follows:
  - Monday to Friday – 7 am to 6 pm;
  - Saturday – 8 am to 4 pm; and
  - Avoiding construction work on Sundays or Public Holidays where possible.

The most likely construction site for the sea cages is the Port of Newcastle (operated by Newcastle Port Corporation). This area is dominated by industrial berths where vessels such as coal tankers, load and unload large amounts of goods on a daily basis (Cardno Ecology Lab, 2010). The sea cage construction will be undertaken in accordance with approvals for the selected land based site.

Conclusion

The risk of the noise associated with the construction of the sea cages having a significant impact on the community is thought to be 'low' when considered in context with the proposed location, which is an existing industrial area, the industry best practices that will be implemented and the short duration and small scale of the works.

(b) Impact on Marine Fauna

Some human activities such as oil exploration, coastal construction, seismic surveying and marine vessel transport, produce noises that overlap the hearing frequency of marine mammals which can interfere with communication and ambient sounds (Miller *et al*., 2000; Foote *et al*., 2004). Sound is the primary means for marine mammals, especially cetaceans, to communicate, detect prey and predators, navigate and obtain information about their environment (Hatch & Wright 2007; Weilgart, 2007a).

Marine fauna behaviour can potentially be disrupted by exposure to anthropogenic noise, including temporary shifts of migratory corridors or habitat areas, masking of calls to prey, conspecifics and/or important environmental sounds, as well as short-term behavioural reactions (Richardson *et al*. 1985). In particular, short-term reactions of cetaceans to disturbances range from alteration of dive rates, changes in direction and speed to increased aerial behaviour (Garciarena 1988; Blane and Jaackson 1995; Rivarola *et al*., 2001; Magalhães *et al*., 2002).

Responses of cetaceans to anthropogenic sound sources have been found to vary within and between species, habitat and sound type (Gulesserian, 2009). However, generally cetaceans appear to have a greater reaction threshold to steady, continuous sounds from stationary industrial activities, such as drilling, and a lower threshold to sound that is novel or increases in strength, such as an approaching vessel (Richardson *et al*., 1995; Richardson and Wursig, 1997). The behavioural state of an animal before being exposed to the activity has been found to strongly influence this threshold. Cetaceans for example, tend to be more responsive to potential disturbances when resting and less reactive when socialising, mating or feeding (Richardson and Wursig, 1997). In addition, an animal's age, sex and environmental factors (e.g. season and location) have been found to influence responses to stimuli (Perry 1998; Weilgart, 2007b).

Gulesserian (2009) monitored the surfacing characteristics of humpback whales on their northern migration while passing a construction site – a desalination plant off Cape Solander in Sydney. The results indicate that whales respond to construction activities in the same way as to vessels, including fewer numbers of blows, shorter surface times and shorter dive times. The blow rate or interval was not found to change in the presence of vessels but the blow interval was significantly different between periods of construction and no construction when there were no vessels (Gulesserian, 2009). However, whales did not respond differently according to the vessel interaction type (control, pre-exposure, exposure, post-exposure), distance to the closest vessel or number of vessels within 1000 m. Only dive times of pods in the absence of construction activities were influenced by the number of vessels i.e. dive time decreased when three or more vessels entered within 1000 m. Hence, construction activities had no additive effect on whale responses to vessels within 1000 m.

There is the potential for the transport and deployment of the sea cages to introduce anthropogenic noise (i.e. acoustic pollution) into the marine environment via increased marine vessel transport due to the towing of sea cage infrastructure and the installation of the anchors and chains. However, the proposed construction site – the Port of Newcastle, has frequent commercial shipping and recreational boating traffic including numerous large bulk shipping vessels, which constantly navigate in and out or moor in this region.

Marine vessel movements between the Research Lease and wharf facilities may be as high as six return trips per day during the deployment stage. Based on the estimates of vessel movements in and offshore of Port Stephens during summer and winter (See Section 8.2.1.2), the vessel movements associated with the deployment of the sea cages would only represent an increase of about 2.5 to 12% (depending on the time of year) of all movements in the region. This increase would also only be for a short duration i.e. several weeks. After the sea cages have been installed the number of marine vessel movements is expected to decrease to one to three return trips per day.

Observers will be employed to keep watch for cetaceans, pinnipeds and turtles while transporting and deploying the sea cage infrastructure to mininise any impacts associated with potential acoustic pollution. A travel distance of no less than 300 m from vessels will be maintained if there are any reports or sightings of marine fauna during transportation (Web Reference 25). Similarly, deployment operations will not be carried out until marine fauna are beyond 300 m from the boundary of the Research Lease.

The 300 m distance is based on the prescribed approach distances to marine mammals in NSW as stated in Clause 61 of the *NSW National Parks and Wildlife Regulation 2009* (Web Reference 25). However, if there are any signs of distress indicated by sudden or erratic changes in behaviour, including quick dives, aggressive behaviour and irregular changes in swimming speed and/or direction, the distance from these animals will be increased. If signs of extreme distress become apparent, deployment operations will cease until the animals are well away from the Research Lease (Web Reference 25).

A Marine Fauna Interaction Management Plan will be implemented during the deployment of the sea cage infrastructure, which includes an Observer Protocol (Appendix 2). Research Lease staff will monitor interactions between marine fauna, the sea cage infrastructure and service vessels. The behaviour and movement pathways of marine fauna, as well as details of the activities occurring in the area and the responses of Research Lease personnel will be documented.

Conclusion

The risk of marine fauna being significantly impacted by noise generated during the transportation and deployment of the sea cage infrastructure is thought to be 'low' when considered in context with the small scale and short duration of the activity, the existing noise levels and the management measures that will be implemented i.e. Marine Fauna Interaction Management Plan and Observer Protocol.

8.1.4 Land Based Infrastructure

Table 18: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts on existing land based infrastructure (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the existing land based infrastructure (i.e. roads, boat ramps, wharfs, jetties and waste facilities) be significantly impacted by the construction and/or operation of the Research Lease?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Is the necessary infrastructure (e.g. roads, wharfs, jetties, electricity & moorings) available in the Port Stephens and Newcastle area?* ▪ *Will any upgrades of existing infrastructure be required?* ▪ *Will there be any impacts on assets e.g. breakwaters or boat ramps?* ▪ *Will the construction and deployment of the sea cage infrastructure impact on air, soil and/or water quality?* ▪ *Are there any issues relating to waste management during the construction and deployment stage that need to be considered?*			
Description	▪ No new infrastructure required as existing land based facilities are adequate, including: o Port of Newcastle o PSFI o Nelson Bay Commercial Fishermen's Co-operative wharf o Port Stephens mooring facilities e.g. d'Albora Marina			
Proposed Management – Mitigation and Monitoring	▪ No specific management initiatives are considered necessary to manage the use of existing land based infrastructure.			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	0	6	0	**Negligible**
Reporting Requirements	Short justification			

Justification of Ranking

The Research Lease project does not require the construction of any new land based infrastructure or any foreseeable upgrades of existing facilities in the region. It is proposed that PSFI, the Port of Newcastle and possibly the Nelson Bay Commercial Fishermen's Co-operative will be utilised for construction and operational activities. Existing marina facilities in Port Stephens would also be used for mooring service vessels.

During the construction stage the movement of marine vessels between the Research Lease and wharf facilities may be as high as six return trips per day to install the sea cage infrastructure. Once the infrastructure is established the movement of vessels are expected to be in the range of one to three return trips per day to undertake feeding, net changing and cleaning, as well as other daily inspections and maintenance.

Vehicular movements to provide goods and services to the vessels will also be greatest during the construction stage. A range of vehicles will be required to supply the required components for the sea cage infrastructure including trucks and trailers. The number of vehicular movements has been estimated to be in the range of three to six movements per day to the wharf facilities at the Port of Newcastle, PSFI and possibly the Nelson Bay Commercial Fishermen's Co-operative.

The Port of Newcastle provides sufficient space for the assemblage of the sea cages and the movement of large vehicles. The wharf facilities at PSFI and the Nelson Bay Commercial Fishermen's Co-operative will also be suitable for transferring materials and providing services but will be restricted to small scale operations. Once the infrastructure has been installed the number of vehicular movements is expected to be reduced to about three to five per week.

Based on traffic data from the NSW Roads and Maritime Services (2004), it is estimated that the annual average daily traffic number for Nelson Bay Road is 13,096. Furthermore, vehicular traffic associated with the construction and operation of the Research Lease will represent less than 0.05% of the total number of vehicles on Port Stephens roads on any given day.

In addition, there are no obvious concerns relating to waste management or degradation of air, soil or water quality during the construction and deployment stage of the project as the activities will occur in an existing industrial area for a short duration.

Conclusion

The risk of existing land based infrastructure being significantly impacted by activities associated with the construction and operational stages of the Research Lease is thought to be 'negligible' when considered in context with the small scale and short duration of the research trial.

8.1.5 Structural Integrity and Stability – Sea Cage Infrastructure

Table 19: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – structural integrity and stability of the sea cage infrastructure (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will severe weather significantly impact on the structural integrity and stability of the sea cage infrastructure?
Level of Impact	Individual facility
Comments and Considerations	▪ *Will the sea cage infrastructure be able to withstand severe weather events?* ▪ *How will structural integrity of the sea cage infrastructure be ensured?* ▪ *Is it possible that the sea cages may break free and become a navigation hazard?* ▪ *What conditions are the sea cages expected to tolerate?*
Description	▪ Eight floating double collared sea cages (18 and 40 m diameter) o Knotless polypropylene or nylon netting ▪ Anchoring and bridle system o 1 to 5 tonne anchors o Heavy chains o 40 mm eight strand polypropylene rope ▪ Wave climate = moderate/high o Predominant wave/swell direction = northeast (summer); east southeast (rest of year) o Significant wave height > 4.5 m occurred < 1% of the time (1987-2004) o Storms = southeast wave direction o High energy waves (2-3m) = 21% of year o Low energy waves (< 1m) = 10% of year
Proposed Management – Mitigation and Monitoring	▪ Structural Integrity and Stability Monitoring Program (Appendix 2). o Regular inspections and maintenance o Inspections and maintenance immediately after severe weather o Nets will be checked for damage after being cleaned at the land based site and before being returned to the Research Lease ▪ Design and modifications o Use of existing and proven technologies o Modifications to sea cage infrastructure will be done by manufacturer or qualified structural engineer o Suitably qualified contractor or structural engineer oversees transport and deployment of sea cages o Verification of structural integrity and stability by manufacturers and/or structural engineers based on recorded wave climate data

Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

Justification of Ranking

The development of modern cage systems has largely occurred over the past 30 to 40 years (Scott & Muir, 2000). Sea cages were originally designed for sheltered inshore waters but are now increasingly being developed for exposed environments (Scott & Muir, 2000). Aquaculture engineering knowledge and sea cage technology has developed greatly since the initial deployment of aquaculture infrastructure in Providence Bay in the late 1990s, particularly with the movement of farms into high energy areas in the northern hemisphere.

Ongoing research is being undertaken into a number of engineering parameters in a range of environments to ensure the sustainable development of aquaculture infrastructure (Web Reference 42). This research is published in the scientific journal, *Aquacultural Engineering*, which aims to apply knowledge gained from basic research, which in turn can potentially be translated into commercial operations (Web Reference 42).

In addition to the ongoing development of engineering standards which are applied to specific components of aquaculture infrastructure, sea cage standards have or are being developed in a number of countries. The Norwegian Standard NS 9415 for example, was introduced in 2004 and a standard is currently being developed for Scotland. Since the standard was introduced in Norway there has been a dramatic decline in equipment failures and consequently, stock losses (Web Reference 43).

NSW DPI and associated industry partners will purchase the sea cage infrastructure from established suppliers or it will be constructed under the guidance of a suitably qualified person. Proven technologies and established engineering knowledge and models will be used during the design process. The design will accommodate the high energy environment of Providence Bay and be tailored to withstand the recorded maximums for wave height, tidal range, swell and wind speed (See Section 6.1, 6.4 and 6.5). Utilisation of the latest engineering knowledge and the sea cage standards will mitigate the risk of equipment failure and the occurrence of escapement events.

The principal structure will remain the same throughout the five year research period but there may be some modifications made to investigate the effectiveness of newly developed components in a high energy environment. However, any modifications made to the sea cages will be evaluated by the manufacturers and/or qualified structural engineers. A structural engineer or suitable qualified contractor will also be appointed to oversee and ensure that the long-term structural integrity, performance and design life of the sea cages is not compromised during transportation and deployment.

The main infrastructure will consist of eight floating double collared sea cages which will be secured using an anchoring and bridle system (Figure 35). The cages will be 18 or 40 m in diameter, depending on the number and size of the cultured fish. The anchoring system will be comprised of 1-5 tonne anchors connected to lengths of heavy chain and 40 mm eight strand polypropylene rope. The length of heavy chain will assist in ensuring that the floating double collared sea cages remain in their designated location and will also act as a ballast to maintain the anchor ropes in a taut state whilst allowing for depth changes associated with tides and wave action.

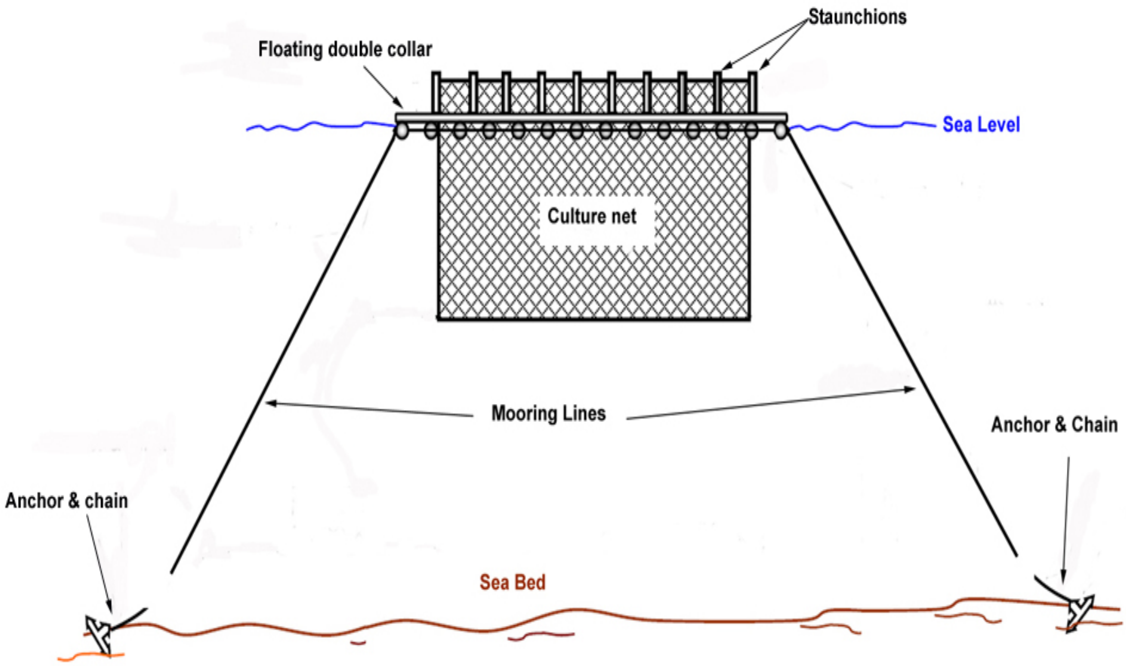

Figure 35: A diagram of the basic components of the sea cage infrastructure (Source: NSW DPI, 2012).

Mooring of the floating double collared sea cages using the anchoring system is likely to be through a bridle system in a grid array or another configuration that may be trialled to test its effectiveness as part of the experimental activities. Small buoys will be attached to the bridle/mooring system to assist with the mooring of the sea cages. This floatation, combined with the sea cages and chains will assist with maintaining taut ropes to prevent marine fauna entanglement and escapees.

The sea cages will be constructed out of HDPE pipes which will be bent and welded to form the circular floating collars. Floatation will be aided by air and/or expanded polystyrene foam contained in the pipes. During construction of the collars, a number of stanchions will be fed onto the pipes to strengthen the structure and to provide a mooring point (Figure 36).

Figure 36: Stanchions fed onto two HDPE pipes to form the double collar sea cage system (Source: NSW DPI, 2012).

The nets that the fish will be cultured in will be made from knotless polypropylene or nylon netting of a mesh size that is suitable for the size class of the fish being cultured. As mentioned above, these nets will be suspended from the floating sea cage structures and a weighting system will be incorporated to ensure the nets maintain an appropriate shape and are secured at the appropriate depth.

The sea cage infrastructure will be inspected regularly (including *in situ* SCUBA diving assessments) and cleaned of biofouling to ensure all components remain structurally sound and stable. Inspections and maintenance of sea cages and nets will also be conducted after net cleaning and severe weather to ensure that structural integrity has not been compromised. The inspection and maintenance procedures will be described in the Structural Integrity and Stability Monitoring Program (Appendix 2).

Conclusion

The risk of the structural integrity and stability of the sea cage infrastructure being significantly impacted (i.e. becoming dislodged or compromised in any way) by severe weather is thought to be ‘low’ when considered in context with the use of existing and proven technologies, including the latest engineering knowledge and sea cage standards, the use of qualified structural engineers to oversee modifications and transportation and the implementation of a Structural Integrity and Stability Monitoring Program which includes regular inspections and maintenance.

8.1.6 Climate Change and Coastal Processes

Table 20: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – climate change and impacts of the sea cage infrastructure on coastal processes and water flow (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the installation of the sea cage infrastructure have a significant impact on coastal processes and water flow in Providence Bay? Is climate change likely to have a significant impact on the operation of the Research Lease?
Level of Impact	Individual facility
Comments and Considerations	▪ *Will the sea cage infrastructure interrupt water movement in Providence Bay e.g. flushing rates, wave action, water circulation or any other coastal processes?* ▪ *Is the sea cage infrastructure likely to cause changes in wave behaviour, including wave dispersion and creation via amendments to orbital/oscillatory motions?* ▪ *Is coastal inundation or wave run up/reflection an issue?* ▪ *Is climate change expected to have a significant impact on the operation of the Research Lease?*
Description	▪ Wave processes in Providence Bay = refraction, shoaling, diffraction and reflection ▪ Wave climate = moderate/high o Predominant wave direction = northeast (summer); east southeast (rest of year) o Storms = southeast wave direction ▪ Semidiurnal and microtidal (mean range 0 to 1.6 m) ▪ Ebb and flood flow = 0.1 to 0.3 m/sec ▪ Current flow = mostly north-south or south-north direction ▪ Significant climate change expected in long-term (i.e. changes occurring over several decades)
Proposed Management – Mitigation and Monitoring	▪ Sea cage design o Streamlined o Flexible o Open ▪ Regular cleaning of nets and mooring lines ▪ Site selection = minimise interactions with wave processes: o Reasonable depth (15-22 m) o Several km from shore, offshore islands and geomorphological formations ▪ Five year research period ▪ Design of sea cage infrastructure - withstand wave climate maximums ▪ Proposed cultured species – broad temperature and salinity tolerances

Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	0	6	0	**Negligible**
Reporting Requirements	Short justification			

Justification of Ranking

Waves travelling from deep water to the shallower areas may be transformed by the processes of refraction, shoaling, attenuation, reflection, breaking and diffraction (Demirbilek, 2002). At the depth of the proposed Research Lease (15 to 22 m), the main wave transformation processes are likely to be refraction, shoaling, diffraction and reflection. Orbital velocities and accelerations in the water column below are also generated by waves.

Infrastructure in the marine environment has the potential to alter existing coastal processes. In particular, solid obstructions can potentially have significant ramifications on wave processes e.g. changes to wave dispersion and creation via amendments to orbital and oscillatory motions, wave run-up, reflection, refraction and diffraction. However, the proposed sea cage infrastructure is not a solid obstruction but an open structure of mesh nets (Figure 37) and mooring infrastructure consisting of ropes and chains, which will be secured to the seafloor using a system of anchors.

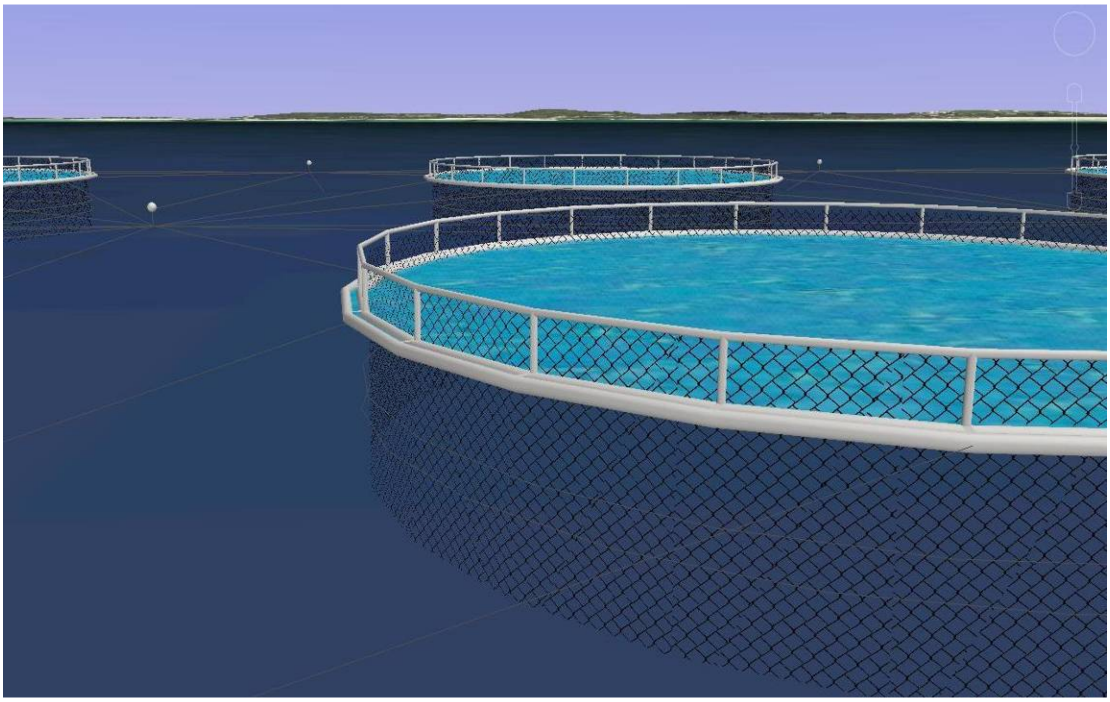

Figure 37: Proposed design for sea cages - open structure of mesh nets (Source: NSW DPI, 2011).

The profile of the Research Lease subsurface infrastructure will not significantly impede the path of waves or currents. The double collar sea cages will be constructed from HDPE pipes which will float on the water's surface and have a degree of flexibility. Waves are expected to pass under, over and through this infrastructure with no significant alteration to wave processes or currents in Providence Bay due to the sea cage's streamlined, open and flexible design. The nets and mooring lines will also be cleaned regularly to ensure biofouling does not build up and obstruct water movement including wave action, currents and flushing.

The Research Lease is situated in an area with an average depth of about 20 m and is located several kilometres from any geomorphological formations (i.e. rocky reefs or bomboras), the coastline (3.5 km) and offshore islands (2 km). This isolated locality will also assist to minimise alterations to wave processes in Providence Bay which are generally more prominent in shallower waters closer to the coastlines, offshore islands and surrounding reefs in which there is greater friction with the seabed or other substrates.

Concerns about the impact of climate change on the operation of the Research Lease have been raised during consultation, including the impact of sea level rise, temperature changes, increased frequency and severity of severe weather, as well as ocean acidification. In regards to rises in temperature and sea level, these factors are considered to be negligible to the research proposed for the Research Lease when considered in context with the five year trial period. Coastal temperatures are predicted to increase by 0.2 - 1.6° C by 2030 (Smith *et. al*., 2010) and sea level on the NSW coast is expected to increase by 0.18 – 0.91 m by 2090 – 2100 (NSW DECC, 2007b). Furthermore, the impact of climate change on marine aquaculture is an issue of concern in the long-term and will need further investigation in the next few decades but is not expected to be of a significant concern in the short-term.

Potential climate change impacts during the five year research period will be mitigated by ensuring that the design of the sea cage infrastructure accommodates the high energy environment of Providence Bay and is tailored to withstand the recorded maximums for wave height, tidal range, swell and wind speed (See Section 6.1, 6.4 and 6.5). The cultured species proposed for the Research Lease also have relatively broad temperature and salinity tolerances so the stock is likely to be able to cope with any fluctuations in these parameters during the research trial.

Conclusion

The risk of coastal processes and water flow being significantly impacted by the installation of the sea cage infrastructure is thought to be 'negligible' when considered in context with the streamline, flexible design of the cages, the regular cleaning regime that will be implemented and the deep water locality away from geomorphological formations. The impact of climate change on the operation of the Research Lease is also thought to be 'negligible' when considered in context with the proposed five year research period, the sea cage design and the species that will be cultured.

Navigation and Interactions with Other Waterway Users

Table 21: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts of Research Lease on navigation and other waterway users (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the Research Lease have a significant impact on navigation and other waterway users in Providence Bay?
Level of Impact	Individual facility
Comments and Considerations	▪ *Will the Research Lease be a navigation hazard for other waterway users?* ▪ *Is the Research Lease in a high use area or area of restricted navigation?* ▪ *Will the boundaries of the lease be marked with buoys and/or lights?* ▪ *How will waterway users be informed and notified about the installation of the sea cage infrastructure?* ▪ *Can other waterway users enter and anchor in or near the lease area?* ▪ *Will the Research Lease exclude other waterway user groups (e.g. dive operators, recreational and commercial fishers, dolphin/whale watching operators) from using an area they previously had access to?* ▪ *Will the Research Lease exclude other waterway users from an area that is unique in the direct and wider study area?* ▪ *How will the security of the lease be maintained?* ▪ *Are there any subsequent ramifications to the exclusion of other waterway user groups from the lease area?*
Description	▪ Area of Research Lease = 20 ha o Total surface area occupied by sea cages = 1 ha ▪ Four navigational marks will be place on the corners of the Research Lease ▪ Other waterway users include recreational and commercial fishers, dive and fishing charters, sailors and whale/dolphin watch operators
Proposed Management – Mitigation and Monitoring	▪ Location = open marine waters o Outside any recognised navigation channels or shipping port approaches o Does not obstruct route predominantly taken by vessels heading to Broughton Island o Does not obstruct recognised yachting courses or significant commercial and recreational areas e.g. fishing grounds, diving sites and whale/dolphin watching areas ▪ Staff will have relevant licences and qualifications, undergo regular training and abide by NSW Maritime regulations. ▪ Four navigational marks will delineate the Research Lease ▪ Traffic Management Plan (Appendix 2)

	▪ Target user groups will be informed about general boating rules in the vicinity of the Research Lease – keep safe distance and do not anchor in the Research Lease given WH&S concerns ▪ Australian Hydrographic Office will be notified, a 'Notice to Mariners' will be issued and official charts amended ▪ Relevant publications and maps will be amended to include Research Lease ▪ Comply with the *Australian Aquaculture Code of Conduct*			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	0	6	0	**Negligible**
Reporting Requirements	Short justification			

Justification of Ranking

The degree of impact of sea cage infrastructure on the safe navigation of vessels and other waterway users in an area depends on its placement in relation to features such as narrow channels, established navigation channels, identified anchorages, recreational and commercial areas, as well as how clearly marked and visible the structures are to other waterway users, particularly during severe weather.

The proposed location for the Research Lease is in the open marine waters of Providence Bay and not in any recognised navigation channels or shipping port approaches. The Research Lease will not obstruct the route predominantly taken by recreational and commercial vessels travelling to Broughton Island or dolphin/whale watching operators that venture north of Cabbage Tree Island. The Research Lease is also not in a recognised SCUBA diving site or significant commercial or recreational fishing ground and should not adversely impact yachting regattas held in the area.

The proposed Research Lease covers an area of 20 hectares which is not unique in the direct or wider area of open ocean in Providence Bay. Target waterway user groups will be informed about general boating rules in the vicinity of the Research Lease and will be strongly recommended against passing and anchoring in the immediate vicinity of the sea cage infrastructure given Work Health and Safety (WH&S) concerns. It is an offence to interfere with or damage the sea cage infrastructure or stock under the FMA.

The security of the Research Lease is important to ensure that the integrity of the research that is conducted is not compromised. The combination of operational visits to the Research Lease along with remote surveillance measures will be employed ensure the security of the Research Lease.

To ensure weather conditions are suitable for the deployment of the sea cage infrastructure, the weather forecast for NSW coastal waters will be consulted. Transportation of the sea cages will occur during a calm sea state to ensure successful deployment and minimise the risk of incidents and infrastructure damage. Before departing the construction site, NSW DPI will comply with any management plan issued by the Newcastle Port Authority to ensure that it is safe to proceed and that no large shipping movements will be interfered along the proposed transport route. Navigation may be slightly impeded during the transportation and deployment of the sea cages i.e. other waterway users will be excluded from the direct transport route but these activities are short-term and will not compromise waterway user safety.

It is a NSW Roads and Maritime Services requirement that the extremities of aquaculture leases are marked with appropriate navigational marks. In the marine environment these marks are required to be lit and the leases must be marked on navigational charts to aid safe navigation. Navigation buoys will be positioned on the four corners of the Research Lease in accordance with NSW Roads and Maritime Services requirements and IALA recommendations (Figure 38).

Figure 38: Navigation markers commonly used to mark the boundaries of aquaculture leases (Source: NSW DPI, 2012).

Navigation safety in the area of the Research Lease will also be maintained by ensuring that all staff partaking in marine vessel transport obtain relevant licences and qualifications, undergo regular training and abide by NSW Roads and Maritime Services regulations and the *Australian Aquaculture Code of Conduct* (Appendix 7). The Code of Conduct specifies that aquaculturists can respect the safety and rights of other waterway users by recognising their needs, promoting methods to minimise user conflicts, encouraging consultation with all waterway users to enable concerns to be identified and resolved, promoting goodwill in the community and providing opportunities for education (Web Reference 17).

The Australian Hydrographic Office will be notified of the location of the Research Lease, a ‘Notice to Mariners’ will be issued and official charts will be amended. NSW Roads and Maritime Services will also be notified of the Research Lease location so relevant publications and maps can be amended to include its location (Figure 39).

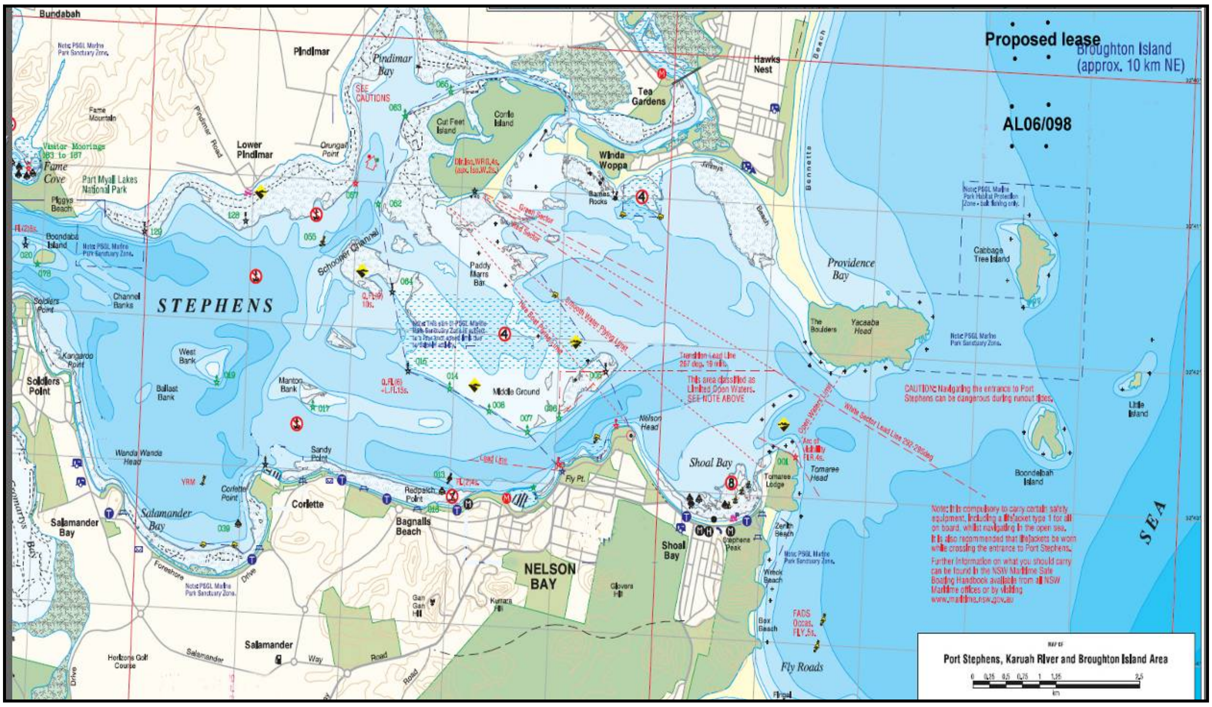

Figure 39: An extract from a NSW RMS map depicting navigation marks in Port Stephens. NSW RMS maps would be updated to include the boundary of the Research Lease and the four navigation markers on the corners of the lease area (Source: NSW RMS, 2011).

A Traffic Management Plan will be implemented to minimise and monitor any impacts on navigation and other waterway users during the construction and operational stage (Appendix 2). All interactions with between the Research Lease and other waterway users will be documented on a daily basis and reviewed periodically.

Conclusion

The risk of safe navigation and other waterway users being significantly impacted by the Research Lease and its operation is considered to be ‘negligible’ as it is not located in a high use area, it is not obstructing safe navigation, it is not located in an area of significant recreational or commercial importance and the area is not unique in the direct or wider study area. In addition, appropriate navigational marks will be displayed, notifications will be made to relevant authorities and the community, amendments will be made to relevant documents, Research Lease staff will act in accord with the *Australian Aquaculture Code of Conduct* (Appendix 7) and waterway user interactions will be regularly reviewed.

8.2 Operational Risks

This section investigates issues relating to the operation of the proposed Research Lease.

8.2.1 Impact on the Community

8.2.1.1 Visual Amenity and Odours

Table 22: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – visual amenity and odours levels (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the Research Lease have a significant impact on visual amenity and/or odour levels in Providence Bay?
Level of Impact	Individual facility
Comments and Considerations	▪ *Will the sea cages be visible from Bennetts Beach, Tomaree Head Summit or Tea Gardens hinterland?* ▪ *Can the sea cages be designed to minimise their visibility from a distance e.g. colour, profile and size?* ▪ *Will a 'fishy odour' or oil slick be detectable from the beach or offshore islands?* ▪ *What management measures are required to ensure odours do not exceed acceptable levels?*
Description	▪ Two major land based vantage points o Summit of Mount Tomaree o Hawks Nest Surf Lifesaving Club ▪ Distance to nearest landmarks: o Bennetts Beach = 3.5 km o Hawks Nest residential area = 4 km o Cabbage Tree Island = 2 km ▪ Four navigation lights may be visible from beach at night.
Proposed Management – Mitigation and Monitoring	▪ Design features that minimise visibility will be utilised o Dark coloured materials o Low profile o Small scale and short-term o Subsurface infrastructure ▪ Waste Management Plan (Appendix 2) o Demand feeding regime using dry pelletised feed (opposed to whole fish) o Regular cleaning of nets o Removal of injured/deceased stock ▪ Vessels used will be similar to existing ▪ Restricted visibility from major land based vantage points

Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

Justification of Ranking

Visual impacts are subjective and difficult to quantify as perceptions and attitudes vary considerably (O'Hanlon, 2004). Marine aquaculture facilities are often placed in open waters where there are no permanent man made structures. The installation of aquaculture infrastructure alters views from passing vessels and potentially adjacent land areas (O'Hanlon, 2004).

Research Lease infrastructure will consist of up to eight floating double collared circular sea cages with a diameter of 18 or 40 m. Additional piping will be secured about 1-2 m above the water's surface to form a railing supported by stanchions, which will be used to secure the culture nets and the bird exclusion nets. The anchoring and bridle system will largely not be visible from the surface except for some lengths of polypropylene rope and small mooring buoys. The four navigation buoys, including flashing lights, will be secured at the corners of the lease, which are likely to be visible from Hawks Nest at night.

A number of design features will be utilised to minimise the visibility of the sea cage infrastructure, including the use of dark coloured materials (e.g. black stanchions), minimising and streamlining surface infrastructure, maximising subsurface infrastructure and maintaining a low profile and small scale design.

The location proposed for the Research Lease is approximately 4 km from Hawks Nest which is the nearest residential area. The township is predominantly screened from view of the Research Lease by coastal sand dunes along the beach front. There are two major land based vantage points in the region with high visitor numbers from which persons may be able to view the sea cage infrastructure, including the summit of Mount Tomaree and Hawks Nest Surf Lifesaving Club. The Summit of Mount Tomaree is not considered to be visually impacted by the Research Lease as it will be blocked from view by Mount Yacaaba (Figure 40). Some elevated locations in the Tea Gardens hinterland could offer a long distance view of the Research Lease during calm sea state conditions.

Hawks Nest Surf Lifesaving Club and car park is positioned 3.5 km southwest of the Research Lease at a slightly elevated position. The sea cage infrastructure, navigation lights (at night) and service vessels are likely to be visible in the distance from this vantage point during calm and clear weather conditions (Figure 41). As Providence Bay is predominately a high energy environment with wave height exceeding 0.7 m for 50% of the year (Willoughby, 1998), it is expected that the sea cages may be difficult to see for much of the trial period.

Research Lease service vessels will be very similar to existing fishing, dive and whale/dolphin watching boats that frequently navigate within Providence Bay and are visible from the shoreline.

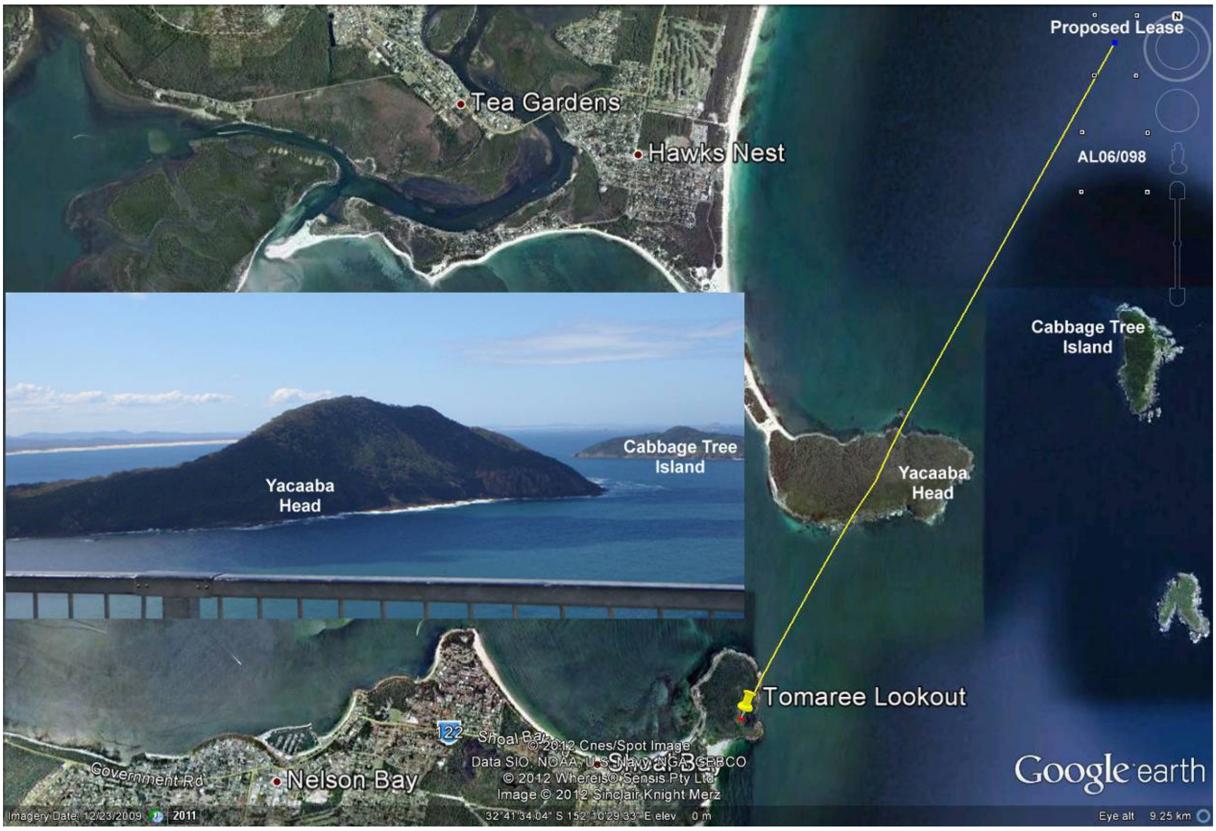

Figure 40: The Research Lease is blocked from view by Mount Yacaaba when viewed from the lookout on Mount Tomaree (Source: NSW DPI, 2012).

