Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Offshore Artificial Reefs (Newcastle, Sydney & Wollongong)

Environmental Assessment/ Draft Public Environment Report

Prepared on behalf of: Industry and Investment NSW
for:
Environmental Assessment (Project 08_0095) and
Draft Public Environment Report (EPBC Referral 2008/4176)

February 2010

Cardno Ecology Lab Pty Ltd

ABN 73 002 379 473
4 Green Street
Brookvale
New South Wales 2100
Australia
Telephone: 02 9907 4440
Facsimile: 02 9907 4446
International: +61 2 9907 4440
ecologylab@cardno.com.au
www.cardno.com.au

Cover Image: Offshore Artificial Reef Unit, Japan. Photo courtesy of I&I NSW.

Invitation to Make a Submission

Industry & Investment NSW (I&I NSW) propose to improve recreational fishing opportunities in NSW by deploying purpose built offshore artificial reefs (OARs) in the vicinity of Newcastle, Sydney and Wollongong. This document provides a detailed description of the proposal and aims to address any potential issues related to the project according to the relevant State and Commonwealth legislation.

The proposal is subject to Part 3A of the *Environmental Planning and Assessment Act 1979* as it is considered to be of State planning significance. It will also be subject to approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Commonwealth *Environment Protection* (*Sea Dumping*) *Act 1981* (EP (SD) Act). As such, the project is being assessed in the format of a single Environmental Assessment/draft Public Environment Report (EA/draft PER) which assesses the requirements of both State and Commonwealth legislation.

The EA/draft PER is now on exhibition for public comment for a minimum period of 30 days. This is an opportunity for the community and stakeholders to view the EA/draft PER and provide feedback which will be considered in the approval process.

Submissions can be provided individually or on behalf of a group, which may help to pool ideas and information. Group submissions should indicate the names of participants or if the group is larger than 10 people, the number of people the submission represents needs to be indicated. When submitting comments on the EA/draft PER, it is helpful to provide reasons and relevant data to support any conclusions. When submitting comments on the EA/draft PER:

- point of view should be clearly stated and listed;
- a summary of the submission can be helpful;
- refer each point to the appropriate section of the EA/draft PER;
- discussions should be separate for each section addressed;
- any relevant factual information may be attached with the source of the information indicated; and
- information provided should be accurate.

Submissions should be lodged in writing by the closing date by any of the following methods:

Online: www.planning.nsw.gov.au

By Post: Director-General
Department of Planning
GPO Box 39
Sydney NSW 2001

In Person: Director-General
Department of Planning
23-33 Bridge Street
Sydney NSW 2000

Copies of the EA/draft PER and supporting documents can be viewed and downloaded at the NSW Department of Planning website www.planning.nsw.gov.au. Questions regarding submissions should also be directed to the Department of Planning:

Telephone: (02) 9228 6111

Fax: (02) 9228 6455

Email: information@planning.nsw.gov.au

Details of the Proponent (I&I NSW):

Address: Locked Bag 21
Orange
NSW 2800

Telephone: (02) 6391 3100

Fax: (02) 6391 3336

Website: www.dpi.nsw.gov.au

Contact Name: Heath Folpp (Manager – Fisheries Enhancement)

Executive Summary

Introduction

Background and Aims

Industry & Investment NSW (I&I NSW - formerly NSW Department of Primary Industries) with funding from the Recreational Fishing Trust, propose to improve recreational fishing opportunities in NSW by deploying offshore artificial reefs (OARs) in the vicinity of Newcastle, Sydney and Wollongong. The first OAR will be deployed off Sydney and the success of the structure will be assessed and monitored before OARs are deployed at the other two locations. The proposal requires approval under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and also under the Commonwealth *Environment Protection* (*Sea Dumping*) *Act 1981* (EP (SD) Act). Separate guidelines have been issued to meet the requirements of both State and Commonwealth legislation. The Department of the Environment, Water, Heritage and the Arts (DEWHA) has, however, requested that all requirements be addressed in a single Environmental Assessment/draft Public Environment Report/ (EA/draft PER) document as the requirements are similar. I&I NSW commissioned Cardno Ecology Lab Pty Ltd to prepare the EA/draft PER. The assessment process is outlined in Figure ES1.

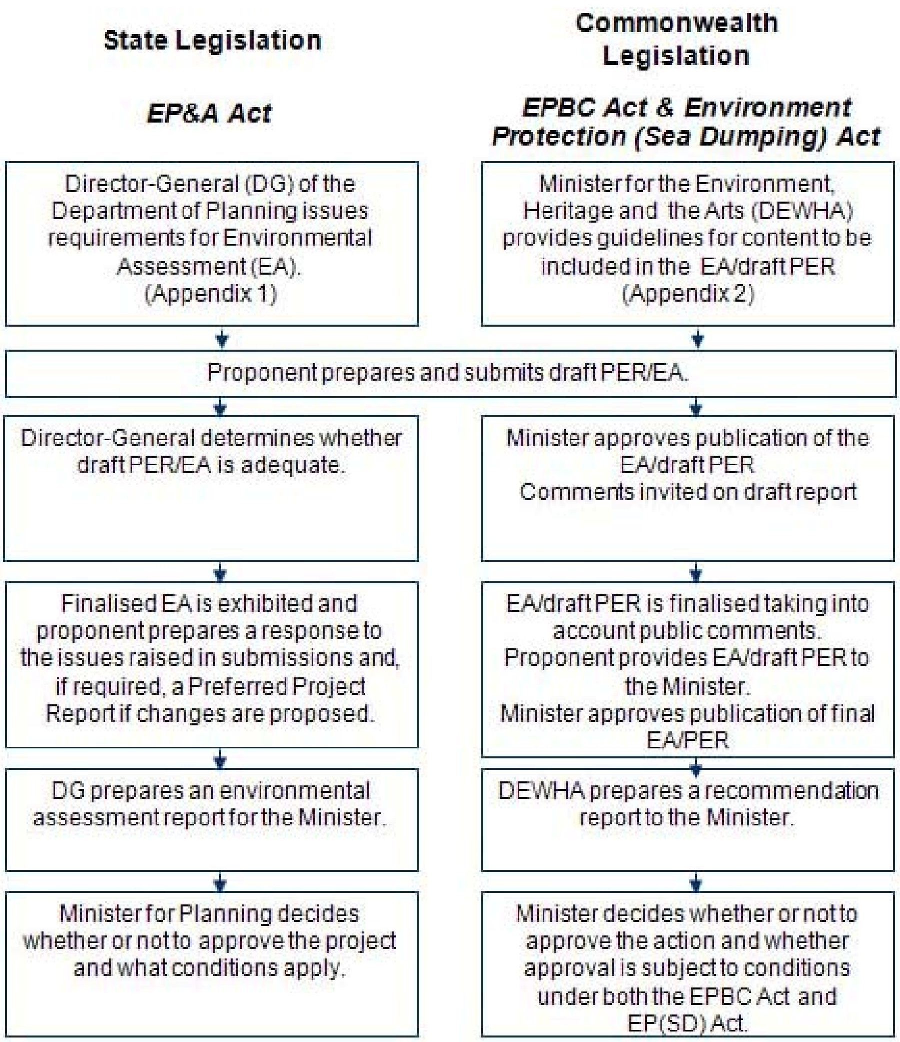


Figure ES1: Steps in the assessment and approvals process.

The primary objective of the proposal is to improve offshore recreational fishing opportunity by creating new fish habitat and providing additional fishing locations. The proposal also includes the implementation of a scientific monitoring program to assess the success of the OARs and help identify any potential impacts on the environment.

The project is funded by the NSW Recreational Fishing Trust and the OARs have been designed and located for the benefit of recreational fishing. Other potential user groups such as commercial fishing operators would not be excluded from utilising the reefs.

Appropriate structure design, exact locations and configurations of the proposed OARs are outlined within the EA/draft PER, but will be finalised subject to the projects approval. Potential locations for staging the construction of the units have also been identified but will also be finalised post-approval.

A significant amount of planning, analysis and consultation has already been undertaken in relation to the design and site selection of the proposed OARs. Cardno Ecology Lab, together with Worley Parsons, were initially engaged by I&I NSW to undertake a desktop constraints mapping study to identify potentially suitable locations for an OAR in the Newcastle, Sydney and Wollongong regions. In that initial report, existing information was used to identify and map the major physical, oceanographic and biological constraints and recommend potentially suitable areas in which to locate the reefs. That report also highlighted gaps in information for which further baseline investigations would be required.

Statutory obligations under State and Commonwealth legislation, areas of responsibility for government departments (State and Commonwealth) and key areas for consideration for the detailed EA/draft PER were identified in a Preliminary Environmental Assessment (PEA) of the proposal, carried out by The Ecology Lab in February 2008 and a subsequent planning focus meeting (PFM) organised by NSW Department of Planning. Requirements to satisfy Commonwealth and State legislation were subsequently issued to I&I NSW. The main requirements of the EA/draft PER are to:

- Provide a detailed description of the project proposal, including the need for the project, alternatives considered, the likely staging of the project and plans outlining the spatial arrangement of the deployed structures;
- Outline the statutory obligations, policies and guidelines relevant to the deployment of artificial reefs in NSW waters;
- Present the views of relevant stakeholders including local, State and Commonwealth government authorities and affected user groups;
- Undertake a risk analysis of potential environmental impacts associated with the project, identifying key issues for further assessment;
- Carry out an assessment of impacts on the following matters of National Environmental Significance (NES):
    - Listed threatened species (Sections 18 and 18A of the Act);
    - Listed migratory species (Sections 20 and 20A of the Act); and
    - The Commonwealth marine area (Sections 23 and 24A of the Act).
- Carry out a detailed impact assessment of key issues specified in the State and Commonwealth guidelines and those identified in the risk analysis. This includes issues relating to:
    - Coastal processes;
    - Flora and fauna;
    - Sediments and water;
    - Navigation and safety;
    - Infrastructure;
    - Heritage; and
    - Land based construction.
- Provide a description of the existing environment, using sufficient baseline data;
- Assess impacts of all stages of the project, including cumulative impacts, taking into consideration relevant statutory provisions, technical policy or guidelines;
- Describe the measures that would be implemented to avoid, minimise, mitigate, rehabilitate/remediate, monitor and/or offset the potential impacts of the project, including detailed contingency plans for managing any potentially significant risks to the environment.
- Provide an environmental management plan (EMP)

- Outline recommended monitoring procedures;
- Provide a statement of commitments outlining all proposed environmental management and monitoring measures which would be implemented;
- Justify the project on economic, social and environmental grounds.

Study Team

Cardno Ecology Lab has coordinated a team of environmental practitioners with extensive experience in ecology, environmental management, oceanography and coastal processes of the NSW coast (Figure ES2). Cardno Ecology Lab has engaged the services of Cardno Lawson Treloar (Coastal, Oceans and Environment Group) to provide expertise in wave behaviour and sediment circulation, navigation and safety, impacts on submerged indigenous heritage and assess environmental impacts associated with the construction, transport and deployment of the structures. Worley Parsons reviewed relevant planning and legislative requirements, contributed to aspects of the risk analysis, provided an overview of the construction and deployment process, assessed impacts associated with the structural stability and recommended procedures to monitor the structural integrity of the OARs. The Department of Environment, Climate Change and Water (DECCW), Waters and Coastal Science Section undertook acoustic seabed surveys and provided maps of habitats in the vicinity of the proposed OAR locations. Finally, Cosmos Coroneos Archaeological Consultants provided background information on shipwrecks that could occur in the vicinity of the proposed OARs.