Figure 41: View of the approximate locations of the Research Lease and the existing aquaculture lease from Hawks Nest Surf Club (Source: NSW DPI, 2012).

Figure 42 depicts the view of a sea cage from the shoreline of Boston Bay in Port Lincoln, South Australia, which is approximately 3 km offshore (Figure 43). Despite the calm sea state conditions, the sea cage and service vessel are only slightly visible from the shoreline. The Research Lease is a greater distance offshore than the depicted sea cage and is positioned in a predominately high energy environment so it is likely to be less visible from the shoreline.

Figure 42: View of a sea cage from the shoreline in Boston Bay, Port Lincoln. The insert depicts a close up of the service vessel and sea cage on the aquaculture lease (Source: NSW DPI, 2012).

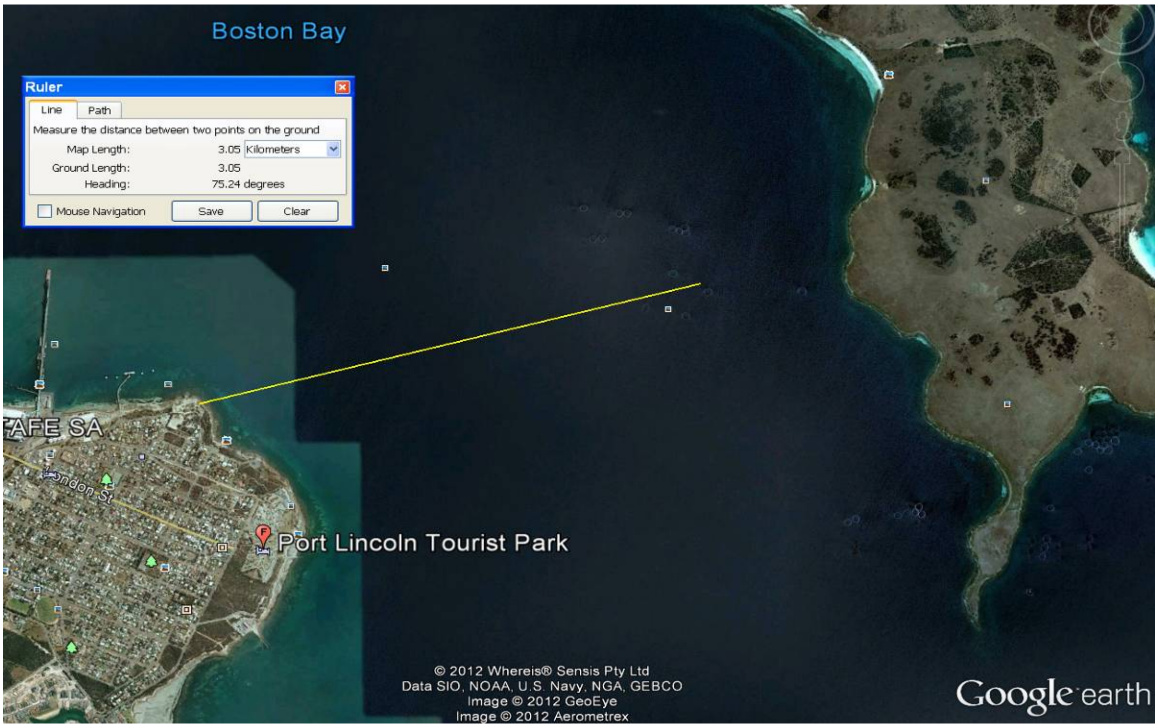

Figure 43: The distance of the sea cage from the shoreline in Boston Bay, Port Lincoln is about 3 km (Source: Google Earth, 2012).

To manage potential odour issues associated with the Research Lease, including dead and decaying stock, waste disposal bins, spilled or incorrectly stored feed, biofouling, chemicals and engine exhausts used on the farm, a number of daily operational and maintenance procedures will be implemented which will be described in the Waste Management Plan (Appendix 2).

Some of the daily operational and maintenance procedures that aim to mitigate potential odour issues include regular cleaning of nets to reduce the amount of biofouling available (e.g. submersible net cleaning robots), using pelletised feed opposed to whole fish thereby minimising oil slicks, regularly removing badly injured, moribund and deceased stock and placing in sealed bins when transporting to an approved disposal facility on shore, using a demand feeding regime to minimise excess food entering the water column and tightly securing storage containers and waste bins with fitted lids.

Conclusion

The risk of the visual amenity of Providence Bay being significantly impacted by the installation of the sea cage infrastructure and activities associated with the operation of the Research Lease is considered to be ‘low’ due to the distance from key landmarks, the sea cage design features that will be utilised, the use of vessels that are similar to existing boats in the area and the high energy sea state conditions that are characteristic of Providence Bay. The risk of the Research Lease significantly increasing odour levels in Providence Bay is also considered ‘low’ due to the Waste Management Plan that will be implemented to mitigate any potential issues.

8.2.1.2 Marine Vessel and Vehicular Transport

Table 23: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – marine vessel and vehicular transport associated with the operation of the Research Lease (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will marine vessel and vehicular transport associated with the operation of the Research Lease have a significant impact on the communities and visitors of Port Stephens and Hawks Nest?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ Will there be a significant increase in the number of marine vessel movements in Port Stephens and Providence Bay due to daily operations and maintenance?
▪ Will there be a significant increase in the number of road vehicle movements around Port Stephens due to daily operations and maintenance?
▪ Is the expected increase in marine vessel and vehicle movements likely to pose navigation and/or congestion issues on the waterways or roads of Port Stephens?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Research Lease marine vessel movements
o 1-7% increase (Port Stephens)
▪ Research Lease vehicular movements
o < 0.05% increase (Port Stephens)</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Staff will obtain relevant licences, qualifications, regular training, abide by regulations and consult weather forecasts
▪ NSW Roads and Maritime Services will be notified when transporting sea cages
▪ Vehicle loads will be safely secured and covered if possible
▪ Movements of vehicles will be limited to normal working hours
▪ Appropriate flags, symbols and signs will be displayed
▪ Traffic Management Plan (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification of Ranking

(a) Marine Vessel Transport

Recreational and commercial boating activity is more intensive during the summer season, particularly around Christmas and New Year and of a lesser intensity during winter (T.

Woodfield 2011, *pers. comm.*). According to Marine Rescue NSW up 200 vessels can use Port Stephens waterways each day during the peak summer period and as few as 20 during winter. The NSW Roads and Maritime Services Regional Boating Safety Officer for Port Stephens commented that a portion of these vessels navigate around the waters west of Cabbage Tree Island predominately to gather bait fish (T. Woodfield 2011, *pers. comm.*).

A number of recreational fishing and diving competitions are also held during the warmer months which dramatically increase vessel movements in the region. The Club Marine Trailer Boat Fishing Tournament for example, was held during March 2012 involving about 440 vessels. Similarly, the NSW Interclub Game Fish Tournament and the Nelson Bay Spearfishing Challenge held in February 2012 involved about 170 and 20-40 vessels, respectively. Two to three commercial fishing vessels operate offshore near and in Providence Bay (W. Bennett 2011, *pers. comm.*) but a number of commercial fishing vessels operate in the estuary.

Vessel movements associated with commercial charters, including diving, fishing, whale and dolphin watching, are also greatest during the warmer months. Dolphin and whale watching operators for example, may undertake up to three return trips per vessel per day in summer where there is currently at least seven vessels operating in Port Stephens. Hence, dolphin and whale watching vessel movements in Port Stephens are estimated to be at least 21 trips during the peak summer period. During winter, dolphin and whale watching operators are estimated to undertake between 1-2 return trips per vessel per day. Four of the seven dolphin and whale watching vessels operate in offshore waters including Providence Bay.

Other commercial charter operators in Port Stephens include two dive operators which are estimated to undertake 1-2 return trips per day, several fishing charter vessels which undertake 1-2 return trips per day, a parasailing operator which undertake 1-5 trips per day, a ferry service between Nelson Bay and Tea Gardens which undertake 3 trips per day, as well as one offshore dolphin swim operator and several operators that undertake scenic tours, sunset dinner cruises and transfers out to Broughton Island based on demand. However, there are also periods where there are no vessel movements due to weather, notably winter, maintenance and consumer demands.

During the operational stage of the Research Lease marine vessel movements are expected to be in the range of one to three return trips per day to undertake data collection, feeding, net cleaning and changing, inspections and maintenance of infrastructure. Consequently, marine vessel transport associated with the Research Lease is not considered significant as such movements would only represent an estimated increase of about 1-7% (depending on the time of year) of marine vessel movements in and around Port Stephens.

A number of management measures will be implemented to ensure the safety of staff and other waterway users while partaking in marine vessel transport. Staff will have relevant licences and qualifications, undergo regular training, abide by NSW Maritime regulations and consult the weather forecast for NSW coastal waters before departing for daily operations and maintenance. Notice of the dates and times for transportation of the sea cages to and from the Research Lease for cleaning, maintenance and repair will be given to NSW Maritime in Nelson Bay, Tea Gardens and Newcastle. Appropriate flags, symbols and signs will also be displayed on marine vessels, such as the Diver Down flag. A Traffic Management Plan will be implemented throughout the operational stage to ensure service vessels associated with the Research Lease do not cause congestion, impede safe navigation or have any other impact on other waterway users (Appendix 2).

Concerns have been raised about potential fuel or oil spills associated with marine vessel movements in the region. NSW Roads and Maritime Services is the responsible regulatory authority under the POEO Act for pollution (including fuel and oil spills) from vessels in the Marine Park. NSW Roads and Maritime Services will be contacted immediately any pollution is detected. In the very unlikely event of a large scale and/or severe pollution incident, the event will be managed in accordance with the *NSW State Waters Marine Oil and Chemical Spill Contingency Plan*.

Conclusion

The risk of the marine vessel transport associated with the Research Lease having a significant impact on other recreational or commercial waterway users via impeding safe navigation and/or access to wharf, mooring and jetty facilities is thought to be 'negligible' when considered in context with the relatively minor increase in vessel movements and the Traffic Management Plan that will be implemented.

(b) Vehicular Transport

The number of vehicular movements during the operational stage is likely to between two and four trips per week to supply feed, facilitate net changes and transport harvested stock. Staff vehicular movements to the location where the marine service vessels are moored would be in the order of two to six trips per day.

Based on the Traffic Volume Data for the Hunter and Northern Rivers Region, it is estimated that the annual average daily traffic number for Nelson Bay Road is 13, 096 (NSW RMS, 2004). Consequently, it is considered unlikely that vehicular movements associated with the Research Lease will have a significant impact on other road users or the integrity of pavements and other road infrastructure as it would represent less than a 0.05% increase in vehicular movements.

The marine vessel mooring facilities proposed for Research Lease vessels have vehicular parking areas which will assist to minimise disruption to other road users. The commercial facility in the Port of Newcastle also has sufficient space for the movement of large vehicles if they are required during the operational stage of the Research Lease. The wharf facilities at PSFI and the Nelson Bay Commercial Fishermen's Co-operative are also suitable for transferring materials and providing services but will be limited to small scale operations.

A Traffic Management Plan will be implemented to ensure the safety of staff and other road users involved with vehicle transport (Appendix 2). Staff will have relevant licences and qualifications, undergo regular training and abide by NSW RMS regulations. All vehicles transporting materials will have their loads safely secured and covered if required. To comply with noise regulations the movements of vehicles, notably trucks and construction vehicles, will be limited to normal working hours and signage will be erected to warn motorists of traffic entering and leaving land based sites if considered necessary.

Conclusion

The risk of the vehicular traffic associated with the Research Lease having a significant impact on other road users via impeding safe driving or increasing congestion levels on roads, in parking areas, around boat ramps or waste facilities is thought to be 'negligible' when considered in context with the relatively minor increase in vehicular traffic and the Traffic Management Plan that will be implemented.

8.2.1.3 Aboriginal and European Heritage

Table 24: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – Aboriginal and European heritage items and areas (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the Research Lease have a significant impact on Aboriginal or European heritage items or areas?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Are there any Aboriginal or European Heritage items and/or areas in Providence Bay?* ▪ *Are there any shipwrecks and plane wrecks in Providence Bay?* ▪ *Will the Research Lease and associated activities have an impact on any heritage items?*			
Description	▪ Original inhabitants of Port Stephens area = Worimi & Wonnarua Aboriginal people ▪ Aboriginal heritage o Two Aboriginal campsites = 2 km south; Cabbage Tree Island o Dark Point (Aboriginal Place) = 7.6 km north west; Myall Lakes NP ▪ European settlement of Port Stephens = 1812 ▪ European heritage o *SS Oakland* shipwreck = 1.7 km southeast o *SS Macleay* shipwreck = 5 km southeast			
Proposed Management – Mitigation and Monitoring	▪ Consultation and seafloor survey results support the assessment that no items or areas of heritage significance ▪ Significant buffer zone to prevent impact (> 2 km)			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	0	6	0	**Negligible**
Reporting Requirements	Short justification			

<u>*Justification of Ranking*</u>

(a) Aboriginal Heritage

"Aboriginal communities have an association and connection to the land. The land and water within a landscape are central to Aboriginal spirituality and contribute to Aboriginal identity. Aboriginal communities associate natural resources with the use and enjoyment of foods and medicines, caring for the land, passing on cultural knowledge and strengthening social bonds. Aboriginal heritage and connection to nature are inseparable from each other and need to be managed in an integrated manner across the landscape" (DECCW, 2010a).

Relevant NSW and Commonwealth Legislation

NSW Aboriginal heritage management is guided by the following legislation (NSW OEH, 2011a):

- *National Parks and Wildlife Act 1974;*
- *Environmental Planning and Assessment Act 1979*;
- *Heritage Act 1977*;
- *Aboriginal Land Rights Act 1983*;
- *Native Title Act 1993* (Commonwealth); and
- *NSW Native Title Act 1994*.

Under the *National Parks and Wildlife Act 1974*, Aboriginal objects and Aboriginal places in NSW are protected and any proposed activity that may harm an Aboriginal object or a declared Aboriginal place must be investigated and assessed (Web Reference 38). After consulting with the NSW NPWS it became apparent that the proposed Research Lease is not subject to the Act as it is sea based. Nevertheless, the proponent still wants to assess if there are any items or areas of Aboriginal heritage value that may be impacted by the Research Lease.

Review of Existing Information

Information and data on Aboriginal heritage in the Port Stephens region was sourced from literature, previous heritage studies, field investigations, database searches and community consultation.

i. Literature

Available literature indicates that Aboriginal people from the Worimi and Wonnarua Tribes are the original inhabitants of Port Stephens and the surrounding regions. The tribal relationships between the Aboriginal clans (*nurras*) in the area are inconclusive but it is believed that there was a definite relationship between clans from Gloucester and the Williams River through to Port Stephens (Roberts, 2000).

Many clans were observed having a well developed kinship structure and extended family groups (Walsh, 1999 cited in Roberts, 2000). All clans on the southern side of Port Stephens (i.e. Nelson Bay area) were of the Worimi Tribe but relationships between clans were apparently not as distinct as they were in the north.

The Stockton Bight area, which extends from the Hunter River to Tomaree Peninsula, was believed to be inhabited by the *Malangal nurra* while the *Garugal nurra* was thought to inhabit the Tilligerry and Karuah region (Roberts, 2000). The Aboriginal people were hunters and gatherers and there are records describing their healthy appearance, large numbers and the abundance of food (Roberts, 2000).

There is a paucity of archaeological surveys in the Port Stephens region but investigations conducted for the Port Stephens Council in 1992 revealed that Aboriginal occupation was predominately confined to the coastal strip and rarely extended beyond 2 km inland (Roberts, 2000).

There are records of fishing in Port Stephens, including canoe trips out to Cabbage Tree and other offshore islands (Roberts, 2000). Aboriginal people of the Worimi Tribe were the first to utilise the islands and were capable watercraft users building canoes from bark stripped from local trees (DECCW, 2010a). The islands provided the Worimi people with ample food resources, including seeds, tubers, shearwaters, seals, shellfish, bird eggs and rainforest fruits (DECCW, 2010a). Evidence of past Aboriginal occupation of Cabbage Tree Island includes two campsites with associated grinding stones, shell middens and tool-making objects (DECCW, 2010a). The sites do not receive conservation management attention as they are adequately protected in their natural state (DECCW, 2010a).

ii. Field Investigations

A survey of the seafloor beneath the area proposed for the Research Lease was undertaken by NSW OEH in November 2011. No large items that may be considered to be of submerged Aboriginal cultural heritage were observed during the swath acoustic survey (Appendix 4).

In addition, field observations have been made and the proposed location for the Research Lease is not in close proximity to a landscape feature that may indicate the presence of Aboriginal objects, such as a headland, sand dune system, cliff face, cave or rock shelter. The site is 2 km from Cabbage Tree Island which is considered a significant buffer zone to ensure there is no impact on the two Aboriginal campsites on this island.

The proposed site is positioned 3.5 km offshore in a high energy marine environment with a depth ranging from 15 to 22 m over a seabed with a substrate of mobile sands. There is no record of any detailed archaeological investigations of the seabed in Providence Bay and this is considered to be largely due to the mobile nature of the sandy seabed and strong current flows in this region which would hamper such investigations.

iii. Database Searches

A database search was conducted to identify any documented Aboriginal cultural heritage issues pertaining to the proposed location and surrounding areas which may be impacted by the Research Lease. NSW DPI undertook a search of the Aboriginal Heritage Information Management System (AHIMS) database. The AHIMS contains information and records about

Aboriginal objects that have been reported to the Director-General of the Department of Premier and Cabinet, and Aboriginal places which have been declared by the Minister to have special significance with respect to Aboriginal culture (Web Reference 39).

The search was conducted in February 2012 for the area proposed for the Research Lease using the co-ordinates: 32.68036 S, 152.19794 E; 32.65282 S, 152.24393 E with a 50 m buffer. The results indicate that no Aboriginal sites or places are recorded or have been declared in or near the location specified (Appendix 8).

A search of the NSW Atlas of Aboriginal Places was also conducted using the search by location option (Web Reference 40). Under Section 84 of the *National Parks and Wildlife Act 1974*, land may be declared as an Aboriginal Place by the Minister for the Environment when it is or was of special significance to Aboriginal culture. Aboriginal Places can have spiritual, ceremonial, historical, social, educational value and/or other significance such as natural resource use or contain objects such as burials, middens, or rock art (Web Reference 40).

Dark Point, a sacred site in the Myall Lakes National Park, was found during the atlas search (Web Reference 40). Worimi people have gathered at this site for ceremonies and feasts for at least the last 4000 years and continue to visit to gather shellfish, fish and pass on cultural knowledge (Web Reference 40). The area predominately consists of sand dunes and is used for conservation purposes where its positioning in a national park assists with the protection of its natural and cultural values (Web Reference 40). Dark Point is situated 7.6 km north of the proposed Research Lease and is not considered to be impacted directly or indirectly by the research activities.

The *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* has been developed to support the process of investigating and assessing Aboriginal cultural heritage (Web Reference 39). The Due Diligence Code was reviewed by NSW DPI to determine if it was applicable to the Research Lease and if an Aboriginal Heritage Impact Permit (AHIP) was required. NSW DPI also consulted with the Worimi Knowledgeholders Aboriginal Corporation (WKHAC) about these matters. The Due Diligence Code and the AHIP were deemed not applicable to the Research Lease.

iv. Community Consultation

Community consultation has attempted to investigate the full extent of Aboriginal cultural heritage which may be impacted as a result of the proposed Research Lease. NSW DPI has consulted with the Worimi Local Aboriginal Land Council, the Karuah Local Aboriginal Land Council and the Worimi Knowledgeholders Aboriginal Corporation. Consultation has been undertaken in the form of a meeting, emails, and telephone conversations.

During the meeting with the WKHAC, no concerns were raised about potential impacts of the Research Lease on known culturally significant sites. WKHAC raised a number of points in relation to the sustainability of the Research Lease. WKHAC expressed their strong association with the land and sea country and stressed the importance of this stewardship when assessing the proposed Research Lease. WKHAC also raised the significance of nearby burial sites and cultural activities that have taken place recently.

(b) European Heritage

Relevant NSW and Commonwealth Legislation

Non-indigenous heritage in NSW is guided by the following legislation:

- *NSW Heritage Act 1977*; and
- *Historic Shipwrecks Act 1976*.

NSW Heritage Act 1977 protects items of natural and cultural environmental heritage in NSW which includes places, works, relics and buildings of cultural, scientific, historic, social, archaeological, architectural, natural or aesthetic significance (Web Reference 41). Shipwrecks identified in the NSW Historic Shipwrecks Database are also protected under this Act. The *Historic Shipwrecks Act 1976* protects historic wrecks and relics in Commonwealth waters.

Review of Existing Information

i. *Literature*

Available literature indicates that European settlement in the Port Stephens region dates back from 1812 when cedar getters arrived and farms became established, such as the Australian Agricultural Company which set up sheep farms (Port Stephens Council, 2008). Between the 1820s to the 1860s gradual growth took place which was aided by agricultural activity and sending imports and exports through Port Stephens by ship.

In the late 1800s and early 1900s growth continued, which was aided by the subdivision of many farms, fishing and oyster industries, timber getting and ship building. The most significant development in the Port Stephens region occurred during the post-war years where the population increased from approximately 44,000 in 1991 to 60,000 in 2006. The majority of this growth occurred on the Tomaree Peninsula and in Medowie (Port Stephens Council, 2008).

There are a number of records in reference to the use of Cabbage Tree Island in Providence Bay (2 km from the Research Lease). The first recorded European visit to Cabbage Tree Island occurred in 1840 where a number of petrels were collected and sent to John Gould, a 19^{th} century naturalist living in London. There are also records of the release of European rabbits on Cabbage Tree Island in 1906 which formed part of a series of experiments on the

Broughton Islands to find a biological control for rabbits. Cabbage Tree Island was also used for war-time target practice by the military in early 1943 (DECCW, 2010a).

ii. Field Investigations

A survey of the seafloor beneath the area proposed for the Research Lease was undertaken by NSW OEH in November 2011. No large items that may be considered to be of submerged European heritage were identified during the swath acoustic survey (Appendix 4).

iii. Database Searches

Shipwrecks

A desktop review of shipwrecks known or potentially occurring in the direct study area was carried out in July 2011. Information was sourced from the NSW Historic Shipwrecks Database (Web Reference 6), NSW Wrecks (Web Reference 7), the Australian Hydrographic Service (Web Reference 8), the Australian National Shipwreck Database (Web Reference 9) and a SCUBA Diving website (Web Reference 10).

Around Port Stephens 128 vessels were identified by the NSW Historic Shipwrecks Database as being wrecked in the region, while the Australian National Shipwreck Database identified 59 vessels. Only three vessels were wrecked within 2 nautical miles (3.6 km) of the proposed Research Lease. Two of these vessels were wrecked onshore while the third, *SS Oakland*, is 1.7 km from the proposed Research Lease and is a popular dive site. The *SS Macleay* was also wrecked in Providence Bay (also a dive site), and is located 5 km from the Research Lease, southeast of Cabbage Tree Island, close to Little Island (Web Reference 10).

Plane Wrecks

A desktop review of plane wrecks known or potentially occurring in the direct study area was carried out in July 2011. Information was sourced from NSW OEH (Web Reference 11), DSEWPaC (Web Reference 12) and Maritime Archaeologist, Tim Smith (Smith, 2004). No evidence of plane wrecks was found from these sources. The most proximal plane wreck known to PSGLMP is 7.5 km south of the proposed Research Lease which crashed in 2006 (D. Harasti 2011, *pers. comm*.).

iv. Community Consultation

NSW DPI has consulted with Maritime Archaeologist, Tim Smith but further consultation was not considered to be warranted due to the findings from the desktop review and the seafloor survey.

Conclusion

The risk of the Research Lease having a significant impact on Aboriginal and European heritage items and/or areas near or in Providence Bay is thought to be 'negligible' when considered in context with the findings from the AHIMS database search (i.e. no declared Aboriginal sites or places), the responses of the WKHAC, Worimi Local Aboriginal Land Council and Karuah Local Aboriginal Land Council, as well as the results of the seafloor survey and the desktop/database searches (i.e. no heritage items detected in area proposed for the Research Lease).

For the identified items and places of heritage significance which include: (1) shipwrecks (2) campsites on Cabbage Tree Island and (3) Dark Point, the Research Lease is considered to be a sufficient distance away to ensure no direct or indirect impacts. In addition, no excavation work is proposed for the Research Lease and the only modification of the mobile sandy seabed will occur from the installation of the anchors. However, a relatively small area is estimated to be disturbed by the anchors (31.5 m^2) but is expected to return to pre-existing conditions when the site is decommissioned at the end of the five year trial.

8.2.1.4 Noise

Table 25: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – noise levels during the operational stage of the Research Lease (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will uncharacteristic noise levels be generated during the operational stage (i.e. in level, type and/or duration) and is it likely to have a significant impact on adjacent communities?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ What types of machinery will be employed during the operational stage?
▪ Will there be a significant increase in noise levels during the operational stage of the project?
▪ Is the noise uncharacteristic for the site or exceed acceptable levels?
▪ Will the noise disturb nearby residential areas?
▪ What time of day will the daily operations and maintenance be carried out?
▪ What mitigation and management measures are available to minimise the level of noise generated?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Hours of operation = daylight hours
▪ Types of machinery = motor vessels, blowers, mobile cranes (73 dB), winches, hand held welders (73 dB), hand tools and small power tools.
▪ Distance to nearest residential area = 4 km</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Comply with Protection of the Environment Operations (Noise Control) Regulation 2008.
▪ Comply with Industry Best Practice for Noise Management.</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification of Ranking

The principal source of noise in Providence Bay is generated by the sea state conditions and vessels movements undertaken by existing waterway users. Vessels in the locality consist of small recreational fishing boats, dive boats, dolphin/whale watching boats, luxury cruisers, commercial fishing trawlers and occasionally small passenger cruise ships. Noise levels will vary depending on weather conditions, background noise, the equipment used and the season. During the warmer months of the year for example, commercial and recreational vessel traffic increases significantly so noise levels are characteristically greater during this time of year.

The operation of the Research Lease will cause a slight increase in noise levels in Providence Bay due to the movements of the service vessels, on board equipment and incidental noise from personnel. However, as the service vessels will be similar to existing recreational and commercial vessels, the noise generated is not considered to be uncharacteristic of the area. Other types of machinery that may be used during the operational stage include hand held welders, mobile cranes, hand tools and small power tools, blowers and winches.

Surrounding communities are not expected to be significantly impacted by the noise associated with the operation of the Research Lease as it is located a considerable distance away from residential areas (e.g. the nearest residential area of Hawks Nest is 4 km southwest) and there will not be a significant increase in vessel movements (i.e. one to three trips per day). The hours of operation for vessel movements and maintenance activities will predominately be restricted to daylight hours. Night operations will only occur in response to emergency incidents, such as after severe weather or reports of suspicious activities.

The distance of the Research Lease from the nearest residential area, the normal daytime operation hours, the sea state, wind conditions and existing background noise will ensure the attenuation of any noise generated by service vessels and associated operational and maintenance activities.

An online modelling program that calculates the damping of sound level with distance (Web Reference 26) indicated that the noise from a hand held welder (73 dB) or a diesel generator (84 dB) used on the Research Lease for example, would be about 1 dB and 12dB, respectively at Hawks Nest. This suggests that the noises associated with the daily operation of the Research Lease are likely to be difficult to hear from nearby beaches and residential areas.

NSW OEH is responsible for the regulation of noise from activities scheduled under the *Protection of the Environment Operations Act 1997* (POEO Act). The *POEO (Noise Control) Regulation 2008* also sets certain limits on noise emissions from vessels, motor vehicles and domestic use of certain equipment (Web Reference 16). This act and regulation will be consulted throughout the operational stage of the research trial to ensure compliance with all relevant provisions (Web Reference 16).

Industry best practices for noise management will be employed during the operation of the Research Lease to minimise the impacts of noise on surrounding communities. Some examples of industry best practices include:

- Keeping all marine vessel motors well maintained and in good condition;

- Fitting sound suppression devices (e.g. mufflers) on equipment where possible;
- Reducing boat speed near sensitive areas;
- Complying with any directions of authorised NSW Maritime officers;
- Acknowledging complaints and aiming to resolve them cooperatively;
- Minimise noise and use courteous language in the vicinity of residential neighbours and other waterway users;
- Maintain good communication between the community and project staff; and
- Ensure truck drivers are informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices e.g. no extended periods of engine idling and minimising the use of engine brakes.

Conclusion

The risk of the noise associated with the operation of the Research Lease having a significant impact on surrounding communities is thought to be ‘negligible’ when considered in context with the distance from residential areas, the relatively small increase in vehicle and vessel movements, the restrictions on operation hours, the noise being predominately characteristic of the area and the implementation of industry best practices.

8.2.1.5 Adjacent Aquaculture Lease

Table 26: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – adjacent aquaculture lease (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the operation of the Research Lease have a significant impact on the adjacent aquaculture lease (Pisces Marine Aquaculture Pty. Ltd.)?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ How close is the adjacent aquaculture lease (Pisces Marine Aquaculture Pty. Ltd.)?
▪ Are the environmental conditions (e.g. water quality and sediment condition) of the adjacent lease likely to be impacted?
▪ Is there enough space between the adjacent lease and the proposed lease to allow for safe navigation?
▪ Will there be an impact on the health management status of the adjacent lease?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Existing aquaculture lease
o Located 500 m south of Research Lease</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Buffer zone and navigation buoys
o Mitigate any navigational issues and environmental interactions e.g. sedimentation and reduced water quality
▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2)
▪ Disease, Parasite & Pest Management Plan</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification of Ranking

An existing aquaculture lease (*Pisces Aquaculture Holdings Pty. Ltd*.) consisting of 30 hectares is located approximately 500 m from the proposed Research Lease in Providence Bay. *Pisces Marine Aquaculture Pty. Ltd*. commenced a trial operation of a Snapper farm in 1999 under the provision of Schedule 3 of the *EP&A Regulation 1994* which allows for the undertaking of trial aquaculture projects in natural water bodies involving species indigenous to NSW for a period of two years.

The commercial fish farm, including the marine based site in Providence Bay and a land based site at Oyster Cove, was approved in 2001. The approved water based development included the construction and operation of a fish farm 3 km offshore of Bennetts Beach which consisted of nine sea cages within a 15 hectare area. Three sea cages were designated to fingerlings while the other six sea cages were for the grow out of fish. The three nursery cages are approved to be stocked with 1,680,000 Snapper and Mulloway fingerlings annually. The approved species are Snapper and Mulloway but there is also an allowance for a small number of bait fish if they become entrapped in the cages (i.e. Slimy Mackerel and Yellowtail Scad). The use of a pelletised feed was also approved and administered using an operator controlled blow feeder.

In March 2004 the commercial fish farm went into voluntary receivership. The aquaculture lease was purchased later that month by *Pisces Aquaculture Holdings*. The fish farm is currently not operating and the entire original infrastructure has been removed from the marine based site.

A buffer zone between the two leases and the installation of navigational buoys on the corners of the Research Lease is critical to mitigating potential navigational and environmental impacts. Vessels used to service the existing and the proposed Research Lease require the ability to navigate to and from the leases from different directions and in a range of sea conditions. It is considered that the distance of approximately 500 m provides adequate buffer between the leases for vessels even when installing and/or removing large components, such as the floating double collar sea cages. The buffer distance of 500 m is also important to mitigate any potential cumulative water quality, health management or benthic impacts associated with either lease.

Data obtained from the benthic monitoring program undertaken during the two year trial on the existing aquaculture lease will be used in conjunction with the monitoring proposed for the Research Lease to ensure there are no significant impacts from the operation of the Research Lease.

A Water Quality and Benthic Environment Monitoring Program and a Disease, Parasite and Pest Management Plan will be implemented over the five year research period (Appendix 2). Disease and pest risks are detailed in Section 8.2.2.5.

Many studies have been conducted on the impacts of marine finfish sea cage farms on the benthic environment in Australian waters and in most cases the impacts have been found to be highly localised and restricted to the area beneath or in the immediate vicinity of sea cages (McGhie *et al*., 2000; Hoskin & Underwood, 2001; DPIWE, 2004; Woods *et al*., 2004; Felsing *et al*., 2005; McKinnon *et al*., 2008; Edgar *et al*., 2010; Tanner & Fernandes, 2010). Macleod *et al.* (2002) for example, found that the extent and severity of impacts on benthic habitats rapidly diminished with both time and distance from sea cages in North West Bay in Tasmania, where impacts were generally not detected at 35 m from the cages.

Similarly, McGhie *et al*. (2000) investigated the composition and rate of degradation of organic waste deposited in the sediment beneath and adjacent to fish cages in the Huon Estuary in Tasmania. The results indicate that organic waste was largely restricted to the area beneath the sea cages where only small amounts dispersed to the 20 m perimeter.

The benthic monitoring program for the two year Snapper farm trial detected a small to moderate number of possible ecological impacts (Hoskin & Underwood, 2001) but there was uncertainty about what could be attributed to the sea cages and what was natural variation. Evidence of changes in the average composition of benthic assemblages and increased variability in time and space was detected. Potential impacts on the abundance of 10 taxa were found, including increases and decreases, as well as evidence of increased diversity but these impacts were not considered to be significant. Furthermore, if no significant impact was detected for sites within the lease, it is considered unlikely that an adjacent lease 500 m away will be impacted by a similar operation.

Providence Bay is a high energy environment with moderate to high wave action and relatively strong current flows so there is rapid exchange of water in this region (See Section 6.4 and 6.5). These dynamic conditions will greatly assist to dilute and disperse dissolved wastes released from the sea cages into the water column before reaching the adjacent lease. Consequently, the buffer distance of 500 m between the leases is considered adequate to avoid cumulative impacts on the water quality and the benthic environment in the adjacent aquaculture lease.

Conclusion

The risk of the Research Lease having a significant impact on the adjacent aquaculture lease is thought to be ‘negligible’ when considered in context with the 500 m buffer zone between the leases, the installation of the navigational buoys that will clearly delineate the Research Lease and the Water Quality and Benthic Environment Monitoring Program that will be implemented during the research trial.

8.2.1.6 Work Health and Safety

Table 27: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – WH&S hazards (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the Research Lease have significant WH&S hazards associated with its construction and/or operation?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *What are the WH&S risks associated with the Research Lease e.g. SCUBA diving, dangerous marine animal encounters, fatigue, manual lifting of heavy object, rope maintenance and collisions?* ▪ *How will WH&S risks associated with the construction, deployment and operation of the Research Lease be mitigated, monitored and managed?* ▪ *Are there any potential pollutant sources in the region that could potentially contaminate the stock and make it unsafe for consumption?* ▪ *What protocols are in place to manage capture and disposal of dead and diseased fish?* ▪ *How will WH&S risks be mitigated, monitored and managed?*			
Description	▪ Potential WH&S hazards o SCUBA diving o Construction and deployment activities o Service and maintenance activities o Use / storage of chemicals, contamination and waste disposal o Navigation			
Proposed Management – Mitigation and Monitoring	▪ Environmental Management Plan (Appendix 2) o WH&S Management Plan o Traffic Management Plan o Waste Management Plan o Structural Integrity & Stability Monitoring Program o Water Quality & Benthic Environment Monitoring Program o Marine Fauna Interaction Management Plan o Disease, Parasite & Pest Management Plan			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

Justification of Ranking

Work Health and Safety (WH&S) legislation replaced the Occupational Health and Safety (OHS) legislation in NSW on 1 January 2012. The new legislation provides greater consistency, certainty and clarity across Australia in making workplace health and safety duties easier to understand. This will enables NSW DPI and industry partners to initiate and utilise nationwide safety policies and procedures developed for sea cage farming activities in other states.

There are a number of potential WH&S hazards associated with the construction, deployment and operation of the Research Lease. The main hazards identified include SCUBA diving, construction and deployment activities, service and maintenance activities, navigation issues, use and storage of chemicals, contamination of feed, stock and the environment, and waste disposal.

As there are no large industrial or commercial operations in the immediate region and the nearest deepwater ocean outfall is 11 km away, point and diffuse pollutant sources are not considered to be a concern and are highly unlikely to conflict with required food safety standards.

SCUBA divers will be required to assist with structural installations, inspections, maintenance and repairs, as well as with environmental monitoring (e.g. collecting benthic samples). WH&S hazards associated with these activities include diving related injuries (e.g. decompression illness), fatigue, marine animal encounters and entanglement in ropes and nets. To mitigate these potential WH&S risks, all diving staff will have relevant qualifications, undergo a WH&S induction program, and a WH&S Management Plan (Appendix 2) will be implemented, including Safe Work Method Statements for SCUBA diving.

Staff involved with the construction and deployment stages will be required to assemble, tow and deploy the sea cage infrastructure, which will include the transportation of materials on marine vessels and vehicles, use of a range of machinery and equipment (e.g. cranes, winches, welders and power tools), lifting heavy loads and navigating in busy waterways. WH&S hazards associated with these activities include physical injuries from machinery and equipment use, manual lifting and/or fatigue, as well as navigation hazards and collisions.

Service and maintenance staff will be required to undertake frequent marine vessel and vehicular movements between the Research Lease, PSFI, the mooring facilities of the service vessels, possibly the Nelson Bay Commercial Fishermen's Co-operative and occasionally, the Port of Newcastle. Staff working on marine vessels will undertake deckhand duties, feeding, net cleaning and changing, inspections and maintenance of the infrastructure, chemical use and storage, removal of moribund and dead fish, waste disposal and water quality sampling, while staff involved with vehicular transport will be transferring personnel, materials and supplies. WH&S hazards associated with these activities include physical injuries from manual lifting and maintenance duties, feed contamination, fatigue, navigation hazards and collisions, spillage and overuse of chemicals and associated food safety and human health issues.

The operation of the Research Lease will occasionally require the use of therapeutics to maintain the health of cultured stock. The daily operation of the Research Lease will also generate waste, including dead and diseased fish, general rubbish and biofouling, as well as increase nutrient inputs into Providence Bay from uneaten food, faecal matter and metabolic by-products. Potential WH&S hazards to human health and the environment associated with these activities includes antibiotic resistance, contamination of feed, stock and/or water quality, disease outbreaks and accumulation of disinfectants, anaesthetics or antibiotic residues (Sapkota *et al.,* 2008).

Research Lease staff and contractors will be required to undertake an induction process before they are permitted to undertake any activity associated with the Research Lease. During inductions details of obligations under the *Work Health and Safety Act 2011,* risks and hazards associated with the Research Lease, personal protective equipment (PPE) requirements and incident reporting procedures will be described.

Risk levels associated with potential Research Lease WH&S hazards and the proposed mitigation measures are described in further detail in the following sections:

- Marine vessel movements and vehicular transport (Section 8.2.1.2);
- Navigation (Section 8.1.7);
- Structural integrity and stability of sea cage infrastructure (Section 8.1.5);
- Chemical use and storage (Section 8.2.2.3);
- Fish feed contamination (Section 8.2.2.2);
- Water quality (Section 8.2.2.1);
- Disease (Section 8.2.2.5);
- Genetics and escapement (Section 8.2.2.4); and
- Waste disposal (Section 8.2.2.13).

Mitigation measures for potential WH&S hazards include the following management plans and monitoring programs which form part of the EMP (Appendix 2):

- WH&S Management Plan;
- Traffic Management Plan;
- Waste Management Plan;
- Structural Integrity and Stability Monitoring Program;

- Marine Fauna Interaction Management Plan;
- Disease, Parasite and Pest Management Plan; and
- Water Quality and Benthic Environment Monitoring Program.

There are also WH&S issues relating to the use of the Research Lease by other waterway users. To mitigate these potential impacts, the Research Lease will be clearly marked with appropriate navigation buoys, listed on navigation charts, a notice to mariners will be issued and public information will be provided on the NSW DPI website regarding the operation of the Research Lease including waterway user obligations.