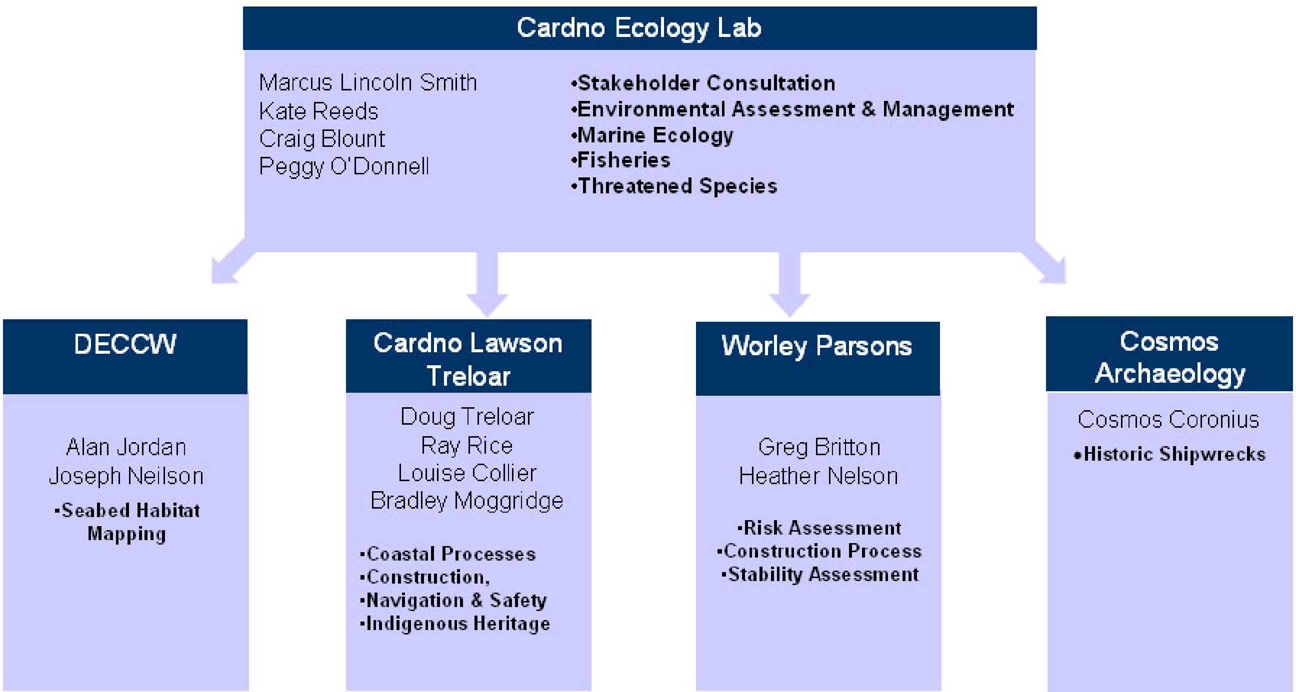


Figure ES2: Offshore Artificial Reefs EA/draft PER study team.

Background to Artificial Reefs

Artificial reefs have been deployed in up to 40 countries around the world for over three decades. Global trends show that older well-established reef deployment practices have been used to enhance artisanal, commercial and recreational fishing, including diving and spearfishing. Newer practices include aquaculture, recreational SCUBA diving, habitat restoration, environmental mitigation and reefs constructed purely for experimental research.

Artificial reefs for recreational fishing and diving have been constructed in Australia since the mid-1960s. In NSW, the use of artificial reefs began in 1966, with the deployment of a series of multi-component artificial reefs made of car bodies and tyres in Lake Macquarie. In the mid-1970s, 12 vessels were scuttled, beginning with the retired ferry the 'Dee Why' sunk off Long Reef in 1976 at a depth of 45 m. In the 1980s, a lack of funding and increasingly stringent environmental legislation meant that artificial reef construction in NSW effectively ceased. The introduction of the Recreational Fishing Trusts in 2001 provided opportunity for further investigation of the use of artificial structures as a fisheries enhancement tool. Since 2002, fish aggregating devices (FADs) consisting of man-made moored structures have been established in NSW to provide additional fishing opportunities for sport and game fishers targeting fast-growing pelagic species such as dolphinfish and marlin. Moored FADs occupy a fixed location and attach to the sea bottom using a weight such as a concrete block. A rope made of floating synthetics such as polypropylene attaches to the mooring and in turn attaches to a buoy (Plate ES1, a). Pelagic fish are attracted to the structure and smaller fish that aggregate there. The success of this project has led to the development of a long running recreational fisheries enhancement program, with 25 FADs deployed from October to June annually from Tweed Heads to Eden and two trial FADs in the Lord Howe Island Marine Park

Since 2005, I&I NSW has installed a number of multi-component artificial reefs using reef ball technology (moulded concrete modules) in areas of bare sand in Lake Macquarie, Botany Bay, St. Georges Basin, Merimbula Lake and Lake Conjola. The reef systems vary in size with the largest system in Lake Macquarie consisting of six artificial reef sets (one reef group), utilising a total of 600 Reef Balls, covering an area of more than 3000 m^2 with a volume of 400 m^3. This program is ongoing and additional estuarine reefs are proposed for construction in future. Implementation of the estuarine artificial reefs involved an environmental assessment process and has an associated long-term monitoring program to evaluate their effectiveness. Results so far indicate that the artificial habitat has been successful in maintaining an increase in fish abundance and diversity and that extensive marine plant growth has occurred on the surface of the reef ball units. The reefs have also been a success in terms of enhancing recreational fishing opportunities. Eight months after construction, catch abundance, catch diversity, and catch rates of recreational species on the artificial reefs were found to be as good as or better than control sites (naturally occurring reefs) within Lake Macquarie. I&I NSW has also carried out studies to develop the most efficient and effective techniques for monitoring the artificial reef fish assemblages which involve a combination of underwater visual census (UVC) and baited remote underwater video (BRUV). Results of these studies have been presented in papers and at international symposia for artificial reefs and habitats. The estuarine artificial reefs project has therefore provided the necessary monitoring and management experience required for larger scale multi-component artificial reefs in NSW coastal waters.

A number of ex-naval vessels have also been scuttled in Australian waters for the purpose of creating artificial reefs for recreational SCUBA diving including the ex-HMAS *Swan* and ex-HMAS *Perth* (WA), the ex-HMAS *Hobart* (South Australia) and the ex-HMAS *Brisbane* (Queensland). In NSW, there are plans to scuttle the ex-HMAS *Adelaide* offshore of Terrigal, (Central Coast, NSW) in April 2010. The *Adelaide* was decommissioned by the Australian Navy in January 2008 and has been handed over to the NSW Government for the purpose of creating a recreational dive site (Plate ES1, d). The artificial reef will include a zone of exclusion to fishing called 'The ex-HMAS *Adelaide* Reserve.' Creation of the artificial reef is expected to boost the local economy (particularly from increased dive tourism and hospitality), enhance marine biodiversity in the vicinity of the scuttled ship and provide ongoing research opportunities for the University of Newcastle which is located nearby.

Historically, artificial reefs have been created out of a range of opportunistic or secondary (waste) materials, including car bodies and discarded tyres. Specifically designed and manufactured reef structures are now used in many countries, with Japan and Korea considered to be the world leaders in artificial reef technology (Plate ES1, e, f). Specifically designed structures are considered more suitable than the dumping/placement of opportunistic materials as they have been demonstrated to be more effective in achieving specific fisheries management objectives. The overall effectiveness and lifespan of manufactured reefs are also believed to yield comparatively greater cost-benefits than the use of secondary materials.

An extensive amount of research has been undertaken into the application, management and performance of artificial reefs. Research has focussed on fisheries ecology and management, ecology of animals and plants found in association with the seabed, design, monitoring, habitat protection and restoration. Despite that research, there is still an ongoing debate in the scientific community about whether artificial reefs increase overall production of a defined area, or whether they merely attract and aggregate existing fish away from nearby natural reefs to a new location. In less complex and reef-limited environments it has been inferred that both attraction and production are likely to interact in driving artificial reef assemblages and that these are extremes along a gradient. Artificial reefs have also been found to attract and aggregate some species while promoting the production of others, the situation is therefore likely to lie between these two extremes.

Whether by attraction and/or production, research indicates that properly designed and managed artificial reefs alter fish and bottom-living assemblages, by increasing the abundance, and in many cases the diversity of fish assemblages, which makes artificial reefs a useful management tool for fisheries enhancement and habitat rehabilitation.

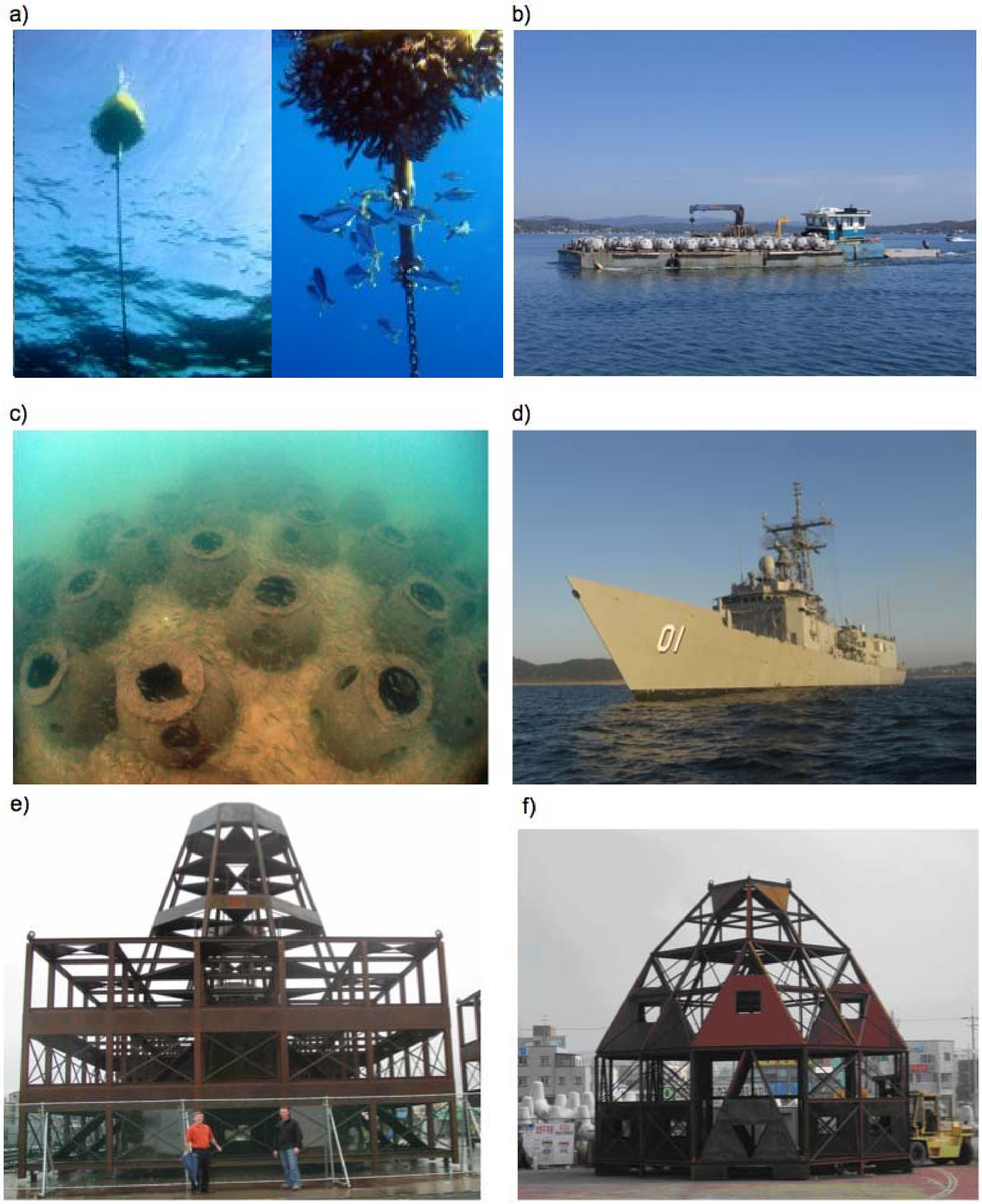


Plate ES1: a) Fish Aggregation Devices (FADs) b) Reef balls being deployed in Lake Macquarie 2005. c) Concrete moulded Reef Balls at Lake Macquarie 2005. d) The ex-HMAS *Adelaide* in transit to Garden Island, Sydney to be prepared for scuttling. e) Korean designed two-storey octagonal steel reef unit. f) Three-storey Korean steel reef unit. Photos courtesy of I&I NSW.

Description of the Proposal

In each study region (Newcastle, Sydney and Wollongong), four individual ‘reef units’ i.e. a reef set will be deployed at water depths between 30 m – 40 m. At this stage the Sydney location has been selected for the first OAR deployment. Subsequent deployments at Wollongong and Newcastle would be dependent on monitoring results and the success of the first Sydney OAR.

Structure Design

An existing Korean design (Plate ES1, e) was initially proposed for a single ‘reef unit’, however, stability assessments carried out as part of the EA/draft PER process indicated that the Korean steel reef designs would not be capable of withstanding extreme storm events in the study regions and therefore did not meet Australian safety requirements.

A new concept design, based on the Korean designs, was therefore developed to suit the oceanographic conditions of the study regions and meet the required safety standards. This concept design will be used for the OAR project (Figure ES3).

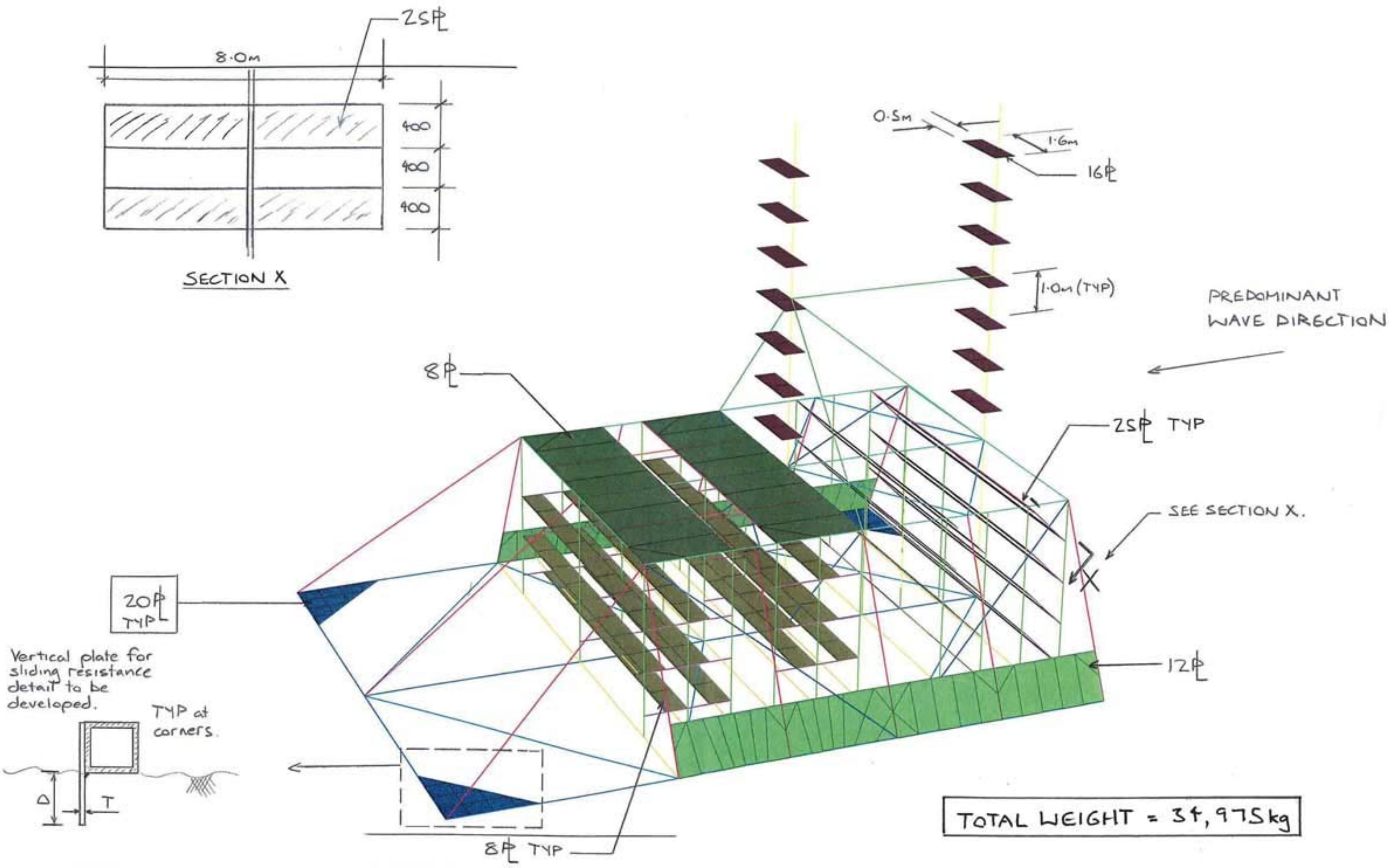


Figure ES3: Drawing of the OAR concept design developed by Worley Parsons.

The proposed OAR units will be 12 m high, 15 m long and 12 m wide and have the bulk of the internal structure within the bottom 4 m, to provide a low centre of gravity. Dimensions of the OAR may vary pending the finalisation of the technical design specifications that will be used for the units manufacture/fabrication, transport and deployment. The structures will be manufactured from steel beams and plates, weigh approximately 35 tonnes (dry weight) and will sit directly on the seabed without the need for additional anchorage, other than the weight of the unit itself.

The proposed concept design aims to retain the functionality of the Korean steel reef designs, while maintaining structural integrity, durability and stability. The design aims to provide habitat for popular angling species such as snapper and yellowtail kingfish. The concept design will require further detailed specification and verification by a structural marine engineer before it can be finalised.

Locations and configurations

The locations of each study region and the wider Newcastle, Sydney and Wollongong study areas are shown in Figure ES4.

GPS positions for each of the OAR units were initially provided by I&I NSW which were used as the basis for the EA/draft PER. It was initially proposed that OAR units would be configured in a diamond arrangement spaced approximately 600 m apart. However, as a result of issues identified in the assessment process, adjustments were made to the initial positions/configuration and alternative (final) locations and configuration proposed. The final (alternate) locations and configuration will be used for the OAR project. The final configuration will be in a line, spaced approximately 200 m apart and placed into areas of bare sand a minimum of 0.5 km from the nearest natural reef.

The final OAR locations that will be used for the OAR project are indicated by blue dots in Figures ES5, ES6 and ES7 and described below:

- Newcastle study region (Swansea). Approximately 3.6 km offshore from Blacksmiths Beach and the entrance to Swansea Channel, configured in a line, at a depth of approximately 28 m. The depth of water over the structures will be approximately 16 m (Figure ES5).
- Sydney study region (South Sydney). Approximately 1.2 km off The Gap and 1.9 km south-east of South Head, configured in a line, at a depth between 36 m – 38 m. The depth of water over the structures will be a minimum of approximately 24 m (Figure ES6).
- Wollongong study region (Port Kembla). Approximately 2.4 km offshore from Perkins Beach, and 2.5 km south of the Five Islands Nature Reserve, configured in a line, at a depth of approximately 34 m. The depth of water over the structures will be approximately 22 m (Figure ES7).

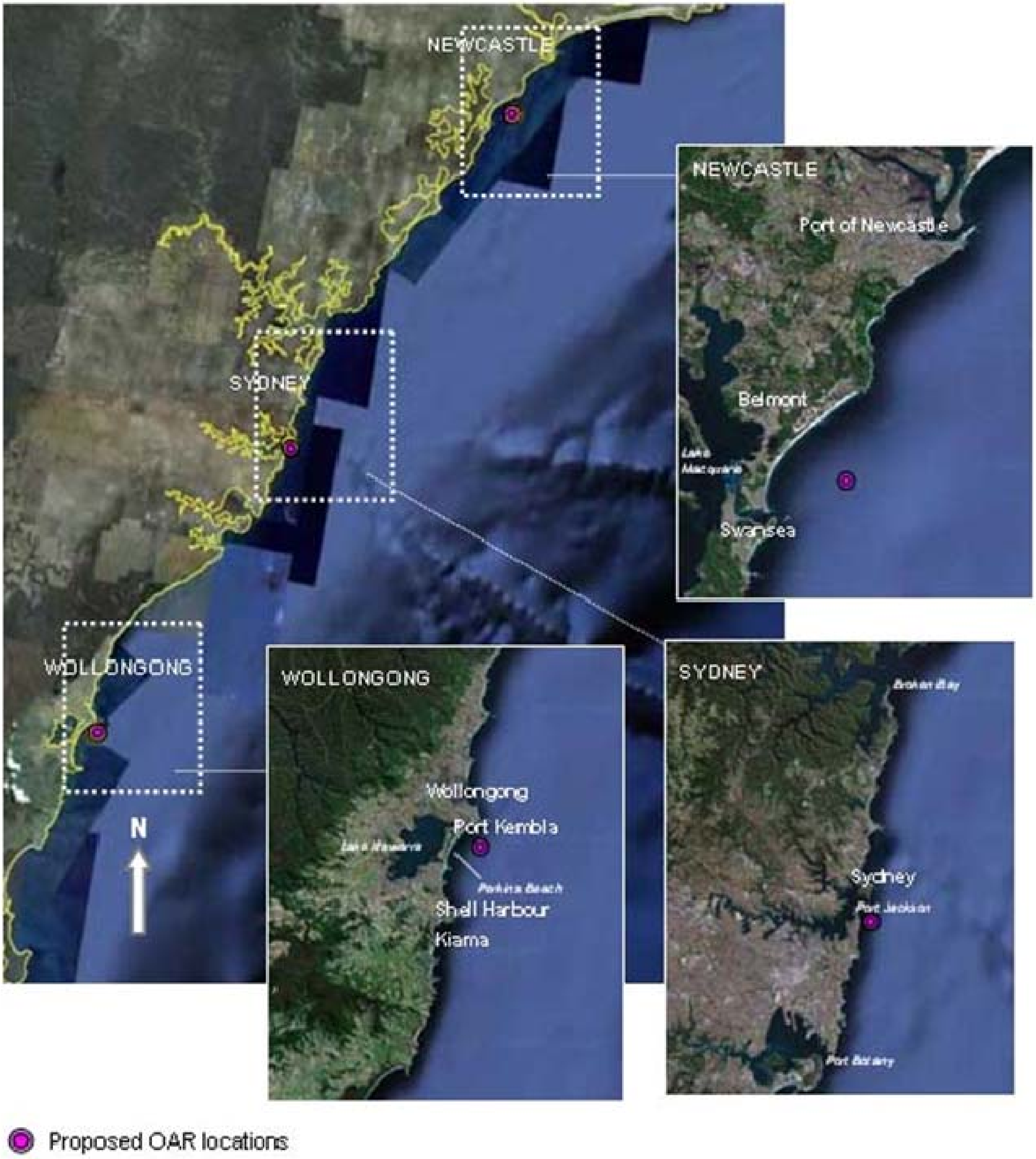


Figure ES4: Overview map of the proposed Newcastle, Sydney and Wollongong OAR study regions.

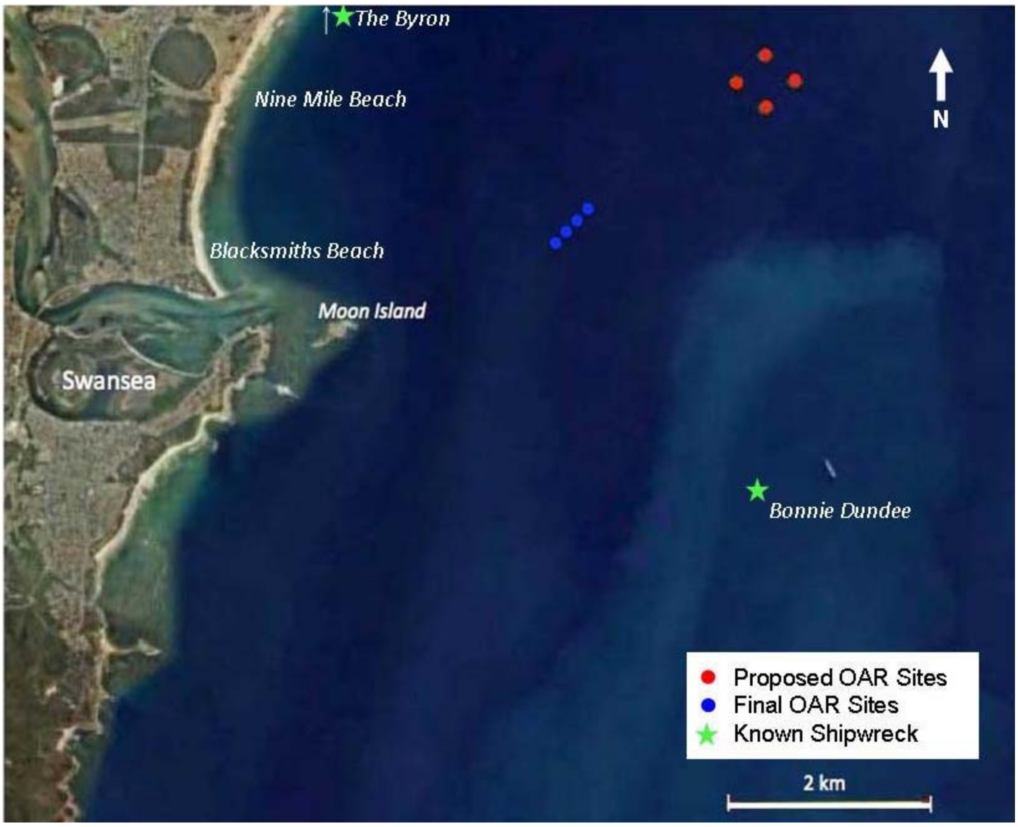


Figure ES5: Initial proposed OAR location (red) and final OAR location (blue) for the Newcastle study region.