For personal safety, recreational boaters, fishers, spear fishermen and divers should remain outside the lease area which will be delineated by four yellow cardinal markers. Under the FM Act it is an offence to interfere or damage anything in the lease area.

Conclusion

The risk associated with WH&S matters during the construction, deployment and operational stages of the Research Lease is thought to be 'low' when considered in context with the EMP that will be implemented to minimise the risks associated with potential hazards and the commitment of the proponent to ensure that all staff personnel and the other waterway users are made aware of their obligations under the WH&S Act and the FM Act.

8.2.1.7 Economics

Table 28: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – economic impacts (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the construction, deployment and operation of the Research Lease negatively impact on the economy of the Port Stephens region?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Will the Research Lease provide additional employment opportunities for the region?* ▪ *Will the Research Lease provide an opportunity for people who were previously displaced from the fishing industry to re-enter into a different sector?* ▪ *Is there potential for the Research Lease to provide economic benefit to the marine tourism sector in the region e.g. sea cages may form a site for visitation during dolphin/whale watch tours?*			
Description	▪ Research operations will increase employment opportunities ▪ Purchase of goods and services will contribute to the local economy			
Proposed Management – Mitigation and Monitoring	▪ No specific management initiatives are considered necessary to manage impacts on the local economy of Port Stephens as the Research Lease is expected to result in positive economic benefits.			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	0	6	0	**Negligible**
Reporting Requirements	Short justification			

<u>*Justification of Ranking*</u>

The primary purpose of the Research Lease is to expand the land based research trials of specific finfish species and to investigate the economic viability of culturing these species in offshore sea cages in NSW waters. The research trial is expected to have a number of direct and indirect benefits to the regional economy of Port Stephens.

The local economy of Port Stephens LGA is made up of tourism, retail trade, construction, agriculture, fishing, aquaculture and oyster farming, manufacturing, defence-government, public administration and safety, health care and social assistance and accommodation and food services (Port Stephens Council, 2008). The implementation of the zoning plan for the PSGLMP in 2007 and the NSW DPI commercial fishing licence buyout resulted in a reduction in fishing effort and the displacement of a large number people from the commercial fishing industry. The Research Lease could potentially represent a source of employment in the fishing industry in Port Stephens for those people that were previously displaced from this industry.

It is hoped that the expertise and facilities of the Nelson Bay Commercial Fishermen's Co-operative will be used to process fish at the completion of the research trial. There may also be potential to support the Commercial Fishermen's Co-operative in Tea Gardens.

The exact number of employment positions that will be created by the Research Lease during the construction, transportation and deployment stages of the Research Lease is not currently known. However, a report on the economic impact of aquaculture on the South Australian economy illustrated that for each full time job generated in marine finfish farming (tuna), processing and transport, there were an additional 1.56 jobs downstream (Econsearch, 2007).

Employment positions will include staff and/or contractors for construction, transportation and deployment of the sea cage infrastructure, including construction workers, welders, crane operators, skippers, deckhands, observers, truck drivers and structural engineers. Staff and contractors will also be required for service, maintenance and hatcheries activities, including commercial divers, skippers, deckhands, technicians, truck drivers, research scientists, veterinary doctors and support staff.

The operation of the Research Lease will result in direct economic benefits to the local economy of Port Stephens and surrounding areas from the purchase of goods, such as fuel and materials, and use of services, such as vessel and vehicle servicing, as well as accommodation and food services for visiting researchers.

The research trial may also provide tourist operators, including dolphin/whale watching, fishing, sightseeing and diving charters, with an additional attraction to visit during tours. Furthermore, the Research Lease will provide the Port Stephens tourist industry with an opportunity to diversify visitors' experiences by visiting the marine finfish aquaculture facilities. This in turn creates greater community awareness about aquaculture and encourages an interest in tourists to source fresh local seafood.

On the Eyre Peninsula in South Australia for example, a seafood trail has been established to showcase the region's aquaculture industry. Similarly, in Twofold Bay on the south coast of NSW marine based tourist operators have been able to diversify their tourism experience by discussing mussel farming in the bay during other tourist activities. These examples showcase how a resource can be shared and sustainably managed, and also illustrate how aquaculture can attract tourists, enhance their experience and contribute to the regional economy.

It is considered unlikely that the Research Lease will have a significant impact on the dolphin and whale watching businesses that may use the inshore area of Providence Bay. The proposed site should not have a significant impact on the dolphin swimming business that operates in the area (M. Haste - Marine Park Manager 2011, *pers. comm*.).

Conclusion

The risk of the Research Lease having a negative impact on the regional economy of Port Stephens is thought to be 'negligible' when considered in context with the fact that aquaculture has been a catalyst for economic development in other localities in Australia. The Research Lease will provide increased employment opportunities and use of local goods and services, as well as provide the tourism industry with an opportunity to diversify experiences available to visitors.

8.2.2 Impacts on the Environment

8.2.2.1 Water Quality, Nutrients and Sedimentation

Table 29: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts on marine habitats in Providence Bay and the wider region (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the Research Lease have a significant impact on marine habitats in Providence Bay and the wider region, including water quality, nutrients and sedimentation?
Level of Impact	Individual facility
Comments and Considerations	▪ *What habitats are present in the direct and wider study area?* ▪ *Could the activity cause changes to the benthic communities e.g. sedimentation, turbidity and nutrients?* ▪ *Have impacts on benthic habitats been found to be far reaching or localised for other sea cage farms in Australian waters?* ▪ *Are there issues in relation to the proposed stocking densities and waste discharge?* ▪ *How will stocking density and associated discharges be monitored and managed?* ▪ *Are dissolved waste inputs (i.e. dissolved metabolic products, uneaten fish feed, faeces, chemicals and nutrients) within acceptable levels so as to avoid adverse impacts on water quality?* ▪ *What are the acceptable levels of dissolved wastes according to the Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters?* ▪ *What is the likely extent of sedimentation i.e. beneath cages and how far from the cage perimeter?* ▪ *How will cumulative impacts on marine habitats i.e. water quality and benthos be monitored?* ▪ *What measures will be implemented to mitigate, monitor and manage water quality and sedimentation issues?*
Description	▪ Proposed duration of trial = five years ▪ Direct marine habitats = soft sediment (sand & coarse sand) ▪ Wider marine habitats = rocky reefs, seagrass beds, mangroves, saltmarsh, sponge, ascidian and soft coral communities ▪ Inputs into marine environment o Residual food o Fish faeces and metabolic by-products o Biofouling o Therapeutics
Proposed Management – Mitigation and Monitoring	▪ Site Selection o High energy environment o Reasonable depth (i.e. 15-22 m)

	o Soft sediment (sand) ▪ Small scale short-term research operation ▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2) ▪ Daily operational and maintenance procedures – minimise nutrient and particulate loading ▪ Fallowing of sea cages			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	2	5	10	**Moderate**
Reporting Requirements	Full management report (Appendix 2)			

Justification of Ranking

Site Selection

Habitat types present in Providence Bay include beaches, islands and rocks, reefs and shoals, subtidal sand, mud and muddy sands, seagrass and rocky intertidal areas. Habitat types, such as boulders, continuous rock, cobbles, overhangs, small caves and gutters and areas of unconsolidated pebbles are also present but are generally associated with the offshore islands (Jordon *et al*., 2010).

There are no known seagrass beds, geomorphological formations (i.e. rocky reefs or bomboras) or any other substantial flora or fauna associations in the area proposed for the Research Lease except for phytoplankton in the water column. The closest marine communities are on the reefs surrounding Cabbage Tree Island which is 2 km south of the Research Lease. Visual interpretation of acoustic backscatter and hillshaded bathymetry data indicate that the seafloor in the survey area consists of relatively homogenous soft sediment, most likely sand, with a depth ranging from 15 to 22 m.

Waste Inputs

Worldwide there is extensive literature on the impacts of marine finfish aquaculture inputs on the marine environment (de Jong & Tanner, 2004). A risk assessment conducted by SARDI on marine finfish aquaculture revealed that the impacts of fish faeces and uneaten feed on water quality and sediments were perceived to be the most important issues for the industry in South Australia (de Jong & Tanner, 2004).

The main types of waste inputs into the marine environment from sea cage aquaculture include residual food, faecal matter, metabolic by-products, biofouling and therapeutics (Pillay, 2004). More specifically, these waste inputs are comprised of organic carbon, nitrogen, phosphorus, carbohydrates, lipids, proteins, ammonia, urea, carbon dioxide, vitamins, pigments, calcium and bicarbonate (Pillay, 2004). The production of faecal matter and metabolic by-products obviously depends on stocking densities and the digestibility of feed while the input of residual food and therapeutics is dependent on operational practices. The input of this organic matter can cause changes to the physical, chemical and biological characteristics of the receiving marine environment (Aguado-Gime'nez & Garcia-Garcia, 2004).

Potential impacts of waste inputs include increased nutrient loads and sedimentation which in turn, can cause eutrophication, smothering of benthic organisms, excessive epiphytic growth on seagrasses (de Jong & Tanner, 2004). Notably, eutrophication of sediments and the water column can lead to increased biological oxygen demand (Gowan, 1994), hypoxia and alter benthic community structure (Macleod *et al*., 2002). The magnitude of the impact largely depends on feed type, feeding regime, digestibility of feed, quantity of waste inputs, the cultured species and husbandry practices (Stewart & Grant, 2002; Islam, 2005), stocking densities, dispersion of wastes by currents and the environmental carrying capacity of the region to assimilate organic inputs (Aguado-Gime'nez & Garcia-Garcia, 2004).

Dissolved Nutrients

The use of pelletised fish feed and the natural metabolic processes of the finfish species in the sea cages of the Research Lease will result in nutrients being discharged into the marine environment in dissolved and solid particulate forms. The dissolved metabolic products originating from the cultured fish predominantly consist of nitrogen in the form of ammonia (NH_3) and urea, as well as small amounts of phosphorus usually in the form of orthophosphate (PO_4^{3-}) (D'orbcastel & Blancheton, 2006). Nitrogen and phosphorus concentrations are often limiting nutrients for primary production in coastal marine environments (de Jong & Tanner, 2004).

Olsen *et al*. (2008) estimated that Atlantic Salmon excretes 36% of ingested nitrogen as dissolved inorganic nitrogen (NH_4) while about 10% of ingested phosphorus is excreted through urine. This is based on the typical composition of extruded pellets for Salmon and Trout which is 45% protein, 22% fat, 16% carbohydrate, 9% ash and 8% moisture. Olsen *et al*. (2008) also estimated that 17% of nitrogen and 38% of the phosphorus ingested by Atlantic Salmon is released in faeces.

Figure 44 outlines the flow of nitrogen (N) associated with fish feeding on sea cage farms, including the retention of nitrogen by fish, the excretion of nitrogen by fish in solid and soluble forms and metabolic by-products, as well as nitrogen inputs into the marine environment from feed wastage. The flow of nutrients associated with fish feeding is similar for phosphorus.

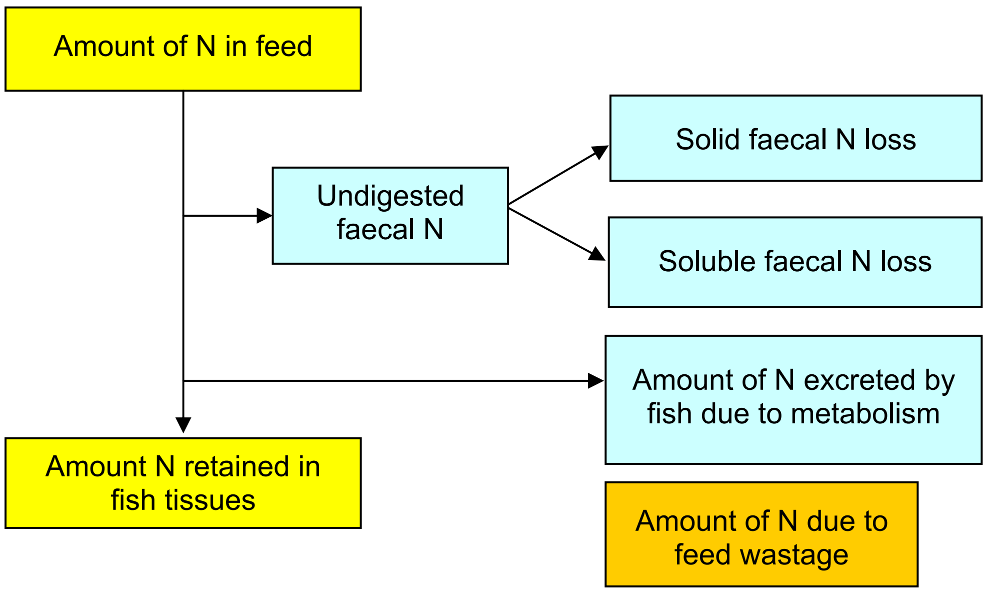

Figure 44: The flow of nitrogen (N) associated with fish feeding on aquaculture farms (Source: NSW DPI, 2012).

As the Research Lease will trial a range of feeds and stocking densities over the five year research period, which have not yet been confirmed, it is difficult to provide estimates for the amount of nutrients which will be discharged into the marine environment. Also, a research objective of the Research Lease is to validate some of the diet development research that has been undertaken with Yellowtail Kingfish in controlled research tanks at PSFI by extending the research to a commercial scale. The research trial will include the trial of new diets and feeding strategies that aim to improve feeding efficiency and growth performance. Data generated from the Research Lease will allow existing tank based growth and nutrient models to be improved which in turn will allow more accurate estimates to be made on the amount of nutrients that are discharged into the marine environment.

The amount of nutrients excreted into the environment by fish will depend on fish species, the nutrient content of the diet, bio-availability of nutrients in the diet and feed intake (M. Booth 2012, *pers. comm.*). These factors ultimately manifest in what is commonly known as the feed conversion ratio (FCR) – the amount of food required to produce one unit of growth (e.g. kilogram) in a fish. Nutrients from pelletised feed that do not end up in fish tissues are ultimately released to the environment.

Scientific data on the retention of nitrogen and phosphorus is available for species cultured in Japan which are similar to the proposed species. For example, Satoh *et al.* (2004) found that nitrogen excretion in Yellowtail Kingfish fed diets with different lipid and phosphorus levels varied between 113 to 146 kg per tonne of fish produced while phosphorus varied between 29 to 47 kg per tonne of fish produced (Table 30).

Table 30: Nitrogen and phosphorus excretion (kg/t) – results of a feeding experiment on Yellowtail (*Seriola quinqueradiata*) (Source: Satoh *et al*., 2004).

Independent variables (g/kg dry diet)	Nitrogen excretion	Phosphorus excretion
Lipid level		
200 (*n* = 6)	145.69[a]	38.52[a]
250 (*n* = 3)	125.41[b]	34.43[ab]
300 (*n* = 3)	113.52[c]	31.18[b]
Supplemental phosphorus		
0 (*n* = 4)	131.79[a]	29.33[c]
2 (*n* = 3)	131.20[a]	33.64[bc]
4 (*n* = 3)	126.53[a]	38.57[b]
7 (*n* = 2)	145.28[a]	47.00[a]

[abc] = mean values in the same column with different superscript letters are significantly different at P < 0.05.
n = number of diet groups.

Similarly, an experiment by Sarker *et al.* (2011) fed Yellowtail Kingfish a range of diets based on partial replacement of fish meal with plant protein sources. Table 31 lists the retention and excretion rates recorded for nitrogen and phosphorus during the study.

Table 31: Retention and excretion of nitrogen and phosphorus in Yellowtail Kingfish fed experimental diets (Source: Sarker *et al*., 2011).

Diet Code	Nitrogen retention (%)*	Nitrogen excretion ($kg\ t^{-1}$)#	Phosphorus retention (%)*	Phosphorus excretion ($kg\ t^{-1}$)#
F49	28.2 ± 0.93	80.3 ± 1.45[b]	22.1 ± 0.62d[e]	17.9 ± 0.23[b]
F49 + P	27.9 ± 0.83	82.0 ± 1.56[b]	21.4 ± 1.59[e]	19.5 ± 0.25[a]
F31 + CA	26.8 ± 0.71	85.9 ± 0.30[ab]	29.6 ± 1.69[bc]	13.3 ± 0.40[c]
F31 + FA	27.0 ± 0.12	84.2 ± 0.53[ab]	26.7 ± 0.94[cd]	14.3 ± 0.12[c]
F23 + CA	26.0 ± 0.00	88.0 ± 2.59[a]	35.7 ± 1.68[a]	10.4 ± 0.58[d]
F23 + FA	26.6 ± 0.48	85.8 ± 1.31[ab]	32.3 ± 0.11[ab]	10.6 ± 0.07[d]

Values (means ± SD) in a column not sharing the same superscript letters are significantly different (P < 0.05).
* Retention (%) = [(Final nutrient content) initial nutrient content)/nutrient intake] x 100.
\# Excretion ($kg\ t^{-1}$) = {[FCR · nutrient in diet (g)) nutrient retained in fish (g)]/production (t)} x 1000.

Table 32 is based on bioenergetic models developed as part of the tank based research conducted at PSFI and provides an indication of the nitrogen outputs expected from the Research Lease at different feed conversion ratios (FCR). These models have been developed by PSFI researchers based on past feed research including that by Bureau *et al.* (2003) and Booth *et al*. (2010). Bureau *et al.* (2003) for example, found that Rainbow Trout reared in commercial cage culture with a FCR of between 1.14 and 1.29 produced 47 and 71 kg of total waste nitrogen and 7.5 and 15.2 kg of total waste phosphorus per tonne of fish produced. Notably, a FCR of 2.5 is considered to be extremely poor. Research conducted on the Research Lease will aim to reduce the FCR through advances in feed formulation and feeding practices.

Table 32: Nitrogen output estimator model (Source: M. Booth 2012, *pers. comm.*).

	Scenario A	Scenario B	Scenario C	Scenario D
Expected FCR	1	1.5	2	2.5
Stock weight (g)	20	20	20	20
Stock #	100,000	100,000	100,000	100,000
Harvest weight (g)	4500	4500	4500	4500
Harvest #	95,000	95,000	95,000	95,000
Harvest biomass (mt)	300.0	300.0	300.0	300.0
Production days (d)	500	500	500	500
Total feed input (mt)	300.0	450.0	600.0	750.0
Crude Protein %	48	48	48	48
Crude Lipid %	20	20	20	20
Crude nitrogen (N) of feed %	7.68	7.68	7.68	7.68
Gross energy MJ/kg	22.0	22.0	22.0	22.0
Total N available from feed (mt)	23.04	34.56	46.08	57.60
Apparent digestibility of N in feed %	90	90	90	90
Total digestible N available from feed (mt)	20.74	31.10	41.47	51.84
Digestible N retention in fish tissue %	50	50	50	50
Total digestible N retained in fish (mt)	10.37	15.55	20.74	25.92
Total faecal N losses (mt)	2.30	3.46	4.61	5.76
50% as solid faecal N (mt)	1.15	1.73	2.30	2.88
50% as soluble faecal N (mt)	1.15	1.73	2.30	2.88
Soluble N losses (gill + urinary) (mt)	10.37	15.55	20.74	25.92
Total solid N waste output (mt)	1.15	1.73	2.30	2.88
Total soluble N waste output (mt)	11.52	17.28	23.04	28.80
Total N output to environment (mt)	12.67	19.01	25.34	31.68
Total N output (kg/mt of feed used)	42.24	42.24	42.24	42.24
Total N output (kg/mt of fish produced)	42.24	63.36	84.48	105.6

The above research and models illustrate that the quantity of nutrients excreted into the marine environment differs greatly depending on the species cultured and the type of feed and how efficiently the feed is converted into tissue biomass. Continuing advances in feed technology and the understanding of the dietary requirements of different species however, has resulted in decreased nutrient discharges from aquaculture facilities.

Water Exchange Calculations

The approximate dimensions of the Research Lease will be about 370 x 530 m with the longest distance running in a north south direction. The Research Lease will be located in water with a depth ranging from 15 to 22 m. The water current in the locality predominately runs in a north south direction at about 0.1 m/s.

To undertake the calculations for the daily volume of water that passes through the Research Lease the length of 530 m and a depth of 20 m has been used.

- Water current @ 0.1m/sec = 6 m/min = 360 m/hr = 8640 m/day
- Water current (m/day) / longest dimension of Research Lease (m) = number of times water will be exchanged per day:
  - 8640 / 530 = 16.3 times/day
- Volume of the Research Lease = length x width x height (m)
  - 530 x 370 x 20 = 3,922,000 m^3
    - 3,922,000 m^3 x 1000 L = 3,922,000,000 L
- Volume of the Research Lease (L) x number of exchanges per day = water exchanged through Research Lease (L/day)
  - 3,922,000,000 x 16.3 = 63.9286 ML/day

Nitrogen Concentration Calculations

To provide an estimate of the total amount of nitrogen released into the waters of Providence Bay, a standing biomass of 300 tonne of fish and a total nitrogen output of 145.69 kg per tonne of fish was used. This output is taken from the highest perceived production capacity (unlikely to reach this level during research trials) and the worst of the three scenarios in Tables 30, 31 and 32. It is assumed that the nitrogen released totally dissolves in the water in the Research Lease.

Nitrogen Load

- Maximum standing biomass (t) x dissolved nitrogen per tonne of stock (kg) = dissolved nitrogen (kg per year)
  - 300 x 145.69 = 43,707 kg N/year
    - 43,707 / 365 = 119.8 kg N/day

Concentration of Nitrogen

- Dissolved nitrogen (µg/day) / water exchanged through Research Lease (L/day) = dissolved nitrogen leaving Research Lease each day (µg/L)
  - 119,800,000,000 / 63,928,600,000 = 1.87 µg/L dissolved N per day

Phosphorus Concentration Calculations

To provide an estimate of the total amount of phosphorus released into the waters of Providence Bay, a standing biomass of 300 tonne of fish and a total phosphorus output of 47 kg per tonne of fish produced were used. This output is taken from the highest perceived production capacity (unlikely to reach this level during research trials) and worst of the scenarios in Tables 30 and 31. It is assumed that the phosphorus released totally dissolves in the water in the Research Lease.

Phosphorus Load

- Maximum standing biomass (t) x dissolved phosphorus per tonne of stock (kg) = dissolved phosphorus (per year and day)
  - o 300 x 47 = 14,100 kg P/year
    - 14,100 / 365 = 38.6 kg P/day

Concentration of Phosphorus

- Dissolved phosphorus (µg/day) / water exchanged through Research Lease (L/day) = dissolved nitrogen leaving Research Lease each day (µg/L)
  - o 38,600,000,000 / 63,928,600,000 = 0.6 µg/L dissolved P per day

The trigger values for nitrogen, total phosphorus, ammonium and oxides of nitrogen in a slightly disturbed marine ecosystem according to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* are provided in Table 33 (ANZECC and ARMCANZ, 2000). These values provide a guideline by which to assess the impact of the Research Lease on water quality in Providence Bay.

Prichard *et al*. (2003) found that the surface waters of south eastern Australia typically have an oxidised nitrogen content of 10 µg/L and a reactive phosphorus content of about 8 µg/L while the deeper nutrient rich waters typically have an oxidised nitrogen content of 70-140 µg/L and a reactive phosphorus content of 20-25 µg/L. The natural concentrations of nitrogen and phosphorus in seawater constantly fluctuate depending on climatic conditions, ocean currents, occurrences of local upwellings and discharges from adjacent land catchments.

Oke & Middleton (2001) for example, investigated the role of the East Australian Current (EAC) in promoting nutrient-rich slope water into the euphotic zone off Port Stephens. A regional model of the NSW coast was presented and simulations indicated that the interaction between the EAC and the continental shelf topography near Laurieton (north of Port Stephens) causes uplifting of slope water. The nutrient-rich slope water is thought to be advected along the shelf to Port Stephens and upwelled to the surface in this region where the EAC separates from the coast (Oke & Middleton, 2001).

The maximum nutrient levels in the water leaving the Research Lease have been estimated to be 1.87 µg/L of nitrogen and 0.6 µg/L of phosphorus. These concentrations are considerably lower than the typically natural background concentrations for oxidised nitrogen of 10 μg/L and reactive phosphorus of about 8 μg/L. The combination of the estimated Research Lease nutrient contributions and the natural background concentrations is also lower than the trigger values recommended in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)* (Table 32). Therefore, it is considered unlikely that the operation of the Research Lease will have a significant cumulative impact on nutrient levels or water quality in Providence Bay or the surrounding region.

Table 33: The default trigger values for water quality parameters according to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* and the estimated values for nutrient inputs into Providence Bay associated with the Research Lease. TN = total nitrogen, NH_4^+ = ammonium, NO_x = oxides of nitrogen and TP = total phosphorus.

	TN μg L^{-1}	**NH_4^+** μg L^{-1}	**NO_x** μg L^{-1}	**TP** μg L^{-1}
ANZECC & ARMCANZ Guidelines	120	20	25	25
Estimations for Research Lease	11.87			8.6

It should be noted that the above nutrient calculations for the Research Lease were based on a worst case scenario. However, to validate the above modelling, water sampling to test the nutrient concentrations in both background and Research Lease waters will be undertaken, at an appropriate scale, to test the nutrient outputs from the Research Lease. This sampling will commence once a sea cage is stocked at commercial levels.

Particulate Matter

Residual food, fish faeces and fouling organisms can accumulate on the seabed beneath sea cage farms and cause changes to the physico-chemical characteristics and benthic community structure of the receiving benthic environment (Edgar *et al*., 2010). Waste food and faeces are predominately composed of organic nitrogen compounds which are denser than seawater so these particles typically settle on the seabed in the immediate vicinity of sea cages (Islam, 2004).

When organic waste deposition exceeds nutrient assimilation rates sediments become anaerobic and the composition of benthic organisms changes (Angel *et al*., 2000 cited in Aguado-Gime'nez & Garcia-Garcia, 2004). Hydrogen sulphide, methane and ammonia can form if extreme anaerobic conditions develop (Pillay, 2004; Islam, 2005).

The level of impact of waste feed is dependent on factors such as current speed, settling velocity, water temperature and pellet degradation, including feeding and ingestion rates (Gowan, 1994; Stewart & Grant, 2002). Pellet size for example, influences the degree of impact on sediments where small pellets have been found to disperse over greater distances than large pellets (i.e. up to 3 times) (Pawar *et al*., 2002). The loss of pellet mass and erosion rates are also greater with increasing current flows and decreasing pellet size (Stewart & Grant, 2002).

Organic enrichment directly leads to an increased oxygen consumption rate and when the oxygen demand exceeds the available supply, sediments becomes anoxic. This in turn brings about changes in the biological and chemical processes in the sediment and the ecology of benthic organisms.

Many studies have been conducted on the impacts of marine finfish sea cage farms on the benthic environment in Australian waters and in most cases the impacts have been found to be highly localised and restricted to the area beneath or in the immediate vicinity of sea cages (McGhie *et al*., 2000; Hoskin & Underwood, 2001; DPIWE, 2004; Woods *et al*, 2004; Felsing *et al*., 2005; McKinnon *et al*., 2008; Edgar *et al*., 2010; Tanner & Fernandes, 2010). Generally the level of impact has been found to decrease with increasing distance away from sea cages (Macleod *et al*., 2002). Macleod *et al*. (2002) for example, investigated the recovery of highly impacted sediment (i.e. high sulphide levels and a community structure indicative of hypoxic and polluted conditions) beneath the sea cages in North West Bay in Tasmania. The extent and severity of the impact was found to rapidly diminish with both time and distance from the cages, and were generally not detected at 35 m from the cages.

Similarly, McGhie *et al*. (2000) investigated the composition and rate of degradation of organic waste deposited in the sediment beneath and adjacent to fish cages in the Huon Estuary in Tasmania. The results indicate that organic waste was largely restricted to the area beneath the sea cages where only small amounts dispersed to the 20 m perimeter.

A study conducted by AIMS on the environmental impacts of the Bluewater Barramundi farm in the Hinchinbrook Channel in Queensland has found that there was no evidence of organic waste accumulation in sediments beneath the cages and that the footprint of the farm on the benthos (assessed by analysis of sediment chemistry) appeared to be restricted to the lease area (McKinnon *et al*., 2008). Despite its operation for more than 20 years, findings indicate that the farm did not have a significant impact on the adjacent marine environment (McKinnon *et al*., 2008). Similarly, remote video transects in marine finfish aquaculture leases in South Australia indicate an apparently healthy seabed, including in the immediate vicinity of the cages (de Jong & Tanner, 2004).

Conversely, a study investigating the impact of tuna cages in Boston Bay, South Australia (Cheshire *et al*., 1996 cited in de Jong & Tanner, 2004) found that epibenthic communities were impacted at a distance of up to 150 m from the lease while impacts on benthic infauna communities were detected at a distance of up to 20 m. However, no impacts were detected when the tuna cages were moved to a more exposed offshore site (Madigan *et al*., 2003).

The trial operation of a Snapper farm in Providence Bay monitored the benthic environment below the sea cages, as well as at control sites outside the aquaculture lease (Hoskin & Underwood, 2001). A small to moderate number of possible ecological impacts were detected but there was uncertainty about what could be attributed to the sea cages and what was natural variation. Evidence of changes in the average composition of benthic assemblages and increased variability in time and space was detected. Potential impacts on the abundance of 10 taxa were found, including increases and decreases, as well as evidence of increased diversity (Hoskin & Underwood, 2001) but these impacts were not considered to be significant.

Therapeutics

Therapeutics may need to be used to treat cultured stock for disease, control pests (e.g. parasites) or assist with the handling and transfer of fish (i.e. anaesthetics) (Pillay, 2004; Burridge *et al*., 2010). There are tight regulations on the type of therapeutics available for use and associated treatment protocols (Burridge *et al*., 2010). The locality, nature and intensity of culture operations and subsequently, the frequency of pest and disease infestations, generally determines the nature and extent of chemical use (Pillay, 2004).

Therapeutics will only be administered to the cultured stock of the Research Lease in accordance with an APVMA approval or after obtaining veterinary approval. Treatments will be on an intermittent (as needed) basis and liners will be used to hold the stock when therapeutic substances are administered to minimise the quantities used, as well as the amount that is released into surrounding waters. Further details of the types of therapeutics that may be used on the Research Lease and potential cumulative impacts on the marine environment are discussed in Section 8.2.2.3.

Modelling

NSW DPI, the Seafood Cooperative Research Centre and the Fisheries Research Development Corporation are in the process of developing models to assist with determining the values of various parameters at which there is efficient but cost effective growth of marine finfish that is below the carrying capacity of the marine environment. Factors such as nutrient content of the fish food, the feed conversion ratios, flushing rates, water temperature, salinity, feed wastage, nutrient loadings, stocking densities and the cost of feed are incorporated into such models and used to predict parameters such as the level of nutrients and organic matter entering the marine environment, expected growth rates and harvest dates.

The Research Lease will assist with the validation of these models where comparisons will be made between the predicted values and the actual outcomes. Of particular interest is the effect of NSW sea surface temperatures on feed intake and growth rates, which are considered to be conducive to rapid growth of the proposed Research Lease research species.

Mitigation Measures

The following mitigation measures will be implemented to minimise the risk of water quality deterioration, eutrophication and excessive sedimentation:

- Site selection
    - high energy environment (See Section 6.4 and 6.5);
    - reasonable depth (i.e. 15-22 m); and
    - soft sediment habitat (sand).

The installation of the sea cages in the high energy environment of Providence Bay at a reasonable depth (i.e. 15-22 m) where waters are well mixed by wave action and tidal currents will greatly assist with mitigating impacts on water quality and the soft sediment environment. These conditions will assist with the dilution and dispersal of suspended and dissolved wastes from the sea cages by providing rapid water exchange and a large bottom area over which wastes can disperse before settling (Alston *et al*., 2006).

- Small scale short-term research operation
- Water Quality and Benthic Environment Monitoring Program

Sampling benthic infauna is a common environmental monitoring tool worldwide (de Jong & Tanner, 2004). Many studies have demonstrated that benthic infauna are a reliable indicator of environmental changes that are induced by increased nutrient and sediment loads (Ritz *et al*., 1990; Weston, 1990).

In South Australia all marine finfish aquaculture licence holders are required to submit an environmental monitoring report annually. This involves quantifying changes in benthic infauna at potentially impacted sites in or near the aquaculture leases and making comparisons with the samples from control sites (de Jong & Tanner, 2004).

The Research Lease monitoring program will include regular sampling before, during and after the research trial at sites in the lease and at control sites outside the Research Lease, where the physico-chemical environment and benthic community structure will be examined.

The monitoring program will provide an opportunity to investigate the impacts of sea cage farms on the benthos in high energy coastal environments, as well as ensure early detection of any changes in the benthic environment so appropriate management responses can be implemented to ensure significant impacts do not occur.

- Fallowing of sea cages (if monitoring results indicate this is necessary and/or for research purposes)

- Implementation of daily operation and maintenance procedures that minimise dissolved and particulate waste inputs, including:
  - regular cleaning of nets to reduce the amount of natural food available (e.g. submersible net cleaning robots);
  - using pelletised feed (opposed to whole fish thereby minimising feeding slicks);
  - using high quality feed of size that is appropriate to the fish – avoid use of small feed particles (Islam, 2004; Alston *et al*., 2006);
  - removal of injured and deceased stock (Pemberton, 1996);
  - keeping fish in a good physiological condition (D'orbcastel & Blancheton, 2006);
  - a demand feeding regime to minimise excess food entering the water column (Alston *et al*., 2006); and
  - optimising feed conversion ratios.
- Conduct diet development research to reduce the impact of wastes, including:
  - improving digestibility of feeds (Amirkolaie, 2011) to optimise nutrient assimilation and minimise waste (Cho & Bureau, 1997; 2001; Amirkolaie, 2011); and
  - adapting feed biochemical composition to the needs of the fish to optimise the conversion index and either minimise faeces production or increase waste removal efficiency (Brinker *et al*., 2005; D'orbcastel & Blancheton, 2006).

Uneaten food entering the marine environment is not only an expensive waste but also has the potential to impact on the surrounding marine environment. This in turn can impact on the health of the cultured stock and potentially jeopardise research operations. Hence, it is in the best interest of the proponent to maintain water quality, prevent eutrophication and minimise sedimentation.

Conclusion

The risk of the Research Lease having a significant impact on marine habitats in Providence Bay and the wider region is thought to be 'low' when considered in context the high energy environment of Providence Bay, the small scale and short-term operation of the Research Lease, the Water Quality and Benthic Environment Monitoring Program and the implementation of a range of daily operational and maintenance procedures that minimise dissolved and particulate waste inputs.

In addition, the estimated nutrient inputs from the Research Lease are well below the recommended values in the *Australian and New Zealand Guidelines for Fresh and Marine*

Water Quality and reviews of impacts from existing Australian sea cage farms indicate that impacts are likely to be highly localised. Estimations for nutrient inputs associated with the operation of the Research Lease are considerably lower than average seawater concentrations and those released from natural sources such as upwelling.

Overall however, the risk of the Research Lease having a significant impact on marine habitats is considered to be 'moderate' due to the uncertainty about many factors such as feed type, variations due to differing species, how different marine communities will respond and the influence of the NSW high energy coastal environment.

8.2.2.2 Fish Feed – Source, Composition and Sustainability

Table 34: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – fish feed; source, composition and sustainability (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the use of fish feed during the operation of the Research Lease have a significant impact on wild fish stocks in Australian and international waters by the means of increasing the demand for bait/trash fish?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Will whole (trash) fish or pelletised feed be used?* ▪ *What is the composition of the feeds – are alternative sources of proteins and lipids going to be trialled i.e. terrestrial based / non-fish sources?* ▪ *What research is being conducted to increase feed conversion ratios?* ▪ *Have you considered farming herbivorous species?*			
Description	▪ Pelletised feed (fish meal, fish oil, animal and plant based components)			
Proposed Management – Mitigation and Monitoring	▪ Small scale short-term research operation ▪ Land based & offshore research - fish meal and fish oil replacements, FCR, diet development ▪ Feed resources - sustainable suppliers ▪ Minimise feed wastage			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

<u>*Justification of Ranking*</u>

Today the majority of marine finfish aquaculture farms use pelletised feed, which is composed of various ingredients including: fish meal; fish oil, crustacean meal; oil seeds; legumes; cereals and lipid sources (e.g. poultry oils and tallows). Traditionally fish meal and fish oil has been sourced from overseas wild capture fisheries. Some countries like the United Kingdom also make fish meal from unsold fish and offal (i.e. heads, skeletons and trimmings left over when the edible portions are cut off). Other countries like Denmark and Iceland use both trash fish and fish processing waste. Globally, fish meal is used in feeds for aquaculture, poultry, pigs and other animals.

A concern about aquaculture of carnivorous fish is that more bait fish weight is required to feed these species than the weight gained for the final product (de Jong & Tanner, 2004). The harvest of wild fish for human consumption or for use as fish meal needs to be undertaken sustainably. Many species of fish harvested for fish meal are unsuitable for human consumption and are managed as sustainable fisheries (Allan, 2004). Worldwide, a range of management strategies and regulations have been put in place by government agencies to improve the sustainability of bait fish fisheries e.g. closed seasons, catch quota and size limits and mandatory fitting of satellite trackers on fishing vessels.

Evidence to date does not support the claim that increasing demand for aquafeeds will destroy bait fish stocks which are used to produce fish meal and oil (Allan, 2004). The species that have been used to make fish meal and fish oil have remained stable despite the increases in aquaculture over the past 20 years. The total use of fish meal by the aquaculture sector has actually decreased over the past decade. For instance, 4.23 million tonnes of fish meal was used in 2005 by the global aquaculture sector while in 2008 the total weight dropped to 3.72 million tonnes.

The total use of fish meal by the global aquaculture sector is predicted to fall to 3.49 million tonnes by 2020 (Tacon, 2011). The reasons for reduced use of fish meal and fish oil supplies is due to tighter quota setting and additional controls on unregulated fishing and the increased use of more cost-effective dietary fish meal replacers (Tacon, 2011).

Fish meal and fish oil substitutes must be found if aquaculture is to continue to grow as there is little prospect that trash fish catches will increase (Allan, 2004). Significant progress has been made to reduce the dependence on fish meal and fish oil through substitution with terrestrial animal meals and plant ingredients both overseas and in Australia (Allan, 2004). Fish meal replacements that have been trialled include blood meal, liver, meat meal, poultry meal, sunflower seed, rapeseed, cottonseed, soybean, carob seed, wheat products, lupins, meals of silkworm pupae, earthworm, pea seed and corn gluten, as well as fungal, algal and bacterial single cell proteins (Tacon, 1994). The presence of anti-nutritional components, toxic factors and biological contaminants need to be carefully controlled when investigating the use of alternate protein ingredients of plant or animal origin (FAO, 2011b).

Successful reports of partial fish meal replacements in feeds for carnivorous marine finfish species are becoming more common and the level of fish meal replacement is increasing. Fish oil replacements have proven more difficult but significant advances have also been made in this area. Glencross *et al*. (2003) for example, found that there were no significant effects on the growth of Australian Snapper after replacing fish oil with soybean oil or canola oil. However there were some changes in the whole body fatty acid composition of fish fed plant oil compared to fish oil diets. Since then ‘finisher’ feeds high in essential, long-chain fatty acids have been trialled and indicate successful fish oil substitution in grow-out feeds without impacting on the health benefits of eating cultured fish (Allan, 2004).

PSFI researchers have been at the forefront of aquaculture feed development in Australia, particularly in the field of replacing fish meal with terrestrial based protein sources. The Research Lease will provide the opportunity to trial these feeds on a commercial scale. One of the primary objectives of the Research Lease is to evaluate and further develop the dietary development research undertaken in small controlled research tanks at PSFI. This will include testing feeding efficiency and growth performance models developed as part of the tank based research, and evaluating the use of terrestrial protein and energy sources as partial or complete replacement of fish meal and fish oil in some aquaculture feeds.

Stock held at the Research Lease will be fed a manufactured feed which will be of a pellet size appropriate to the size of the cultured stock and may include:

- Meat meal;
- Fish meal;
- Poultry meal;
- Oilseeds (e.g. canola, soybean);
- Fish oil;
- Legumes (e.g. lupins, peas, faba beans);
- Cereals (e.g. wheat, corn, sorghum); and
- Vitamin and mineral supplements.

NSW has access to large volumes of agricultural ingredients and by-products for use in aquafeeds. The cost of many of these commodities is lower than imported fish meal and fish oil which encourages their use in manufactured feeds. It is a common misconception that hormones or growth promoters are used in aquaculture feeds but these substances are not used in aquaculture feeds on farms in NSW.

Formulated feeds, which include commercially manufactured pellets and farm-made aquafeeds (Figure 45), are preferable to the use of wet fish such as pilchards. They increase the flexibility of feed formulation and allow for control over pellet characteristics, such as nutritional content and quality, pellet buoyancy and hardness, product consistency, nutritional quality, transport volume, product stability and hygiene. Therefore, the use of formulated feeds should lead to improved environmental performance and enhance overall efficiency at the farm level (FAO, 2011b).

Herbivorous fish species have not been considered for the research trial as they are not commercially viable. Herbivorous species generally have slow growth rates, are not well accepted in the market place, are perceived to have low quality flesh and as a result attract a low price.

Figure 45: Different pelletised aquaculture feeds. The larger feed is used for broodstock at PSFI while the smaller pellets are used to feed fingerlings (Source: NSW DPI, 2012).

The Research Lease will provide a valuable opportunity to trial the dietary formulations developed at PSFI. This will not only assist in gaining a better understanding of the dietary requirements of the trialled finfish species but will also aid in further reducing the reliance on fish meal and oils in aquaculture diets ensuring that the aquaculture industry can develop in a sustainable manner. The long-term viability and competitive edge of the aquaculture industry in NSW is partly dependent on finding alternatives to fish meal and fish oil replacements (de Jong & Tanner, 2004).

Mitigation Measures

The following mitigation measures will be implemented to ensure that Research Lease practices are sustainable, as well as reduce aquaculture's reliance on fish meal and oils for aquafeeds:

- Small scale short-term research operation;
- Implementation of daily operational and maintenance procedures that minimise feed wastage, including:
    - o Use of high quality feed of a size that is appropriate to the fish – avoid use of small feed particles (Islam, 2004; Alston *et al*., 2006); and

   - A demand feeding regime to minimise excess food entering the water column (Alston *et al*., 2006).
- Continue research on fish meal and fish oil replacements, increasing feed conversion ratios, diet development and offshore trials; and
- Source feed resources from sustainable suppliers.

Conclusion

The risk of fish feed used during the operation of the Research Lease having a significant impact on wild fish stocks in Australian and international waters by means of increasing the demand for bait fish and trash fish is thought to be ‘low’ when considered in context with the Research Lease being a small scale short-term research operation. Conversely, the Research Lease is likely to benefit trash fish and bait fish stocks in the long-term by undertaking research to reduce reliance on these species for fish meal and oil.

8.2.2.3 Chemical Use

Table 35: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – chemical use (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will chemical use associated with the Research Lease have a significant impact on the surrounding marine environment or communities?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *What chemicals will be used e.g. antibiotics, parasiticides, disinfectants, vaccinations and anaesthetics?* ▪ *How will chemical use be regulated?* ▪ *How will any potential impacts on the environment, including water quality, marine flora and fauna, be mitigated, monitored and managed?*			
Description	▪ Chemicals/therapeutics that may be used on the Research Lease: o Antibiotics o Parasiticides o Anaesthetics			
Proposed Management – Mitigation and Monitoring	▪ Chemicals will be administered in accordance with APVMA or via a prescription from a licensed veterinarian ▪ Frequency and doses of treatments will be kept to a minimum ▪ Liners will be used when therapeutics are not administered orally ▪ Comply with the *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research*			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	2	5	10	**Moderate**
Reporting Requirements	Full management report (Appendix 2)			

Justification of Ranking

Worldwide, a range of chemicals are used in aquaculture for the purpose of transporting live organisms, in feed formulation, health management, manipulation and enhancement of reproduction and for processing and adding value to the final product (Douet *et al*., 2009). Chemicals and therapeutics include antifoulants, fertilisers, disinfectants, antibacterial agents, parasiticides, feed additives, anaesthetics and breeding hormones (Tacon & Foster, 2003; Burridge *et al*., 2010).

The operation of the Research Lease is likely to require the use of some chemicals and therapeutics (i.e. veterinary pharmaceuticals) to treat cultured stock for disease, control pests and assist with diagnostic procedures, fish handling, post-harvest transportation and euthanizing fish (i.e. anaesthetics) (Pillay, 2004; Barker *et al.,* 2009; Burridge *et al.,* 2010). More specifically, antibiotics (e.g. oxytetracycline) and parasiticides (e.g. hydrogen peroxide and anthelmintics such as praziquantel) may be administered to cultured stock at land based sites, on board service vessels or in the waters of the Research Lease. No generic vaccinations are proposed for the stock in the Research Lease but the development of vaccines for particular health issues may be investigated if a suitable research partner is identified.

Management practices have evolved and fish husbandry has improved over the past 20 years (Burridge *et al.,* 2010). As a result there has been a reduction in the use of many chemicals for aquaculture (Burridge *et al*., 2010). The Research Lease will aim to keep chemical usage to a minimum by maintaining the health of the cultured stock by undertaking the following:

- Regular monitoring;
- Prompt treatment of any infections;
- Stocking fish at densities that minimises stress;
- Positioning the sea cages in an area with adequate flushing;
- Implementing measures to minimise harassment from predators;
- Using high quality feed; and
- Regularly cleaning nets to avoid accumulation of biofouling organisms.

The types of chemicals available for use and the associated treatment protocols are tightly regulated (Burridge *et al*., 2010). Chemical use associated with the operation of the Research Lease will be in accordance with the Australian Pesticides and Veterinary Medicines Authority (APVMA), which is an Australian government statutory authority that strictly governs chemical use and centralises the registration of all agricultural and veterinary chemical products in the Australian marketplace (Web Reference 28). Alternatively, a prescription from a licensed veterinarian will be obtained prior to administering chemicals or therapeutics to the cultured stock. The appropriate Material Safety Data Sheets (MSDS) will also be consulted when using chemicals on the Research Lease and due care will be taken to ensure the safety of staff, stock and the environment (Barker *et al*., 2009).

"It is illegal to supply fish or other animal products for human consumption if they contain residues of chemicals above the legal limits (i.e. Maximum Residue Limit) set in the Food Standards Code (as adopted into the *NSW Food Act 2003*)" and no residue at any detectable level is permitted if there is no limit set in the Standard (Barker *et al*., 2009). Similarly, use of unregistered stock medicines (veterinary chemical products) or off-label products is not permitted and cannot be authorised by a veterinarian if the treated fish may be consumed in the future by humans (Barker *et al*., 2009).

In regards to on-board operations, chemicals including fuel, cleaning liquids (soap), toilet products, oils and therapeutics, will be secured in storage containers with tightly fitted lids. Regular servicing of all boats and equipment; daily inspections and appropriate 'start up' and 'shut down' procedures will ensure early identification of any issues (e.g. potential spillages or leaks) and prompt remedial action by appropriately trained staff. Any residual or out of date chemicals will be transferred to land based facilities and disposed of in an appropriate manner.

Environmental Impacts of Therapeutic Chemicals

Some chemical compounds are more persistent or stable in the environment than others and some are more rapidly broken down by naturally occurring processes such as sunlight and water temperature (Lunestad, 2008). The environmental fate of antibiotics and anthelmintic drugs depends to a large degree on their physico-chemical properties. Once released into the aquatic environment these chemicals are distributed through the water and can reach the sediments, thus potentially affecting both pelagic and sedimentary organisms (Horvat *et al*., 2012). These chemicals are mostly degraded by processes such as biodegradation, chemical degradation, photo-chemical degradation or they can react with other compounds in the environment.

Ultimately, the concentration and ecotoxicological impact of a chemical or it's metabolites reaching the aquatic environment from a sea cage facility is dependent on the stocking density, the concentration, timing and frequency of a treatment, the dynamics of the particular site they are released from (e.g. current flow, wave action, water temperature, turbidity) and the physico-chemical processes occurring at that location (Horvat *et al.,* 2012).

Application of therapeutic chemicals used in aquaculture, whether by bathing or by in-feed treatment has the potential to impact on the environment if over used. The use of chemicals such as hydrogen peroxide in the aquatic environment is considered low risk, however bathing fish is time consuming, expensive and can lead to stress in fish. For these reasons, therapeutics aimed at controlling parasites are increasingly being offered as in-feed treatments (Sorum, 2008). This has many benefits including the reduction in the amount of chemical used and greater accuracy of dose rate. In–feed treatment also greatly reduces labour costs and significantly reduces the crowding stress experienced by fish during bathing procedures.

Chemicals used in aquafeeds are generally applied on the surface (top-coated) or in the mash to form part of the extruded pellet. If necessary, anthelmintics and antibiotics will be incorporated in-feed when used on the Research Lease. Controlling parasitic or bacterial diseases in farmed fish nearly always means treating the entire population due to the rapid spread of disease in a common water body (Sorum, 2008).

Chemicals used in-feed are disseminated in the aquatic environment in several ways (Lunestad, 2008; Sorum, 2008; Horvat *et al*., 2012). Firstly in unconsumed feed pellets that may pass through or be washed from the sea cage pens, secondly via undigested faecal material and thirdly via excretions which may carry the parent chemical or metabolic products derived from the parent chemical into the water. Uneaten pellets may be ingested directly by other marine pelagics congregating around the outside of the sea cages, and fragments of pellets or faecal material containing therapeutics may be captured by sessile and planktonic filter feeding organisms around and underneath the sea cages.

A thorough assessment will be conducted by appropriately qualified personnel prior to the use of any therapeutics on the Research Lease in Providence Bay to determine the safest treatment concentration and method to prevent any adverse effects on marine organisms, the environment and surrounding communities. Each treatment event will be assessed individually to ensure that variation in correlated factors are accounted for, such as seawater temperature, previous use and accumulation in the area, degradation rates and toxicity levels. Only therapeutics that pose a negligible to low risk will be used on the Research Lease.

Resistance to Chemical Treatments

Use of antibiotics to control pathogens in aquaculture has raised concerns about the potential of drug resistance in both target and non-target animals as well as in bacterial organisms (Horvat *et al.,* 2012). These concerns are not unique to aquaculture and similar issues predominate in terrestrial livestock industries as well as in human health. Most drugs used in aquaculture to date are similar to drugs used in terrestrial agriculture and to those used for treating household pets and humans (Sorum, 2008). In all cases the over use of these drugs has led to some resistance in the target organism. Reduction in the use of antibiotics is a major goal of all food producing industries and the aquaculture industry worldwide is pushing for development of suitable vaccines to guard against potential diseases (Sorum, 2008). For instance, the successful introduction of vaccines against *Vibrio* and *Aeromonas* infections in the 1990s led to major reductions in the use of antibiotics in most countries farming Atlantic Salmon (Sorum, 2008).

Water is a good medium for unintentionally transferring chemicals into the environment. While all care will be taken when feeding medicated pellets it is inevitable that some chemicals will reach and interact with the near and intermediate environments. Impacts on bacteria in the environment, both pathogenic and those which function in the food web and as decomposers of organic material will likely be stimulated to acquire some level of resistance to the particular chemical if over used.

The risk of resistance is significantly reduced by firstly correctly diagnosing the disease and secondly by prudential use of all chemicals used in treating a disease. Thirdly, the employment of better on-farm management practices and strategies coupled with strict health management procedures and/or the development of vaccines (WHO 2001; Sorum, 2008) will reduce the need for use of all antibacterial chemicals. Due to pressures from governments, consumers and green groups, responsible fish farming companies are employing aquaculture best practices which are science-based to continuously improve performance standards for aquaculture to assure quality wholesome foods produced through environmentally and socially responsible means. The Research Lease activities would investigate and develop guidelines related to aquaculture best practices for sea cage based aquaculture.

Overview of Main Chemicals

A brief overview of the main groups of chemicals and therapeutics that are likely to be used during the operation of the Research Lease is provided below:

(a) Antibiotics

More than 100 bacterial species have been linked to diseases in marine and freshwater fish farming (Lunestad, 2008). Antibiotics such as oxytetracycline may be used occasionally on the Research Lease to inhibit and eliminate pathogenic bacteria infecting the stock (Burridge *et al*., 2010). A number of factors determine the toxicity of antibiotics in the marine environment, such as the specific antibiotic used, how much is released, type of organisms exposed, whether it accumulates within organisms and degradation rates in water and sediment (Douet *et al*., 2009; Horvat *et al*., 2012). In particular, antibiotics degrade by hydrolysis, microbial degradation, chemical degradation (oxidation) and photo-degradation (Douet *et al*., 2009). No detectable antibiotic residue is permitted in fish consumed by humans in Australia (Barker *et al*., 2010).

Oxytetracycline is a broad-spectrum synthetic antibiotic that is widely used in aquaculture to treat a broad range of bacterial infections (e.g. *Furunculosis* and *Vibrio* species) in fish and crustaceans (Powell, 2000 cited in Burridge *et al*., 2010; Barker *et al*., 2010). Oxytetracycline has a low toxicity (i.e. 96 h LC50 for fish is > 4 g kg^{-1}), relatively high water solubility (Burridge et al., 2010) and rapidly degrades in seawater (Douet *et al*., 2009).

A range of studies have investigated the toxicity of oxytetracycline on marine organisms. Chinook Salmon for example, were injected with this compound twice a year for three years and no signs of toxicity were observed (Douet *et al*., 2009). Oxytetracycline is reported to have low toxicity in fish (Douet *et al*., 2009) and a 6 to 7 day half-life in Blue Mussels and a 10 day half-life in Japanese Oysters (Pouliquen *et al*., 1996).

The use of oxytetracycline during the operation of the Research Lease will be rare and only relatively small amounts will be used due to the limited scale and short-term life of the Research Lease. On occasions where it is used, the proponent will adhere to appropriate withholding periods. Management measures will focus on the prevention of disease outbreaks and antibiotics will only be used as a last resort. Consequently, oxytetracycline is not considered to pose a significant risk to the marine environment or the community.

(b) Parasiticides

Parasite infestations (e.g. sea lice, gill and skin flukes and flatworms) can cause major mortality in farm raised fish if left untreated and use of parasiticides are sometimes necessary to control and eradicate fish parasites (Burridge *et al*., 2010).

Hydrogen Peroxide

Hydrogen peroxide is a strong oxidizing agent that is widely used in treating stock for fungal (Rach *et al*., 2000) and sea lice infections (Burridge *et al*., 2010). It is currently used in South Australia to treat monogenean infection of Yellowtail Kingfish in sea cages using a liner and additional aeration.

Use of hydrogen peroxide is considered to have low environmental risk as it decomposes into oxygen and water, it is completely miscible with water (Burridge *et al*., 2010) and there are no persistent contaminants that will accumulate in the environment (Schmidt *et al*., 2006). Hydrogen peroxide concentrations naturally occurring in seawater range from 0.001 to 0.0136 mg/L (Schmidt *et al.,* 2006) and its degradation rate varies widely from 0.00034 to 0.017 mg/L/hr (Johnson *et al*. 1987 cited in Schmidt *et al*., 2006). According to a study in Bruno and Raynard (1994), 21% and 54% of hydrogen peroxide decomposed after 7 days in seawater at the temperatures of 4°C and 15°C, respectively. However, when the seawater was aerated 45% and 67% decomposed after 7 days, respectively.

Anthelmintics

Anthelmintics are used to treat farmed fish species against monogenean, digenean and cestode parasites. Monogeneans can multiply rapidly in intensive farming facilities because of their direct life-cycle, which necessitates early diagnosis followed by rapid and effective treatment to prevent benign infections from becoming pathogenic (Tubbs & Tingle 2006; DAO, 2006). Anthelmintics can be effective against ectoparasites (external on skin or gills) and endoparasites (internal gastro-intestinal) of fish and are almost exclusively available for oral administration via in-feed treatment (Lunestad, 2008).

Praziquantel is a broad-spectrum synthetic anthelmintic commonly used to treat internal platyhelminth parasites in livestock, domestic animals and humans. The drug has also been used for treating fish parasites (e.g. common skin fluke and *Neobenedenia girellae)* and is approved in Japan for aquaculture usage against *Benedenia seriolae* (a skin fluke of *Seriola* species) (Yamamoto *et al*., 2011).

Typically praziquantel is administered orally in-feed and less frequently as a bathing treatment (Tubbs & Tingle 2006a). The efficacy of in-feed doses of praziquantel has been tested on monogeneans *Zeuxapta seriolae* (gill fluke) and *B. seriolae* infecting Yellowtail Kingfish in South Australian sea cages (Tubbs & Tingle 2006b; Williams *et al*., 2007). This chemical is also effective against *Cardicola* blood fluke infestations in Southern and Pacific Bluefin Tuna (Hardy-Smith *et al.,* 2012; Shirakasi, 2012). Of the anthelmintics tested in fish, praziquantel appears to be one of the most effective against gill and skin flukes (Hardy-Smith *et al*., 2012).

The oral bioavailability of praziquantel administered in-feed to Yellowtail Kingfish is approximately 50% (Tingle & Tubbs, 2006a). When administered to Yellowtail Kingfish via oral preparations, praziquantel concentration in plasma and skin fell below detectable limits after 24 hours, while intravenously administered praziquantel was not detectable after 48 hours. The elimination half-life of praziquantel ranged between 6.6 and 8.6 hours when administered orally in solution and intravenously, respectively (Tubbs & Tingle, 2006a). It has also been found to be extensively metabolised in the liver (Harvat *et al.*, 2012).

Praziquantel is rapidly and reversibly absorbed by the parasite and is believed to have two immediate actions in susceptible organisms. At low therapeutic concentrations the drug causes spastic paralysis in the target organism, which causes the target organism to lose their attachment to the host (Hardy-Smith *et al*., 2012). At higher therapeutic doses praziquantel induces vacuolisation and vesiculation of the parasite tegument. This cases the organism, (most notably endoparasites) to suffer osmotic and nutritional imbalance and allows the hosts own internal defence mechanisms to destroy the parasitic worm (Hardy-Smith *et al*., 2012).

Praziquantel lacks mutagenic potential in humans and has no harmful effects on fertility, foetal and maternal toxicity in animal reproductive toxicity and teratogenicity studies in the rat and rabbit, and in embryotoxicity studies in the mouse, rat and rabbit (WHO, 2002). Praziquantel is widely approved for medicinal use in cats, dogs and sheep including pregnant animals. The drug was not found to be carcinogenic in rats or hamsters treated for 104 and 80 weeks, respectively. In summary, reviews of original reports and their evaluation by official agencies have concluded that praziquantel lacks significant toxic potential in laboratory experiments (WHO, 2002).

Benzimidazoles are the largest class of anthelmintics used to treat endo-parasites in domestic animals. Benzimidazoles are among the most potent therapeutants known with complete larvicidal activity. However, they have a relatively low mammalian toxicity and lack activity toward other organisms (Lunestad, 2008). Benzimidazoles are thought to inhibit the synthesis of micro-tubuli by inhibiting polymerisation of tubulin. They also inhibit uptake of external glucose (a major nutrient for parasites) and the secretion of acetylcholinesterase, which leads to paralysis and dislodgement of the parasite (Lunestad, 2008). Benzimidazoles are generally considered safe compounds which are used widely in livestock (Hardy-Smith *et al.*, 2012).

(c) Anaesthetics

The use of anaesthetics to assist with procedures such as diagnostic procedures, fish handling, post-harvest transportation and artificial breeding, is considered to pose minimal risk to the marine environment (Douet *et al*., 2009; Burridge *et al*., 2010). The use of anaesthetics during the operation of the Research Lease will be infrequent and in accordance with the *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research* developed by the NSW DPI Animal Care and Ethics Committee.

Anaesthetics will be employed at low doses and may be administered to stock in containers on service vessels, during transport, at land based facilities or *in situ*. However, anaesthetics are considered to pose minimal risk to the marine environment as only low doses will be used (Barker *et al*., 2009). Doses will also be adapted to the specific conditions including the species, temperature and salinity (Douet *et al*., 2009).

Conclusion

The risk of chemicals used during the operation of the Research Lease having a significant impact on the marine environment and/or the surrounding communities is thought to be ‘low’ when considered in context with the APVMA and licensed veterinarians regulating chemical use, the infrequent treatments, the low doses used, the regular investigations into safe treatment concentrations and methods, the use of liners and the small scale and short-term life of the Research Lease, as well as the proponent’s commitment to comply with the *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research*. However, the overall risk for chemical use associated with the Research Lease is considered to be ‘moderate’ due to the current knowledge base on ecotoxicity, degradation rates and the potential impacts of chemicals in the NSW coastal marine environment.

8.2.2.4 Genetics and Escapement

Table 36: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – genetics and escapement (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">If cultured stock escapes, will they have a significant impact on the genetic integrity of wild populations, competition and predation levels and/or food chains?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ Are escapees likely to threaten wild stocks by causing increased competition for resources e.g. space, food or food chains?
▪ Could feral populations become established if cultured stock escape into the wild?
▪ Are the cultured stock native to region i.e. is Port Stephens within their natural range?
▪ If cultured stock escapes, is it likely they will have an impact on the genetic integrity of wild stocks?
▪ Are cultured stocks likely to survive to breeding age?
▪ Will the Research Lease exacerbate the KTP - 'introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW (FM Act)?
▪ Is there a protocol to recapture escapees?
▪ Are any measures going to be taken to ensure that the genetic composition of broodstock is maintained at an appropriate level?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Cultured species are native to NSW waters
▪ Some stock may escape during five year research period</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Broodstock source - local stocks and/or same genetic population
▪ First generation is cultured - no artificial selection and sufficient number of pairs used when breeding to maintain genetic integrity
▪ Daily operation and maintenance procedures to minimise predatory interactions
▪ Stock will be only be relocated during calm sea state conditions
▪ Structural Integrity and Stability Monitoring Program (Appendix 2)
▪ Escapee Recapture Protocol (Appendix 2)
▪ Sea cage infrastructure will be based on existing and proven technologies to withstand recorded wave climate maximums</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>1</td><td>6</td><td>6</td><td>Low</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Full justification</td></tr>
</table>

Justification of Ranking

Loss of genetic diversity is a potential concern if escapees establish breeding stocks in the wild and cross breed with wild populations (Pillay, 2004). The genetic integrity of wild stocks is most at risk when farmed fish originate from broodstock outside the range of the local genetic population.

Fingerlings produced for the Research Lease will be derived from broodstock that has either been collected from stocks local to the marine farming activity or from the same recognised genetic population. Broodstock will be collected from local genetic populations in sufficient numbers to ensure that the genetic diversity of the fingerlings produced for stocking is not compromised. There will be no artificial selection or use of genetically modified organisms - all farm fish will be first generation offspring of captured wild broodstock.

There are various ways in which cultured fish can escape from sea cages, including during severe weather events, predator attacks, vandalism, during net changes or as a result of net failure (e.g. manufacturing defects or worn nets) (PIRSA, 2003). Cultured stock escapees can potentially decrease the genetic integrity of wild stocks, impact on food chains and wild populations via predation and/or competition, introduce disease and pests, establish feral populations and impact on the socio-economics of a region (de Jong & Tanner, 2004).

The ability for escaped farmed fish to contribute to wild stock genetics is determined by their ability to survive to breeding age. Escapees must be reproductively mature, spawn viable eggs or sperm which must mix with the spawn of wild fish to produce offspring (PIRSA, 2003). The offspring must then survive to breeding age and reproduce with existing wild stocks. A genetic in or out-breeding depression will only be created if the wild stock is genetically distinct enough from the farm fish (PIRSA, 2003). Fish require an appropriate series of environmental cues (e.g. lunar cycles, temperature and light intensity) and a readily available high quality diet to become reproductively mature (PIRSA, 2003).

As farmed fish are conditioned to human presence and the supply of high quality pellet feed, their foraging abilities and survival skills in the wild are likely to be limited. This is supported by studies on the gut contents of escaped fish which indicate that these fish do not feed well and in turn would limit gonad development (O'Sullivan *et al*., 1998; PIRSA, 2003). Escaped fish are also more likely to be predated on as they have not learnt to avoid dangerous situations, which further reduce their chance of surviving to breeding age (PIRSA, 2003).

Furthermore, if fish were to escape and the highly unlikely event of successful cross breeding occurred, the genetics of the farm and wild stock would be the same and there would be no impact on the integrity of the wild gene pool (PIRSA, 2003).

Escapees can also potentially impact on food chains by increasing competition and predation levels. For example, escapees could increase competition with other carnivorous fish and/or increase predation levels on bait fish (de Jong & Tanner, 2004). In Tasmania however, Atlantic Salmon has been farmed since the early 1980s and there is no evidence that escapees have formed self-sustaining populations in the wild (O'Sullivan *et al*., 1998). O'Sullivan *et al*. (1998) studied their stomach contents and found very little food which supports the idea that escapees are not efficient predators and may not be impacting on food competition levels or food chains (de Jong & Tanner, 2004). This study concluded that the impact of escaped Salmon on food competition and predation levels with other native fish was minimal but the degree of impact is likely to vary with changes in the number of escapees, concentration and whether they feed or not.

Many of the surveys that have found evidence to suggest that escapees have an impact on native fish populations were conducted on species that are exotic to the region (de Jong & Tanner, 2004). To minimise the risk of escapees having an impact on native fish species and to ensure that there is no risk that feral populations will become established, the Research Lease will only be stocked with fish species that are native to the region.

The extent of competition between escaped farm fish and wild stock is largely dependent on the ecological niches they occupy, feeding habits and survival rates (Pillay, 2004). However, as cultured fish usually have poor survival skills and given that escapee events associated with the Research Lease are expected to be minimal and infrequent, the risk of farm fish having a competitive advantage over wild stock is considered to be low (de Jong & Tanner, 2004).

Concerns have also been raised about skeletal deformities in cultured fish escapees being passed on to wild populations. Skeletal deformities in cultured fish have been observed in varying levels of prevalence on marine fish farms in Australia (PIRSA, 2003). However, farm fish deformities are usually related to the management of stock during their larval stages. The effects of nutrition, water temperature and husbandry practices on the occurrence of deformities is thoroughly documented in scientific literature (PIRSA, 2003). Furthermore, farm fish deformities cannot be passed on to wild fish as they are not a result of genetics.

Mitigation Measures

The range of mitigation measures that will be implemented to minimise the risk of escapement events are discussed below:

- Utilisation of sea cage design features (i.e. exclusion and barrier techniques), as well as daily operational and maintenance procedures that will minimise predatory interactions (Kemper *et al*., 2003; McCord *et al*., 2008) including:

- o highly visible anti-predator nets with a small mesh size (about 6 cm) represent a physical and visible deterrent where bright colours are thought to possibly interfere with the predators ability to see fish within the nets;
- o fully enclosed double bottomed net (shark guard) to prevent marine predators from accessing the bottom of the sea cages;
- o highly visible bird exclusion nets (surface) loosely secured over the top of the cages to dissuade seabirds and seals from perching on the nets or railings and diving into the cages;
- o raised railings (i.e. 1-2 m above sea level) to prevent seals from interacting with staff and jumping into the pens (Pemberton, 1996; Kemper *et al*., 2003; DAFF, 2007);
- o elimination of all safe roosting and perching places to deter seabirds and seals;
- o use of large round cages with low stocking densities to reduce accessibility of stock to seals (note: square cages can be manipulated by seals as the corners represent points of weakness) (C. Cartwright, *pers. comm*. cited in DAFF, 2007); and
- o regular cleaning of nets to reduce the amount of natural food available, use of pelletised feed, prompt removal of injured and deceased stock and a demand feeding regime.

- Sea cage infrastructure will be purchased from an existing manufacturer or a certified structural design engineer will be employed to design the sea cages using established engineering knowledge and proven technologies. The design will accommodate the high energy environment of Providence Bay and be tailored to withstand the recorded maximums for wave height, tidal range, swell and wind speed (See Section 6.1, 6.4 and 6.5).
- Implementation of Structural Integrity and Stability Monitoring Program (Appendix 3)
  - o regular inspections, maintenance and repair of sea cage infrastructure to ensure rope tautness and net integrity, particularly after severe weather, including comprehensive *in situ* inspections (Pemberton, 1996); and
  - o newly deployed nets or nets that have been removed for cleaning will be thoroughly checked before stocking (TO, HAG & and PA Pty Ltd, 2005).
- Transfers of stock (e.g. due to net cleaning, harvesting or relocation to larger cages) will be conducted in weather conditions that do not pose a high risk of fish

escapement (e.g. avoid high wind and large swell conditions) (TO, HAG & and PA Pty Ltd, 2005).

- Regular staff training/education will be provided and safety measures will be implemented for any operational or maintenance procedure that may result in an escapement event if not performed correctly (TO, HAG & and PA Pty Ltd, 2005).
- Implementation of the Escapee Recapture Protocol which will detail the procedures for recapture attempts (Appendix 3). Recaptures are possible as escapees tend to remain in close proximity to fish farms for prolonged periods and there is evidence to suggest that escapees prefer pellets to their natural diet (PIRSA, 2003).
- All escapee events will be recorded and reported to the regulator - NSW DPI (de Jong & Tanner, 2004).

Conclusion

The risk of escapees having a significant impact on the genetic integrity of wild populations, competition and predation levels and/or food chains is thought to be ‘low’ when considered in context with the small scale and short-term operation of the Research Lease, the use broodstock that will be sourced locally or from the same genetic population, the use of breeding techniques that will ensure genetic integrity, the poor survival skills of cultured stock, the Structural Integrity and Stability Monitoring Program and the Escapee Recapture Protocol that will be implemented, as well as the operational and maintenance procedures that will minimise predatory interactions and escapee events.

8.2.2.5 Disease and Introduced Pests

Table 37: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – cultured stock diseases, disease transmission and introduced pests (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the Research Lease have a significant impact on the occurrence of pathogens in wild populations and/or significantly increase the risk of the establishment of pests?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ What processes and regulations are in place to ensure that hatchery reared stock is disease free before released into the sea cages?
▪ Are cultured stocks likely to transfer diseases to wild stock?
▪ Is it likely that disease from cultured stock may be passed on to other fauna in the region via escapees, the passage of pathogens through the water or intermediary hosts?
▪ Will the Research Lease exacerbate the KTP - ‘introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW?
▪ What mitigation and management measures are available to minimise the risk of disease transmission to wild stock from the escape of cultured stock and introducing marine pests?
▪ Will the health of cultured stock be closely monitored?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Cultured species – native to region
▪ Native disease and parasites - minor/controllable
▪ Exotic disease and parasites - negligible/low risk</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Disease, Parasite & Pest Management Plan (Appendix 2)
o Minimal stress – stocking densities, water quality, predatory interactions
o Regular fish health monitoring (surveillance program)
o Report ‘declared diseases’, unexplained mortalities, suspected marine pests and noxious species
o Biofouling management
o AQUAVETPLAN
o Species specific health management protocols as required
▪ Hatchery Management Plan
o NSW Hatchery Quality Assurance Scheme accreditation</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>3</td><td>3</td><td>9</td><td>Moderate</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Full management report (Appendix 2)</td></tr>
</table>

Justification of Ranking

A wide variety of disease causing organisms and parasites exist worldwide (de Jong & Tanner, 2004). Disease is not just the result of the pathogen itself but a complex interaction between the pathogen, the aquatic animal and the environmental conditions (PIRSA, 2002). Pathogens types include parasites, fungi, bacteria and viruses, which usually infect fish when their immune system is depressed, the epidermis is damaged and/or succeeding periods of severe stress caused by factors such as poor water quality or rough handling (Barker *et al.,* 2009).

Disease and parasites are likely to spread faster in sea cage farms than in the wild but strict health monitoring programs help to ensure early identification of pathogens so appropriate management is implemented before severe infestations occur (PIRSA, 2003). However, prevention of infections is generally much easier than control and can usually be achieved by careful handling, good husbandry practices and maintenance of water quality (PIRSA, 2003; Barker *et al.,* 2009).

Worldwide, there are documented cases of exotic diseases being introduced to wild fish from translocated farm fish which have had severe impacts on local fish populations (e.g. Heggberget *et al*., 1993). Minimal research has been conducted on the transfer of native and exotic diseases from cultured stock to wild fish in Australia (de Jong & Tanner, 2004). Difficulties associated with determining the origin of pathogens in wild stocks and establishing any links with diseases of cultured fish hinders the identification of direct pathogen transfer between cultured and wild fish (Windsor & Hutchison, 1990). However, cultured stocks are checked and declared healthy and free of diseases and parasites when they are transferred into sea cages so it is more likely that the initial transfer of pathogens is from wild to cultured stock (Bouloux *et al*., 1998; PIRSA, 2003).

There is no definitive evidence that marine aquaculture has caused an increase in the occurrence of 'native' pathogens in wild stocks according to de Jong & Tanner (2004). Several studies in the northern hemisphere have correlated intense aquaculture areas with high infection rates in wild stock (e.g. Bjord & Finstad, 2002) but these studies do not provide evidence of a casual linkage between aquaculture and disease prevalence in wild fish as local environmental conditions were not considered (de Jong & Tanner, 2004).

There is a paucity of information on pathogens of species such as Yellowtail Kingfish in Australia but more is understood about pathogens of salmonids as they have been farmed in Tasmania since the early 1980's (O'Sullivan *et al*., 1998). However, further research is required on potential pathogens and their interaction with fish cultured in sea cages and wild stocks.

Exotic Pathogens and Pests

Wild fish are likely to more susceptible to exotic pathogens as they may lack the innate immune response that animals are thought to have for ‘native’ diseases and parasites (de Jong & Tanner, 2004). However, as NSW DPI will source broodstock for fingerling production from local populations or individuals from the same genetic population (See Section 3.7), the risk of exotic fish species establishing feral populations and introducing exotic pathogens to wild populations is considered negligible.

A risk assessment process will be used to evaluate exotic pathogen and pest hazards if any stock or equipment is imported from other Australian states. An assessment will be made on the likelihood of potential pathogens entering, becoming established and spreading in the surrounding environment and associated consequences (Bartley *et al*., 2006).

Marine pests could potentially be spread by ballast water, vessel hull biofouling and in niche areas (Commonwealth of Australia, 2009). Biofouling levels on vessels may seem insignificant but the pest potential of some species enables small numbers to rapidly increase due to fast breeding rates (Commonwealth of Australia, 2009). If service vessels for the Research Lease are sourced from outside NSW they could represent a marine pest risk for the region so their movements will need to comply with the *National Biofouling Management Guidelines for Commercial Fishing Vessels* (Commonwealth of Australia, 2009). If the origin port is known to have significant marine pest issues then a risk assessment will be undertaken and mitigation measures may be required to prevent translocation of pests.

Hatchery Disease Management

The initial step in preventing the occurrence of diseases and parasites in aquaculture stocks starts with the production of quality disease and parasite free hatchery stock. This is accomplished through the implementation of strict hatchery procedures.

PSFI hatchery facility that will be used to produce the fingerlings for stocking the Research Lease is accredited under the *NSW Hatchery Quality Assurance Scheme* (HQAS) (NSW DPI, 2010). The objectives of the HQAS standards are to maintain genetic integrity and produce fish that are healthy and free of pests and non-target species (NSW DPI, 2010). The scheme was developed to produce native freshwater fish fingerlings for recreational fishing enhancement stocking programs and aquaculture production but is considered to be applicable and will be used for the culture of marine finfish species for research and commercial purposes. A feature of the HQAS is the maintenance of a Health Management Plan, surveillance and early detection of disease, prompt response and treatment of stock and biosecurity procedures for the facility and stock management.

The *Hatchery Manual for the Production of Australian Bass, Mulloway and Yellowtail Kingfish* (Fielder & Heasman, 2011) will also be used as a guideline for the development of hatchery best practices. Notably, the manual provides details of symptoms and control/prevention methods for specific pathogens in hatcheries (Fielder & Heasman, 2011). A Hatchery Management Plan will be developed for the Research Lease by NSW DPI based on these guidelines (Appendix 2).

Translocation

Permits and veterinary clearance will be required for all imported or translocated stock. However, it is likely that imported stock will be restricted to fertile eggs from other Australian hatcheries which will be translocated to PSFI hatchery. The eggs will be subject to stringent hatchery practices and surveillance regimes, as well as possibly ozone treatment to ensure there is no risk of introducing disease or parasites to the hatchery (Appendix 2).

Fingerlings will be sampled and thoroughly examined before they are translocated to the sea cages. Visual inspections for any signs of disease or parasites, histopathological examinations and the polymerize chain reaction (PCR) investigations may be used to test for pathogens. The fingerlings will also undergo a preventative prophylactic treatment for pathogens prior to translocation to the sea cages. If any known or suspected case of disease or parasites is detected, the infected stock will be quarantined and treated.

Fingerling transport containers will be disinfected with chlorine before and after they are used to further minimise the risk of hatchery fish transmitting disease and parasites to wild stocks. Transport water may also be disinfected prior to use for transporting fish to the Research Lease. Water quality in these containers will be carefully monitored to ensure maintenance of appropriate standards, particularly in regards to dissolved oxygen. Every attempt to minimise stress to fish before they are released into the sea cages will be made (e.g. sedation during transport) as stress triggers internal reactions and the release of hormones (e.g. cortisol) (Web Reference 33). These reactions can directly and indirectly compromise the immune system which in turn can make fish more susceptible to disease and parasitic infections (Web Reference 33).

Sea Cage Disease Management

Regular monitoring of the health of the cultured stock in the sea cages will be undertaken and if signs of disease are detected, prompt treatment will occur to ensure that the occurrence and severity of disease and parasite infections are kept under control. Any known or suspected case of a notifiable aquatic disease (‘declared diseases’) listed under the FMA, as well as any unexplained or unusual mortalities and disease outbreaks will be investigated.

Stress to stock will be minimised wherever possible to reduce the risk of disease outbreaks and infections as environmental stresses lower their natural resistance (Snieszko, 1974). A range of sea cage design features (i.e. exclusion and barrier techniques) and daily operational and maintenance procedures will be implemented to minimise predatory interactions and therefore stress levels (Kemper *et al*., 2003; McCord *et al*., 2008) including:

- highly visible anti-predator nets with a small mesh size (about 6 cm) represent a physical and visible deterrent where bright colours are thought to possibly interfere with the predators ability to see fish in the nets;
- fully enclosed double bottomed net (shark guard) to prevent marine predators from accessing the bottom of the sea cages;
- highly visible bird exclusion nets (surface) loosely secured over the top of the cages to dissuade seabirds and seals from perching on the nets or railings and diving into the cages;
- raised railings (i.e. 1-2 m above sea level) to prevent seals from interacting with staff and jumping into the pens (Pemberton, 1996; Kemper *et al*., 2003; DAFF, 2007);
- elimination of safe roosting and perching places to deter seabirds and seals;
- use of large round cages with low stocking densities to reduce accessibility of stock to seals (note: square cages can be manipulated by seals as the corners represent points of weakness) (C. Cartwright, *pers. comm*. cited in DAFF, 2007); and
- regular cleaning of nets to reduce the amount of natural food available, use of pelletised feed, prompt removal of injured and deceased stock and a demand feeding regime.

Stock stress levels will also be minimised by maintaining appropriate stocking densities in the sea cages (Barker *et al*., 2009). The stocking density will vary depending on the research that is being undertaken at the time but the perceived maximum production capacity is estimated to be 300 tonnes. The Research Lease provides an opportunity to investigate the appropriate stocking densities for the proposed fish species in the coastal environment of NSW.

Biofouling on sea cages can potentially harbour pathogens and reduce water flow and quality, which in turn can increase the risk of cultured stock contracting pathogens (Braithwaite *et al*., 2007). Biofouling can also act as an attractant to wild fish both as food and refuge and therefore its removal reduces its attractiveness to wild fish species that may also harbour naturally occurring diseases and parasites (Braithwaite *et al*., 2007). Cage nets will be cleaned *in situ* or on land as required where a range of methods will be trialled as part of the research activities, such as submersible net cleaning robots (Waste Management Plan - Appendix 2).

Therapeutics may need to be used to treat cultured stock with disease and parasites if there are no other alternatives but treatments will be infrequent and only low doses will be used. The APVMA tightly regulates chemical use and prescriptions are required from licensed veterinarians prior to the use of many therapeutics (See Section 8.2.2.3 - Chemical Use). Regular investigations into safe treatment concentrations and the most effective application methods, as well as the use of liners to minimise the amount released into the marine environment and the small scale and short-term of the research trial, further minimise the risks associated with therapeutic use.

Emergency Biosecurity Procedures

Emergency response protocols to deal with aquatic animal disease events have been developed by NSW DPI in accordance with the provisions of *Australian Aquatic Veterinary Emergency Plan* (AQUAVETPLAN). AQUAVETPLAN was developed with the aim of building and enhancing the capacity of the management of aquatic animal health in Australia.