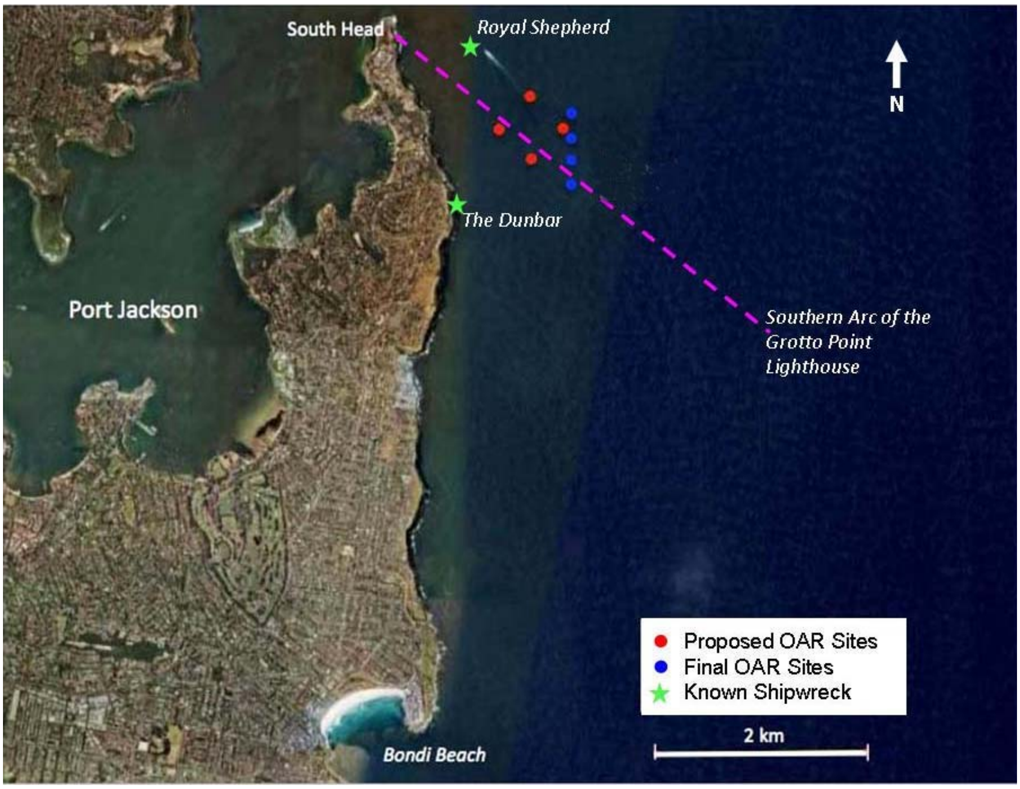


Figure ES6: Initial proposed OAR location (red) and final OAR location (blue) for the Sydney study region.

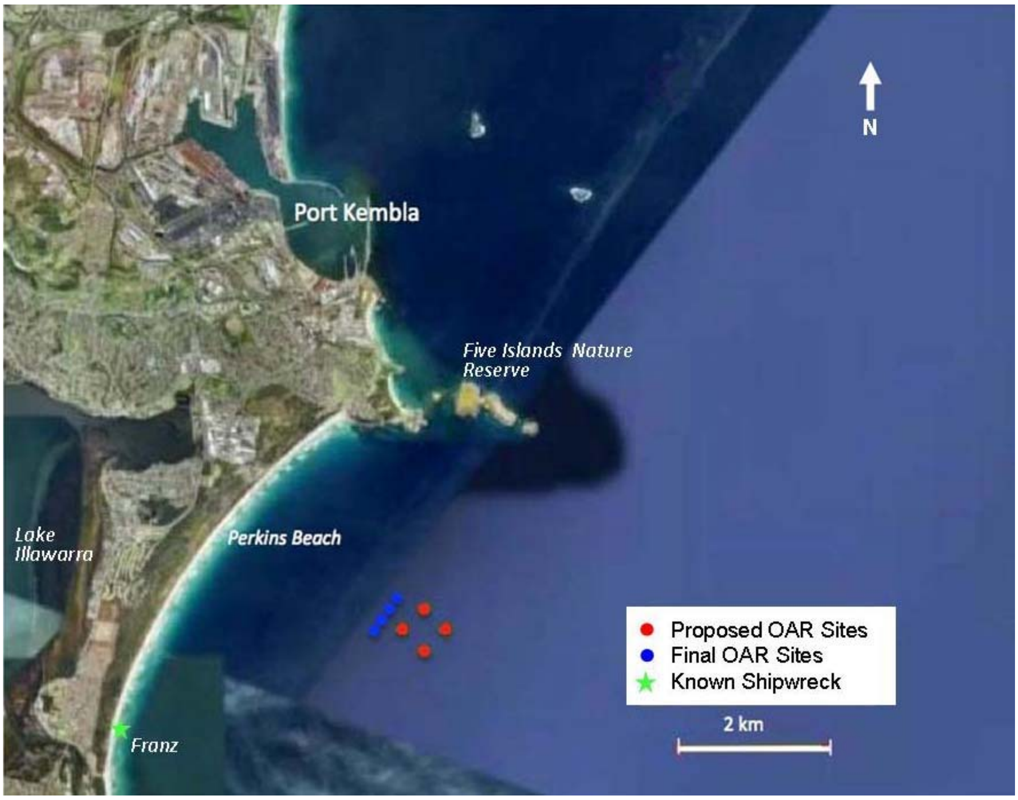


Figure ES7: Initial proposed OAR location (red) and final OAR location (blue) for the Wollongong study region.

The units will be constructed at a suitable waterside location, loaded onto a cargo barge, transported to the deployment site and lowered to the seabed by crane. It is expected that the construction, transport and deployment process will together take approximately 7 - 8 months to complete depending on conditions.

The exact location of the waterside construction area will be finalised subject to the projects approval and once a suitable contractor has been appointed.

The nominal operational lifespan of the OAR units is estimated to be 30 years based on the materials used and the likely rates of corrosion. It is likely, however, that the structures will remain operational for longer than this. As the current design does not allow for the units to be removed intact at the end of their operational lifespan, the following options for decommissioning will be considered:

- Option A – Provided the structures are verified to be structurally sound for removal, the units would be lifted intact by crane to a barge and transported to a waterside location, where the units would be cleaned, dismantled and disposed of at an appropriate land-based facility.
- Option B – If it is not feasible for the units to be removed intact, then they would be dismantled by commercial divers in-situ, sections craned onto a barge and transported to a waterside facility where the pieces would be cleaned and disposed of at an appropriate land-based facility.
- Option C – Structures would remain in-situ on the sea-bed and be allowed to gradually break-down over time. Monitoring of the structures would continue.

These options will provide a contingency for decommissioning at any stage during the operational life of the OAR if required, although the option of removing the units intact is unlikely to be feasible towards the end of the operational lifespan. Removal of the units (Options A or B) would also be subject to a separate environmental assessment.

The Existing Coastal Environment

A desktop review was carried out of the available information relating to coastal processes, seabed morphology, flora and fauna (including threatened species), areas of conservation significance, navigation and safety, infrastructure and heritage in the context of the wider study regions. Matters of National Environmental Significance (NES) relating to threatened species and the Commonwealth marine area were also reviewed for the relevant study regions.

The three study regions lie within the Hawkesbury Shelf marine bioregion, which extends from the Hunter River at Stockton, south to Shellharbour. Hawkesbury sandstone is a dominant feature of the coastline and has been eroded to create vertical cliffs, intersected by drowned river valleys such as Sydney Harbour and the Hawkesbury River that minimise potential for coastal sedimentation. The bioregion features around 24 estuaries, including barrier estuaries such as Lake Macquarie, coastal lakes such as Wamberal and Dee Why lagoons and a large embayment, Botany Bay. Approximately 2000 km^2 of oceanic and estuarine waters occur within the bioregion. Ocean water depths typically reach between 40 m – 60 m within the 3 nm limit of State waters, although depths of nearly 120 m are found off Botany Bay.

The long-term wave, wind and current data available for the three study regions indicated that coastal conditions were relatively similar in terms of wave climate, wind speeds and prevailing ocean currents. Tidal currents however, were notably stronger at the entrances to Lake Macquarie, Port Jackson and Botany Bay. The prevailing wave direction across the study regions is from the south, south-east with extreme wind speeds occurring mostly from the south. The variability of the East Australian Current both season-to-season and year-to-year also has a significant influence on biological productivity in the Region

The OARs will be placed on bare sand in water about 30 m - 40 m deep. The species assemblages that occur in sandy sediments within the wider study areas have been described. A diverse range of marine invertebrates was recorded, dominated by polychaete worms, crustaceans and molluscs and with significant differences in assemblages being found with depth. In NSW, a few common groups make up the fish fauna of sandy areas. Stingarees and guitarfish are the most common cartilaginous fish represented. Flatheads (Platycephalidae), which are voracious predators and whiting (Sillaginidae), which feed on bottom-living organisms, are the most common commercially important groups of bonyfish that occur in this habitat. There are also many small species of fish that feed on plankton.

The seabed habitat maps produced by the Department of Environment, Climate Change and Water (DECCW) indicate there are extensive areas of rocky reef in 30 m – 40 m water depth from Broken Bay to Bondi, but within the vicinity of the Sydney OAR location the seabed is predominantly fine to medium-grained golden and grey sands. There is little information on offshore reef and sand habitats in the Newcastle and Wollongong study regions. Rocky reefs provide substratum for the attachment of sessile organisms such as seaweeds, sponges and corals and are known to support quite different assemblages to those of soft and/or unconsolidated sediments. Sand and reef habitats across the wider study areas have been shown to support diverse assemblages of fish, many of which are recreationally and commercially important and depend on this habitat for food, shelter and/or spawning sites at some stage during their lives. Many species are affected by the topography of the reef and are more abundant in areas of greater physical complexity.

Marine turtles and marine mammals that live in the pelagic environment may also pass close by to where the OARs would be situated. Some of these have potential to occur in the study regions all year round (i.e. marine turtles, seals and dolphins) while others such as the much larger baleen whales (e.g. humpback whale, *Megaptera novaeangliae*) and southern right whale (*Eubalaena australis*) are seasonal.

A number of species known or predicted to occur in the wider study areas are protected from recreational and commercial fishing under State and Commonwealth legislation. The EPBC Act, the NSW government 'BioNet' and the DECCW threatened species databases were searched for threatened species, populations and communities listed in the EPBC Act, NSW *Threatened Species Conservation Act 1995* (TSC Act), the *Fisheries Management Act 1994* (FM Act) and the *National Parks and Wildlife Act 1974* (NP&W Act) that are likely or predicted to occur in the three study regions. The search carried out in February 2009, focused on marine fish, mammals, reptiles, algae/vegetation, invertebrates and seabirds occurring in the Hunter/Central Rivers, Sydney Metro and Southern Rivers Catchment Management Authorities (CMAs)/ Natural Resource Management Regions (NRMRs). In total, 43 species of marine mammal (cetaceans and pinnipeds), 51 species of fish (37 of which were syngnathiformes, i.e. seahorses, pipefish, pipehorses, ghost pipefish, seamoths and seadragons) and 7 species of marine reptile (including seasnakes and marine turtles) were listed across the CMA/NRMRs. Threatened and protected seabirds included albatrosses, petrels, shearwaters, terns, skuas, gulls, gannets and the endangered population of little penguins (*Eudyptula minor*) at Manly. A number of Aquatic Reserves and Nature Reserves also occur within the wider OAR study areas.

Additional Studies

Field Studies

Additional field studies were carried out to bridge the gaps in existing information identified in the earlier PEA report and the literature review for the EA/draft PER and provide the level of detail needed to address the PER/EA requirements. Field data will also be used as a baseline for future monitoring studies, where appropriate.

Data on local currents, physical characteristics of the seabed, benthic ecology, fish, sediment particle size distribution, heavy metal contaminants and water quality in each of the three metropolitan regions were collected during field investigations carried out between December 2008 and March 2009. Results of these studies are summarised in Table ES1.

Table ES1: Summary of oceanographic, physical and biological characteristics of the three direct study areas from field investigations carried out in December 2008 and March 2009.

1. Oceanographic Characteristics	
Currents	A snapshot of ocean current data in each of the three study regions showed that average current speeds were similar at the three study regions, but varied in direction, see below: ▪ Newcastle – under 0.25 m/s flowing to the south-west; ▪ Sydney – under 0.1 m/s flowing to the south-east; and ▪ Wollongong – approximately 0.1 m/s flowing to the north.
2. Physical Characteristics	
Seabed Characteristics	Seabed habitat mapping using side-scan sonar was carried out by the DECCW HABMAP team to map the physical characteristics of the seafloor and to identify areas of unsuitable seabed (such as reef), obstacles or features of cultural significance (e.g. uncharted shipwrecks or submerged Aboriginal deposits). A four km^2 area covering the direct study area at each of the three locations was surveyed (Figure ES8). Underwater video footage was also taken to provide a visual record of the seafloor. Habitat features specific to each study region are described below: ▪ Newcastle - The seabed gently sloped to the east, south-east and consisted of bare, relatively flat or rippled fine to coarse-grained sand, with some shell grit. . No reef was observed (Figure ES8, a). ▪ Sydney - The seabed gently sloped to the east, south-east and consisted of bare, relatively flat or rippled fine to coarse-grained sand, with some shell grit. . Areas of steep, nearshore rocky reef, approximately 5 m in vertical relief, were present approximately 400 m to the south and south-west of the southernmost OAR unit within the study area (Figure ES8, b).

Table ES1: Continued.

2. Physical Characteristics	
Seabed Characteristics	▪ Wollongong - The seabed gently sloped to the east, south-east and consisted of bare, relatively flat or rippled fine to coarse-grained sand, with some shell grit. Extensive areas of rocky reef were present to the east, south-east and south, south-west of the Wollongong study area (Figure ES8, c). No anomalous features were observed in any of the direct study areas that would warrant further investigation for historic or cultural significance.
Sediment Type	Sediments collected at the three study regions were similar, consisting of a high percentage of sand and a negligible amount of gravel. Coarser fractions were due to shell grit and occasional large shell fragments.
Contaminants	Concentrations of heavy metals within the sediments were well below the ANZECC/ARMCANZ interim sediment quality guidelines (ISQG) lower trigger values for marine systems at all locations.
Water Quality	Water quality was similar in all regions and complied with recommended ANZECC/ARMCANZ guidelines for all parameters sampled, except for percentage saturation of dissolved oxygen (DO), which was slightly below recommended guidelines at all locations.
3. Biological Characteristics	
Benthic assemblages	Animals living on or within the seabed were sampled at the proposed deployment locations and control locations by deploying a Ponar benthic grab from a boat (Plate ES2, a). Benthic assemblages in all study regions were diverse and characterised by large numbers of crustaceans (Plate ES2, c) and polychaetes (Plate ES2, d) with fewer representatives of other phyla (i.e. molluscs and echinoderms). The assemblages differed among regions and among sites within locations. Benthic assemblages were most diverse in the Wollongong study region and least diverse in the Sydney study region. These patterns are broadly consistent with those from earlier studies of benthic assemblages of sandy habitats associated with the three study regions.
Fish assemblages	Fish were sampled at the proposed deployment locations and control locations using Baited Remote Underwater Video Stations (BRUVS) (Plate ES2, b). Fish assemblages predominantly consisted of species that live on or close to the sandy bottom, although some pelagic and reef-associated species were also observed (PlateES2, e, f). Similar to the invertebrates, the fish assemblages also differed among regions and among locations within regions. Two to three times more fish were recorded in the Newcastle and Sydney study regions than in the Wollongong region. The Newcastle study region had the greatest numbers of individuals but the least diverse range of species. Sydney was the most diverse of the three locations. The chinaman leatherjacket (*Nelusetta ayraudi*), long-spine flathead (*Platycephalus longispinis*), silver trevally (*Pseudocaranx dentex*) and clupeids (herrings, sardines and pilchards) were the most abundant fish. No threatened or protected species were recorded during the surveys.

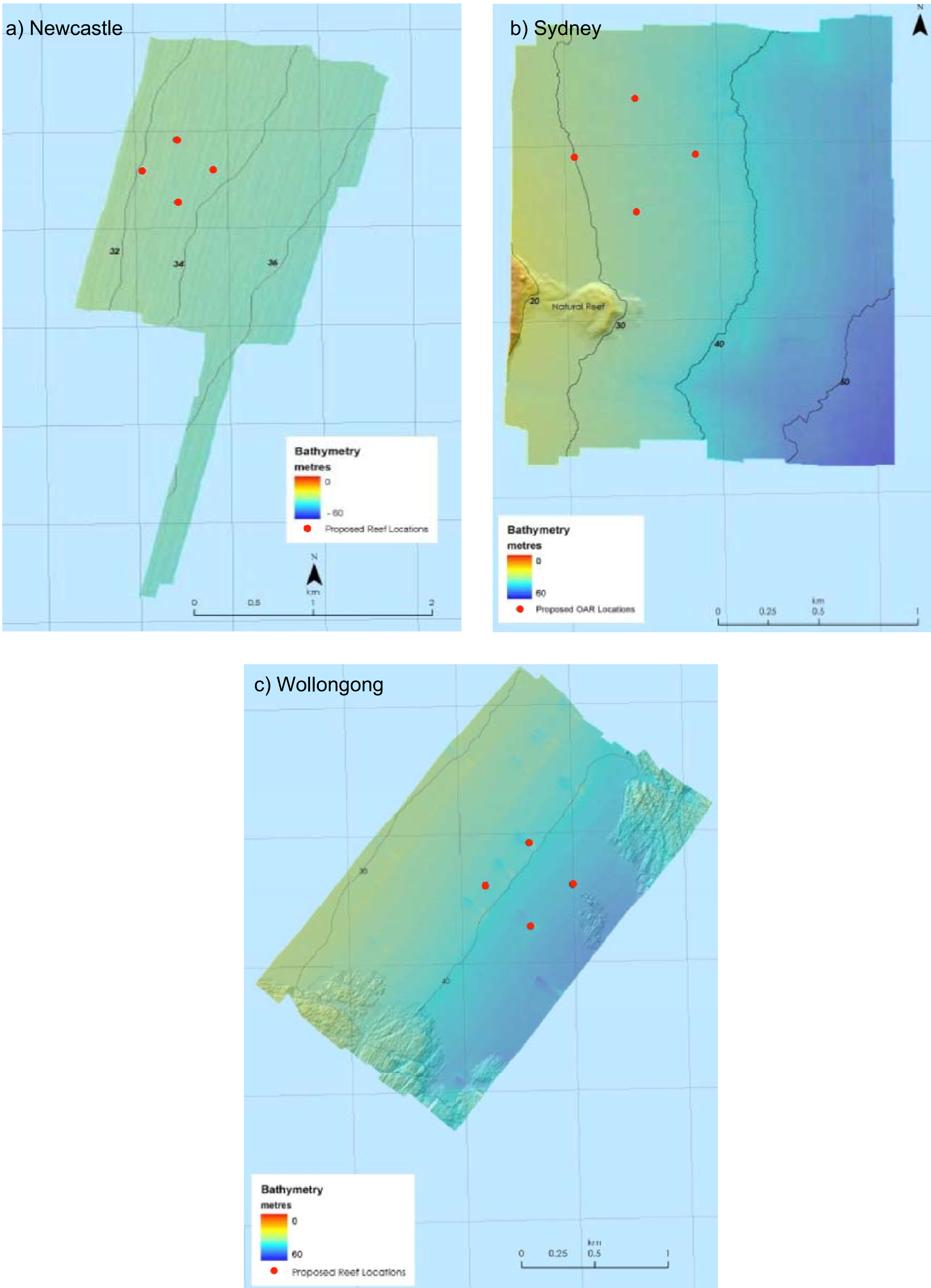
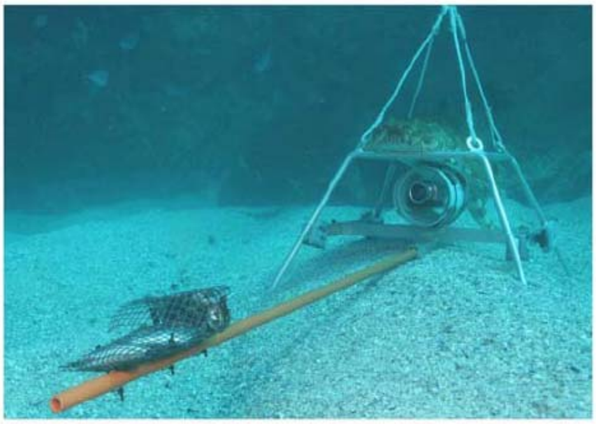


Figure ES8: Bathymetry with hillshaded relief at the a) Newcastle, b) Sydney and c) Wollongong study areas. Depths shown along contour lines are in metres AHD. Red dots indicate the initially proposed reef unit locations. Source: DECCW.

a)

b)



c)

d)

e)

f)

Plate ES2: a) Sampling for macroinvertebrates with a Ponar Grab on the vessel 'Krista' in January 2009. b) The BRUVS unit positioned on the seabed. c) An aorid amphipod crustacean collected during the benthic survey. d) Polychaete worm - family: Onuphidae, collected during the benthic survey. e) Chinaman leatherjacket (*Nelusetta ayraudi)* and Port Jackson shark (*Heterodontus portusjacksoni)* in the foreground of a BRUVS unit deployed in January 2009. f) Yellow-tail scad (*Trachurus novaezelandiae)* in the foreground of a BRUVS unit deployed in January 2009.

Stability Assessment

A desktop assessment was also carried out to ensure the proposed OAR units would be stable under local oceanographic conditions.

A series of stability assessments were carried out on the existing Korean steel reef designs which were initially provided by I&I NSW (Plate ES1, e and f). These designs were not considered capable of resisting overturning and sliding forces under the predicted oceanographic conditions to an acceptable factor of safety. A new OAR concept design was therefore developed within the design parameters of the proposal to meet Australian standards and the required factor of safety. This design is to be used as a basis for the final design and manufacture of the structures (Figure ES3).

Consultation

Relevant statutory and non-statutory authorities, port corporations, commercial fishing operators and recreational fishing associations/organisations were consulted as part of the EA/draft PER. Stakeholders were sent project information via email and post and contacted by telephone. A number of stakeholders also attended meetings organised by I&I NSW and Cardno Ecology Lab at venues in Newcastle, Sydney and Wollongong. A number of issues relating to navigation and safety, threatened species, conflict between user groups, obstruction to commercial trawling, over-exploitation of fisheries resources and overlap with other proposals were identified. These issues have been considered in the impact assessment and addressed by various mitigative and management measures.

Identification of Risks and Key Issues

Risk analysis was carried out to help identify potential impacts associated with construction, transport, deployment and the long-term operation of the OAR. This allowed potential issues and impacts to be considered in terms of the likelihood and consequence of impacts occurring to give an indication of their overall significance (i.e. whether they were of high, moderate or low significance) for further assessment. This did not mean that where the level of significance was high, the project should not proceed or that an issue should be ignored if the level of significance is considered low, but rather that the issue may need greater or less effort in management and mitigation. The key issues, potential hazards and risks associated with construction, transport and deployment of the OARs are summarised in Table ES2 whilst those associated with their long-term operation are summarised in Table ES3.

Construction-related impacts on air quality, waste, traffic and soils were generally considered to be of low significance, with the exception of noise pollution that could potentially have a significant detrimental impact on urban areas adjacent to, or in the vicinity of, the proposed construction sites. Although construction related impacts were generally considered to be of low risk, measures to ensure minimal impact and best practise are outlined in the EMP. Issues related to the deployment of the units were of moderate significance and included the potential for damage or incorrect positioning (which could lead to instability) and temporary increase in turbidity. High significance issues included the potential for conflict with shipping and/or other waterway users during deployment and OH&S risks to the barge crew.

Low significance impacts associated with long-term operation included potential impacts on the inshore coastal environment and introduction of invasive marine pests. Following the stability assessments carried out by Worley Parsons, the new OAR concept design was considered to be at low risk of sliding or overturning under extreme weather conditions (i.e. a 100 year storm event). Moderate significance issues related to long-term operation were mostly associated with biological aspects of the environment, particularly those that could occur within the direct study area. Issues included the direct loss of sandy habitat and associated fauna, potential changes to benthic, epibenthic and fish assemblages inhabiting areas of sand and proximal natural reef habitat, increased fishing effort and the potential for the attraction and aggregation of fish from natural reef to the OAR. Potential impacts on threatened and protected species considered of moderate significance included harm from marine debris and pollution in the vicinity of the OAR (from boating activity) and potential interruption of migration corridors for cetaceans (but not for other groups). Potential impacts on threatened and protected species that occur in association with nearby Nature Reserves were also considered at moderate risk.

Processes that could compromise the stability of the units were also identified as moderately significant. These included the potential for scouring and/or deposition at the base of the units and excessive corrosion and/or marine growth.

The potential for OARs to result in increased fishing mortality was considered a risk of high significance. Increased fishing mortality from an increase in fishing effort could potentially occur within the study area and if aggregation of fish was not sufficiently balanced by increased production. The potential for increased fishing mortality would, however, be dependent on the species that occur on the OAR as different types of species are affected differently. A further risk assessment was carried out to provide an indication of which species likely to occur on the OARs would be most vulnerable to fishing mortality.

The personal safety of spearfishers utilising the OARs, the safety of divers during monitoring and maintenance inspections and the risk of insufficient clearance of vessels over the OARs were also identified as high significance issues.

Table ES2: Summary of the risks associated with construction, transport and deployment of the OAR. L = Likelihood of risk occurring, C = Consequence of risk occurring. N/A = Not applicable. Orange, yellow and green blocks represent high, moderate and low significance respectively. * indicates a health and safety issue.