A series of manuals detailing approaches to national disease preparedness and aquaculture animal disease events, including technical response and control strategies and guidelines for dead stock disposal are provided in the AQUAVETPLAN (Web Reference 34). Details of these procedures will be contained in the Disease, Parasite and Pest Management Plan (Appendix 2). NSW DPI has demonstrated experience and capacity to deal with aquatic animal disease emergencies. For example, NSW DPI has had to respond to and manage QX and Pacific Oyster Mortality Syndrome events in the NSW oyster industry.

Conclusion

The risk of the Research Lease having a significant impact on the occurrence of pathogens in wild populations is thought to be ‘low’ when considered in context with the implementation of the Disease, Parasite and Pest Management Plan, which includes guidelines and protocols for surveillance regimes and monitoring, how to reduce stress to stock, the implementation of strict husbandry practices, the reporting of notifiable aquatic diseases and the removal of biofouling. The Research Lease will also comply with the NSW Hatchery Quality Assurance Scheme.

In addition, the introduction of exotic pathogens and pests into the surrounding region will be minimised by culturing species that are native to NSW waters and implementing biosecurity procedures. However, due to limited information on the risks of pathogens and pests associated with sea cage farms in Australian waters, a ‘moderate’ risk ranking is considered the most appropriate until further research is conducted on the issue.

8.2.2.6 Artificial Lights

Table 38: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts of artificial lights on light sensitive species (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the installation of four navigation lights on the corners of the Research Lease and the use of service vessel lights have a significant impact on any light sensitive species, notably seabirds?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ What type of navigational lights will be installed to mark out the boundary of the lease?
▪ Will the service vessels be operating at night and coming in close proximity to any of the offshore islands?
▪ Is the lighting or illumination likely to have any impact on any light sensitive species?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Possible light sensitive species
o Gould’s petrels
o Little penguin
o Wedge-tailed shearwaters
o Sooty shearwaters
o Short-tailed shearwaters
o White-faced storm petrels
▪ Four navigation lights on corners of Research Lease
o Range ≥ 4 nautical miles
o Flashing
o Vertical divergence ≥ 9 degrees</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Site selection
o Research Lease > 2 km from offshore islands
o Research Lease north of residential areas (not exacerbate light pollution)
▪ Hours of operation = predominately daylight
▪ Vessel lights – shielded and concentrated downwards
▪ Marine Fauna Interaction Management Plan (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>1</td><td>6</td><td>6</td><td>Low</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Full justification</td></tr>
</table>

Justification of Ranking

Artificial lights have been raised as a potential issue associated with aquaculture projects in Providence Bay due to the perception that navigation and vessel lights may cause disorientation and stress to some species of seabirds and possibly impede their navigation abilities when returning to their nests on the offshore islands at night. Gould's petrels (*Pterodroma leucoptera leucoptera*), the little penguin (*Eudyptula minor),* wedge-tailed shearwaters (*Puffinus pacificus*), sooty shearwaters (*Puffinus griseus*), short-tailed shearwaters (*Puffinus tenuirostris*) and white-faced storm petrels (*Pelagodroma marina*) are among the species that breed on Cabbage Tree Island, Boondelbah Island and/or Broughton Island (DECCW, 2010a).

There is a paucity of literature about the impact of artificial lights on the seabird species, including why they are attracted to them (Verheijen, 1985). McNeil *et al*. (1993) proposed that nocturnal birds may be more sensitive to lights because these species have larger eyes than diurnal birds and their retinas have a greater number of photoreceptor cells. Montevecchi (2006) suggested that species which consume bioluminescent prey are likely to have greater sensitivity to artificial lights. Petrels for example, may have a tendency to search for lights to increase their chance of a meal as many predominately feed on bioluminescent squid (Montevecchi, 2006). Inexperience may also be an important factor as young birds rely on visual cues (e.g. moon or starlight) to reach the ocean during their first flight and illuminated areas may cause confusion and impede their navigation abilities. Young petrels do not appear to fly directly into lights but rather circle illuminated areas and eventually become disorientated and land due to exhaustion (Telfer *et al*., 1987).

A range of studies have been conducted on the impacts of light pollution associated with street lighting, house lights, shopping centres and offshore oil rigs on wildlife (Verheijen, 1985; Rodriguez & Rodriguez, 2006). The lighting associated with these sources has been found to disrupt migrating birds, cause behavioural anomalies, disorientation and increase mortalities of some seabird species (Rodriguez & Rodriguez, 2006). Several cities in the United States and Canada have reduced the light emitted from skyscrapers at night during migration seasons and saved millions of birds from dying as a result of disorientation. The National Audubon Society in New York and the Toronto Fatal Light Awareness Program are among the initiatives that have instigated these changes (The Royal Commission of Environmental Pollution, 2009).

The artificial lighting associated with the Research Lease will consist of four low intensity navigation strobe lights attached to buoys and positioned with a low profile on the corners of the lease in accordance with NSW Maritime requirements. These requirements include a light that has a range of at least 4 nautical miles in clear conditions (transmissivity of 0.74), a flash character to suit the type of cardinal mark and a minimum vertical divergence of 9 degrees (Solar Technology Australia, n.d.; IALA, 2008). Flashing white strobe lights are considered less likely to attract night-migrating birds at night than non-flashing white and red lights (Web Reference 31). In addition, service vessels will be fitted with the standard navigational safety lights (e.g. masthead, side, stern and all round lights) appropriate to the type and size of the vessels.

Light restrictions are currently in place for the Habitat Protection Zone surrounding Cabbage Tree Island which is a bait fishing area. The restrictions were implemented due to the possibility of vessel lights, notably bait fishers, confusing and causing stress to Gould's petrels and little penguins returning to their nests at night (Web Reference 30). No lights can be switched on for longer than 5 minutes in any 60 minute period except for a light required to be used under the *Navigation Act 1901* or the *Marine Safety Act 1998*. A bait collection light suspended less than 5 m high and that projects a spread of light downwards has to be less than 20 m at the widest point (Web Reference 30).

Cabbage Tree Island and Boondelbah Island are the only known breeding sites of the Gould's petrel in the world (NSW DEC, 2006). The breeding season is from late September to May with nesting predominately occurring on the western side of Cabbage Tree Island in two steeply sloping gullies amongst rock scree, rock crevices and dead palm-fronds sheltered under canopies (Web Reference 1). During the breeding season the Gould's petrel is nocturnal and both parents share chick feeding responsibilities for up to 13 weeks (NSW DEC, 2006). Breeding colonies of the little penguin also occur on Cabbage Tree Island, Boondelbah Island and Broughton Island, where it is the only penguin species that breeds in Australia (DECCW, 2010a). It is a diurnal forager which mainly feeds in inshore waters around the mainland coast or breeding islands (Gales & Pemberton, 1990).

Light pollution in the Providence Bay is primarily from the residential areas of Hawks Nest and Tea Gardens. The Research Lease is located to the north of these residential areas and the offshore islands (except for Broughton Island). In particular, the Research Lease is 2 km from Cabbage Tree Island and 4 km from Boondelbah Island. Hence, any lighting associated with the Research Lease is not likely to exacerbate any existing light pollution issues in Providence Bay associated with the residential areas.

The hours of operation for the Research Lease will be restricted to daylight hours and night work will only occur if there is an emergency, such as to repair infrastructure from storm damage or due to vandalism. If night operations are undertaken, lighting on service vessels will be restricted to interior and navigation lights, lights will be shielded to concentrate light downward specifically onto the work site and staff will navigate well away from Cabbage Tree Island when commuting to and from the Research Lease. Reed *et al*. (1985) for example, found that the number of grounded petrels decreased by more than 40% on Kauai, Hawaii when lights were shielded to avoid upward radiation. Similarly, shielding and changing the frequency of lighting on oil rigs was found to reduce light pollution impacts on seabirds in the North Sea (Van De Laar, 2007).

Recent investigations suggest that the navigation abilities of the Gould's petrel are not impacted by maritime navigation lights but this species does become distressed when artificial lights are in close proximity to their breeding habitat (Y. Kim 2011, *pers. comm.*). However, these observations are not conclusive and it is recommended that any interactions between seabirds and the Research Lease are closely monitored to ensure that there are no adverse effects from the navigational marker or vessel lights (Marine Fauna Interaction Management Plan – Appendix 2).

Conclusion

The risk of artificial lights used during the operation of the Research Lease having a significant impact on light sensitive species, notably the Gould's petrel and the little penguin, is thought to be 'low' when considered in context with the distance from the offshore islands, the positioning of the Research Lease away from residential areas, the use of low intensity flashing white strobe lights with a low profile, the hours of operation largely being restricted to daytime and the measures that will be implemented to shield vessel lights if night work is required.

8.2.2.7 Entanglement and Ingestion of Marine Debris

Table 39: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – entanglement and ingestion of marine debris (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the Research Lease have a significant impact on the occurrence of entanglements and ingestion of marine debris?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ Is the sea cage infrastructure likely to result in entanglements of marine fauna?
▪ What species are susceptible to entanglements based on findings from other sea cage farms in Australian waters?
▪ Will the facility increase the risk of marine fauna ingesting marine debris i.e. will it release any solid waste into the environment?
▪ How will entanglements be mitigated, monitored and managed?
▪ How will an entanglement be dealt with e.g. emergency response team?
▪ Are ‘pingers’ (acoustic deterrent devices) effective and will they be trialled?
▪ How will lines be kept taught constantly to ensure the risk of entanglements is minimised?</td></tr>
<tr><td>Description</td><td colspan="4">▪ KTP – entanglement and ingestion of marine debris
▪ Cages, mooring lines and anti-predator nets = potential entanglement</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Maintenance and operational procedures – minimise attraction of predators
▪ Sea cage design features – entanglement avoidance (i.e. exclusion and barrier techniques
▪ Marine Fauna Interaction Management Plan (Appendix 2)
o Marine Fauna Entanglement Avoidance Protocol
▪ Structural Integrity and Stability Monitoring Program (Appendix 2)
▪ Waste Management Plan (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>1</td><td>6</td><td>6</td><td>Low</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Full justification</td></tr>
</table>

<u>*Justification of Ranking*</u>

The Key Threatening Process - entanglement and ingestion of marine debris, which is listed under the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999*, is potentially relevant to the Research Lease. Entanglement refers to the process in which wild fauna become caught in the physical structures of mariculture facilities, including floating cages, anti-predator nets and mooring lines (McCord *et al*., 2008). Marine debris consists of raw plastics, packaging materials, fishing gear (nets, ropes, line and buoys) and convenience items and is sourced from ship waste, the seafood industry, recreational activities and both rural and urban discharges into rivers, estuaries and coastal areas.

Marine animals can become entangled in or ingest anthropogenic debris which can lead to a range of lethal and sub-lethal effects, such as reduced reproductive success, fitness, ability to catch prey and avoid predators, strangulation, poisoning by polychlorinated biphenyls, infections, blockages, increased drag, perforations and loss of limbs (Web Reference 4).

A range of marine fauna are potentially vulnerable to entanglement in aquaculture infrastructure and ingesting marine debris including whales, dolphins, seals, sharks, teleosts, marine turtles and seabirds.

Whales

A range of whale species have been sighted in the coastal waters of NSW, including humpback whales, southern right whales, pygmy sperm whales, false killer whales, melon-headed whales, short-finned pilot whales, long-finned pilot whales, minke whale, dwarf minke whales, killer whales, sperm whales and blue whales (Appendix 5; 7 and 8).

The risk of entanglement of humpback whales and southern right whales is of particular concern because they are among the most commonly sighted species off the coast of Port Stephens, they often swim close to the coast, are frequently sighted resting in large embayments and their populations are increasing steadily (Allen & Bejder, 2008; Web Reference 23). Humpback whales and southern right whales migrate along the east coast of Australia while on their annual migration between their feeding and breeding grounds from May to November each year. As Providence Bay is in their migration route, the sea cage infrastructure of the Research Lease could potentially impact upon resting habitat availability, slightly alter migration pathways and represent an entanglement hazard.

Sperm whales generally inhabit deep waters greater than 200 m but there has been the occasional sighting in the inshore waters of NSW (Bannister *et al*., 1996). Consequently, it is possible that sperm whales may pass through the waters off Port Stephens but it is considered unlikely that this species will enter the shallow waters near the Research Lease.

Similarly, blue whales and minke whales mainly inhabit oceanic waters but there has been the occasional sighting of these species in the inshore waters of NSW (Bannister *et al*., 1996; Web Reference 2). It is possible that Providence Bay could form part of this species migration route over winter and may represent a proportion of blue whale resting habitat but is considered unlikely. The other species have rarely been sighted in the coastal waters off Port Stephens.

There are reported cases of negative whale interactions with finfish farms in Australian waters. A humpback whale for example, broke through the walls of a tuna sea cage in Port Lincoln, South Australia in 1993 and was trapped in the cage for about two days before being successfully released (Kemper & Gibbs, 2001). Similarly, an unidentified whale, most likely a southern right whale or humpback whale, collided with the side of a salmon cage in Tasmania (Pemberton, 1991). These interactions can be avoided if appropriate mitigation measures are implemented (See below – Mitigation Measures).

The trial operation of a Snapper farm in Providence Bay for example, resulted in no entanglements of whales in the sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2012, *pers. comm*.).

There are records of entanglements of large baleen whales in the ropes of the marine industries of Western Australia but the issue is not considered to constitute a large ecological pressure on whale stocks (Campbell, 2011). Over 90% of the entanglements were sourced to the fishing gear of the West Coast Rock Lobster Fishery (WCRLF) (Campbell, 2011). However, the WCRLF uses much finer ropes than those proposed for the Research Lease, and the ropes are free floating via small buoys and not maintained in a taut state. These incidences of entanglement were investigated to determine what factors, if any, could explain the rate of interaction e.g. increasing population sizes (Campbell, 2011). Based on the estimated whale population growth rate of 10% it was speculated that the rate of entanglement could double approximately every 7 years. Analysis of entanglement data however, revealed that incidences have increased over the years but the rate of increase has been considerably lower than what was expected. This may be correlated to a range of mitigation actions undertaken by the WCRLF, including changes to practices and rope length, as well as reduced fishing effort (Campbell, 2011).

In addition, recent data suggests that calf mortality rates are increasing which is indicative of a population that may be reaching its carrying capacity (D. Coughran, *pers. comm.* cited in Campbell, 2011). In Western Australia, the issue of entanglement of is not thought to represent a threat to population recovery of large baleen whales as the entanglement rate is very low in relation to the estimated population size (<0.01%) (Campbell, 2011).

Dolphins

Entanglements of dolphins in aquaculture gear are documented for the South Australian and Tasmanian aquaculture industries. There are records of entanglement for short beaked common dolphins (*Delphinus delphis*), common bottlenose dolphins (*Tursiops truncatus*) and Indo-Pacific bottlenose dolphins in anti-predator nets of finfish farms (Kemper *et al*., 2003). In South Australia, most of reported fatal entanglements have been in large meshed anti-predator nets (> 15 cm) on farms located in shallow waters (Kemper & Gibbs, 2001; McCord *et al*., 2008). Similarly, fatal entanglements in Salmon farms in Tasmanian waters were also due to anti-predator nets that were not enclosed at the bottom so dolphins could become trapped between the main and anti-predator nets (Kemper *et al*., 2003). It is not known how dolphins become entangled as it is thought that they are acoustically and visually aware of the nets (Kemper, 1998).

However, the likelihood of entanglement of dolphins in finfish cages with today's technology is considered to be low if a number of mitigation measures are implemented. The incidence of dolphin entanglements has decreased since the introduction of strategies to mitigate interaction with dolphins in the South Australian and Tasmanian aquaculture industries. The most critical mitigation measures include the use of anti-predator nets with a mesh size no greater than 6 cm as dolphins are able to detect smaller meshed nets at greater distances (e.g. 5 cm mesh net at 310 m) than larger mesh nets (e.g. 11 cm mesh net at 130 m) (Kemper, 1998), as well as using enclosed anti-predator nets, keeping all lines and nets taut and properly weighted, removing stock mortalities and minimising the attraction of wild fish (Kemper *et al*., 2003; Benetti, 2005 cited in McCord *et al*., 2008) (See below – Mitigation Measures). The trial operation of a Snapper farm in Providence Bay for example, resulted in no entanglements of dolphins in the sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.).*

Seals

There are records of interactions between seals and the salmonid farms in Tasmania and the Southern Bluefin Tuna farms in South Australia, including injuries, drowning and fatal entanglements in anti-predator nets (DAFF, 2007). Australian fur seals, mostly juvenile and adult males, are considered the main predator of salmonid farms but New Zealand fur seals have also been found interacting with these farms. Fur seals are known to cause damage to mariculture gear and can be very aggressive in their attempts to prey on caged fish (Kemper *et al*., 2003).

A study conducted by the South Australian Museum revealed that the death of three pinnipeds was linked to the use of inadequate anti-predator nets (Kemper & Gibbs, 1997).

The nets had a large mesh size, unrepaired holes, were not enclosed at the bottom and were loose and baggy (Pemberton, 1996). Inappropriate feeding practices, such as shovelling frozen pilchards, and insufficient height for fences have also been linked to entanglement incidents in the past (Kemper *et al*., 2003). These anti-predator nets have since been phased out on Tuna farms and there have not been any official reports of entanglements subsequently (C. Cartwright, *pers. comm*. cited in DAFF, 2007).

Providence Bay, notably Cabbage Tree Island, is used intermittently as a haul-out site for an increasing number of non-breeding seals (NSW MPA 2011, *pers. comm*.). The species that have been sighted in this area include the Australian fur seal (*Arctocephalus pusillus doriferus),* the New Zealand fur seal *(Arctocephalus forsteri)* and on rare occasions, the leopard seal (*Hydrurga leptonyx*). The periodic feeding of farm fish and the likely congregation of wild fish stock around the sea cages in response to these feeding events may attract seals into the vicinity of the Research Lease.

NSW DPI aims to minimise the risk of seal entanglements through the implementation of a range of mitigation measures, notably enclosed anti-predator nets, regular maintenance and repair of nets, keeping taut lines and nets, pelletised feeds and promptly removing dead and injured fish (See below – Mitigation Measures). The trial operation of a Snapper farm in Providence Bay resulted in no entanglements of finfish in sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.*).

Sharks

A range of shark species have been recorded in coastal waters off Port Stephens, such as Bronze Whalers, Hammerheads, Grey Nurse Sharks, Tiger Sharks and Great White Sharks (Worth & Joyce, 2001). There is a limited amount of information regarding interactions between sharks and mariculture facilities. Some studies suggest that sharks lose interest in cages if they are not given food rewards e.g. discarded stock (R. Johnson, *pers. comm.* cited in McCord *et al*., 2008).

The Port Stephens region is one of two primary residency regions for juvenile and subadult Great White Sharks on the east coast of Australia during spring and summer (Bruce & Bradford, 2008). This region is known for its abundance of suitable prey including teleosts (finfish) and elasmobranchs (other sharks and rays) (Bruce & Bradford, 2008). Hence, out of all the species present in the region the most frequent interactions are likely to be with Great White Sharks (*Carcharodon carcharias)* due to their numbers, seasonal migration and movement patterns in Providence Bay.

There are four main signals that have been found to attract sharks to marine aquaculture farms and these include the captive fish, mortalities, slicks generated during feeding events and the stress responses of injured and captured fish (Bruce, 1998). According to Bruce (1998), the primary cause of shark damage to cages and nets is due to attempts to gain access to dying fish or mortalities. Consequently, the proponent aims to minimise the risk of entanglements through the implementation of a range of mitigation measures, notably prompt removal of dead and injured fish and using highly visible nets (See below - Mitigation Measures). Furthermore, the trial operation of a Snapper farm in Providence Bay resulted in no entanglements of sharks in the sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.*).

Marine Turtles

In NSW there are resident groups of green turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*) and hawksbill turtles (*Eretmochelys imbricata*) while leatherback (*Dermochelys coriacea*) and flatback turtles (*Natator depressus*) are occasionally sighted (Environment Australia, 2003). Most of these species are vagrants which are thought to use the warm waters of the East Australian Current each summer to disperse southward. The NSW marine turtle populations are at the southern limits of the species known distribution and outside the limits of the normal breeding ranges (Cogger, 2003). However, there are reports of turtles nesting in the PSGLMP on beaches near Forster (i.e. One Mile Beach and Diamond Beach) (D. Harasti 2012, *pers. comm.).* These nesting beaches are considered to be a sufficient distance from the Research Lease (i.e. more than 60 km) to avoid potential impacts on turtle breeding.

There are concerns about the potential impact of entanglement and ingestion of marine debris associated with the Research Lease on turtles foraging and resting in Providence Bay. However, the trial operation of a Snapper farm in Providence Bay resulted in no entanglements of turtles in the sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 D. Liszka 2011, *pers. comm.*). According to Environment Australia (2003), there is no available evidence to suggest any turtle mortalities from aquaculture activities. The proponent will adopt a precautionary approach and implement a range of mitigation measures to ensure the risk of entanglement and ingestion of marine debris is minimised (See below – Mitigation Measures).

Teleosts

There is a paucity of information pertaining to entanglement interactions with wild fish and mariculture cages. However, there is little evidence to suggest that entanglement is a major management issue with wild fish. The occurrence of entanglements are likely to be dependent on factors such as the cultured species, the mesh size of the nets and whether the cages would act as gillnets (McCord *et al*., 2008). However, it is reasonable to suggest that the cages would not pose a significant entanglement risk to wild fish in Providence Bay. Furthermore, the trial operation of a Snapper farm in Providence Bay resulted in no entanglements of finfish in sea cage infrastructure over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.*).

Seabirds

Sixty seven bird species, including seabirds, have been implicated in depredation events on fish farms worldwide and 58 species are considered responsible for documented losses. A range of seabird species visit the coastal waters off Port Stephens, including cormorants, pelicans, penguins, shearwaters, giant-petrels, storm-petrels, terns, gulls, albatrosses, sea eagles and ospreys (Appendix 5). Based on the results of the trial operation of a Snapper farm in Providence Bay over two year statutory monitoring period (1999-2000), the most frequent marine fauna interaction was with seabirds. The species recorded included cormorants, Australasian gannets, terns, seagulls, white-bellied sea eagles, albatrosses and shearwaters, and these interactions varied from birds flying over the lease, diving around the cages, perching on the bird exclusion nets, to entanglements (Worth & Joyce, 2001). Only a relatively small number of entanglement incidents occurred over the two year period and all of the birds were safely released (Worth & Joyce, 2001).

The extent and rate of entanglements is thought to be dependent on seabird population numbers and their behavioural adaptability to sea cage facilities. Literature suggests that diving seabirds such as cormorants pose the greatest threat and are most likely to become entangled (Parkhurst, 1994 cited in McCord *et al*., 2008). However, the risk of fatal seabird entanglements and ingestion of marine debris associated with the Research Lease will be largely negated by the implementation of a range of mitigation measures (See below – Mitigation Measures).

Dugongs

Dugongs predominately inhabit north Australian waters but occasionally visit the coastal and estuarine waters of NSW (Web Reference 23). Five separate sightings of individuals and pairs in estuaries on the central coast of NSW were documented during the austral summer of 2002/03. Allen *et al*. (2004) suggested that warm currents, low rainfall and the abundance of seagrass (primary food source) may have drawn some individuals south of their accepted range.

Port Stephens contains the largest area of seagrass in the bioregion, including *Posidonia, Zostera* and *Halophila* (8 km^2 or 5% of the state total) (Anon, 2006). Port Stephens is also connected to Myall Lakes via the Myall River, which contains the highest proportional cover of seagrass in the bioregion (71% of open water) (Anon, 2006). Hence, the region could potentially represent an important foraging ground for dugongs in the future. In regards to the Research Lease, no seagrass beds are present as environmental conditions are unsuitable for their growth in this locality so it is considered unlikely for dugongs to congregate in the vicinity of the sea cages. However, the proponent will adopt a precautionary approach and implement a range of mitigation measures to ensure the risk of entanglement and ingestion of marine debris is minimal (See below – Mitigation Measures).

Mitigation Measures

The following mitigation measures will be implemented to minimise the risk of entanglement and ingestion of marine debris to marine fauna:

- Utilisation of sea cage design features i.e. exclusion and barrier techniques that minimise the risk of the entanglement and the attraction of marine fauna (Kemper *et al*., 2003; McCord *et al*., 2008) which include:
  - highly visible, thick ropes and anchor lines kept under tension at all times (e.g. 40 mm eight strand rope) - reduced flexibility minimises risk of entanglements;
  - highly visible, taut and rigid culture net properly weighted with a small square mesh size (< 3 cm for nursery nets and 6 cm for adult stock) (DAFF, 2007);
  - highly visible anti-predator nets with a small mesh size (about 6 cm) represent a physical and visible deterrent where bright colours are thought to possibly interfere with the predators ability to see fish in the nets. The anti-predator nets also provide a subsurface barrier for echolocating species to identify as a physical obstruction and consequently avoid (Pemberton, 1996);
  - proper weighting of anti-predator nets to ensure no billowing and adequate separation between culture and anti-predator nets (McCord *et al*., 2008). A buffer distance of 1-2 m has proven to be most effective (Schotte & Pemberton, 2002);
  - no looped lines, perimeter lines or unnecessary floating/buoy lines – only those specified by the structural engineers or manufacturers;
  - fully enclosed double bottomed net (shark guard) to prevent marine predators from accessing the bottom of the sea cages;
  - elimination of safe roosting and perching places to deter seabirds and seals;

- highly visible bird exclusion nets (surface) loosely secured over the top of the cages to dissuade seabirds and seals from perching on the nets or railings and diving into the cages;
- raised railings (i.e. 2 m above sea level) to prevent seals from interacting with staff and jumping into the pens (Pemberton, 1996; Kemper *et al*., 2003; DAFF, 2007); and
- use of large round cages with low stocking densities to reduce accessibility of stock to seals (note: square cages can be manipulated by seals as the corners represent points of weakness) (C. Cartwright, *pers. comm*. cited in DAFF, 2007).

▪ Implementation of Structural Integrity and Stability Monitoring Program (Appendix 2)

- regular inspections, maintenance and repair of sea cage infrastructure (Pemberton, 1996);
- maintain rope tautness and net integrity, particularly after severe weather (Kemper *et al*., 2003); and
- remove non functioning nets from the water (Kempers *et al*., 2003).

▪ Implementation of daily operational and maintenance procedures that minimise the attraction of wild fish and other potential predators, including:

- regular cleaning of nets to reduce the amount of natural food available (e.g. submersible net cleaning robots);
- using pelletised feed (opposed to whole fish thereby minimising feeding slicks);
- demand feeding regime to minimise excess food entering the water column;
- removal of injured and deceased stock (Pemberton, 1996); and
- optimising feed conversion ratios.

▪ Human activity associated with daily operations and maintenance may help to deter marine predators (McCord *et al*., 2008).

▪ Implementation of the Waste Management Plan which details disposal procedures for wastes such as dead fish, biofouling, obsolete infrastructure (e.g. worn ropes) and domestic garbage, as well as daily operational and maintenance procedures to minimise odour emissions, escape of marine debris and accidental spillages e.g. storage bins on vessels will be secured and have tightly fitted lids (Appendix 2).

▪ Implementation of the Marine Fauna Interaction Management Plan which will involve monitoring and recording all marine fauna interactions with the sea cages, vessels and/or humans during the operational stage, as well as any behavioural changes such as movement corridors and foraging/socialising patterns (Appendix 2).

- Implementation of the Marine Fauna Entanglement Avoidance Protocol which will detail a response plan for entanglement incidences including procedures to be followed, training and equipment required and reporting incidents, as well as maintenance measures to ensure entanglement hazards are minimised. A committee will be formed to monitor the implementation and effectiveness of the entanglement mitigation measures – these will be revised and modified if considered necessary (Appendix 2).

Acoustic Devices

Acoustic harassment devices (AHDs) have been trialled worldwide as a means to deter pinnipeds from finfish farms. These devices generate sound using a combination of frequency and intensity that is aversive to marine mammals in order to keep them away from aquaculture farms (Reeves *et al*., 1996 cited in Kempers *et al*., 2003). AHDs are high amplitude devices opposed to 'pingers' i.e. acoustic deterrent devices (ADD), which are lower amplitude devices that use ultrasounds to prevent cetacean bycatch in some fisheries (Kempers *et al*., 2003).

Marine finfish farms in South Australia have trialled the use of AHDs, including the use of seal scarers (e.g. AirMar db plus II, Poseidon T88) on tuna farms. Farmers did not adopt the devices as they were considered to act more like a 'dinner bell' opposed to a repellent (DAFF, 2007). A report on Salmon farms in British Columbia recommended that AHDs be phased out after it was revealed that the devices appeared to lose effectiveness over time as pinnipeds became accustomed to or deafened by them or hunger and previous successes motivated them to endure the sounds emitted (Environmental Assessment Office, 2001). Many studies confirm the habituation of predators to deterrents (Petras, 2003 cited in McCord *et al*., 2008).

Failure of AHDs can occur from improper deployment of the equipment, poor maintenance and/or due to sounds not being particularly aversive to the target species. AHDs have been found to be most successful when sound levels have intensity close to 200 dB re 1 μP at 1 m away but this level poses a risk of hearing impairment in pinnipeds. Other possible side effects of AHDs and ADDs include permanent loss in hearing in target and non-target species, loss of ability to echolocate (cetaceans only) (Kempers *et al*., 2003) and habitat exclusion (Berggren *et al*., 2002).

The general consensus is to avoid the use of AHDs on marine finfish farms due to a high level of uncertainty about their effectiveness, the varying responses from different marine mammals (Petras, 2003 cited in McCord *et al*., 2008) and the risks involved to marine fauna (DAFF, 2007). Studies on ADDs have generally focused on their effectiveness in deterring small cetaceans (i.e. dolphins and porpoises) away from fishing nets (Franse, 2005). The Research Lease may consider trialling the effectiveness of ADDs in deterring a range of marine mammals, notably whales, away from sea cage farms. However, further investigations into the potential risks of ADDs to marine fauna need to be made before consideration is given to their use.

Conclusion

According to Kemper *et al*. (2003), it is possible to virtually eliminate entanglement risks for marine predators by adopting appropriate design features, being vigilant with gear maintenance and using appropriate feeding regimes. Hence, the risk of entanglement and ingestion of marine debris associated with the Research Lease is thought to be 'low' when considered in context with the sea cage design features, daily operational and maintenance procedures, the Structural Integrity and Stability Monitoring Program, the Marine Fauna Interaction Management Plan, the Marine Fauna Entanglement Avoidance Protocol and the Waste Management Plan that will be implemented.

8.2.2.8 Animal Welfare

Table 40: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – animal welfare concerns (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the operation of the Research Lease conflict with NSW animal welfare requirements?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ Is there any relevant animal welfare legislation that needs to be incorporated into the husbandry techniques used at the aquaculture facilities?
▪ What obligations does the licence holder have in relation to the Animal Research Act 1985?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Finfish will be cultured in sea cages (18-40 m diameter)
▪ Finfish will be required to be transported from hatcheries to sea cages</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ All staff will be made aware of their obligations under the Animal Research Act 1985
▪ Research will be reviewed by NSW DPI Animal Care and Ethics Committee
▪ Comply with Australian Code of Practice for the Care and Use of Animals for Scientific Purposes and the Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research
▪ Comply with the Australian Aquaculture Code of Conduct
▪ Waste Management Plan (Appendix 2)
▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2)
▪ Disease, Parasite and Pest Management Plan (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification of Ranking

The research proposed for the Research Lease will require the transportation and cultivation of a number of finfish species, including Yellowtail Kingfish and Mulloway. The fish stock will initially be held in land based tanks at PSFI or at the facilities of an industry partner and then transferred to the sea cages in Providence Bay for grow out. Potential animal welfare concerns include activities associated with the transportation and culture of the stock, such as manual handling, the use of therapeutics (e.g. anaesthetics), the confinement of stock to a designated area (i.e. tanks and sea cages), stocking densities, disposal procedures for diseased fish, feed quality and environmental conditions (e.g. water quality and dissolved oxygen concentrations).

The *Animal Research Act 1985* governs any research involving vertebrates in NSW. It was introduced to protect the welfare of animals, by ensuring their use in research is always humane, considerate, responsible and justified (Web Reference 22). All research must be covered by a current Animal Research Authority and issued by an accredited Animal Care and Ethics Committee. The proposed research will be reviewed by NSW DPI Animal Care and Ethics Committee before the Research Lease commences operation.

To mitigate any animal welfare concerns, the Research Lease will comply with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* (NHMRC *et al*., 2004) and the *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research* developed for NSW DPI (Fisheries) Animal Care and Ethics Committee (Barker *et al*., 2009). The transport and husbandry techniques and practices will also comply with the *Australian Aquaculture Code of Conduct* (Web Reference 17) which includes a number of guiding principles for aquaculturists to achieve humane treatment of animals, such as:

- Seeking the development of farm expertise in ecological sustainability and health management;
- Promoting maintenance of sustainable and efficient stocking densities;
- Addressing the biological and physical requirements of the farmed species;
- Encouraging the installation of anti-predator devices that exclude predators but do not cause injury;
- Seeking methods that reduce stress when transferring and harvesting stock;
- Endorsing humane slaughter methods;
- Supporting the development of appropriate contingency plans to deal with the spread of diseases, parasites and other pathogens and unplanned releases of aquaculture stock;
- Encouraging the containment of diseased or infected stock and immediate reporting of any mass mortalities of stock or other environmental problems to the relevant agencies;
- Identifying responsibilities for environmental monitoring proportionate to possible environmental benefits and risk;
- Providing guidelines on reporting and analysis of findings;

- Promoting the appropriate disposal of dead stock in a manner to ensure no diseases or pathogens are released into natural waterways; and
- Encouraging research and development programs that are funded and supported jointly by governments and industry to increase knowledge and understanding of aquaculture operations and interactions with the environment.

To further assist with the mitigation of animal welfare concerns associated with the Research Lease, all staff will be made aware of their obligations under the *Animal Research Act 1985.* In particular, the stocking density of the sea cages will be kept at a level that minimises stress to the stock and their health will be monitored on a regular basis to ensure early detection of any disease, parasites, fungal infections or other health conditions that may arise. The sea cage infrastructure will be cleaned of biofouling on a regular basis to reduce the potential of it harbouring disease or parasites and the use of therapeutics will be kept to a minimum and only used in accordance with APVMA or succeeding veterinary approval.

In addition, surface and subsurface anti-predator nets will be secured around the sea cages to exclude potential predators preventing harassment and associated stress to stock. A Waste Management Plan, Water Quality and Benthic Environment Monitoring Program and Disease, Parasite and Pest Management Plan will also be implemented and will provide guidelines on factors such as appropriate disposal of dead and diseased fish, monitoring of environmental conditions and minimising the risk of disease and escapees (Appendix 2).

Conclusion

The risk of the Research Lease conflicting with NSW animal welfare requirements is thought to be ‘negligible’ when considered in context with the proponent’s agreed compliance with the obligations of the *Animal Research Act 1985* and the use of the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* and the *Australian Aquaculture Code of Conduct* and the *Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research,* as well as the review that will be conducted by the NSW DPI Animal Care and Ethics Committee and the mitigation measures that will be implemented.

8.2.2.9 Vessel Strike and Acoustic Pollution

Table 41: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – vessel strike and acoustic pollution (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the operation of the Research Lease have a significant impact on the occurrence of vessel strikes and/or the level of acoustic pollution?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Will there be an increased risk of vessel strikes to marine fauna due to marine vessel traffic associated with daily operations and maintenance of the facility?* ▪ *Will observers need to be employed to reduce the risk of vessel strikes?* ▪ *Is the noise generated by the facility and associated activities likely to disturb any species of marine fauna e.g. rattling of chains?* ▪ *If vessel strikes and acoustic pollution are considered potential threats to marine fauna, what measures would be implemented to mitigate, monitor and manage these impacts?*			
Description	▪ Research Lease marine vessel movements o 1-7% increase (Port Stephens waters)			
Proposed Management – Mitigation and Monitoring	▪ Observer Protocol ▪ Maintain appropriate distances from marine fauna ▪ Adhere to NSW Roads and Maritime Services speed limits ▪ Travel at 25 knots when in the port, within 500 m of seal haul-out site on Cabbage Tree Island and when within 200 m of marine fauna ▪ Slow down in sensitive areas ▪ Hours of operation = predominately daylight ▪ Vessel motors – well maintained			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

Justification of Ranking

Vessels in Port Stephens waters consist of small recreational fishing boats, dive boats, dolphin and whale watching boats, luxury cruisers, commercial fishing trawlers and occasionally small passenger cruise ships. The number of vessels in Providence Bay and associated acoustic pollution levels vary according to weather conditions and seasons, where commercial and recreational vessel traffic is significantly greater over summer.

During the operational stage of the Research Lease, marine vessel movements will be in the range of one to three return trips per day to undertake feeding, net cleaning and changing, inspections and maintenance of infrastructure. Consequently, vessel movements in the Port Stephens region to service the Research Lease are estimated to potentially increase by up to 1% in summer and about 7% in winter. This is not expected to have a significant impact on the occurrence of vessel strikes to marine fauna or acoustic pollution levels as this is not considered to be a significant increase in vessel movements.

An Observer Protocol will be implemented where Research Lease staff will routinely keep watch for marine fauna, notably dolphins, turtles and seals, when travelling between the lease and land based facilities. Research Lease vessels will adhere to NSW Roads and Maritime Services speed limits and slow down in sensitive areas. In particular, vessels will be restricted to a maximum speed of 25 knots in Port Stephens which is in accordance with current restrictions for commercial vessels operating in the port. Research Lease vessels will also slow down to a maximum speed of 25 knots if marine fauna are observed within 200 m of the vessel and when within 500 m of the seal haul-out site on Cabbage Tree Island.

The risk of vessel strikes will also be reduced by restricting vessel movements and maintenance activities to predominately daylight hours. Marine vessel motors will be well maintained to ensure engine noises are kept to a minimum.

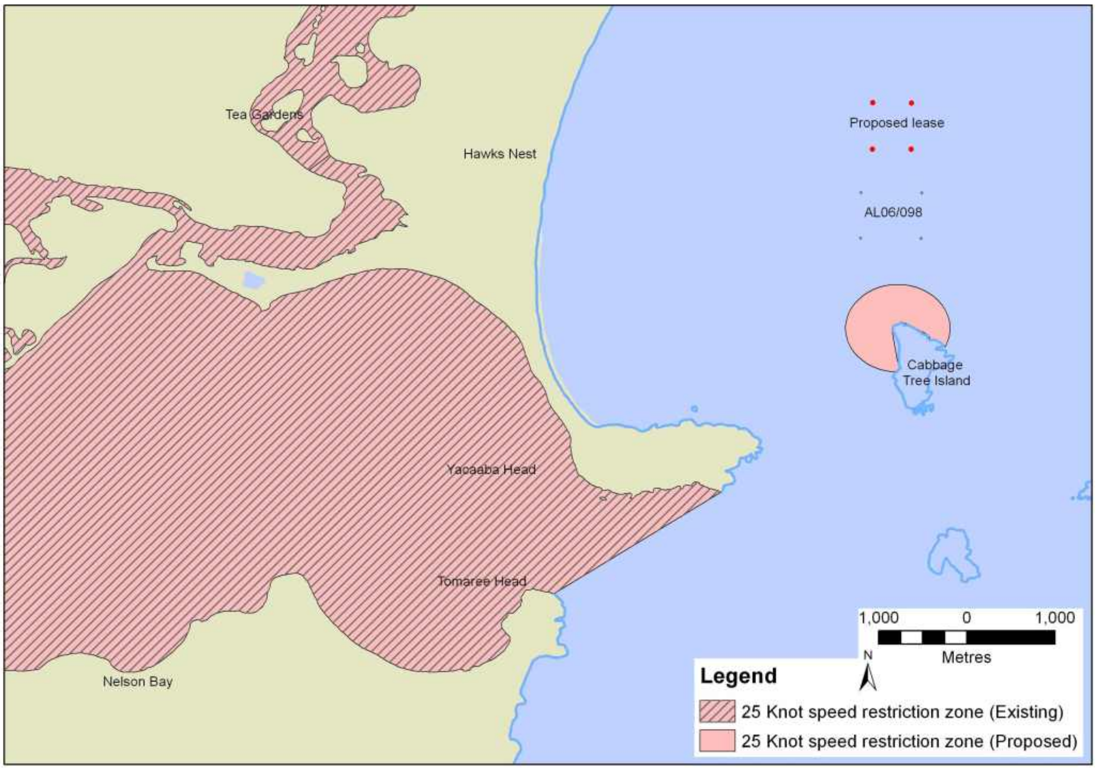

Figure 46: Speed restriction zones within Port Stephens and Providence Bay (Source: NSW DPI, 2012).

Conclusion

The risk of the Research Lease having a significant impact on the occurrence of vessel strikes to marine fauna or acoustic pollution levels is thought to be ‘low’ when considered in context with the small increase in vessel movements and the mitigation measures that will be implemented, including the Observer Protocol, adhering to speed restrictions, slowing down in sensitive areas, maintaining appropriate distances from marine fauna, restricting Research Lease activities to predominately daylight hours and maintaining vessel motors.

8.2.2.10 Threatened / Protected Species and Matters of NES

Table 42: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts on threatened species, protected species and matters of NES (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the operation of the Research Lease have a significant impact on threatened species, protected species and/or matters of NES?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ Are any threatened or protected species likely to be impacted by the facility?
▪ Is the facility going to disturb habitat of any threatened or protected species e.g. foraging, breeding, resting or migratory habitat?
▪ Will the facility have a significant impact on matters of NES and/or other protected matters listed under the EPBC Act?
▪ What measures will be implemented to mitigate, monitor and manage potential impacts on threatened / protected species and matters of NES?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Threatened and protected species (State)
o 1 'presumed extinct' species
o 2 'critically endangered' species
o 10 'endangered' species
o 33 'vulnerable' species
o 42 'protected' species
▪ Matters of NES (Commonwealth)
o 30 'threatened' species
o 35 'migratory' species
o 49 'listed marine' species
o 13 'whales and other cetacean' species
o 1 Ramsar wetland (See Section 8.2.2.12)</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Assessment of Significance - State (Appendix 9)
▪ Assessment of Significance - Commonwealth (Appendix 10)
▪ Environmental Management Plan (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>1</td><td>6</td><td>6</td><td>Low</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Full justification</td></tr>
</table>

Justification of Ranking

(a) Assessment of Significance (State)

The NSW DEC Threatened Species Database and the NSW DPI Threatened and Protected Species Listing were searched for threatened and protected species, populations and communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act) that are likely or predicted to occur in the Hunter/Central Rivers Catchment Management Authority marine zone subregion.

Only threatened species that were known or considered likely to occur in the study area (based on general species distribution databases) and/or known to utilise habitat in the study area were considered further in an Assessment of Significance (Appendix 9). These species were assessed according to the *Threatened Species Assessment Guidelines* (NSW DECC, 2007a; NSW DPI, 2008). It should be noted that this does not include 'protected' species which do not require an Assessment of Significance.

Overall, seven species of fish, three species of marine turtle, four cetacean species, two pinnipeds, one sirenian (the dugong) and fifteen species of seabirds were assessed according to the assessment guidelines issued and in force under Section 94A of the TSC Act and Section 220ZA of the FM Act.

Fish

Species of threatened fish under the FM Act considered likely to occur in the wider study area include:

- the 'critically endangered' Grey Nurse Shark (*Carcharias taurus*);
- the 'endangered' Scalloped Hammerhead (*Sphyrna lewini*);
- the 'vulnerable' Great Hammerhead (*Sphyrna mokarran*);
- the 'vulnerable' Great White Shark (*Carcharodon carcharias*);
- the 'presumed extinct' Green Sawfish (*Pristis zijsron*);
- the 'endangered' Southern Bluefin Tuna (*Thunnus maccoyii*); and
- the 'vulnerable' Black Cod (*Epinephelus daemelii*).

Potential impacts on these fish which could occur or be exacerbated by the proposed Research Lease were identified as:

- the potential to increase the impact of the key threatening process (KTP) of '*injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris'* (EPBC Act);
- pollution (decline in water quality, oil slicks, foul odours);
- the potential to alter migratory movements;

- the potential to increase the impact of the key threatening process (KTP) of '*introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW (*FM Act*);*
- the escape of research specimens into wild populations and associated issues e.g. genetic integrity, competition and the spread of disease; and
- the potential to change behaviour and attract increased numbers of sharks and other fish, notably Great White Sharks.

The Assessments of Significance revealed that the Research Lease is unlikely to have a significant impact on any of the species identified above so Species Impact Statements were not conducted (Appendix 9). Important breeding, feeding or resting areas are unlikely to be impacted by the Research Lease and a range of mitigation measures will be implemented to manage potential risks. The Research Lease will also be stocked with fish species which are native to NSW coastal waters so there is no risk of introducing non-indigenous fish.

Cetaceans

Cetacean species protected under the TSC Act that are likely to occur in the wider study area include:

- the 'endangered' southern right whale (*Eubalaena australis*);
- the 'vulnerable' humpback whale (*Megaptera novaeangliae*);
- the 'vulnerable' sperm whale (*Physeter macrocephalus*); and
- the 'endangered' blue whale (*Balaenoptera musculus*).

Records show that the southern right whale and humpback whale are likely to occur in the study region. Sperm whales and blue whales are not commonly sighted in the waters in Providence Bay but could occur in the wider study area.

Potential impacts on cetaceans which could occur or be exacerbated by the Research Lease were identified as:

- increased risk of vessel strike;
- increased acoustic pollution;
- the potential to alter migratory movements;
- reduced availability of resting habitat;
- pollution (decline in water quality, oil slicks and foul odours); and
- the potential to increase the impact of the KTP of '*entanglement or ingestion of anthropogenic debris in marine and estuarine environments*' (TSC Act).

The Research Lease is not considered to have a significant impact on any cetacean species such that a Species Impact Statement would be necessary. This is mainly due to the transient nature of the species and that important, mating, feeding or resting areas are unlikely to be impacted by the Research Lease, as well as the range of mitigation measures that will be implemented to manage these potential risks.

Marine Turtles

Marine turtle species that are likely to occur in the wider study area and that are listed under the TSC Act include:

- the '*vulnerable'* green turtle (*Chelonia mydas*);
- the '*endangered'* leatherback turtle (*Dermochelys coriacea*); and
- the '*endangered'* loggerhead turtle (*Caretta caretta*).

Potential impacts on marine turtles that could occur or be exacerbated by the proposed Research Lease were identified as:

- increased risk of vessel strike and acoustic pollution;
- reduced availability of foraging and/or resting habitat;
- the potential to increase the impact of the KTP of '*entanglement or ingestion of anthropogenic debris in marine and estuarine environments*' (TSC Act); and
- pollution (decline in water quality, oil slicks, foul odours).

The Research Lease is not considered to have a significant impact on marine turtles such that a Species Impact Statement would be necessary. This was mainly due to the absence of important nesting, mating or feeding areas in the direct study area, as well as the mitigation measures that will be implemented to manage these potential risks.

Pinnipeds and Sirenians

Pinniped and sirenian species considered likely to occur in the wider study area include:

- the 'vulnerable' Australian fur seal (*Arctocephalus pusillus doriferus*);
- the 'vulnerable' New Zealand fur seal (*Arctocephalus forsteri*); and
- the 'endangered' dugong (*Dugong dugon*).

The Australian fur seal, the New Zealand fur seal and dugong do occur in the wider study area noting a seal haul-out ground on Cabbage Tree Island. Potential issues which could occur or be exacerbated by the Research Lease on pinnipeds and sirenians were identified as:

- increased acoustic pollution;
- increased risk of vessel strike;
- reduced availability of foraging and/or resting habitat;
- pollution (decline in water quality, oil slicks and foul odours); and

- the potential to increase the impact of the KTP of '*entanglement or ingestion of anthropogenic debris in marine and estuarine environments*' (TSC Act).

Although pinnipeds and sirenians (particularly seals) are likely to forage in Providence Bay, the Research Lease is not considered to have a significant impact such that a Species Impact Statement would be necessary. This is mainly due to the relatively low abundance of these species in Port Stephens waters and the range of mitigation measures that will be implemented to manage these potential risks.

Seabirds

A generic assessment was undertaken for some species that use the same foraging techniques and/or habitat e.g. seabirds in the same species group such as albatrosses. Intertidal and wading birds such as sandpipers, curlews and plovers, for example, were excluded from the assessment as they are unlikely to be directly or indirectly impacted due to the distance between the Research Lease and their habitat. A few other seabird species were also excluded from the assessment due to their NSW distribution being restricted to isolated islands, such as Lord Howe Island or due to sightings being extremely rare or nonexistent in NSW, which was revealed when their distribution was cross referenced with other literature.

Seabird species listed under the TSC Act that are known to roost or breed on land near the proposed Research Lease include:

- the 'vulnerable' Gould's petrel (*Pterodroma leucoptera*) – Cabbage Tree Island and Boondelbah Island.

Cabbage Tree Island, Boondelbah Island, Little Island, Yacaaba Head and Broughton Island are located 2 km, 4 km, 4 km, 3 km and 9.5 km, respectively from the proposed Research Lease.

Potential impacts on seabirds which could occur or be exacerbated by the proposed Research Lease were identified as:

- pollution (decline in water quality, oil slicks, foul odours);
- behavioural changes i.e. changes to food sources and interactions with other fauna;
- ingestion of therapeutics via consumption of treated stock;
- disturbance and disorientation due to artificial lights (navigation lights); and
- the potential to increase the impact of the KTP of '*entanglement or ingestion of anthropogenic debris in marine and estuarine environments*' (TSC Act).

The Research Lease is not considered to have a significant impact on any seabird species such that a Species Impact Statement would be necessary. This is mainly due to the range of mitigation measures that will be implemented to manage these potential risks.

(b) Assessment of Significance (Commonwealth)

NSW DPI assessed the potential impacts of the Research Lease with reference to the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) and according to the EPBC Act Policy Statement 1.1 (Significant Impacts Guideline 1.1) in conjunction with EPBC Act Policy Statement 2.2 (Offshore Aquaculture).

The matters of national environmental significance (NES) which need to be considered and assessed under the EPBC Act include:

- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- the Commonwealth marine environment;
- World Heritage properties;
- National Heritage places;
- Great Barrier Reef Marine Park; and
- nuclear actions.

To determine which matters required assessment, NSW DPI undertook a search using the EPBC Act Protected Matters Search Tool on 30th March 2012. The search tool generated a summary of matters protected by the EPBC Act which may relate to or occur in the area of the Research Lease (Appendix 6), including:

Matters of National Environmental Significance

- Threatened Species = 30
- Migratory Species = 35
- Wetlands of International Significance = 1 (See Section 8.2.2.12)

Others Matters Protected by the EPBC Act

- Listed Marine Species = 49
- Whales and Other Cetaceans = 13

An assessment was conducted on these matters protected by the EPBC Act which could potentially be impacted directly or indirectly by the operation of the facility (Appendix 10).

30 Listed Threatened Species (Sections 18 and 18A of the EPBC Act)

- 1 'critically endangered';
- 8 'endangered'; and
- 21 'vulnerable'

Two of the 'threatened' species listed as 'vulnerable', including the stuttering frog (*Mixophyes balbus*) and the brush-tailed rock-wallaby (*Petrogale penicillata*), were not assessed as they are terrestrial and considered unlikely to interact with the Research Lease.

35 Migratory Species (Sections 20 and 20 A of the EPBC Act)

- 16 seabirds;
- 3 terrestrial birds;
- 8 marine mammals;
- 3 sharks; and
- 5 reptiles.

49 Listed Marine Species

- 6 marine reptiles;
- 2 fur seals;
- 1 dugong;
- 18 birds; and
- 22 syngnathiforms.

13 Whales and Other Cetaceans

- 6 dolphins; and
- 7 whales.

Two bird species - the satin flycatcher (*Myiagra cyanoleuca*) and the spectacled monarch (*Monarcha trivirgatus*) listed under the categories of 'migratory' and 'listed marine' species, were not assessed as they are terrestrial and considered unlikely to interact with the Research Lease.

Some species assessed in regards to the matters of NES were included in multiple categories. For example, the southern giant petrel (*Macronectes giganteus*) is listed as endangered in the 'threatened' species list and as a 'migratory' species and a 'listed marine' species.

In addition to those identified by the EPBC Act Protected Matters Report, an assessment was conducted on several species that are listed under the EPBC Act and are known to occur in the Port Stephens region but did not appear in the search results. These included the providence petrel (*Pterodroma solandri*), flesh-footed shearwater (*Puffinus carneipes*), osprey (*Pandion haliaetus*), sooty tern (*Sterna fuscata*) and little tern (*Sterna albifrons*).

The assessment of matters of NES and other matters protected under the EPBC Act considered potential impacts associated with all stages of the proposed Research Lease, including construction, deployment, operation and decommissioning.

Potential impacts are not thought to be significant when considered in context with the small scale and short-term operation of the Research Lease, the low stocking density, the minor increases in vessel movements and vehicular traffic, the distance from critical habitat and reefs, as well as the use of design features and daily operational and maintenance procedures that will minimise entanglement risks and predatory interactions. Noise generated will predominately be characteristic of the area and service vessels will be similar to existing vessels that use Providence Bay.

Potential impacts are also not thought to be significant when considered in context with the characteristics of the proposed site, including the absence of environmentally sensitive or unique areas, the soft sediment seafloor (mobile sands), the high energy wave climate and the extensive area of similar unobstructed habitat in the direct and wider area. The small area of habitat disturbed from the installation of the anchors is expected to return to pre-existing conditions relatively quickly after the removal of the sea cage infrastructure. Broodstock will be sourced locally or from the same genetic population, and hatchery protocols will ensure that genetic integrity is maintained, healthy fish are stocked into the cages and pest or unwanted organisms are not introduced to the site.

In addition, a range of industry best practices, management plans, protocols and monitoring programs identified in the EIS and EMP will be implemented to mitigate any potential risks associated with entanglement, ingestion of marine debris, vessel strike, acoustic pollution, navigation lights, disease and pests, escapees and genetic integrity, chemical use, water quality, predatory interactions, behavioural changes, alterations to migratory pathways and important habitat areas.

Conclusion

The risk of the Research Lease having a significant impact on threatened species, protected species, matters of NES or any other matters protected under the EPBC Act is thought to be ‘low’ when considered in context with the small scale and short-term operation of the Research Lease and the various mitigation measures that will be implemented to minimise risks associated with entanglement, ingestion of marine debris, vessel strike, acoustic pollution, navigation lights, disease and pests, escapees and genetic integrity, chemical use, water quality, predatory interactions, behavioural changes, alterations to migratory pathways and important habitat areas. Based on the results of these assessments it has been concluded that a referral under the provisions of the EPBC Act is not necessary.

8.2.2.11 Migratory Pathways, Behavioural Changes and Predatory Interactions

Table 43: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts on migratory pathways, behaviour and predatory interactions (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the operation of the Research Lease have a significant impact on the migratory pathways, behaviour and/or predatory interactions of any species?			
Level of Impact	Individual facility			
Comments and Considerations	▪ *Is the facility situated in any known migratory pathways?* ▪ *Is the facility likely to disturb humpback whale, southern right whale and/or Great White Shark migratory pathways?* ▪ *Are any species expected to experience behavioural changes due to the operation of the Research Lease?* ▪ *Will the sea cages increase the number of sharks in the area and consequently the risk of shark attacks?* ▪ *Are the fur seals on Cabbage Tree Island likely to interact with the sea cages?* ▪ *What measures will be implemented to mitigate, monitor and manage potential impacts on migratory pathways, behavioural changes and predatory interactions?*			
Description	▪ Cabbage Tree Island – fur seal haul-out site ▪ Port Stephens – 100-150 resident Indo-Pacific dolphins ▪ East coast – migratory pathway for whales ▪ Providence Bay – nursery ground for juvenile Great White Sharks (spring-summer)			
Proposed Management – Mitigation and Monitoring	▪ Small scale short-term research operation ▪ Minimise marine fauna attraction & interactions o Sea cage design features o Daily operational & maintenance procedures o Human activity o Structural Integrity & Stability Monitoring Program (Appendix 2) ▪ Marine Fauna Interaction Management Plan (Appendix 2) o Deployment of acoustic receivers (sharks)			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	2	5	10	**Moderate**
Reporting Requirements	Full management report (Appendix 2)			

<u>*Justification of Ranking*</u>

(a) Migratory Pathways

Humpback and Southern Right Whales

Humpback and southern right whales migrate between summer feeding grounds in Antarctica and warmer winter breeding grounds in the tropical and subtropical areas along the east coast of Australia (Web Reference 1) with individuals migrating up to 10,000 km each year (Baker *et al.,* 1990). The northern migration occurs between May to August while the southern migration to Antarctic waters occurs during September to December. Whales typically stay closer to the coast in shallower waters during the southward migration, particularly calving females and females with young, and are frequently sighted resting in large embayments (Bannister *et al*., 1996; Web Reference 1; Web Reference 23).

Several factors have been attributed as triggers for the northward migration including prey availability, location of feeding ground, breeding condition, water temperature, the extent of sea-ice, predation risk and reduced light conditions (Vang, 2002; DEH, 2005a). The east Australian humpback whale population migrates along the continental shelf close to the coast up to southern Queensland and from there whales disperse into the lagoonal waters of the Great Barrier Reef (Paterson *et al.,* 1994 cited in Vang, 2002).

Humpback whales have been found to exhibit a high degree of site fidelity towards both breeding and feeding grounds (Clapham *et al.,* 1993). The migratory movements of the eastern Pacific humpback whales are clearly non-random (Vang, 2002). Urban *et al.* (2000) for example, found evidence of preferred migratory destinations. Several studies suggest that humpback whale site fidelity is a maternally driven trait (Baker *et al.*, 1994; Urban *et al*., 2000) but there is also evidence to suggest that a combination of genetic traits and imprinting is used by whales to return to breeding grounds (Baker *et al.,* 1994).

Speculations about navigation tools used by migrating whales include following bottom topography parallel to the coast and “spy-hopping” to maintain orientation (Gaskin, 1982 cited in Vang, 2002), as well as following the direction of ocean currents and other water masses (Matthews, 1966). Females at the end of lactation and weaning yearlings are the first to commence the northward migration, which are followed by juveniles, mature males with resting females and lastly, females in late pregnancy (Matthews, 1966). Conversely, females in early pregnancy and juveniles are the first to commence the southern migration, followed by mature males and females in early lactation (Matthews, 1966).

There is a paucity of information on the critical habitat of humpback and southern right whales, as well as the adaptability and flexibility of their habitat requirements (DEH, 2005a; DEH, 2005b). Narrow corridors and a funnelling effect have been observed along a few sections of the east Australian coastline where physical and other barriers cause the majority of the population to pass close to the shore (i.e. within 30 km of the coast) which in turn leads to the formation of large assemblages (DEH, 2005a). Islands with suitable water temperature are also conducive to the formation of large whale assemblages (Matthews, 1966).

On the east coast of Australia important migratory pathways for humpbacks include the eastern sides of Stradbroke Island and Moreton Bay Island in Queensland (DEH, 2005a). Important resting areas for humpbacks on the east coast used during the southern migration include the Whitsundays, Hervey Bay, Moreton Bay, the Swain Reefs complex, the Great Barrier Reef, the Palm Island Group and Bell Cay in Queensland, as well as Cape Byron and Twofold Bay in NSW (Figure 47) (DEH, 2005a). Southern right whale migration patterns are poorly known but this species is known to frequent inshore areas including large embayments (Figure 48) (DEH, 2005a).

The size of the east Australian humpback whale population is currently estimated at about 17,500 with an annual rate of increase of approximately 10.9% (Noad *et al*., 2011), while the population size of southern right whales has been estimated at 2,100 individuals with a 7% annual rate of increase (Web Reference 23). Concerns have been raised about the impact that coastal aquaculture infrastructure may have on the migratory pathways of these whales, particularly as these species frequent inshore waters and their populations are expected to continue to increase in the future.

Whales are regularly sighted in coastal waters off Port Stephens during the migration season (June to November) but no area has been identified as important resting, calving or feeding habitat in the region. The exact migration pathway of humpback and southern right whales is uncertain so it is difficult to assess the impact of the Research Lease on migration routes of these species. However, the proposed Research Lease is a small scale short-term operation where the total area of lease is 20 hectares.

If whales migrate through Providence Bay there is approximately 3 km of unobstructed waters to the west of the Research Lease in which they can safety navigate through (i.e. based on a 500 m clearance from the shore) and 2.5 km to the south of the Research Lease and north of Cabbage Tree Island. It is expected that the area obstructed by the sea cages (i.e. less than 370 x 530 m) is unlikely to have a significant impact of whale migratory pathways given that there are extensive areas of similar habitat available in the direct and wider study area which whales can use for this purpose. However, given the uncertainty about critical whale habitat and their migratory pathways, a Marine Fauna Interaction Management Plan will be implemented to monitor the movement patterns of whales in Providence Bay, interactions with the Research Lease and any behavioural changes.

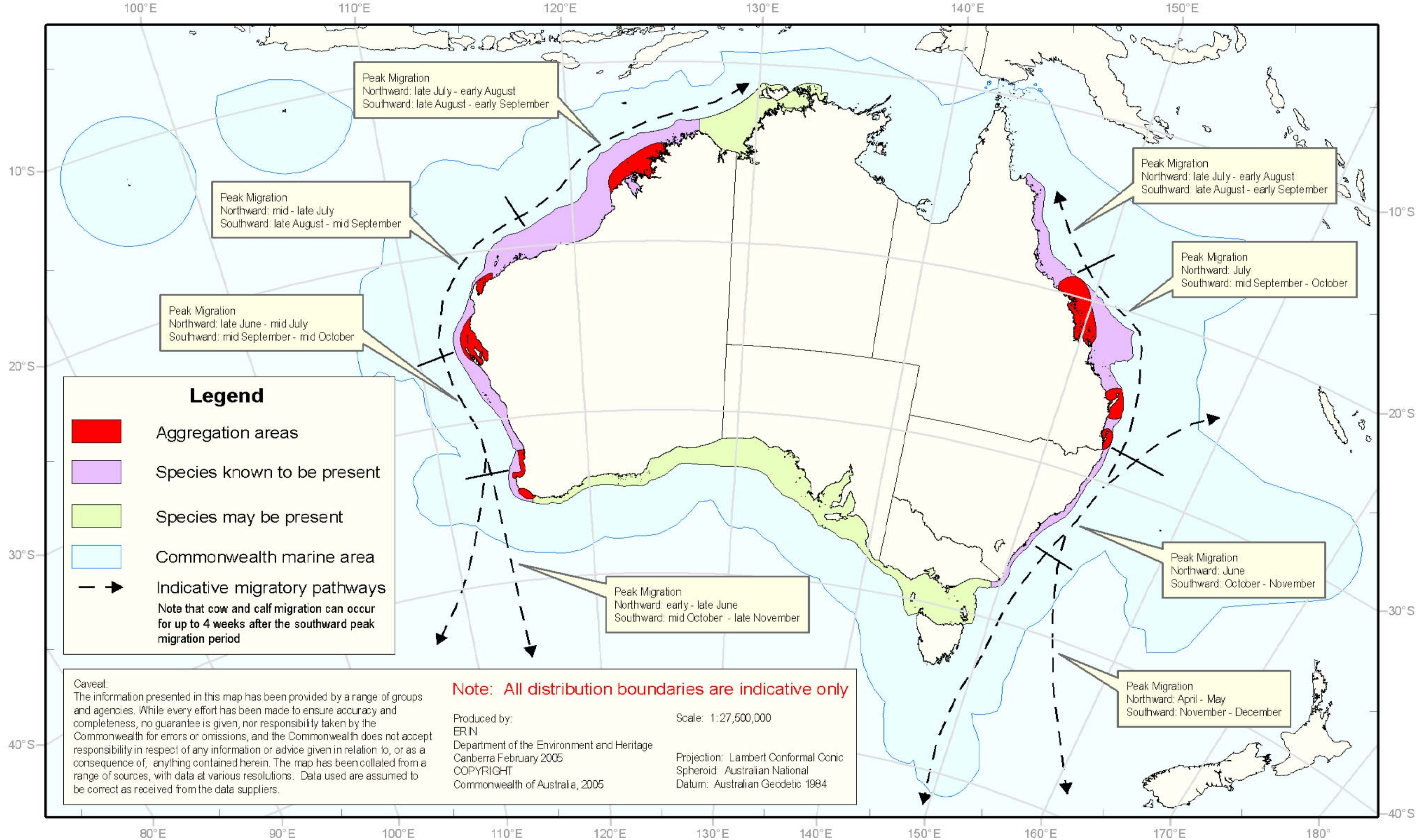

Figure 47: Distribution, migration and recognised aggregation areas of the humpback whale (Source: DEH, 2005).

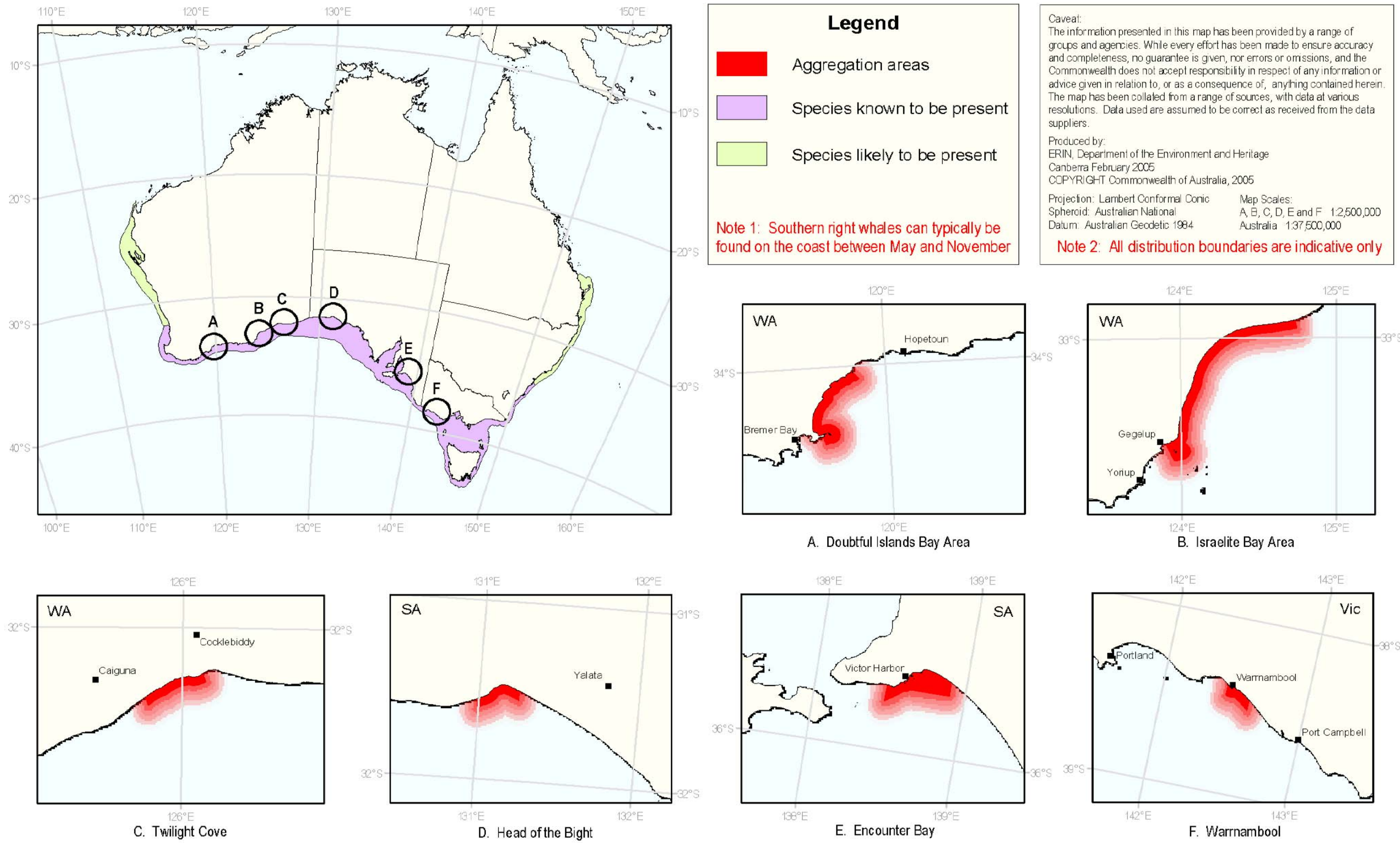

Figure 48: Distribution and recognised aggregation areas of the southern right whale (Source: DEH, 2005).

Great White Sharks

The Port Stephens region is one of two primary residency regions for juvenile and subadult Great White Sharks on the east coast of Australia – the other being Corner Inlet of eastern Victoria (Bruce & Bradford, 2008). Bruce & Bradford (2011) defined the footprint of the nursery area to extend 50-60 km along the coast from Stockton Beach (south of Port Stephens) to Mungo Brush in the north and 25 km offshore to the 120 m depth contour in mid-shelf region. Acoustic monitoring data indicates that juvenile sharks are resident to the nursery area for extended periods ranging from weeks to months between September and February but the highest numbers of sharks have been detected from November to January. Interactions with Great White Sharks need to be considered due to their density, seasonal migration and movement patterns in Providence Bay (Figure 49).

Bruce & Bradford (2011) found that Great White Sharks were not evenly distributed along the length of Hawks Nest Beach. Sharks showed a higher level of occupancy of the southern end of the beach between Yacaaba Head and the Hawks Nest Surf Life Saving Club. Individual sharks were found to spend an average of 26.3% of hours in the first kilometre and 51.1% of their time in the first 3 km of the beach (Figure 50). The juvenile sharks were also found to spend a significant amount of time in the surf zone in water with a depth of 1-5 m. It is unclear why the sharks occupied the southern end of Hawks Nest Beach for a greater percentage of time. Some suggestions include the degree of protection from swell due to Yacaaba Head and nearby islands or the movements of prey (Bruce & Bradford, 2011).

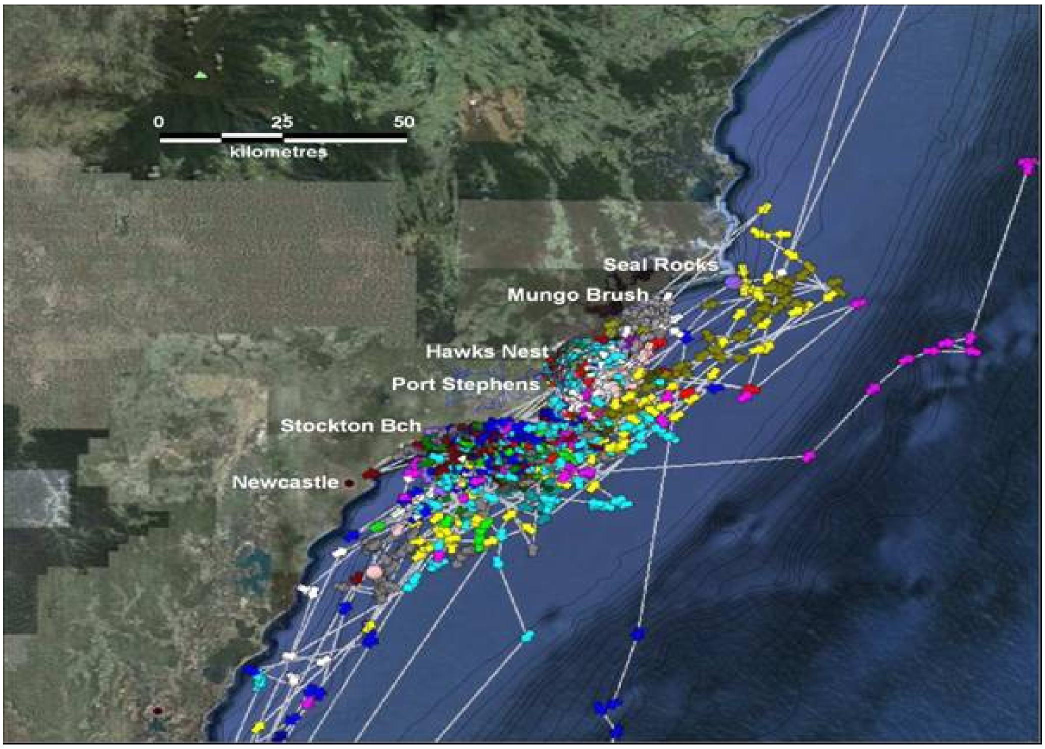

Figure 49: Argos-satellite derived positions for tagged and tracked Great White Sharks on Australia's east coast from 2007-2011 – positions of each shark is colour coded (Bruce & Bradford, 2011).

The Research Lease is a small scale short-term operation with a total area of 20 hectares (i.e. 370 x 530 m). There is approximately 3.5 km of unobstructed waters to the west of the Research Lease in which the sharks can safety navigate through and 2.5 km to the south of the Research Lease and north of Cabbage Tree Island. The obstruction caused by the sea cages is considered unlikely to have a significant impact on the migratory pathways of Great White Sharks in Providence Bay given that extensive areas of similar habitat are available in the direct and wider study area.

To ensure that the Research Lease does not have a significant impact on shark local and migratory movements in proximity to the Research Lease, the occurrence, timing, behaviour and/or duration of occupation will be monitored at the Research Lease, nearby localities and suitable reference locations using a range of sampling methods such as visual census techniques, passive and active acoustic tracking studies and recording incidental sightings and behaviours.

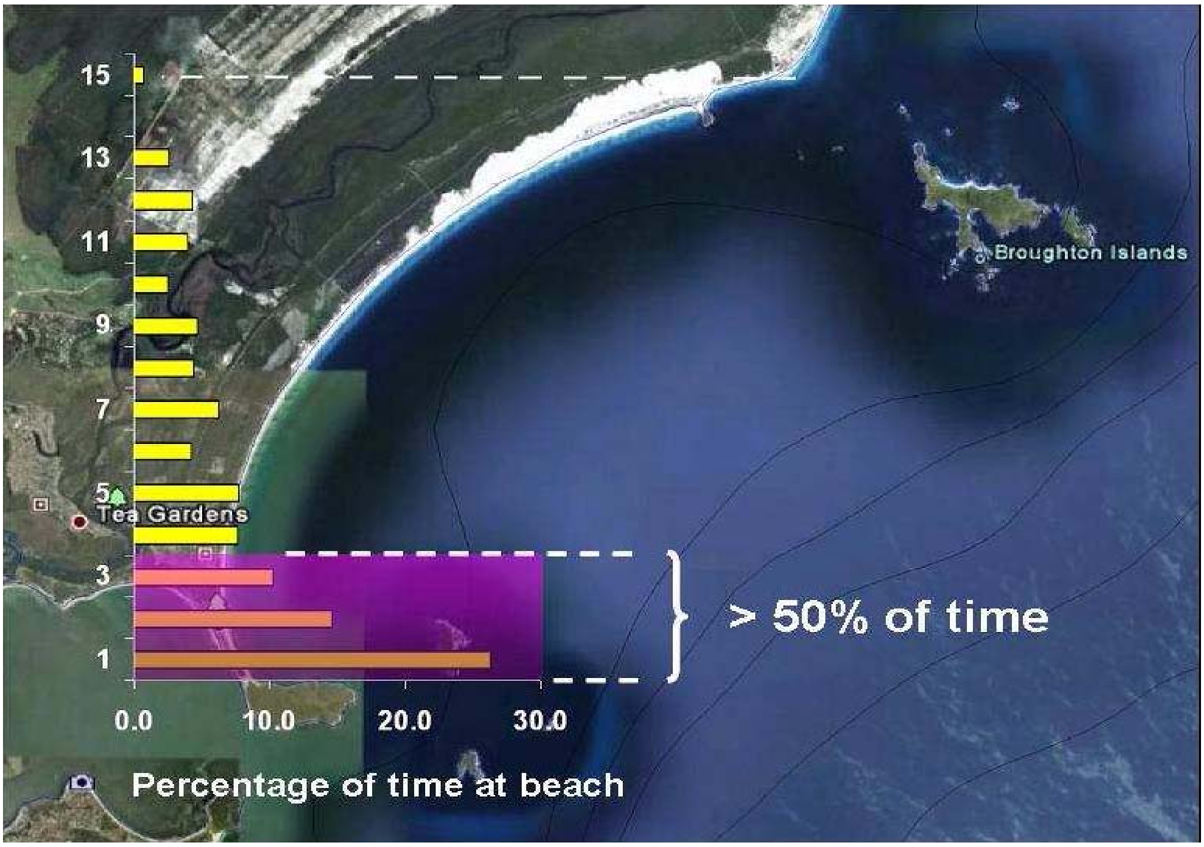

Figure 50: Distribution of Great White Shark activity along Hawks Nest Beach (Source: Bruce & Bradford, 2011).

(b) Behavioural Changes and Predatory Interactions

A number of species in Providence Bay represent potential predators of the fish cultured in the sea cages of the Research Lease, including sharks, seals, seabirds and dolphins. It is difficult to predict the extent and severity of depredation losses and gear destruction, which largely depends on feeding behaviour, aggressiveness, the predator's population biology, migratory movements and the effectiveness of control measures (McCord *et al*., 2008). Marine predators can cause direct damage to finfish farms including tearing holes in nets and mutilating stock, as well as indirect damage, such as inducing stress to the stock and thereby reducing quality and/or size (Ladenburg & Sturges, 1999 cited in McCord *et al*., 2008). Potential interactions that are detrimental to marine predators include injury, entanglement and behavioural changes due to habituation to a predictable food source (DAFF, 2007).

Sharks

The operation of the Research Lease has raised concerns about the risk of increased numbers of sharks visiting Providence Bay, potential behavioural changes and the associated impact on the safety of other waterway users, notably SCUBA divers, swimmers and Research Lease staff.

There is limited published literature on the interactions between sharks and aquaculture facilities in Australia and worldwide (de Jong & Tanner, 2004). In South Australia, Bronze Whalers are the most common shark species which interacts with sea cages but there are also reports of Great White Sharks interactions (de Jong & Tanner, 2004). Conversely, the trial operation of a Snapper farm in Providence Bay resulted in no negative shark interactions with the sea cages over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.*).

Catch and effort data from the commercial shark fishery in Spencer Gulf, South Australia, was analysed on a monthly and annual basis to provide insight into the potential impacts of Yellowtail Kingfish farms on shark activity in the area (PIRSA, 2003). Evidence of a seasonal increase in whaler shark abundance was detected for the warmer months of the year in the gulf and the west coast waters. SARDI scientists concluded that the biomass of cultured stocks was very low relative to other species and that it was very unlikely that the cultured stock would represent a significant incentive for additional sharks to enter the gulf (PIRSA, 2003). SARDI scientists also concluded that it is likely that naturally present sharks will initially be inquisitive about sea cages but if no food rewards are available (i.e. injured fish and mortalities), sharks are likely to become disinterested (PIRSA, 2003; R. Johnson, *pers. comm.* cited in McCord *et al*., 2008).

Concerns have been raised that the fish in the sea cages may act as attractants and alter localised shark movements. In particular, there are concerns that the sea cages will increase the duration that sharks occupy the area proposed for the Research Lease and therefore increase the risk of capture in the anti-predator nets and/or incidental hooking (N. Otway 2012, *pers. comm*.). Juvenile Great White Sharks for example, feed almost exclusively on fish species, such as Snapper, Australian Salmon and Yellowtail Kingfish (N. Otway, unpublished data). Similarly, necropsies of Grey Nurse Sharks have shown that their diet consists of species such as Mulloway, Kingfish and Snapper (N. Otway, unpublished data). Hence, the fish species proposed for the Research Lease are among the primary prey already consumed by the shark species that inhabit Providence Bay.

Furthermore, it is likely that sharks will initially be inquisitive about the captive fish in the sea cages but if no rewards are provided (i.e. injured fish or mortalities), and sufficient barriers are installed, sharks are expected to lose interest as observed on other sea cage farms (PIRSA, 2003; R. Johnson, *pers. comm.* cited in McCord *et al*., 2008).

Bruce (1998) further supports that the primary cause of shark damage to cages and nets is related to attempts to gain access to dying fish and mortalities, while captive fish and slicks generated during feeding events are also considered to be key shark attractants. These signals will be mitigated by a number of operational and maintenance procedures, such as using pelletised feed opposed to whole fish and regularly removing moribund and dead stock.

To address the concern about the safety of Research Lease staff and other waterway users (e.g. SCUBA divers), acoustic listening devices have been deployed by NSW MPA and CSIRO at the proposed lease site, *SS Oakland* and around Cabbage Tree Island. The occurrence, timing, behaviour and/or duration of shark occupation can then be monitored before the deployment of the farm. In addition, Research Lease staff will use visual census techniques and recording of incidental sightings and behaviours. Increasing numbers of Great White and Grey Nurse Sharks are being tagged with R-coded acoustic tags (Bruce & Bradford, 2011; Otway & Ellis 2011) which could provide the basis for one component of a comprehensive monitoring study (N. Otway 2012, *pers. comm*.).