Receptor/Issue	Hazard/Negative Impact	Scale: Small (≤1 km)		Scale: Large (1-10 km)	
		L	C	L	C
1. Noise					
	Noise pollution from construction activities				
2. Sediments and Water Quality					
	Reduction in water quality in waterway adjacent to construction area (stormwater run - off)				
	Increased turbidity during deployment				
	Mobilisation of contaminated sediments during deployment				
3. Air Quality					
	Reduction of local air quality				
4. Waste					
	Generation of harmful waste materials				
5. Traffic					
	Increase in traffic volume				
	Parking congestion				
6. Soil					
	Soil contamination/erosion				
7. Structural Integrity and Stability					
	Risk of damage to structures during deployment			N/A	N/A
	Incorrect positioning/orientation resulting in instability of units			N/A	N/A
8. Navigation & Safety					
	Conflict with shipping and/or other water users				
	Damage to cargo barge during transport/deployment				
9. Flora and Fauna					
	Disruption to migratory marine mammals				
10. Occupational Health and Safety					
	Inadequate temporary work facilities resulting in poor OH & S.	*	*	N/A	N/A
	Health and safety matters resulting in injury or loss of life during deployment	*	*	N/A	N/A

Table ES3: Summary of the risks associated with long-term operation of the OAR. L = Likelihood of risk occurring, C = Consequence of risk occurring. N/A = Not applicable. Orange, yellow and green blocks represent high, moderate and low significance respectively. * indicates a health and safety issue.

Receptor/Issue	Hazard/Negative Impact	Scale: Small (≤1 km) L	Small (≤1 km) C	Large (1-10 km) L	Large (1-10 km) C
1. Coastal Processes & Oceanography:					
Nearshore coastal processes	Inshore wave climate				
	Change to beach erosion/deposition	N/A	N/A		
Local Seabed	Local scouring/deposition around units			N/A	N/A
2. Structural Integrity and Stability					
	Loss of structural integrity e.g. from corrosion or excessive marine growth			N/A	N/A
	Risk of sliding or overturning			N/A	N/A
3. Flora and Fauna					
Benthos	Direct loss of habitat				
	Change to sedimentary characteristics				
	Changes to benthic assemblages				
	Increased predation by fishes from the OAR on benthos				
	Commercial trawling in areas not previously trawled				
Proximal natural reef	Changes to benthic assemblages				
	Change to fish assemblages				
Pelagic Environment					
Plankton	Concentration of plankton				
Fish	Loss of habitat (benthic species)				
	Attraction/aggregation				
	Increased fishing effort				
	Increased mortality (from aggregation)				
Threatened and protected species					
Fish	Incidental capture				
	Aggregation of threatened or protected species				
	Harm from marine debris and pollution (KTPs)				
	Interruption of movement corridors (e.g. GNS)				
	Increased predation				
	Loss of habitat				
	Introduction of harmful marine pests				
Marine Turtles	Harm from marine debris and pollution (KTPs)				
	Incidental capture				
	Boat strike				
	Acoustic disturbance				
	Interruption of movement corridors				
	Loss of habitat				
	Introduction of harmful marine pests				
Cetaceans	Harm from marine debris and pollution (KTPs)				
	Incidental capture				
	Boat strike				
	Acoustic disturbance				
	Interruption of movement corridors				

Table ES3: Continued.

Receptor/Issue	Hazard/Negative Impact	Scale: Small (≤1 km) L	Small (≤1 km) C	Large (1-10 km) L	Large (1-10 km) C
Cetaceans continued					
	Loss of habitat				
	Introduction of harmful marine pests				
Pinnipeds and Sirenians	Harm from marine debris and pollution (KTPs)				
	Incidental capture				
	Boat strike (sirenians only)				
	Acoustic disturbance				
	Interruption of movement corridors				
	Loss of habitat				
	Introduction of harmful marine pests				
Seabirds	Harm from marine debris and pollution (KTPs)				
	Incidental capture				
Invasive Marine Pests					
	Introduction of invasive marine pests				
The Commonwealth Marine Area					
	Impact on and activities within the Commonwealth Marine Area	N/A	N/A		
Areas of Conservation Significance	Impacts on Nature Reserves				
	Impacts on Aquatic Reserves				
	Impacts on Critical Habitats				
	Loss of commercial fishing ground			N/A	N/A
	Conflict between user groups				
	Risk OAR does not achieve goals				
	Gear hook-up			N/A	N/A
	Collision from crowding		*		*
	Impacts on commercial fish stocks				
	Increased encounters with dangerous marine animals		*		*
	Injury or drowning (spear fishing)		*	N/A	N/A
5. Sediments and Water					
	Leaching of contaminants				
6. Navigation and Safety					
	Clearance				
	Anchor fouling			N/A	N/A
	Increased vessel traffic				
7. Infrastructure					
	Congestion/crowding at boat ramps				
	Lack of amenities				
8. Heritage					
	Impacts on historic shipwrecks			N/A	N/A
	Impacts on submerged aboriginal deposits				
	Conflict with areas of spiritual significance/dreamings				
	Negative impacts on aesthetic amenity				
9. Occupational Health and Safety					
	Injury or loss of life during diver maintenance or monitoring inspections		*		*

Assessment of Key Issues/Impacts

Key Issues, potential impacts and recommended mitigation or management measures are summarised in Tables ES4 and ES5 below. The predicted outcomes, given that the recommended mitigation/management measures are applied, are also stated.

Table ES4: Summary of key issues, potential impacts, mitigation/management measures and predicted outcomes related to the construction, transport and deployment of OARs.

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
1. Noise		
Noise pollution from construction activities.	The maximum noise level for industrial and commercial premises (i.e. 75 dB) would not be exceeded for sensitive surrounding receptors. Specific hours of operation during the construction stage would be complied with.	No significant impacts expected.
2. Sediments and Water		
Contamination from stormwater run-off at the construction site.	The contractor would prepare a WQMP (Water Quality Management Plan) as part of the CEMP. As a minimum, this would include provisions for the capture, storage, testing, treatment and release of stormwater runoff from the construction site as outlined in the EMP.	No significant impacts expected.
Contamination of the marine environment during deployment.	The contractor would ensure that: ●prior to deployment, the structures are cleaned of all slag, rust, water, oil, paint and other substances; ●only adequately treated salt or freshwater liquid waste would be permitted for discharge into marine waters; and ●other non-liquid waste materials that may be harmful or hazardous to aquatic life or that result in an unsightly appearance, are not disposed of into the waters.	No significant impacts expected.
3. Air Quality		
Reduction in local air quality (from dust and exhaust emissions).	An Air Quality Management Plan (AQMP) would be prepared by the contractor as a component of the CEMP. The contractor would ensure that: ●material transported by truck is covered; ●works cease in extreme wind conditions (i.e. > 40 km/h); ●Plant and equipment is maintained to minimise exhaust emissions; and ●that the correct specification, storage, and preparations of raw materials to minimise requirements for shot blasting or further cleaning is used. Air quality would be maintained in accordance with the National Ambient Air Quality Standards and as outlined in the EMP	No significant impacts expected.

Table ES4: Continued

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
4. Waste		
Generation and disposal of construction related waste or harmful materials.	The contractor would prepare a Waste Management Plan (WMP) as a component of the CEMP in accordance with the Waste Avoidance and Recovery Strategy and the relevant local government Development Control Plan. The contractor would ensure that: appropriate planning and ordering of materials takes place to minimise waste; •waste material is recycled where possible; •waste material is treated and disposed of according to EPA guidelines on the Assessment, Classification and Management of Liquid and Non-Liquid Waste; •every precaution is taken to prevent structural metal debris from falling into the ocean; •scrap material, including sea-fastenings are disposed of onshore and that dumping of scrap at sea is not permitted.	No significant impacts expected.
5. Traffic		
Increase in local traffic volume/parking congestion.	The contractor would prepare a detailed Traffic Management Plan (TMP) as part of the CEMP. The contractor would ensure that: •provisions are made for truck parking and manoeuvring; •truck and construction traffic routes are established; •parking zones for construction traffic are designated; •signage is erected to warn motorists of traffic entering and leaving the works site if required; •stabilised access points are established to minimise damage to the surrounding environment; •the movement of construction vehicles is limited to general construction work hours in order to comply with noise regulations.	No significant impacts expected.
6. Soil		
Potential for soil contamination/erosion within the construction site.	The contractor would prepare an Erosion and Sediment Control Plan as part of the CEMP in accordance with the Managing Urban Stormwater – Soils and Construction guidelines. Bunding and catchment drains would be used where appropriate and clean water directed around the site.	No significant impacts expected.
7. Structural integrity and stability.		
Damage to structures during deployment.	I&I NSW would ensure that a suitably qualified contractor is appointed. Lift analyses would be carried out to ensure barges and vessels are stable during the loading transportation and deployment process. Specific procedures would be required for each of the loading, transportation and deployment stages which are outlined in the EMP.	No significant impacts expected.

Table ES4: Continued

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Incorrect positioning/ orientation.	Use of GPS equipment and diver inspection would ensure the correct location and orientation.	No significant impacts expected.
8. Navigation and safety		
Conflict with other waterway users during transportation and deployment.	Communication and clearance from relevant Port Authorities would be obtained to ensure it is safe to undertake the transport and deployment process. The contractor would ensure the correct navigational lighting is displayed on the barge. Appropriate temporary navigational aids would be provided on the structure and vessel during deployment and anchor buoys positioned at anchor locations.	No significant impacts expected.
Damage to cargo barge.	Detailed lift and mooring analyses to be carried out by the appointed contractor as outlined in the EMP. Loading, transportation and deployment procedures to be carried out as outlined in the EMP.	No significant impacts expected.
9. Flora and Fauna		
Disruption to marine mammals during transportation and deployment.	Transport and deployment stages would not go ahead if there are reports of marine mammals (particularly whales), in the vicinity of the transport route or deployment site. Operations would be temporarily stopped should migratory marine mammals be observed within 300 m of the deployment site.	No significant impacts expected.
10. OH&S		
Health and safety of contracting staff during the construction, transportation and deployment stages.	I&I NSW would ensure that a suitably qualified contractor is appointed. The appointed contractor would be responsible for the preparation of a OH&S Plan and ensuring the temporary construction site and barge are adequate in terms of OH&S.	No significant impacts expected.

Table ES5: Summary of key issues, mitigation/management measures and predicted outcomes related to the long-term operation of OARs.

Potential Impacts	Mitigation/ Management Measure	Predicted Outcome (with mitigation)
1. Structural Integrity and Stability		
Risk of sliding or overturning.	The proposed OAR concept design has been developed to resist overturning or sliding in a 100 year storm event. The final design would be verified by a structural marine engineer and developed in accordance with Australian standards for similar marine structures. Local scouring/ deposition around the base of the units would be monitored over the operational life of the units.	No significant impacts expected.
Loss of structural integrity from corrosion or excessive marine growth.	The final design would be verified to meet Australian standards for corrosion allowance and structural capability for the 30 year design life.	No significant impacts expected.

Table ES5: Continued.

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
	Monitoring would be carried out over the duration of the design life to ensure the structural integrity of the unit. Units would be inspected for unforseen stresses, movement from the deployment location, orientation, corrosion and thickness of marine growth.	
	Findings of inspections would be compared to design documentation and previous studies to determine if changes have occurred.	
2. Flora and Fauna		
a) Benthos		
Change to soft sediment assemblages.	Monitoring of soft sediment assemblages.	No significant impacts expected.
b) Proximal Natural Reef		
Change to epibenthic and fish assemblages of proximal natural reef.	There would be a minimum distance of 500 m between the OAR and adjacent natural reefs. Monitoring of fish assemblages and habitat utilisation and epibenthic assemblages in the wider study area.	No significant impacts expected.
c) Pelagic Environment		
Potential for OARs to contribute to over-exploitation of target species. (e.g. through increased fishing effort).	Monitoring of fish assemblages (i.e. species catch composition, size-frequency distribution, catch rates) Ensure that user groups are informed of minimum catch sizes and bag limits. Promote catch and release	No significant impacts expected.
d) Threatened and Protected Species (including Matters of NES)		
Incidental catch	Monitoring of threatened species occurrence on OARs.	No significant impacts expected.
Potential to increase the risk of entanglement or injury from harmful marine debris (e.g. discarded fishing gear).	Inspection for and removal of fouled fishing gear or debris hooked on the OARs to prevent injury or entanglement of threatened/protected species.	
Boat strike Acoustic disturbance from boating activity	Mechanisms for reporting of sightings or interactions with threatened species in the vicinity of the OARs. Provision of relevant educational information relating to threatened species (including boating regulations in the vicinity of large cetaceans) would be included in a set of OAR 'User Guidelines' made available to target user groups.	
e) Invasive Marine Pests		
Colonisation of OAR structures by marine pests.	Monitoring to determine the type and extent of invasive marine pests.	Minor incursions possible but overall, no significant impact expected.
Potential for spread of marine pests (e.g. *Caulerpa taxifolia*) via recreational boating.	Assessment and potential removal of marine pests would be carried out according to the National Introduced Marine Pest Information System (NIMPIS) guidelines.	

Table ES5: Continued.