Additional mitigation measures proposed for the Research Lease include anti-predator nets and regular human activity in the Research Lease which may help to deter sharks (See below - Mitigation Measures).

Seals

Pinnipeds are considered to cause the most damage to aquaculture facilities worldwide (Jamieson and Olesiuk, 2001 cited in McCord *et al*., 2008). Fur seals in particular, are known to cause damage to mariculture gear and can be very aggressive in their attempts to prey on caged fish (Kemper et al., 2003).

The Australian fur seal (*Arctocephalus pusillus doriferus*) and the New Zealand fur seal (*Arctocephalus forsteri*) are commonly recorded in the Port Stephens region but there are also occasional sightings of leopard seals (*Hydrurga leptonyx*). Providence Bay, notably Cabbage Tree Island located 2 km south, is has become a haul-out site for an increasing number of non-breeding seals using the site annually (NSW MPA 2011, *pers. comm*.). The periodic feeding of farm fish and the likely congregation of wild fish stock around the sea cages in response to these feeding events may attract seals into the vicinity of the Research Lease and could potentially modify their feeding behaviour and their interactions with humans.

Negative interactions between seals and tuna farms in South Australia for example, include seals basking on net rings and causing stress to stock, entering enclosures and consuming stock, biting dead fish lying against nets and damaging nets, and the occasional attack on farm workers such as divers removing dead fish (DAFF, 2007). The extent of interactions between fur seals and salmonid farms in Tasmania has been greater than that experienced by South Australian tuna farms (DAFF, 2007). Improving anti-predator nets is an area of ongoing innovation and research for the Tasmanian and South Australian aquaculture industries.

The most effective mitigation against negative seal interactions with marine finfish farms have proven to be appropriate net design, appropriate feeding regimes, constant vigilance, gear maintenance and site placement (Pemberton, 1996; Kemper *et al*., 2003).

Seabirds

Birds can be major predators on aquaculture farms, notably diving seabirds such as cormorants and gannets, which are known to be persistent in their attempts to predate on farm stock. The periodic feeding of farm fish and the likely congregation of wild fish around sea cages in response to feeding events has been known to attract seabirds to farms, modify their feeding behaviour and result in habituation due to a predictable food source (McCord *et al*., 2008).

Based on the monitoring results of the trial operation of a Snapper farm in Providence Bay over two years (1999-2000), the most frequent marine fauna interaction was with seabirds. The species recorded included cormorants, Australasian gannets, terns, seagulls, white-bellied sea eagles, albatrosses and shearwaters. These interactions varied from birds flying over the lease, diving around the cages, perching on the bird exclusion nets to successful disentanglements (Worth & Joyce, 2001). In particular, the great cormorant (*Phalacrocorax carbo*), the Australasian gannet (*Morus serrator*) and the little penguin (*Eudyptula minor*) are regularly sighted in Port Stephens waters and may represent potential predators. However, no interactions with little penguins were reported during the operation of the previous fish farm in Providence Bay.

Furthermore, it is considered unlikely that the Research Lease will have a significant impact on any species of seabird as negative interactions will be mitigated by adopting appropriate net design, appropriate feeding regimes, being constantly vigilant and maintaining gear (Pemberton, 1996; Kemper *et al*., 2003).

Dolphins

The most frequently reported interaction between dolphins and fish farms is that dolphins are attracted to prey around the farm opposed to predating on fish in the sea cages (Diaz Lopez *et al*., 2005). A study conducted on bottlenose dolphins (*Tursiops truncates*) on the north-eastern coast of Sardinia for example, revealed that dolphins were attracted to aquaculture farms but there were no observations of predation attempts on cultured stock (Diaz Lopez *et al*., 2005).

Similarly, the trial operation of a Snapper farm in Providence Bay, only 500 m from the Research Lease, resulted in no negative dolphin interactions with the sea cage farm over a two year statutory monitoring period (1999-2000) (Worth & Joyce, 2001) or during the ongoing operation of the farm up until 2004 (D. Liszka 2011, *pers. comm.*).

It is considered unlikely that dolphins will represent a significant predatory concern to the Research Lease. However, behavioural changes associated with feeding around fish farms, notably feeding patterns and social structure, could represent a potential concern and will be closely monitored during the operation of the Research Lease (Marine Fauna Interaction Management Plan – Appendix 2).

Mitigation Measures

The proponent aims to minimise any risks of negative marine fauna interactions including behavioural changes and predatory interactions, through the implementation of a range of proven mitigation measures which are described below:

- Utilisation of sea cage design features i.e. exclusion and barrier techniques that minimise the attraction of sharks, seals, seabirds and dolphins and potential negative interactions (Kemper *et al*., 2003; McCord *et al*., 2008) which include:
    - highly visible, taut and rigid culture net properly weighted with a small square mesh size (< 3 cm for nursery nets and 6 cm for adult stock) (DAFF, 2007);
    - highly visible anti-predator nets with a small mesh size (about 6 cm) represent a physical and visible deterrent where bright colours are thought to possibly interfere with the predators ability to see fish in the nets (Pemberton, 1996);
    - proper weighting of anti-predator nets to ensure no billowing and adequate separation between culture and anti-predator nets (McCord *et al*., 2008). A buffer distance of 2 m has proven to be most effective (Schotte & Pemberton, 2002);

    - fully enclosed double bottomed net (shark guard) to prevent marine fauna from accessing the bottom of the sea cages;
    - highly visible bird exclusion nets (surface) loosely secured over the top of the cages to dissuade seals and seabirds from perching on the nets or railings and diving into the cages;
    - elimination of all safe roosting and perching places to deter seals and seabirds;
    - raised railings (i.e. 1-2 m above sea level) to prevent seals from interacting with staff and jumping into the pens (Pemberton, 1996; Kemper *et al*., 2003; DAFF, 2007); and
    - use of large round cages with low stocking densities to reduce accessibility of stock to seals (note: square cages can be manipulated by seals as the corners represent points of weakness) (C. Cartwright, *pers. comm*. cited in DAFF, 2007).

- Implementation of daily operational and maintenance procedures that minimise the attraction of potential marine predators including:
    - regular cleaning of nets to reduce the amount of natural food available (e.g. submersible net cleaning robots);
    - using pelletised feed (opposed to whole fish thereby minimising feeding slicks);
    - prompt removal of injured and deceased stock (Pemberton, 1996); and
    - demand feeding regime to minimise excess food entering the water column.
- Human activity associated with daily operations and maintenance may help to deter marine predators (McCord *et al*., 2008).
- Implementation of the Marine Fauna Interaction Management Plan which will involve recording and monitoring interactions with marine fauna during the operational stage, including interactions with the sea cages, vessels or humans, as well as any behavioural changes such as in movement corridors and foraging/socialising patterns (Appendix 2).
- Comparisons of data from acoustic receivers (listening stations) positioned in Providence Bay will be made on shark abundance and movements before, during and after the operation of the Research Lease to assess potential impacts on shark migratory pathways, behaviour and human safety.
- Implementation of Structural Integrity and Stability Monitoring Program (Appendix 2)
    - remove non functioning nets from the water (Kempers *et al*., 2003);

- o regular inspections, maintenance and repair of sea cage infrastructure (Pemberton, 1996); and
- o maintain rope tautness and net integrity, particularly after severe weather (Kemper *et al.,* 2003).

Conclusion

The risk of the Research Lease having a significant impact on migratory pathways, the behaviour of marine fauna and predatory interactions is thought to be ‘low’ when considered in context with: the small scale and short-term of the research operation, the extensive area of unobstructed waters in Providence Bay and the range of mitigation measures that will minimise the attraction of marine fauna and associated interactions.

Mitigation measures include sea cage design features, daily operational and maintenance procedures, regular human activity and the Structural Integrity and Stability Monitoring Program, as well as the Marine Fauna Interaction Management Plan which will monitor any interactions.

The overall risk however, is considered to be ‘moderate’ given that there is uncertainty about whale and shark critical habitat, migratory pathways, potential behavioural changes and predatory interactions, particularly as human safety is involved. This risk ranking will ensure adequate management attention is provided for these issues until the research activities validate this assessment.

8.2.2.12 Areas of Conservation Significance

Table 44: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – impacts on areas of conservation significance (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

Issue	Will the operation of the Research Lease have a significant impact on any areas of conservation significance?
Level of Impact	Individual facility
Comments and Considerations	▪ *What areas of conservation significance are present in the region?* ▪ *How far are the areas of conservation significance from the Research Lease?* ▪ *Are any of the areas of conservation significance likely to be impacted by the Research Lease?* ▪ *Are any matters of NES likely to be impacted by the Research Lease, notably Wetlands of International Significance?* ▪ *Are any areas of 'critical habitat' likely to be impacted by the facility, notably Cabbage Tree Island (Gould's petrel) and Broughton Island (Grey Nurse Shark)?* ▪ *Is the Research Lease likely to have any draw down effects on natural reef areas?* ▪ *What measures will be implemented to mitigate, monitor and manage any potential impacts on areas of conservation significance?*
Description	Distance to areas of conservation significance: ▪ Port Stephens-Great Lakes Marine Park ▪ Sanctuary Zone (Cabbage Tree Island) = 1.5 km ▪ Sanctuary Zone (Broughton Island) = 9.5 km ▪ Gould's petrel Critical Habitat/John Gould Nature Reserve (Cabbage Tree Island) = 2 km ▪ GNS Critical Habitat (Little Broughton) = 10 km ▪ GNS Critical Habitat (Big and Little Seals Rocks) = 40 km ▪ GNS Critical Habitat (The Pinnacle) = 60 km ▪ Boondelbah Nature Reserve = 4 km ▪ Ramsar Wetland (Myall Lakes) = < 10 km ▪ Myall Lakes National Park (inc. Broughton Island and Yacaaba Headland)
Proposed Management – Mitigation and Monitoring	▪ Site Selection o High energy environment o Buffer zone o Mobile sands ▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2)

	o Regular sampling – before, during and after trial Daily operational and maintenance procedures – minimise waste inputs and biofouling ▪ Small scale short-term research operation			
Risk Assessment Values				
Organisation / Person	**Consequence**	**Likelihood**	**Risk Value**	**Risk Ranking**
NSW DPI	1	6	6	**Low**
Reporting Requirements	Full justification			

Justification of Ranking

Areas of conservation significance include Marine Protected Areas, Ramsar wetlands, national parks, nature reserves and areas of critical habitat declared under the *Fisheries Management Act 1994* and the *Threatened Species Conservation Act 1995*.

Areas of conservation significance in the Port Stephens region include the Port Stephens Great-Lakes Marine Park, the Sanctuary Zones surrounding Cabbage Tree Island and Broughton Island, the John Gould Reserve (Gould's petrel critical habitat), Little Broughton, The Pinnacle, Big and Little Seals Rock (Grey Nurse Shark critical habitat), as well as the Ramsar Wetlands of the Myall Lakes, the Myall Lakes National Park and Boondelbah Nature Reserve (Figure 51). The distances between these conservation areas and the Research Lease are listed in Table 44.

Potential direct impacts of the Research Lease on areas of conservation significance include increased nutrient concentrations, sedimentation, reduced water quality, chemical pollution, increased quantities of marine debris and other wastes, reduced visual amenity and odour emissions. However, it is considered unlikely that the Research Lease will have any direct impacts on areas of conservation significance due to the distance between these areas (buffer zone), the small scale and short operational timeframe of the research trial, as well as the range of mitigation measures that will be implemented to restrict detectable changes to in the boundaries of the Research Lease.

Daily operational and maintenance procedures will be implemented to minimise the input of wastes, such as uneaten fish food, faeces, metabolic by-products and therapeutics. A demand feeding regime will be used to minimise excess food entering the water column, feed conversion ratios will be optimised, high quality pelletised feed of an size appropriate to the fish will be used and injured and deceased stock will be removed regularly (Pemberton, 1996; Alston *et al*., 2006).

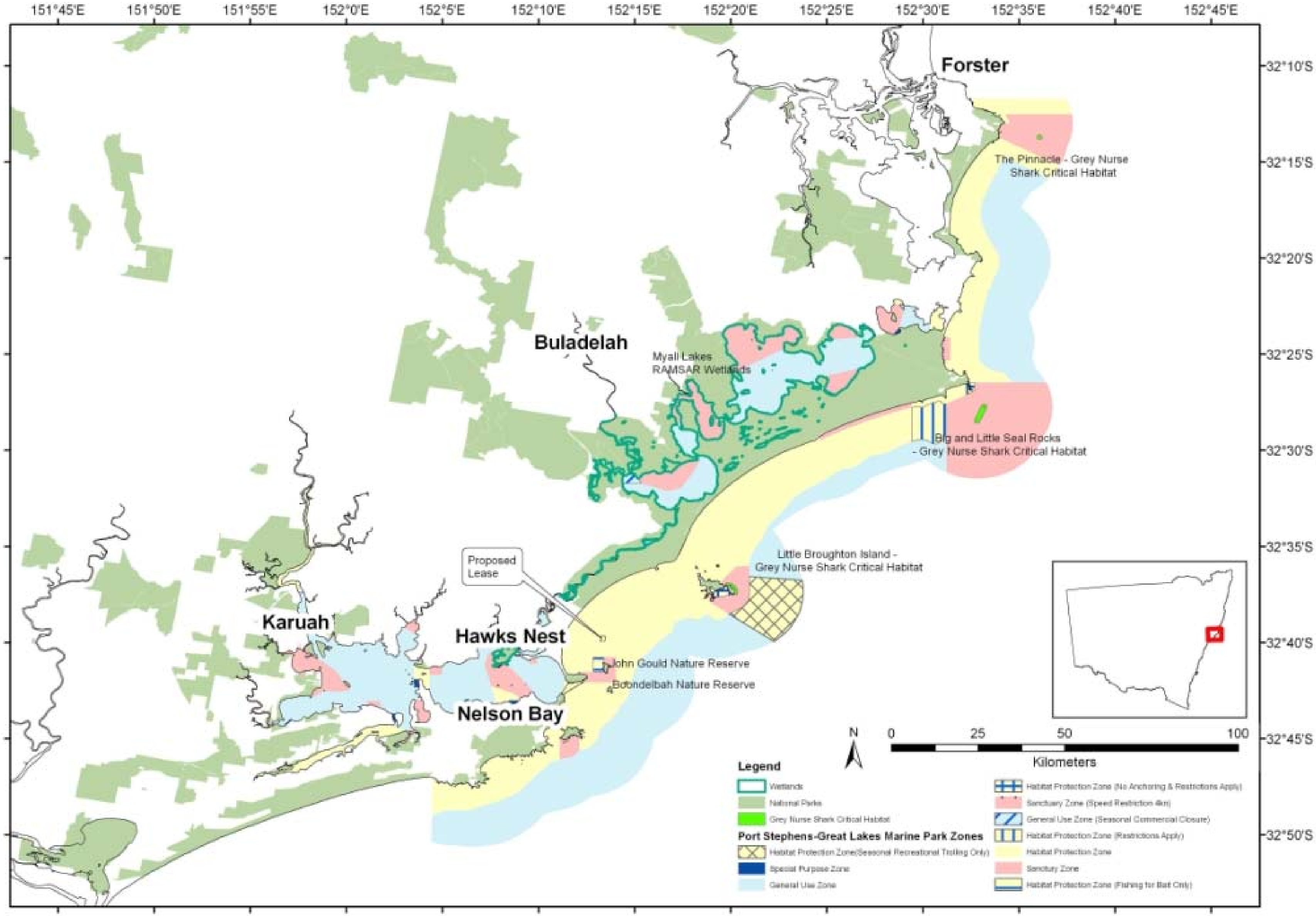

Figure 51: Areas of conservation significance near and/or within Providence Bay (Source: NSW DPI, 2012).

Providence Bay is a high energy environment with strong currents and tidal movements (See Section 6.4 and 6.5) so it is expected that the small quantities of wastes will quickly be diluted, dispersed and broken down. A Water Quality and Benthic Environment Monitoring Program will be implemented and samples will be taken before, during and after the research trial, including areas both in and outside the boundaries of the Research Lease (Appendix 2). If any parameters are outside the acceptable range, notably nutrient concentrations and sedimentation, practices will be modified until acceptable levels are regained.

Areas of conservation significance could be indirectly impacted by the Research Lease if species associated with these areas forage in its vicinity. Potential indirect impacts include entanglements, ingestion of marine debris, behavioural changes due to a predictable food source, disorientation from artificial lights, increased risk of vessel strike and acoustic pollution. Similarly, it is considered unlikely that the Research Lease will have indirect impacts on areas of conservation significance due to the small scale and short operational timeframe of the research trial and the range of mitigation measures that will be implemented to minimise marine fauna interactions (See Section 8.2.2.1; Section 8.2.2.3; Section 8.2.2.6; Section 8.2.2.7; Section 8.2.2.9; Section 8.2.2.10).

The Gould's petrel, which breeds on Cabbage Tree Island (critical habitat) and Boondelbah Island, is not considered to be threatened by Research Lease as this species does not forage in areas close to shore (NSW DEC, 2006). No area of critical habitat on Cabbage Tree Island or Boondelbah Island will be removed, modified or isolated and indirect impacts are considered unlikely. However, there are concerns about artificial lights causing stress and disorientation to seabirds returning to their nests at night, notably the Gould's petrel and the little penguin. To minimise the risk of this potential issue, Research Lease staff will keep a distance from these islands, operations will be restricted to predominately daylight hours and the behaviour of these species and any interactions with the Research Lease will be monitored for the duration of the research trial (See Section 8.2.2.6).

The location of critical habitat of the Grey Nurse Shark in the PSGLMP ranges from 10 to 60 km from the Research Lease. The habitat predominately utilised by this species is rocky reef but small sandy gutters in the reef matrix are considered the preferred microhabitat (Web Reference 2). This species is thought to move away from reefs to feed at night but the extent of this range is unknown (Smale, 2005).

Grey Nurse Shark may use Providence Bay as a foraging ground and may be attracted to the Research Lease due to the likely congregation of wild fish around the sea cages. However, wild fish attractants will be minimised by a range of daily operational and maintenance procedures. Entanglement risks will also be mitigated by the implementation of a Marine Fauna Interaction Management Plan and a Marine Fauna Entanglement Avoidance Protocol

(See Section 8.2.2.7; Appendix 2). The Research Lease will not modify any core reef habitat of the Grey Nurse Shark or isolate any reef areas from other habitat used by the species or impede its movements in the wider area.

Aquaculture is permissible within General Use and Habitat Protection Zones of the PSGLMP but is prohibited within Sanctuary Zones. The site selection process for the Research Lease carefully considered the habitat types within Providence Bay and avoided sensitive habitats and areas of conservation significance, such as rocky reefs, seagrass beds and Sanctuary Zones. It is proposed that the Research Lease is to be situated in a Habitat Protection Zone over a habitat type consisting of soft sediment (predominately sand), which is extensively represented in Providence Bay. The installation and removal of the sea cage infrastructure is unlikely to have a significant impact on this dynamic habitat type which is expected to return to its original state relatively quickly once the infrastructure is removed at the end of the five year research trial.

The Research Lease could potentially function as an artificial reef and therefore, may act as a fish aggregating device (FAD). The term FAD has been used for a wide variety of drifting, surface floating or mid-water objects which have the primary purpose of facilitating the harvest of fish (mostly pelagic species) (Pears & Williams, 2005). Artificial reefs and FADs are permitted within marine parks in NSW provided they are assessed in accordance with the objects of the *Marine Parks Act 1997* and any other legislative or regulatory requirements (NSW MPA, 2009).

If the Research Lease functions as an artificial reef or FAD, there is the potential for 'draw down' effects on natural reef areas, which in turn could cause changes to natural reef and fish assemblages. If fish are drawn away from the protection of their natural habitat for example, they may become more susceptible to capture, which in turn could impact on the dynamics of adjacent natural reef assemblages (Cardno Ecology Lab, 2010).

Effects on adjacent natural reefs are likely to be dependent on factors such as the distance from the Research Lease and the type of fish found on nearby reefs that may be attracted to the sea cages. Investigations of fish assemblages inhabiting artificial reefs have shown that the local area of influence may range from 5 to 50 m depending on the reef size and local environmental conditions (Fabi & Sala 2002). The most extensive rocky reef habitat in Providence Bay is near Broughton Island particularly to the southeast where the reef extend up to 5 km offshore (NSW OEH, 2011b). There is also a very narrow band of shallow fringing rocky reef that extends up to 170 m offshore of Yacaaba Headland (Jordon *et al*., 2010) and a maximum of 270 m from Tomaree Headland (NSW OEH, 2011b). The closest rocky reef to the proposed Research Lease is around 2 km to the south adjacent to Cabbage Tree Island (NSW OEH, 2011b). These distances from the Research Lease are considered sufficient to minimise the risk of interaction between resident natural and artificial reef populations (Cardno Ecology Lab, 2010).

Regular cleaning of the sea cage infrastructure (i.e. biofouling removal) will also reduce the attractiveness and suitability of the Research Lease for reef fish species. The Research Lease is likely to attract mostly pelagic species similar to recreational fishing FADs installed along the NSW coastline to enhance recreational fishing opportunities. However, it should be noted that it is not an intention of the Research Lease to attract or facilitate the harvest of wild fish. Waterway users will be advised not to pass or anchor in proximity to the sea cage infrastructure due to WH&S concerns.

With reference to the Significant Impacts Guideline 1.1, it is considered that the Research Lease will not impact on any region of the Myall Lakes National Park, including the Myall Lakes - a Wetland of International Significance which is located within 10 km of the Research Lease. No area of national park or wetland will be modified or destroyed and the Research Lease will not change the hydrological regime, impact on water quality, native species or introduce invasive species to the wetland.

Matters identified in the *Guidelines for Developments Adjoining Land and Water Managed by the Department of Environment, Climate Change and Water* were also considered in context of the Research Lease (DECCW, 2010b). The applicable issues included visual amenity, odours and cultural heritage which have been assessed in Section 8.2.1.1 and Section 8.2.1.3, respectively.

Conclusion

The risk of the Research Lease having a significant impact on areas of conservation significance is thought to be ‘low’ when considered in context with the distance between these areas, the high energy environment of Providence Bay, the substrate type present, the small scale and short operational timeframe of the research trial, as well as the range of mitigation and management measures that will be implemented to restrict detectable changes to within the boundaries of the Research Lease and minimise negative interactions with marine fauna that may forage in the vicinity of the Research Lease.

8.2.2.13 Waste Disposal

Table 45: Summary of comments, proposed management measures, risk assessment values and reporting requirements for the issue – waste disposal (modified from Fletcher *et al*., 2004; Vom Berg, 2008).

<table>
<tr><td>Issue</td><td colspan="4">Will the waste generated from the operation of the Research Lease have a significant impact on the environment or humans?</td></tr>
<tr><td>Level of Impact</td><td colspan="4">Individual facility</td></tr>
<tr><td>Comments and Considerations</td><td colspan="4">▪ What is the protocol for disposing of dead fish and biofouling?
▪ What is the protocol for disposal of general waste and worn infrastructure?
▪ What measures will be implemented to mitigate, monitor and manage issues associated with waste disposal?</td></tr>
<tr><td>Description</td><td colspan="4">▪ Waste production
o Bio waste (dead fish & biofouling)
o General waste
o Obsolete/worn infrastructure</td></tr>
<tr><td>Proposed Management – Mitigation and Monitoring</td><td colspan="4">▪ Waste Management Plan (Appendix 2)
▪ Water Quality & Benthic Environment Monitoring Program (Appendix 2)</td></tr>
<tr><td colspan="5">Risk Assessment Values</td></tr>
<tr><td>Organisation / Person</td><td>Consequence</td><td>Likelihood</td><td>Risk Value</td><td>Risk Ranking</td></tr>
<tr><td>NSW DPI</td><td>0</td><td>6</td><td>0</td><td>Negligible</td></tr>
<tr><td>Reporting Requirements</td><td colspan="4">Short justification</td></tr>
</table>

Justification of Ranking

The operation of the Research Lease will generate a range of wastes, including bio waste (i.e. dead fish and biofouling), general waste (e.g. plastic, containers and bags) and obsolete/worn infrastructure (e.g. ropes and nets).

Daily operational and maintenance procedures of the Research Lease will include the removal of dead and moribund fish from sea cages. Fish mortalities predominantly occur during the fingerling stage of production when the fish are most vulnerable to natural processes and management events, such as stocking of the cages. The industry best practice is to manage stock to ensure mortalities are less than 5% throughout a production cycle.

Collected fish will be put into waste storage bins on service vessels where lids will be tightly secured to prevent spillages, attraction of pests or odour issues. The waste bins will then be returned to land and depending on the quantity of waste, it will be disposed of potentially through the Nelson Bay Commercial Fishermen's Co-operative waste disposal facility or transported by road to an appropriate composting or waste disposal facility in the local area. The containers will then be cleaned and disinfected before being returned to the service vessels (Worth & Joyce, 2001). All dead and moribund fish will be taken ashore for disposal – under no circumstances will dead or moribund fish be disposed of at sea (Environment Protection Authority, 2007).

The Research Lease infrastructure will be colonised naturally by a range of marine biofouling organisms, such as algae, ascidians, molluscs and barnacles. The removal of this biofouling from the infrastructure is important to reduce its resistance to currents and wave action which may jeopardise the integrity of the infrastructure e.g. stress moorings and deform nets (Braithwaite *et al*., 2007). Biofouling removal is also important to maintain water quality in cages, reduce the availability of habitat for diseases and parasites and to minimise the attraction of wild fauna (e.g. herbivorous fishes) which feed on it and can cause damage to nets (Braithwaite *et al*., 2007).

The Research Lease cage nets will be cleaned *in situ* or on land where a range of methods will be trialled as part of the research activities, such as submersible net cleaning robots. The potential impact of biofouling on the benthic environment will depend on a range of factors, such as the quantity of fouling organisms, the assimilation capacity of the environment, the benthic fauna beneath the cages such as scavengers. During the trial operation of the Snapper farm in Providence Bay for example, scuba divers observed that the decomposition of fouling organisms deposited on the seafloor beneath the cages was aided by bioturbation by foraging fish (D. Liszka 2011 *pers. comm*. cited in Worth & Joyce, 2001), including:

- Port Jackson Sharks (*Heterodontus portusjacksoni*);
- Wobbegongs (*Orectolobus sp*.);
- Blue-spotted Stingrays (*Dasyatis kuhlii*);
- Fiddler Rays (*Trygonorhina fasciata*);
- Sand Flatheads (*Platycephalis caeruleopunctatus*);
- Shovelnose Rays (*Aptychotrema vincentiana*);
- Small-toothed Flounders (*Pseudorhombus jenynsii*);
- Numb Rays (*Hypnos monopterygium*);
- Eastern Fortescues (*Centropogon australis*);
- Snapper (*Pagrus auratus*);

- Tailor (*Pomatomus saltatrix*); and
- Three-barred Porcupine Fish (*Dicotylichthys punctulatus*).

A Water Quality and Benthic Environment Monitoring Program will be implemented to monitor potential impacts of biofouling and assist with the development of environmentally sustainable practices (Appendix 2). Video and photo documentation of the seafloor beneath the sea cages is likely to be one of the techniques used to monitor and assess the impact of *in situ* cleaning of biofouling.

During the five year research trial it is expected that the sea cage infrastructure, such as ropes and nets, will wear and need to be replaced. The daily operation of the Research Lease will also generate general waste, such as plastics, containers and bags. These wastes will be secured in waste bins on the service vessels and transported by road to an appropriate waste disposal facility in the area.

The Research Lease will also follow industry best practice guidelines such as:

- Waste materials will be reduced, reused and recycled where possible;
- Lease infrastructure removed from the lease will be returned to shore for processing, recycling or disposal;
- General wastes will be returned to shore for processing or disposal;
- All sewage wastes will be contained on service vessels in onboard holding tanks or chemical toilets and disposed of through an approved vessel sewage discharge point on return to port, and
- Residual materials that cannot be reused or recycled will be disposed of at an approved waste management facility.

Conclusion

The risk of waste generated from the operation of the Research Lease having a significant impact on the environment or humans is thought to be 'negligible' when considered in context with the small scale and short-term operation of the research trial and the Waste Management Plan that will be implemented to ensure that wastes are appropriately handled, transported and disposed.

9 ENVIRONMENTAL MANAGEMENT

The Environmental Management Plan (EMP) will ensure that the commitments in the EIS, subsequent assessment reports and any approval or licence conditions are fully implemented. Appendix 2 contains a preliminary draft of the EMP which consists of a series of the sub-management plans, monitoring programs and protocols that address the potential environmental impacts identified in Section 8. The EMP will be finalised upon development approval and will include information such as operational objectives, indicators, performance criteria, sampling methods, data requirements, timeframes, specific locations and emergency response plans.

The objectives of the EMP are to ensure that the Research Lease is sustainably managed and that its operation does not have a significant impact on the marine environment, surrounding communities or staff. The EMP will aim to ensure the following:

- Aquaculture best practices are employed during all stages of the Research Lease;
- Marine fauna interactions are minimised;
- Water quality is maintained and nutrient inputs are kept within safe levels for humans and marine communities;
- The structural integrity and stability of the sea cage infrastructure is maintained;
- The occurrence of disease, parasites, pests and escapees is minimised and if these events do occur, prompt management and/or remedial action will be implemented;
- The safety of staff and surrounding communities is maintained;
- Waste is appropriately disposed;
- Navigational safety in Providence Bay, the Port of Newcastle and Port Stephens is maintained; and
- The performance of the Research Lease is regularly evaluated by reviewing environmental management reports and monitoring records.

The EMP will be used as a reference for staff and contractors involved with the various stages of the Research Lease. NSW DPI will be committed to and responsible for ensuring that all mitigation and management measures are carried out as described in the EMP.

10 CONCLUSION

Sustainable seafood production is a key focus of the NSW Government's State Aquaculture Steering Committee to support future demands of food security for the state. The gap between capture fishery supply and the growing demand for seafood can only be met by aquaculture. The NSW Government recognises the need to look at opportunities for sustainable and viable aquaculture development that is built upon sound research. Aquaculture supports the regional economies of NSW and will be an increasingly important contributor to the future food security needs of the state.

PSFI has been working in marine finfish research since the early 1990s and Snapper (*Pagrus auratus*) sea cage farming research commenced in the inshore waters of Botany Bay in 1993. Successful hatchery and nursery research for Mulloway (*Argyrosomus japonicus*), Yellowtail Kingfish (*Serioli lalandi*) and other marine finfish needs to be extended and validated in sea cages trials. The Research Lease will allow the NSW Government to extend its successful marine hatchery research at PSFI with the principal objective to conduct specific research on the sustainable development of sea cage aquaculture in NSW waters. The Research Lease will provide an opportunity to prove species suitability, validate equipment and technology, and monitor the marine environment. The results of this research will in turn support evidence based policy development for future sustainable seafood production in NSW.

The proposed site for the Research Lease off Port Stephens is in close proximity to PSFI which has suitable fish rearing and land based infrastructure. The proposed site also has suitable characteristics for cage based aquaculture (e.g. water quality, sandy bottom and moderate current flow), there is a history of finfish farming in the area and the harbour infrastructure of Nelson Bay enables necessary logistical support to be easily provided. Port Stephens is a key location in NSW for aquaculture research and the commercial production of oysters, barramundi, silver perch, freshwater crayfish and hatchery stock.

This EIS has been prepared to accompany an application for a five year, 20 hectare Research Lease off Port Stephens. The EIS provides a thorough and transparent assessment of the potential risks associated with the proposed activity and proposes a number of measures to address the potential impacts of the Research Lease development and its activities. Through the employment of industry best practice, management plans, protocols and monitoring programs identified in the EIS and EMP it is concluded that the proposed research activity will not have a significant environmental, social or economic impact.

Potential impacts are not thought to be significant when considered in context with the small scale and short-term operation of the Research Lease, the low stocking density, the minor increases in vessel movements and vehicular traffic, the distance from key landmarks, the existing aquaculture lease, residential areas, critical habitat and reefs, as well as the use of design features that will minimise visual impacts. Noise generated will predominately be characteristic of the area and service vessels will be similar to existing vessels that use Providence Bay.

Potential impacts are also not thought to be significant when considered in context with the characteristics of the proposed site, including the absence of environmentally sensitive or unique areas, the soft sediment seafloor (mobile sands), the high energy wave climate and the extensive area of similar habitat in the direct and wider area. The small area of habitat disturbed from the installation of the anchors is expected to return to pre-existing conditions relatively quickly after the removal of the sea cage infrastructure.

The proposed site is not a high use area, safe navigation will not be obstructed, the site is not of significant recreational or commercial importance and the lease will be clearly delineated with navigation buoys. Items and places of heritage significance in the region are located a sufficient distance away from the proposed site to ensure no direct or indirect impacts. Broodstock will be sourced locally or from the same genetic population, and hatchery protocols will ensure that genetic integrity is maintained, healthy fish are stocked into the cages and pest organisms are not introduced to the site.

The Research Lease may act as a catalyst for economic development as it will provide increased employment opportunities and use local goods and services, as well as provide the tourism industry with an opportunity to diversify experiences available to visitors. The Research Lease is also likely to improve the sustainability of aquaculture feeds by undertaking research to reduce reliance on fish meal and oil. Ultimately, the results from the monitoring programs and reviews of the effectiveness of the management plans, protocols and other mitigation measures will provide valuable information to support evidence based policy development for future sustainable seafood production in NSW.

11 REFERENCES

Australian Bureau of Agricultural and Resource Economics and Sciences (2011) Australian fisheries statistics 2010. ABARE and FRDC, Canberra.

Aguado-Gime'nez, F. and Garcia-Garcia, B. (2004) Assessment of some chemical parameters in marine sediments exposed to offshore cage fish farming influence: a pilot study. *Aquaculture* **242**: 283-296.

Allan, G. (2004) *Fish For Feed vs Fish For Food.* Proceedings of the ATSE Crawford Fund Conference - Fish, Aquaculture and Food Security held on 11 August at ATSE Crawford Fund Parliament House, Canberra. pp 20-28.

Allen, S., Marsh, H. and Hodgson, A. (2004) Occurrence and conservation of the dugong (Sirenia: Dugongidae) in New South Wales. *Proceedings of the Linnean Society of New South Wales* **125**, 211-216.

Allen, S. & Bejder, L. (2008) Southern Right Whale *Eubalaena australis* sightings on the Australian coast and the increasing potential for entanglement. *Pacific Conservation Biolog*y **9** (3): 228-233.

Alston, D.E., Cabarcas-Núñez, A., Helsley, C.E., Bridger, C. and Benetti, D. (2006) Standardized Environmental Monitoring of Open Ocean Cage Sites: Basic Considerations. World Aquaculture World Aquaculture Society, USA. **June:** 24-26.

Amirkolaie, A.K. (2011) Reduction in the environmental impact of waste discharged by fish farms through feed and feeding. *Reviews in Aquaculture* **3**: 19-26.

Anon (2006) *Socio-Economic Assessment of the Port Stephens – Great Lakes Marine Park*. NSW MPA.

Astles, K.L., Holloway, M.G., Steffe, A., Green, M., Ganassin, C and Gibbs, P.J. (2006) An ecological method for qualitative risk assessment and its use in the management of fisheries in New South Wales, Australia. *Fisheries Research* **82**; 290–303.

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) *Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality*. ANZECC and ARMCANZ, Canberra and Auckland.

Baker, C.S., Palumbi, S.R., Lambertsen, R.H., Weinrich, M.T., Calambokidis, J. and O'Brien, S.J. (1990) Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. *Nature* **344**: 238-240.

Baker, C.S., Slade, R.W., Bannister, J.L., Abernethy, R.B., Weinrich, M.T., Lien, J., Urban, R.J., Corkeron, P.J., Calambokidis, J., Vasquez, O. and Palumbi, S.R. (1994) Hierarchical structure of mitochondrial DNA gene flow among humpback whales *Megaptera novaeangliae*, world-wide. *Molecular Ecology* **3**: 313-327.

Barker, D., Allan, G.L., Rowland, S.J., Kennedy, J.D. and Pickles, J.M. (2009) *A Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research* 3rd Edition. NSW DPI, Port Stephens.

Bartley, D.M., Bondad-Reantaso, M.G. and Subasinghe, R.P. (2009) A risk analysis framework for aquatic animal health management in marine stock enhancement programmes. *Fisheries Research* **80**: 28-36.

Bannister, J.L., Kemper, C.M., Warneke, R.M. (1996) *The Action Plan for Australian Cetaceans*. Australian Nature Conservation Agency, Canberra.

Ben-Atia, I., Lutzky,S., Barr, Y., Gamsiz, K., Shtupler, Y., Tandler, A. and Koven, W. (2007) Improved performance of gilthead Sea Bream, *Sparus aurata*, larvae after ozone disinfection of the eggs. *Aquaculture Research* **38**: 166-173.

Berggren, P,P.R. Wade, J. Carlström, A. and Read, J. (2002) Potential limits to anthropogenic mortality for harbour porpoises in the Baltic Region. *Biological Conservation* **103**: 313-322.

Bjorn, P.A. and Finstad, B. (2002) Salmon lice, *Lepeophtherius salmonis* (Kroyer), infestation in sympatric populations of Arctic char, *Salvelinus alpinus* (L.) and sea trout, *Salmo trutta* (L.), in areas near and distant from salmon farms. *ICES Journal of Marine Science* **59**: 131-139.

Blane, J.M., and Jaackson, R. (1995) The impact of ecotourism boats on the St. Lawrence beluga whales. *Environmental Conservation* **21**(3): 267-269.

Booth, M.A., Allan, G. and Pirozzi, I. (2010) Estimation of digestible protein and energy requirements of Yellowtail Kingfish *Seriola lalandi* using a factorial approach. *Aquaculture*, **307**: 247-259.

Bouloux, C., Langlais, M. and Silan, P. (1998) A marine host-parasite model with different biological cycle and age structure. *Ecological Modelling* **107**: 73-86.

Braithwaite, R.A., Cadavid Carrascosa, M.C. and McEvoy, L.A. (2007) Biofouling of salmon cage netting and the efficacy of a typical copper-based antifoulant. *Aquaculture* **262**: 219-226.

Brinker, A., Koppe, W. and Rosch, R. (2005) Optimised effluent treatment by stabilised trout. faeces. *Aquaculture* **249**: 125–144.

Bruce, B. and Bradford, R. W. (2008) *Spatial dynamics and habitat preferences of juvenile white sharks – identifying critical habitat and options for monitoring recruitment*, CSIRO Marine and Atmospheric Research. Tasmania.

Bruce, B. and Bradford, R. W. (2011) *Near-shore habitat use by juvenile white sharks in coastal waters off Port Stephens*. CSIRO Marine and Atmospheric Research, Tasmania.

Bruno, D.W. and Raynard, R.S. (1994) Studies on the use of hydrogen peroxide as a method for the control of sea lice on Atlantic Salmon. *Aquaculture International* **2**: 10–18.

Bureau, D.L., Gunther, S.J. and Cho, C.Y. (2003) Chemical Composition and Preliminary Theoretical Estimates of Waste Outputs of Rainbow Trout Reared in Commercial Cage Culture Operations in Ontario. *North American Journal of Aquacultur*e **65**: 33–38.

Burridge, L., Weis, J.S., Cabello, F., Pizarro, J. and Bostick, K. (2010) Chemical use in salmon aquaculture: A review of current practices and possible environmental effects. *Aquaculture* **306**: 7-23.

Butler, E., Parslow, J., Volkman, J., Blackburn, S., Morgan, P., Hunter, J., Clementson, L., Parker, N., Bailey, R., Berry, K., Bonham, P., Featherstone, A., Griffin, D., Higgins, H., Holdsworth, D., Latham, V., Leeming, R., McGhie, T., McKenzie, D., Plaschke, R., Revill, A., Sherlock, M., Trenerry, L., Turnbull, A., Watson, R. and Wilkes, L. (2000) *Huon Estuary Study - Environmental Research for Integrated Catchment Management and Aquaculture*. *Final report to Fisheries Research and Development Corporation. Project Number 96/284*. CSIRO Division of Marine Research, Marine Laboratories, Hobart.

Campbell, R. (2011) *Assessing and managing interactions of protected and listed marine species with commercial fisheries in Western Australia*. Report to the Fisheries Research and Development Corporation. Fisheries Research Report No. 223. Department of Fisheries. Western Australia.