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
	Relevant educational information on how to minimise the spread of marine pests would be included in a set of OAR 'User Guidelines' made available to target user groups.	
3. Commercial and Recreational Fishing		
Loss/obstruction to trawling (Newcastle study region only)	The final OAR location aims to minimise loss/obstruction to approximately 0.01km^2 of potential trawling areas. An alternative (line) configuration has been recommended to minimise loss of trawling area and potential for obstruction/gear hook up.	This impact is considered to be of moderate significance.
Risk of injury or drowning (spearfishing)	A set of User Guidelines would inform different user groups on best practice, personal responsibility and safety within the OAR management area.	This risk is considered to be of high significance but manageable through appropriate education.
Conflict between user groups	Monitoring. A code of conduct for user groups would be outlined in the OAR User Guidelines. Commercial fishing groups would be informed of the final OAR locations. Formal consultation between sectors would be undertaken to resolve any issues of conflict (or similar).	No significant impacts expected
4. Sediments and Water		
Leaching of heavy metal contaminants into adjacent sediments (e.g. iron oxide).	It would be ensured that structures are manufactured from materials that conform to Australian Standards for minimum corrosion rates. Monitoring of adjacent sediments (according to ANZECC/ARMCANZ guidelines) to ensure acceptable levels of contaminant are not exceeded.	No significant impacts expected.
5. Navigation and Safety		
Insufficient clearance	Sufficient clearance between the upper part of OARs and transiting vessels would be ensured, accounting for coincidence of severe weather conditions and Lowest Astronomical Tide (LAT). A minimum clearance of 20 m would be ensured at the proposed Sydney location as specified by Sydney Port Authority.	No significant impacts expected.
Anchor fouling/gear hookup	The Australian Hydrographic Office would be informed of the finalised OAR locations. Locations would be charted on maritime maps and a notice to mariners issued to warn of the OAR location. Appropriate locations have been selected in consultation with Ports Authorities and NSW Maritime to ensure units are placed away from designated anchorage areas.	Anchor fouling by large commercial vessels is considered unlikely. It would be likely that fishing gear would become snagged or lost on the structures. A minor, but acceptable level of impact is therefore expected.

Table ES5: Continued.

Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
	It would be recommended in the User Guidelines that anchoring does not occur within the OAR management area. OAR units would be regularly inspected in accordance with the EMP so that fouled gear may be removed and would not become a hazard to marine life.	
Vessel traffic	Recreational vessels utlising OARs would be instructed to give way to commercial vessels. User groups would be informed of a code of conduct and recreational boating guidelines in the OAR management area.	Unlikely but possible that impacts related to vessel traffic could occur. Acceptable level of risk expected.
6. Infrastructure		
Congestion at boat ramps and insufficient facilities.	OAR locations have been selected in major urban centres where the provision of boat ramps and facilities is considered to be sufficient for the expected demand. Monitoring questionaires are recommended to determine the need for improvements or upgrades.	No significant impacts are expected.
7. Heritage		
Impacts on historic shipwrecks and submerged items of cultural significance.	OAR will be deployed in areas where there are no historic shipwrecks or items of cultural significance.	No significant impacts expected.
Impacts on spiritual significance or visual amenity (Wollongong study region).	Aboriginal stakeholder groups in the Wollongong study region would be informed of the final locations to ensure the visual amenity and spiritual significance of the region was not compromised.	No significant impacts expected.
8. OH&S		
Health and safety of divers during maintenance and monitoring inspections.	A Safe Work Method Plan would be implemented for diving in the appropriate conditions by the group carrying out the work, and as a minimum would include a temporary fishing closure at those times. This is outlined in the EMP.	No significant impacts expected.

Environmental Management

All of the potential issues identified in the impact assessment could be removed or minimised to an acceptable level of risk by implementation of one or more of the following:

- minor changes to the initially proposed OAR locations and configurations;
- mitigation or management measures outlined in the EMP; and/or
- appropriate monitoring.

Final Locations and Configuration

The impact assessment indicated that a number of potential impacts relating to commercial fishing, proximal natural reef and aspects of navigation and safety could be eliminated or minimised by changing the reef configurations and locations initially proposed by I&I NSW. The alternative (final) configuration, for all study regions, is for a line arrangement running north to south rather than a diamond. This would make it easier to drift fish with the current, improve navigation for commercial vessels and reduce the area occupied by the reef set. The final OAR locations are described in Section 3 (Figures ES5, ES6 and ES7, indicated by blue dots).

For the Sydney and Wollongong study regions, only minor adjustments to the initial locations (at the scale of 100 m – 300 m) were necessary. Further desktop studies would not be required for the final locations as the scale of the original studies is considered to be sufficient. Site-specific biological sampling will, however, be required as part of the recommended Monitoring Plan.

The final Newcastle location is outside the direct study area and although the scale at which many impacts were assessed in the EA/draft PER is still relevant for planning considerations, additional site-specific information is needed. As a minimum, this would require further swath mapping to identify habitats and possible obstructions. Collection of site-specific current data would not be necessary as conditions recorded at the original Newcastle location are likely to be similar at the final location. Further biological sampling would be required to assess potential impacts at the site, and would also be required as part of the Monitoring Plan.

As only one of the three study regions would be selected for the initial OAR deployment a rapid assessment method was used to determine the suitability of each of the proposed study regions. Based on this rapid assessment it is recommended that Sydney be the site for the initial OAR deployment. Sydney was ranked as the most suitable location followed equally by Newcastle and Wollongong. Although the Sydney location is indicated as the preferred site for the initial project, both Newcastle and Wollongong are still considered to be highly suitable locations for the installation of an OAR.

Environmental Management Plan (EMP)

A number of potential impacts will be mitigated or managed by implementing the EMP that has been developed as part of the EA/draft PER. The EMP will also provide a reference for the contractor that is appointed to undertake the construction, transportation and deployment stages of the project. A detailed construction environmental management plan (CEMP) should, however, be developed by the appointed contractor, once a suitable construction area has been selected.

A management area will be established around the OAR, by creation of a Crown Reserve under the *Crown Lands Act 1989*. This will include the area directly occupied by the units and a further 500 m buffer zone in every direction. It is important to note that this will *not* be an 'exclusion zone', but an area appropriate to manage potential issues outlined within the EMP.

The EMP also recommends that target user groups be informed of best practice and a code of conduct within the OAR Management Area by provision of 'User Guidelines'. The guidelines will include, but not be limited to, information on OAR locations, methods to minimise impacts on threatened/protected species, methods to minimise the spread of marine pests and boating safety in the OAR Management Area.

Monitoring Plan

A Monitoring Plan has been developed that outlines appropriate procedures to detect changes in significant components of the marine environment, assess impacts on threatened species, assess the structural integrity of the units and to investigate the success of the OARs in terms of catch rates, catch composition and popularity with anglers. The plan also outlines how the colonisation of the OARs will be documented and procedures to monitor water quality and sediment characteristics. Locations, timing, review periods and appropriate management procedures for each relevant issue are also outlined in the plan.

Statement of Commitments

I&I NSW is committed to ensuring that environmental stewardship is effectively applied throughout the construction, transport, deployment and long-term operation of the proposed OAR. Having successfully implemented artificial reefs in estuarine locations and fish aggregation devices in offshore locations, I&I NSW has an understanding of the management and monitoring requirements and the resources and expertise necessary to ensure that significant environmental impacts are avoided, appropriately mitigated or managed.

A considerable amount of planning and consultation work has also been undertaken prior to the environmental assessment stage to identify and minimise potential constraints and select locations likely to have the least environmental impact, with optimal results.

The EA/draft PER has identified measures to mitigate and manage potential environmental impacts specific to the proposed OAR project that I&I NSW are committed to. These measures have been consolidated into an EMP and a Monitoring Plan.

In summary, actions committed for the project are as follows:

- Construction, transport and deployment activities will be carried out in accordance with procedures outlined in the EMP. The appointed contractor will be fully certified and qualified to carry out the works as outlined in the EMP safely and efficiently and will develop an additional CEMP and OH & S plan to address site-specific environmental and safety issues.
- A management area will be established around the OAR, in consultation with the Land and Property Management Authority by creation of a Crown Reserve under the *Crown Lands Act 1989*.
- Information on activities permitted within the proposed management area and user guidelines including a code of conduct will be provided via the I&I NSW website and through relevant publications to ensure best practice and safety during the operational life of the OAR.
- Long-term management of the proposed OARs will be the responsibility of I&I NSW and carried out in accordance with the EMP. This includes implementing measures to manage and mitigate impacts on flora and fauna (including threatened species and matters of national environmental significance), water and sediments, navigation and safety, infrastructure, commercial and recreational fishing.
- Monitoring of the OARs will be carried out by I&I NSW for a minimum period of three years.
- Monitoring and review will be carried out to ensure the structural integrity and stability of the units as described in the EMP and Monitoring Plan.
- Monitoring and review will be carried out to mitigate any potential impacts on threatened and protected species (including matters of NES) as described in the EMP and Monitoring Plan.
- I&I NSW will be responsible for the removal of fouled gear and debris collected on the OARs, that could be harmful to threatened or protected species as described in the EMP and Monitoring Plan.
- Monitoring and review of catch rates, species catch composition, size-frequency distribution and habitat utilisation of fish will be carried out within the study areas as described in the EMP and Monitoring Plan.
- Monitoring and review will be carried out to ensure that the proposal is effective in meeting the project objectives and that target user groups are satisfied with the operation of the OARs.
- I&I NSW will ensure that appropriate sand penetration tests are carried out in the final OAR locations.
- At the time of preparation of the EA/draft PER, no minerals licence applications were found to occur within the vicinity of the proposed OARs. I&I NSW will, however, consult the relevant databases for offshore minerals exploration licences and applications which have potential to conflict with the final proposed OAR locations in advance of any approved deployment.

I&I NSW are also committed to ensuring that local community groups, LALCs, commercial fishing groups and the general public are informed of the project staging and EMP for the proposed OARs as it may develop in future.

Conclusion and Justification

Recreational fishing is an important leisure activity for approximately 17 % of the NSW population (approximately 1 million people) and is considered by the government to provide significant social and economic benefits. In NSW, approximately 30 % of the total fishing effort takes place between the shoreline and 5 km offshore (Henry and Lyle 2003). It is likely that the proposed offshore artificial reefs would contribute to long-term socio-economic benefits on local communities by improving fishing opportunity and expenditure on fishing related items and services. There may also be increased opportunity for employment in fishing related industries. In the short-term, the construction, transport and deployment stage of the project would provide employment for a number of engineers, labourers and support staff.

The deployment of OARs would complement existing recreational fishing enhancement projects managed by I&I NSW, such as the deployment of fish aggregation devices (FADs) and the estuarine artificial reef (EAR) projects which have proven successful as fisheries enhancement tools over the past seven years.

Provided that the project is managed as described in the EMP and Monitoring Plan, the proposal is not considered to have a significant environmental impact. All issues that have been identified in the EA/draft PER are considered to be appropriately mitigated for or pose an acceptable and manageable level of impact.

The proposal is considered to be acceptable in terms of its potential environmental impact on relevant matters of NES as there would be no direct impacts on habitat or resources important for threatened/migratory species or regional values of the Commonwealth marine area. Indirect impacts from the placement of the OARs, or associated fishing activity, on individual animals or populations that are matters of NES would be negligible and unlikely, provided OARs are managed and monitored as outlined in the EMP. As a precaution, regular monitoring would be carried out by different methods to detect the presence of threatened species in the vicinity of the OARs. In the unlikely event that a threatened species was considered to be vulnerable, appropriate mitigative action to remove the risk (as specified in the EMP) would be taken.

It is extremely likely that the proposal will provide high quality fishing opportunity, contribute to productivity within the management area (in the long-term), provide additional fishing locations and potentially relieve pressure on natural reef habitats. Monitoring studies would contribute valuable fisheries information and could also provide opportunities for research and education. The project is considered to be consistent with the objects of the EP&A Act, the FM Act and principles of environmentally sustainable development (ESD).