Cardno Ecology Lab (2010) *Offshore Artificial Reefs (Newcastle, Sydney & Wollongong) Environmental Assessment - Draft Public Environment Report*. Industry and Investment, Sydney.

Cho, C.Y. And Bureau, D.P. (1997) Reduction of waste output from salmonid aquaculture through feeds and feeding. *The Progressive Fish-Culturist* **59**: 155–160.

Cho, C.Y. and Bureau, D.P. (2001) A review of diet formulation strategies and feeding systems to reduce excretory and feed wastes in aquaculture. *Aquaculture Research* **32**: 349–360.

Clapham, P.J., Baraff, L.S., Carlson, C.A., Christian, M.A., Mattila, D.K., Mayo, C.A., Murphy, M.A. and Pittman, S. (1993) Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. *Canadian Journal of Zoology* **71**, 440-443.

Cogger, H.G. (2003) *The Status of Marine Reptiles in New South Wales*, NSW NPWS.

Commonwealth of Australia (2009) *National Biofouling Management Guidelines for Commercial Fishing Vessels*. Commonwealth of Australia.

Council of Australian Governments (1992) *The National Strategy for Ecologically Sustainable Development*. AGPS, Canberra.

de Jong, S. and Tanner, J. (2004) *Environmental Risk Assessment of Marine Finfish Aquaculture in South Australia*. SARDI Aquatic Sciences Publication No. RD03/0044-4. SARDI Aquatic Sciences, Adelaide.

Demirbilek, Z. (2002) *Estimation of Near-shore Waves*. In: Part Chairman, Coastal Engineering Manual, Part 2 , Part Name Chapter 3 , Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

Department of Environment and Heritage (2005a) *Humpback Whale Recovery Plan 2005-2010*, DEH, Canberra.

Department of Environment and Heritage (2005b) *Southern Right Whale Recovery Plan 2005-2010*. DEH, Canberra.

Department of Sustainability, Environment, Water, Population and Communities (2004) *A review of the Tasmanian Finfish Farming Benthic Monitoring Program*. DPIWE, Hobart.

Diaz Lopez, B., Marini, L. and Polo, F. (2005) The Impact of a Fish Farm on a Bottlenose Dolphin Population in the Mediterranean Sea. *An International Journal of Marine Sciences* **21** (2): 65-70.

D'orbcastel, E.R. and Blancheton, J.P. (2006) The wastes from marine fish production systems: characterization, minimization, treatment and valorization. *World Aquaculture*, World Aquaculture Society, USA **September**: 28-70.

Dosdat, A., Servais, F., Metailler, R., Huelvan, C. and Desbruyeres, E. (1996) Comparison of nitrogenous losses in five teleost fish species. *Aquaculture* **141**: 107-127.

Douet, D.G., Le Bris, H. and Giraud, E. (2009) *Environmental aspects of drug and chemical use in aquaculture: A overview*. The use of veterinary drugs and vaccines in Mediterranean aquaculture. Options Méditerranéennes A/ no. 86.

EcoSearch Pty Ltd (2007) *The Economic Impact of Aquaculture on the South Australian State and Regional Economies, 2005/06*. PIRSA Aquaculture, South Australia.

Edgar, G.J., Davey, A. and Shepherd, C. (2010) Application of biotic and abiotic indicators for detecting benthic impacts of marine salmonid farming among coastal regions of Tasmania. *Aquaculture* **307**: 212-218.

Environmental Assessment Office (2001) *Salmon Aquaculture Review*. Report of the Environmental Assessment Office, British Columbia, Canada.

Environment Australia (2003) *Recovery Plan for Marine Turtles in Australia*. Environment Australia, Canberra.

Environment Canada (2001) *Priority Substances List Assessment Report - Formaldehyde.* Environment Canada and Health Canada, Canada.

Environment Protection Authority (2007) EPA *Guidelines - Managing aquaculture stock mortalities*. EPA, South Australia.

Fabi, G. and Sala, A. (2002) An assessment of biomass and diel activity of fish at an artificial reef (Adriatic Sea) using a stationary hydroacoustic technique. *ICES Journal of Marine Science* **59**: 411-420.

Food and Agriculture Organisation (1988) *Indo-Pacific Fisheries Council: Report of the Seventh Session of the Working Party of Experts on Aquaculture - Bangkok, Thailand. 1-6 August 1988.* FAO, Rome.

Food and Agriculture Organisation (2010) *The State of World Fisheries and Aquaculture*. FAO, Rome.

Food and Agriculture Organisation (2011a) *State of World Fisheries and Aquaculture*. Food and Agriculture Organization of the United Nations, Rome.

Food and Agriculture Organisation (2011b) *FAO Technical Guidelines for Responsible Fisheries. Supplement 5: Aquaculture Development - Use of wild fish as feed in aquaculture*. FAO, Rome.

Felsinga, M., Glencrossa, B. and Telfer, T. (2005) Preliminary study on the effects of exclusion of wild fauna from aquaculture cages in a shallow marine environment. *Aquaculture* **243**: 159-174.

Fielder,S., Cheviot, L. and Vandenberg, L. (2004) Section 4.7 Effect of salinity and feed type on growth and survival of juvenile Yellowtail Kingfish, *Seriola lalandi*. Feed Technology For Temperate Fish Species, Volume 1: Feeding Strategies. Aquafin CRC Project 1B5 Industry and Investment NSW, Aquafin CRC, Fisheries Research and Development Corporation, NSW.

Fielder, S. and Heasman, M.P. (2011) *Hatchery Manual for the Production of Australian Bass, Mulloway and Yellowtail Kingfish*. NSW DPI, Port Stephens.

Fletcher, W.J., Chesson, J., Fisher, M., Sainsbury, K.J., and Hundloe, T.J. (2004) *National ESD Reporting Framework: The 'How to' Guide for Aquaculture. Version 1.1*. FRDC, Canberra.

Foote, A.D., Osborne, R.W., and Hoelzel, A.R. (2004) Environment: Whale-call response to masking boat noise. *Nature* **428**: 910.

Franse, R. (2005) *Effectiveness of Acoustic Deterrent Devices (pingers)*. Leiden University, United Kingdom.

Gales, R and Pemberton, D (1990) Seasonal and Local Variation in the Diet of the Little Penguin, *Endyptula minor*, in Tasmania. *Australian Wildlife Research* **17:** 231–259.

Garciarena, D. (1988) The effects of whale watching on right whales in Argentina. *Whalewatcher* **Fall**: 3-5.

Glencross, B., Hawkins, W. and Curnow, J. (2003) Evaluation of canola oils as alternative lipid resources in diets for juvenile Red Sea Bream, *Pagrus auratus*. *Aquaculture Nutrition* **9**: 305–315.

Gowan, R.J. (1994) Mapping eutrophication associated with aquaculture development. *Journal of Applied Ichthyology* **10**: 242-257.

Gulesserian, M. (2009) *The Impacts of Human Activities on Humpback Whales (Megaptera novaeangliae) Migrating North Past Sydney, Australia*. Unpublished master's thesis. Macquarie University, Sydney.

Hardy-Smith, P. Ellis, D., Humphrey, J., Evans, M., Evans, D., Rough, K., Valdenegro, V. and Nowak, B. (2012) In vitro and in vivo efficacy of anthelmintic compounds against blood fluke (*Cardicola forsteri*). *Aquaculture* **334-337**: 39-44.

Hatch, L.T. and Wright, A.J. (2007) A brief review of anthropogenic sound in the ocean. *International Journal of Comparative Psychology* **20**: 121-133.

Heggberget, T.G., Johnsen, B.O., Hindar, K., Jonsson, B., Hansen, L.P., Hvidsten, N.A. and Jensen, A.J. (1993) Interactions between wild and cultured Atlantic Salmon – a review of the Norwegian experience. *Fish Research* **18**: 123-146.

Henry, G.W. and Lyle, J.M. (2003) *The National Recreational and Indigenous Fishing Survey. Final Report to the Fisheries Research and Development Corporation and the Fisheries Action Program Project FRDC 1999/158*. NSW Fisheries Final Report Series No 48. NSW Fisheries, Cronulla.

Horvat, A.J.M., Petrovic, M., Babic, S., Pavlovic, D.M., Asperger, D., Pelko, S., Mance, A.D. and Kastelan-Macan, M. (2012) Analysis, occurrence and fate of anthelmintics and their transformation products in the environment. *Trac-Trends in Analytical Chemistry* **31**: 61-84.

Hoskin, M.G. and Underwood, A.J. (2001) *Manipulative Experiments to Assess Potential Ecological Effects of Offshore Snapper Farming in Providence Bay, NSW – Final*

Report for Pisces Marine Aquaculture Pty Ltd. Marine Ecology Laboratories, University of Sydney, NSW.

IALA (2008) *IALA Recommendation O-139 on the Marking of Man-Made Offshore Structures*. IALA, France.

Islam, M.S. (2005) Nitrogen and phosphorus budget in coastal and marine cage aquaculture and impacts of effluent loading on ecosystem: review and analysis towards model development. *Marine Pollution Bulletin* **50**: 48-61.

Jenny Rand and Associates and Dain Simpson Associates (2010) *Port Stephens Tourism Plan 2010 Diagnostic Report*. Industry & Investment NSW, Port Stephens Council & Port Stephens Tourism Limited, Port Stephens.

Jordon, A., Davies, P., Ingleton T., Foulsham E., Neilson J. and Pritchard T.R. (2010) *Seabed Habitat Mapping of the Continental Shelf of NSW*. DECC. Sydney South.

Jung, S.H., Kim, J.W., Jeon, I.G. and Lee, Y.H. (2001) Formaldehyde residues in formalin-treated olive flounder (*Paralichthys olivaceus*), black rockfish (*Sebastes schlegeli*), and seawater. *Aquaculture*, **194**: 253-262.

Kemper, C.M. (1998) *Presentation 1: Overview of dolphin behaviour and interaction with at-sea aquaculture cages.* Proceedings of the Marine Animal Interaction Working Group Workshop held from 25-26 May at Primary Industries and Resources South Australia Fisheries and Aquaculture, Spencer Institute of TAFE, Port Lincoln, South Australia. pp 9-11.

Kemper, C.M. and Gibbs, S.E. (2001) Dolphin interactions with tuna feedlots at Port Lincoln, South Australia and recommendations for minimising entanglements. *Journal of Cetacean Research and Management* **3**: 283-292.

Kemper, C.M., Pemberton, D., Cawthorn, M., Heinrich, S., Mann, J., Wursig, B., Shaughnessy, P. and Gales, R. (2003) Chapter 11: Aquaculture and Marine Mammals: Coexistence or conflict? Marine Mammals: Fisheries, Tourism and Management Issues. N. Gales, M. Hindell and R. Kirkwood, CSIRO Publishing, Melbourne.

Kiemer, M.C.B. and Black, K.D. (1997) Effects of hydrogen peroxide on gill tissues of Atlantic salmon, *Salmo salar* L. *Aquaculture:* **153**: 181–189.

Kulmar, M., Lord, D. and Sanderson, B. (2005) *Future Directions for Wave Data Collection in New South Wales*. Proceeedings of the 17th Australasian Conference on Coastal and Ocean Engineering and the 10th Australasian Port and Harbour Conference, 2005 Coasts and Ports Australasian Conference, edited by M Townsend and D Walker, conference held from 20-23 September at Adelaide, South Australia, Institution of Engineers, Australia. pp 167-172.

LaPatra, S. E. and MacMillan, J. R. (2009) Fish Health Management and the Environment Environmental Best Management Practices for Aquaculture C.S. Tucker and J.A. Hargreaves, Wiley-Blackwell, Oxford, UK.

Lunestad, B.T. (2008) Veterinary drug use in aquaculture Improving farmed fish quality and safety O. Lie, Woodhead Publishing Ltd, Cambridge, England.

Macleod, C., Crawford, C., Mitchell, I. and Connell, R. (2002) Evaluation of sediment recovery after removal of finfish cages from Marine Farm Lease No. 76 (Gunpowder Jetty), North West Bay – Technical Report Series 13. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Hobart.

MacLeod, C., Crawford, C. and Moltschaniwskyj, N.A. (2004) Assessment of long-term change in sediment condition after organic enrichment: defining recovery. *Marine Pollution Bulletin* **49** (1-2): 79-88.

MacLeod, C., Moltschaniwskyj, N.A. and Crawford, C. (2008) Ecological and functional changes associated with long-term recovery from organic enrichment. *Marine Ecology Progress Series* **365**: 17-24.

Madigan, S., Loo, M., Cheshire, A. and Clarke, S. (2003) *Southern Bluefin Tuna (Thunnus maccoyii) licence-based environmental monitoring report, Dinko Tuna Farmers Pty Ltd, Licence Area FB 00037*, SARDI Aquatic Sciences, Adelaide.

Magalhães, S., Prieto, R., Silva, M.A., Gonçalves, J., Afonso-Dias, M., and Santos, R.S. (2002) Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. *Aquatic Mammals* **28**(3): 267-274.

Magendans, D.L., Booth, Allan, G. L. and Smullen, R. (2010) Section 4.11 - Effect of winter or summer water temperatures on weight gain, feed intake and feed conversion ratio of juvenile Yellowtail Kingfish (*Seriola lalandi*) fed a range of different commercial feeds Feed Technology For Temperate Fish Species, Volume 2: Diet Development. Aquafin CRC Project 1B5 Industry and Investment NSW, Aquafin CRC, Fisheries Research and Development Corporation, NSW.

Matthews, L.H. (1966) *Whales, Dolphins and Porpoises*. K.S. Norris. University of California, California.

McCord, M., Shipton, T. and Sauer, W. (2008) *Irvin & Johnson's Proposed Aquaculture Project, Mossel Bay - Marine Vertebrate Assessment*. CCA Environmental Pty Ltd, Cape Town.

McGhie, T.K., Crawford, C.M., Mitchell, I.M. and O'Brien, D. (2000) The degradation of fish-cage waste in sediments during fallowing. *Aquaculture*, **187**: 351-366.

McKinnon, D., Trott, L., Duggan, S., Brinkman, R., Alongi, D., Castine, S. and Patel, F. (2008) *Environmental Impacts of Sea Cage Aquaculture in a Queensland Context – Hinchinbrook Channel Case Study (SD576/06)*. Australian Institute of Marine Science, Townsville.

McNeil, R., Drapeau, P. and Pierotti, R. (1993) Nocturnality in colonial waterbirds: occurrence, special adaptations, and suspected benefits Current Ornithology D.M. Power, D.M. Plenum Press, New York, pp 187–245.

Miller, P.J.O., Biassoni, N., Samuels, A., and Tyack, P.L. (2000) Whale songs lengthen in response to sonar. *Nature* **405** (6789): 903.

Montevecchi, W.A. (2006) Influences of artificial light on marine birds. Ecological Consequences of Artificial Night Lighting: C. Rich and T. Longcore. Island Press, Washington, D.C, pp 94–113.

National Health and Medical Research Council, Commonwealth Scientific and Industrial Research Organisation, Australian Research Council and Australian Vice-Chancellors' Committee (2004) *Australian code of practice for the care and use of animals for scientific purposes*. National Health and Medical Research Council, Commonwealth Scientific and Industrial Research Organisation, Australian Research Council and Australian Vice-Chancellors Committee, Canberra.

Noad, M.J., Dunlop, R.A., Paton, D. and Kniest, E. (2011) *An update of the east Australian humpback whale population (E1) rate of increase*. Report to the Scientific Committee of the International Whaling Commission, Hammersmith, London, UK. SC/63/SH22. Available upon request from the IWC Secretariat: Secretariat@IWCoffice.org.

NSW Department of Environment and Conservation (2006) *Gould's Petrel (Pterodroma leucoptera leucoptera) Recovery Plan*. NSW DEC, Hurstville.

NSW Department of Environment and Climate Change (2007a) *Threatened Species Assessment Guidelines – The Assessment of Significance*. NSW DECC, Sydney South.

NSW Department of Environment and Climate Change (2007b) *Floodplain risk management guideline: practical consideration of climate change*. NSW DECC, Sydney South.

NSW Department of Environment and Climate Change (2009) *Interim Construction Noise Guideline*. NSW DECC, Sydney South.

NSW Department of Environment, Climate Change and Water (2010a). *John Gould Nature Reserve and Boondelbah Nature Reserve Plan of Management*. NSW DECCW, Nelson Bay.

NSW Department of Environment, Climate Change and Water (2010b). *Guidelines for developments adjoining land and water managed by the Department of Environment, Climate Change and Water*. NSW DECCW, Sydney.

NSW Department of Planning and Infrastructure (2009) *Assessment Report - Pisces Marine Fishfarm Section 96(2) Modification*. NSW DoPI.

NSW Department of Primary Industries (2008) *Threatened Species Assessment Guidelines – The Assessment of Significance*. NSW DPI.

NSW Department of Primary Industries (2010) *NSW Hatchery Quality Assurance Scheme For the production of native fish fingerlings for recreational fishing enhancement stocking and aquaculture production*. NSW DPI, Port Stephens.

NSW Marine Parks Authority (2009) *Policy on artificial reefs and fish attracting devices in NSW marine parks*. NSW MPA, NSW.

NSW Office of Environment and Heritage (2011a) *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. NSW Office of Environment and Heritage and Department of Premier and Cabinet, Sydney.

NSW Office of Environment and Heritage (2011b) *Hawks Nest Sea Cage Investigation – Seafloor Mapping*. NSW DPI, Port Stephens.

NSW Roads and Maritime Services (2004) Traffic *Volume Data For Hunter and Northern Regions 2004*. NSW RMS, NSW.

Obach, A. (2012) *Direction of Aquaculture R&D for the Next Ten Years*. Proceedings of the Skretting Australasian Aquaculture Conference held 1-4 May 2012 at Melbourne, Victoria.

Ogawa, K. (1996) Marine parasitology with special reference to Japanese fisheries and mariculture. *Veterinary Parasitology* **64**: 95-105.

O'Hanlon, E. (2004) *Visual Impact Assessment – Stage 2 of Aquaculture Mussel Farming for Twofold Bay*. Eden Shellfish Pty Ltd and NSW Cultured Mussel Growers Association, NSW.

Oke, P. R., and Middleton, J.H. (2001) Nutrient enrichment off Port Stephens: The role of the East Australian current. *Continental Shelf Research* **21**: 587-606.

Otway, N.M. and Ellis, M.T. (2011) Pop-up archival satellite tagging of *Carcharias taurus*: movements and depth/temperature-related use of south-eastern Australian waters. *Marine and Freshwater Research* **62**: 607–620.

O'Sullivan, D., Purser, J. and Munday, B. (1998) *Potential Impacts of Marine Farming of Atlantic Salmon in South Australia - Escaped stock and other interactions*. Prepared for PIRSA Aquaculture Group, Adelaide.

O'Sullivan, D. (2003) Electric fence provides low impact way to reduce fish losses to seals. *Austasia Aquaculture* **17**: 19−21.

Paerl, H.W. (1997) Coastal eutrophication and harmful algal blooms: importance of atmospheric deposition and groundwater as "new" nitrogen and other nutrient sources. *Limnology and Oceanography* **42**: 1154-1165.

Pawar, V., Matsuda, O. and Fujisaki, N. (2002) Relationship between feed input and sediment quality of the fish cage farms. *Fisheries Science* **68**: 894-903.

Pears, R.J. and Williams, D.McB. (2005) *Potential effects of artificial reefs on the Great Barrier Reef: Background paper. CRC Reef Research Centre Technical Report No. 60*. CRC Reef Research Centre, Townsville.

Pemberton, D., Brothers, N. and Copson, G. (1991) Predators on marine fish farms in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* **125**: 33-35.

Pemberton, D. (1996) *Port Lincoln tuna farms, dolphins, seals, sharks and seabirds*. Unpublished report to Tuna Boat Owners Association of Australasia and Primary Industries South Australia. Parks and Wildlife Service, Tasmania: 8 pp.

Perry, C. (1998) *A review of the impact of anthropogenic noise on cetaceans*. Report for the Environmental Investigation Agency, London, UK SC/50/E9: 27pp.

Pillay, T.V.R. (2004) *Aquaculture and the Environment*. Fishing New Books, Calton, Victoria.

PIRSA (2002) *Fish Health – Fact Sheet*. Primary Industries and Resource Management South Australia, Adelaide.

PIRSA (2003) *PIRSA Aquaculture: A response to environmental concerns of Yellowtail Kingfish (Seriola lalandi) farming in South Australia and some general perceptions of aquaculture*. Primary Industries and Resource Management South Australia, Adelaide.

Port Stephens Council (2008) *Port Stephens Council Community Profile - 2006 Census*. Port Stephens Council, Port Stephens.

Pouliquen, H., Le Bris, H., Buchet, V. and Pinault, L. (1996) Comparative study on the contamination and decontamination of Japanese oyster *Crassostrea gigas* and blue mussel *Mytilus edulis* by oxytetracycline and oxolinic acid. *Marine Ecology Progress Series* **133**: 143-148.

Pritchard, T.R., Lee, R.S., Ajani, P.A., Rendell, P.S., Black, K. and Koop, K. (2003) Phytoplankton Responses to Nutrient Sources in Coastal Waters off South-eastern Australia. *Aquatic Ecosystem Health and Management* **6**: 105-117.

Rach, J.J., Gaikowski, M.P. and Ramsay, R.T. (2000) Efficacy of hydrogen peroxide to control parasitic infestations on hatchery-reared fish. *Journal of Aquatic Animal Health* **12**: 267–273.

Reed, J.R., Sincock, J.L. and Hailman, J.P. (1985) Light attraction in endangered Procellariiform birds: reduction by shielding upward radiation. *Auk* **102**: 377–383.

Richardson, J.W., Fraker, M.A., Würsig, B., and Wells, R.S. (1985) Behaviour of Bowhead Whales (*Balaena mysticetus*) summering in the Beaufort Sea: Reactions to industrial activities. *Biological Conservation* **32** (3): 195-230.

Richardson, W.J., Greene Jr, C.R., Malme, C.I., and Thompson, D. (1995) *Marine Mammals and Noise*. Academic Press Inc., San Diego, California.

Richardson, W.J., and Würsig, B. (1997) Influences of man-made noise and other human actions on cetacean behaviour. *Marine and Freshwater Behaviour and Physiology* **29**(1): 183-209.

Ritz, D.A., Lewis, M.E. and Shen, M. (1990) Response to organic enrichment of infaunal macrobenthic communities under salmonid sea cages. *Marine Biology* **103**: 211-214.

Rivarola, M., Campagna, C., and Tagliorette, A. (2001) Demand-driven commercial whalewatching in Peninsula Valdes (Patagonia): conservation implications for right whales. *Journal of Cetacean Research and Management* **2**: 145-151.

Roberts, L. (2000) *Archaeological Feasibility Study – Snapper Farm Oyster Cove*. Pisces Marine Aquaculture Pty. Ltd., Nelson Bay.

Rodriguez, A. and Rodriguez, B. (2009) Attraction of petrels to artificial lights in the Canary Islands: Effects of the moon phase and age class. *Ibis* **151**: 299–310.

Rowling, K., Hegarty, A. and Ives, M. (eds.) (2010) *Status of fisheries resources in NSW 2008/09*. NSW DPI, Cronulla.

Sarker, M. S. A., Satoh, S., Kamata, K., Haga, Y. and Yamamoto, Y. (2012) Supplementation effect(s) of organic acids and/or lipid to plant protein-based diets on juvenile yellowtail, *Seriola quinqueradiata* Temminck et Schlegel 1845, growth and, nitrogen and phosphorus excretion. *Aquaculture Research* **43**: 538–545.

Satoh, S., Sarker, M.S.A., Satoh, K. and Kiron, V. (2004) Effects of dietary lipid and phosphorus levels on nitrogen and phosphorus excretion in young *yellowtail Seriola quinqueradiata* : A preliminary observation. *Fisheries Science* **70**: 1082–1088.

Samuelsen, O.B, Torsvik, V. and Ervik, A. (1992) Long-range changes in oxytetracycline concentration and bacterial resistance towards oxytetracycline in a fish farm sediment after medication. *Science Total Environment* **114**: 25–36.

Sapkota, A., Sapkota, A. R., Kucharski, M., Burke, J., McKenzie, S., Walker, P. and Lawerance, R. (2008) Aquaculture practices and potential human health risks: Current knowledge and future priorities. *Environment International* **34**: 1215-1226.

Schmidt, L.J., Gaikowski, M.P. and Gingerich, W.H. (2006) *Environmental Assessment for the Use of Hydrogen Peroxide in Aquaculture for Treating External Fungal and*

Bacterial Diseases of Cultured Fish and Fish Eggs. U.S. Geological Survey, Biological Resources Division, Wisconsin.

Scott, D.C.M. and Muir J.F. (2000) Offshore Cage Systems - A Practical Overview. Institute of Aquaculture, University of Stirling. Scotland.

Short, A.D. (1985) Rip-current type, spacing and persistence, Narrabeen Beach, Australia. *Marine Geology* **65**: 47-71.

Short, A.D. and Trenaman, N.L. (1992) Wave climate of the Sydney region, an energetic and highly variable ocean wave regime. *Australian Journal of Marine and Freshwater Research* **43**: 765-791.

Smale, M. J. (2005) The diet of the ragged-tooth Shark *Carcharias taurus* Rafinesque 1810 in the Eastern Cape, South Africa. *African Journal of Marine Science* **27**(1): 331-335.

Smith, T. (2004) Plane Sailing: The archaeology of aircraft losses over water in New South Wales. Australia *Bulletin of the Australasian Institute for Maritime Archaeology* **28**: 111-122.

Smith S.D.A., Jordan, A., Creese, R.G. and Gladstone, W. (ed) (2010) *The Marine Environment of the Hunter-Central Rivers Region of New South Wales: A review of current knowledge.* A report prepared for the Hunter-Central Rivers Catchment Management Authority. National Marine Science Centre, Coffs Harbour.

Snieszko, S.F. (1974) The effects of environmental stress on outbreaks of infectious diseases of fishes. *Journal of Fish Biology* **6**: 197–208.

Solar Technology Australia (n.d.) *Navigation Aid System for Marking Aquaculture Leases*. NSW Waterways Authority, NSW.

Sorum, H. (2008) Antibiotic resistance associated with veterinary drug use in fish farms Improving farmed fish quality and safety O. Lie, Woodhead Publishing Ltd, Cambridge, England.

Soto, D., Jara, F. and Moreno, C. (2001) Escaped salmon in the inner seas, southern Chile: facing ecological and social conflicts. *Ecological applications* **11**: 1750-1762.

Standards Australia and Standards New Zealand (1999) *AS/NZS ISO 4360:1999: Australian/New Zealand Standard. Environmental management systems - General guidelines on principles, systems and supporting techniques*. Standards Australia, Standards New Zealand, Canberra, Wellington.

Standards Australia and Standards New Zealand (2000) *Environmental Risk Management – Principles and Process (HB 203:2000)*. Sydney, Wellington.

Stewart, A.R.J. & Grant, J. (2002) Disaggregation rates of extruded salmon feed pellets: influence of physical and biological variables. *Aquaculture Research* **33**: 799-810.

Tacon, A.G.J. (1994) *Feed ingredients for carnivorous fish species alternatives to fish meal and other fishery resources*. Food and Agriculture Organisation of United Nations, Rome.

Tacon, A.G.J. (2003) *Global trends in aquaculture and compound aquafeed production – a review.* International Aquafeed Directory and Buyers Guide 2003. Turret West Ltd, United Kingdom.

Tacon, A.G.J. and Forster, I.P. (2003) Aquafeeds and the environment: policy implications. *Aquaculture* **226**: 181-189.

Tanner, J.E. and Fernandes, M. (2010) Environmental Effects of Yellowtail Kingfish Aquaculture in South Australia. *Aquaculture Environment Interactions* **1**: 155-165.

Tassal Operations Pty Ltd, Huon Aquaculture Group Pty Ltd and Petuna Aquaculture Pty Ltd (2005) *EIS for Macquarie Harbour Marine Farming Development Plan*. Tassal Operations Pty Ltd, Huon Aquaculture Group Pty Ltd and Petuna Aquaculture Pty Ltd, Tasmania.

Telfer, T.C., Sincock, J.L., Byrd, G.V. and Reed, J.R. (1987) Attraction of Hawaiian seabirds to lights: conservation efforts and effects of moon phase. *Wildlife Society Bulletin* **15**: 406–413.

Tubbs, L.A. and Tingle, M.D. (2006a) Bioavailability and pharmacokinetics of a praziquantel bolus in kingfish *Seriola lalandi*. *Diseases of Aquatic Organisms* **69**: 233-238.

Tubbs, L.A. and Tingle, M.D. (2006b) Effect of dose escalation on multiple dose pharmacokinetics of orally administered praziquantel in kingfish *Seriola lalandi*. *Aquaculture* **261**: 1168-1174.

Underwood, A.J. and Hoskin, M.G. (1999) *Ecological Sampling For Assessment of Potential Environmental Impacts of the Trial Snapper Farm at Port Stephens, NSW (Pisces Marine aquaculture Pty Ltd) – Draft Report*. Marine Ecology Laboratories, University of Sydney, NSW.

Urban, R.J., Jaramillo, A.L., Aguayo, A.A.L., Guevara, D.L.P.P., Salinas, M>Z., Alvarez, C.F., Medrano, L.G., Jacobsen, J.K., Balcomb, K.C., Claridge, D.E., Calambokidis, J., Steiger, G.H., Straley, J.M., von Ziegesar, O., Waite, J.M., Dahlheim, M.E., Darling, J.D. and Baker, C.S. (2000) Migratory destinations of humpback whales wintering in the Mexican Pacific. *Journal of Cetacean Research and Management* **2**: 101-110.

Vang, L. (2002) *Distribution, abundance and biology of Group V humpback whales Megaptera novaeangliae: A review.* Environmental Protection Agency, Queensland.

Van de Laar, F. (2007) *Green light to birds - Investigation into the effect of bird-friendly lighting*. NAM, Netherlands.

Verheijen, F.J. (1985) Photopollution: artificial light optic spatial control systems fail to cope with. Incidents, causations, remedies. *Experimental Biology* **44**: 1–18.

Vom Berg, F. (2008) *Finfish Aquaculture in Western Australia: Final ESD Risk Assessment Report for Sea-cage and Land-based Finfish Aquaculture*. Department of Fisheries, Perth.

Weilgart, L.S. (2007a) A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology* **20**: 159-168.

Weilgart, L.S. (2007b) A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology* **20**: 159-168.

Weston, D.P. (1990) Quantitative examination of macrobenthic community changes along an organic enrichment gradient. *Marine Ecology Progress Series* **61**: 233-244.

World Health Organisation (2002) Report of the WHO Informal Consultation on the use of Praziquantel during Pregnancy/Lactation and Albendazole/Mebendazole in Children under 24 months. WHO.

Wilkinson, J. (2004) *NSW Fishing Industry: Changes and Challenges in the Twenty-First Century. Briefing Paper No 11/04.* NSW Parliamentary Library Research Service, NSW.

Williams, R.E. (2009) Oral treatments for monogenean parasites of farmed yellowtails *Seriola* spp. (Caringidae). PhD Thesis, School of Environmental Sciences, The University of Adelaide, South Australia.

Willoughby, M.A. (1998) *Marine Aquaculture Structures Off Port Stephens – Design Conditions*. Pisces Marine Aquaculture Pty Ltd, NSW.

Woods, G., Brain, E., Shepherd, C. and Paice, T. (2004) *Tasmanian Marine Farming Environmental Monitoring Report: Benthic Monitoring (1997 – 2002)*. DPIWE, Hobart.

Worth, G. and Joyce, N. (2001) *Environmental Impact Statement For A Commercial Snapper Farm Proposed For Providence Bay, NSW*. Pisces Marine Aquaculture Pty. Ltd., Nelson Bay.

Internet References

Web Reference 1

NSW Department of Environment and Conservation (2005) "NSW Threatened Species Profile Search" Retrieved 20/09/11 from http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.

Web Reference 2

NSW Department of Primary Industries (2005) "Threatened Species Conservation - What is currently listed?" Retrieved 07/07/11 from http://www.dpi.nsw.gov.au/fisheries/species-protection/conservation/what-current.

Web Reference 3

Department of Sustainability, Environment, Water, Population and Communities (2011) "Protected Matters Search Tool" Retrieved 22/09/11 from http://www.environment.gov.au/arcgis-framework/apps/pmst/pmst.jsf.

Web Reference 4

NSW Office of Environment and Heritage (2011) "List of Key Threatening Processes" Retrieved 23/09/11 from http://www.environment.nsw.gov.au/threatenedspecies/KeyThreateningProcessesByDoctype.htm.

Web Reference 5

NSW Office of Environment and Heritage (2011) "The Different Types of Parks and Reserves" Retrieved 23/09/11 from http://www.environment.nsw.gov.au/parktypes/TypesOfParks.htm.

Web Reference 6

NSW Office of Environment and Heritage (2011) "Maritime Heritage Online NSW" Retrieved 20/06/11 from http://maritime.heritage.nsw.gov.au/public/themesInfo.cfm?pagename=Shipwrecks.

Web Reference 7

NSW Wrecks (2010) "NSW Wrecks" Retrieved 20/07/11 from http://www.nswwrecks.info/About%20Us.html.

Web Reference 8

Department of Defence (2011) "Australian Hydrographic Service" Retrieved 20/07/11 from http://www.hydro.gov.au/.

Web Reference 9

Department of Sustainability, Environment, Water, Population and Communities (2011) "Australian National Shipwreck Database" Retrieved 20/07/11 from https://apps5a.ris.environment.gov.au/shipwreck/public/wreck/search.do.

Web Reference 10

McFadyen, M. (2011) "Michael McFadyen Scuba Diving Website" Retrieved 23/07/11 from http://www.michaelmcfadyenscuba.info/news.php.

Web Reference 11

NSW Office of Environment and Heritage (2011) "The Cultures and the Heritage of NSW." Retrieved 20/07/11 from http://www.environment.nsw.gov.au/nswcultureheritage/.

Web Reference 12

Department of Sustainability, Environment, Water, Population and Communities (2008) "Heritage places in New South Wales." from http://www.environment.gov.au/heritage/places/nsw/index.html.

Web Reference 13

Commission for the Conservation of Southern Bluefin Tuna (2011) "About Southern Bluefin Tuna" Retrieved 29/09/11 from http://www.ccsbt.org/site/about_bluefin_tuna.php.

Web Reference 14

METOC (2011) "Coastal Sea Surface Temperatures." Retrieved 11/07/11 from http://www.metoc.gov.au/products/data/aussst.php.

Web Reference 15

Bureau of Meteorology (2011) "Climate statistics for Australian locations - Monthly climate statistics (Nelson Bay)." Retrieved 11/07/11 from http://www.bom.gov.au/climate/averages/tables/cw_061054.shtml.

Web Reference 16

NSW Office of Environment and Heritage (2011) "Noise." Retrieved 06/01/12 from http://www.environment.nsw.gov.au/noise/index.htm.

Web Reference 17

Primary Industries and Regions SA (2011) "Code of Conduct" Retrieved 16/01/12 from: http://www.pir.sa.gov.au/aquaculture/monitoring__and__assessment/code_of_conduct

Web Reference 18

NSW DPI (2011) "Yellowtail Kingfish" Retrieved 16/01/12 from: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0012/375969/Yellowtail-Kingfish.pdf

Web Reference 19

Commission for the Conservation of Southern Bluefin Tuna (2011) "Commission for the Conservation of Southern Bluefin Tuna" Retrieved 16/01/12 from: http://www.ccsbt.org/site/index.php

Web Reference 20

NSW Department of Primary Industries (2011) "Mulloway" Retrieved 16/01/12 from: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/375919/Mulloway.pdf

Web Reference 21

NSW Department of Primary Industries (2011) "Catch statistics 2006-2007" Retrieved 16/01/12 from: http://www.dpi.nsw.gov.au/fisheries/commercial/catch-statistics

Web Reference 22

NSW Department of Primary Industries (2011) "Animal care and ethics" Retrieved 16/01/12 from: http://www.dpi.nsw.gov.au/fisheries/aquaculture/publications/general/animal-care-and-ethics

Web Reference 23

Department of Sustainability, Environment, Water, Population and Communities (2011) "Species Profile and Threats Database." Retrieved 07/07/11 from http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

Web Reference 24

NSW Office of Environment and Heritage (2011) "Scientific Committee Final Determinations" Retrieved 08/07/11 from http://www.environment.nsw.gov.au/committee/ListofScientificCommitteeDeterminations.htm.

Web Reference 25

NSW Office of Environment and Heritage (2011) "Approaching whales and dolphins in NSW" Retrieved 24/02/12 from http://www.environment.nsw.gov.au/animals/WhaleRegulation.htm

Web Reference 26

Sengpielaudio (2011) "Damping of sound level with distance" Retrieved 24/02/12 from http://www.sengpielaudio.com/calculator-distance.htm

Web Reference 27

FRDC, DEH and DRS (2006) "Australian Aquaculture – Industry Employment and Major Species" Retrieved 28/02/12 from http://adl.brs.gov.au/mapserv/fishcoast/maps/map04_aquculture_employment_ver2.gif

Web Reference 28

APVMA (2006) "About the APVMA" Retrieved 29/02/12 from http://www.apvma.gov.au/about/index.php

Web Reference 29

Anthoni, J.F. (2006) "The chemical composition of seawater" Retrieved 7/03/12 from http://www.seafriends.org.nz/oceano/seawater.htm#composition

Web Reference 30

NSW MPA (2006) "Port Stephens-Great Lakes Marine Park Zoning Plan User Guide" Retrieved 8/03/12 from www.mpa.nsw.gov.au/pdf/psglmp-zoning-plan-user-guide.pdf

Web Reference 31

New Mexico Department of Game and Fish (2001) "Communication Tower Guidelines" Retrieved 8/03/12 from http://www.wildlife.state.nm.us/conservation/habitat_handbook/documents/CommunicationTowerGuidelines.pdf.

Web Reference 32

NSW DPI (2011) "Proposed Marine Finfish Research Lease off Port Stephens" Retrieved 8/03/12 from http://www.dpi.nsw.gov.au/fisheries/aquaculture/info/research-lease

Web Reference 33

Gordon, K. (2003) "Bacterial Fish Diseases in Australian Aquafarming" Retrieved 23/03/12 fromhttp://www.aquafarmer.com.au/Bacterial_Fish_Diseases_In_Australian_Aquafarming.html

Web Reference 34

NSW DPI (2011) "Snapper *Pagrus auratus*" Retrieved 20/03/12 from http://www.dpi.nsw.gov.au/fisheries/recreational/saltwater/sw-species/Snapper

Web Reference 35

Australian Museum (2010) "Snapper, *Pagrus auratus* (Bloch & Schneider, 1801)" Retrieved 20/03/12 from http://australianmuseum.net.au/Snapper-Pagrus-auratus-Bloch-Schneider-1801

Web Reference 36

NSW DPI (2010) "Snapper *Pagrus auratus*" Retrieved 20/03/12 from http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/375943/Snapper.pdf

Web Reference 37

FAO (2009) "Production from aquaculture by country and by species" Retrieved 20/03/12 from ftp://ftp.fao.org/FI/CDrom/CD_yearbook_2009/root/aquaculture/c1.pdf

Web Reference 38

Office of Environment and Heritage (2012) "Regulation of Aboriginal cultural heritage" Retrieved 30/03/12 from http://www.environment.nsw.gov.au/licences/achregulation.htm

Web Reference 39

Office of Environment and Heritage (2011) "What information can you obtain from AHIMS?" Retrieved 30/03/12 from http://www.environment.nsw.gov.au/licences/WhatInformationCanYouObtainFromAHIMS.htm

Web Reference 40

Office of Environment and Heritage (2012) "NSW Atlas of Aboriginal Places" Retrieved 30/03/12 from http://www.environment.nsw.gov.au/AboriginalPlaces/index.htm

Web Reference 41

NSW Legislation (2012) "Heritage Act 1977 No 136" Retrieved 31/03/12 from http://www.legislation.nsw.gov.au/maintop/view/inforce/act+136+1977+cd+0+N

Web Reference 42

Elsevier (2012) "Aquacultural Engineering" Retrieved 01/06/12 from http://www.journals.elsevier.com/aquacultural-engineering

Web Reference 43

Prevent Escape (2012) "A case study: Extent and cases of escapes in Norway" Retrieved 01/06/12 from http://preventescape.eu/ ?page_id=35

12 APPENDICES