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Guideline Heading	This Report
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(c) Objective of the action	1.1
(d)i Legislative background	1.2
(d)ii Specific location including coordinates and maps	4.3
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(f) How the action relates to any other actions	4.6
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(a) The precise location	4.3
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4. Description of the Environment	
(a) Information about listed threatened and migratory species	Appendix 7 and 6.1.2.4
(b) Information on oceanographic and coastal processes	6.1.1
(c) A description of the surrounding Commonwealth marine area likely to be impacted	6.1.2.5 and Section 6
5. Relevant Impacts in relation to:	
(a) The potential direct and consequential impacts on listed threatened and migratory species	Appendix 7, 8.1.9 and 8.2.3.4
(b) The Commonwealth marine area	8.2.3.6
(c) Whether impacts are likely to be unknown unpredictable or reversible	8.2.3.4 and 8.2.3.6
(d) The significance of the relevant impacts	Appendix 7, 8.2.3.4 and 8.2.3.6
(e) Technical data and other information needed for a detailed assessment	See Technical Reports
(f) The social and economic consequences of the action	8.2.10
6. Proposed safeguards and mitigation	
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(d) A description of the relevant monitoring, enforcement and review procedures	n/a
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(c) Documented responses to the consultation	5.0, Appendix 4 and Appendix 5
(d) Identification of affected parties and description of their views	5.0

9. Information Sources (a) The source of information (b) How recent the information is (c) How the reliability of the information was tested (d) Uncertainties regarding the information	 16 (References) 16 (References) 16 (References) n/a
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Glossary

Australian Height Datum (AHD)	A common national plane of level corresponding approximately to mean sea level.
Artificial Reef	A man-made structure placed underwater to promote marine life in areas of generally featureless bottom.
Bed Load	That portion of the total sediment load that flowing water moves along the bed by the rolling or saltating of sediment particles.
Benthic	Living on or in the seabed.
Benthos	The collection of organisms attached to or resting on the bottom sediments (i.e. epifauna) and those which burrow into the sediments (i.e. infauna).
Biodiversity	The variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part.
Biomass	Total quantity or weight of organisms in a given area.
Biota	The flora and fauna of a given area.
Bioturbation	The mixing of sediments by macrofauna.
Carrying Capacity	The maximum equilibrium population size in a given area or habitat.
Cartilaginous	Refers to fishes which have a skeleton made of cartilidge (soft and flexible gristle-like, material that provides support to the body) i.e. sharks and rays.
Commercial Species	Species in a catch that are kept and sold due to their commercial value.
Continental Shelf	The gently sloping seabed extending from the shore to a depth of approximately 200 m.
Demersal	Living at or occurring near or on the seabed (c.f. pelagic).
Density Dependence	Usually refers to negative effects whereby population growth is curtailed by crowding, predators and competition.
Diurnal	A daily variation, as in day and night.
Ecosystem	All the organisms in a community, together with the associated physical environmental factors (living and non-living) with which they interact.
Eddies	Large, approximately circular, swirling movements of water, often metres or tens of metres across. Eddies are caused by shear between the flow and a boundary or by flow separation from a boundary.
Epifauna	Animals that live on or are attached to the surface of, the seabed or subtidal habitat (including artificial structure).
Erosion (Shoreline)	Volume of sand eroded from the beach-face in a particular storm.
Estuarine	Habitat lying at the interface between freshwater and marine environments; usually the mouths of streams and rivers.
Fecundity	A measure of the ability to produce offspring by the maternal adult.

Fishing Effort	A function of the number of participating fishers, number of fishing events (e.g. fishing trips) and time (days/hours) spent fishing.
Foreshore	The area of shore between low and high tide marks and land adjacent thereto.
Geomorphology	The study of the origin, characteristics and development of land forms.
H_{max}	Maximum wave height in a specified time period.
H_s (Significant Wave Height)	The average of the highest 1/3 of wave heights in a wave record (H1/3), or from the zeroth spectral moment.
Incidental Catch	Species caught which are not the primary target of a fishing operation.
Infauna	Aquatic animals living within the sediment.
Intertidal	The portion of shoreline between low and high tide marks, that is intermittently submerged.
Invasive Marine Pest	Organisms (usually transported by humans) which successfully establish themselves and then overcome otherwise intact, pre-existing native ecosystems.
Leaching	The process by which soluble materials such as salts, nutrients, pesticide chemicals, or contaminants, are washed into surrounding sediments or are dissolved and carried away by water.
Littoral Zone	An area of the coastline in which sediment movement by wave, current and wind action is prevalent. In shoreline change computations this is the sum of the Active Height and Active Depth.
Littoral Drift Processes	Wave, current and wind processes that facilitate the transport of water and sediments along a shoreline.
Loadout	Process by which structures are loaded on to barges for transportation offshore.
Macrofauna	Organisms associated with sediment and retained in a sieve of 1.0 mm.
Marine Protected Area (MPA)	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.
Numerical Modelling	The mathematical representation of the physical processes involved in sea flows and sediment transport. These models are often run on computers due to the complexity and detail of the mathematical relationships that describe the physical processes. In this report, the models referred to involve wave, current and sediment transport processes.
Pelagic	In marine ecology this is applied to organisms that inhabit open water.
Plankton	The vast diversity of organisms below 0.5 mm in size that drift with the ocean currents.
Population	Any collection of potentially interbreeding organisms in a given area.
Productivity	When applied to fish stock, the term productivity gives an indication of the birth, growth and death rates of a stock.

Saltation	The movement of sediment particles along the bed of a water body in a series of 'hops' or 'jumps'.
Sediment Load	The quantity of sediment moved past a particular cross-section in a specified time by wave action.
Sediment Transport (Rate)	The rate at which sediment is transported along a beach – mainly driven by wave caused sediment agitation and longshore currents.
Semi-diurnal	A twice-daily variation, for example, two high tides per day.
Shear Strength	The capacity of the bed sediments to resist shear stresses caused by flowing water without the movement of bed sediments.
Shear Stress	The stress exerted on the seabed by flowing water/waves. The faster the velocity of flow the greater the shear stress.
Shoals	Shallow areas created by the deposition and build-up of sediments.
Subtidal	Waters below the low-tide mark.
Taxon (plural taxa)	The named taxonomic unit to which individuals, or sets of species, are assigned (e.g. genus, species, family etc).
Tides	The regular rise and fall in sea level in response to the gravitational attraction between the Sun, Moon and Earth.
Total Length (fish)	Length from tip of the snout to the tip of the tail.
T_P	Wave energy spectral peak period, that is, the wave period associated with the highest ordinate in the wave energy spectrum.
Maximum size (fish)	The maximum reported size.

Abbreviations

ADCP	Acoustic Doppler Current Profiler.
AMCA	Australian Communications and Media Authority.
AMSA	Australian Marine Safety Authority
ANZECC/ARMCANZ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT.
ARI	Average Recurrence Interval.
BACI	An approach to sampling design (Before, After, Control, Impact).
BRUVS	Baited, Remote, Underwater, Video, Station.
CD	Chart Datum.
CEMP	Construction Environmental Management Plan.
CMA	Catchment Management Authority.
dB	Decibels
DECCW	Department of Environment, Climate Change and Water (NSW).
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth).
EAC	East Australia Current.
EMP	Environmental Management Plan.
EPA	Environment Protection Authority (State).
EPBC	Environment Protection and Biodiversity Conservation Act (Commonwealth).
H_{max}	Maximum wave height in a specified time period.
H_s (Significant Wave Height)	The average of the highest 1/3 of wave heights in a wave record (H1/3), or from the zeroth spectral moment.
KTP	Key Threatening Process.
$L_{Aeq\ (15\ min)}$	Ambient noise level for a given period (e.g. 15 min).
LALC	Local Aboriginal Land Council.
MSL	Mean Sea Level.
NATA	National Association of Testing Authorities.
NES	National Environmental Significance.
NIMPIS	National Introduced Marine Pest Information System.
NPA	National Parks Association.
NRMR	Natural Resource Management Region.
OAR	Offshore Artificial Reef.
OH&S	Occupational Health and Safety.

PER	Public Environment Report
PSD	Particle Size Distribution.
SEPP	State Environmental Planning Policy.
SREP	Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.
T_P	Wave energy spectral peak period, that is, the wave period associated with the highest ordinate in the wave energy spectrum.

1 Introduction

1.1 Background and Aims

Industry & Investment NSW (I&I NSW - formerly the NSW Department of Primary Industries), with funding from the Recreational Fishing Trust, propose to improve recreational fishing opportunities in NSW by deploying offshore artificial reefs (OARs) in the vicinity of Newcastle, Sydney and Wollongong. It is initially proposed to deploy an OAR at one location to enable monitoring and assessment of the success of the OAR before proceeding with the other two locations. The proposal is considered a Major Project under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and approval will be determined through an Environmental Assessment (EA). The proposal also requires approval under Commonwealth legislation, as it is considered to have a significant impact on matters of National Environmental Significance (NES) and the construction of artificial reefs is regulated under the *Environment Protection* (*Sea Dumping) Act 1981* (EP (SD) Act). Separate guidelines have been issued to meet the requirements of both State and Commonwealth legislation (Appendices 1 and 2). The Department of the Environment, Water, Heritage and the Arts (DEWHA) has requested that all requirements are addressed in a single EA/draft PER document. I&I NSW commissioned Cardno Ecology Lab Pty Ltd (formerly The Ecology Lab Pty Ltd) to prepare the EA/draft PER (i.e. this report).

The primary objective of the proposal is to improve offshore recreational fishing opportunity by creating new fish habitat and providing additional fishing locations. The proposal also includes the implementation of a long-term scientific monitoring program to assess the effectiveness of the OARs and identify any potential impacts on the environment. The project is funded by the Recreational Fishing Trust and the OARs have been designed and located for the benefit of recreational fishing. Other potential user groups such as commercial operators would not be excluded from utilising the reefs.

The deployment of the offshore artificial reefs (OARs) would complement existing recreational fishing enhancement projects managed by I&I NSW, such as fish aggregation devices (FADs) and the estuarine artificial reef (EAR) project, which have proven successful fisheries enhancement tools over the past seven years. Deployment of offshore fishing reefs is also considered to be consistent with objectives of the NSW *Fisheries Management Act 1994* (FM Act) by conserving, developing and sharing fisheries resources of the State for the benefit of present and future generations.

The following terms relevant to locations and configurations are referred to throughout the report. These terms are also important as they are used to define the scale and extent of potential impacts.

- Reef unit – a single artificial reef unit.
- Reef set – two or more individual reef units (i.e. the multi-component artificial reef or OAR).
- Reef group – two or more reef sets.
- Direct study area – the area occupied by each ‘reef set’, including an area of approximately 4 km^2.
- Wider study area – the area outside of the direct study area within the study region.
- Study regions – the three metropolitan regions selected for OAR installation (Newcastle, Sydney and Wollongong).

The OARs would be deployed off Newcastle, Sydney and Wollongong. In each study region, the proposal is for the installation of four individual ‘reef units’ at water depths between 30 m – 40 m. The four ‘reef units’ would collectively create a ‘reef set’ (i.e. a multi-component artificial reef). Initially only one of the three locations would be selected for the deployment of a reef set. Reef units would rest directly on the seabed and would not require additional anchorage other than the weight of the unit. The proposed design for reef units has drawn upon the extensive research and development undertaken in Korea and Japan, where artificial reefs have successfully been used to enhance recreational and commercial fisheries for over 30 years. The design of the reef units has been adapted to suit local conditions and popular recreational angling species such as snapper and yellowtail kingfish.

Appropriate structure design, exact locations and configurations of the proposed OARs are outlined within Sections 4.2 and 4.3, but would be finalised subject to the projects approval. Potential locations for staging the construction of the units have also been identified but would be finalised post-approval (Section 4.4).

Creating a successful artificial reef entails planning, monitoring and evaluation measured against project goals and objectives to ensure that the maximum benefits are achieved. A significant amount of planning has already been undertaken in relation to the design and site selection of the proposed OARs. Prior to this EA/draft PER, Cardno Ecology Lab together with Worley Parsons was commissioned by I&I NSW to identify potentially suitable locations for the OAR structures in the vicinity of Newcastle, Sydney and Wollongong. The initial report (The Ecology Lab 2008a) used existing information to identify and map the major physical, oceanographic and biological constraints and recommend potentially suitable areas to locate the reefs. The report also highlighted gaps in information where further baseline investigations would be required.

As part of the EP&A Act, Part 3A process, I&I NSW then commissioned a Preliminary Environmental Assessment (PEA) of the proposal, carried out by Cardno Ecology Lab in February 2008 (Technical Report A). The PEA, together with feedback from a Planning Focus Meeting (PFM) conducted by I&I NSW, identified statutory obligations under State and Commonwealth legislation, areas of responsibility for government departments and key areas for consideration in a more detailed Environmental Assessment of the proposal. Participants from a range of government agencies and relevant stakeholders were initially consulted, including NSW Department of Planning, NSW Department for Environment, Climate Change and Water (DECCW), NSW Department of Lands, Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA), NSW Maritime Authority and relevant Port Authorities. The final Director Generals Requirements (DGRs) were received by I&I NSW on 25 July 2008 (Appendix 1). Requirements to satisfy Commonwealth legislation were issued in May 2008 (Appendix 2).

The EA/draft PER addresses both State and Commonwealth requirements and provides sufficient information to be used as a reference for determination of the proposal by the Department of Planning (NSW) and DEWHA. The main requirements of this EA/draft PER are to:

- Describe the project proposal, including the need for the project, alternatives considered, the likely staging of the project and plans outlining the spatial arrangement of the deployed structures;
- Outline the statutory obligations, policies and guidelines relevant to the deployment of artificial reefs in NSW waters;
- Present the views of relevant stakeholders including local, State and Commonwealth government authorities and affected user groups;
- Undertake a risk analysis of potential environmental impacts of the project associated with the construction, transport, deployment and operation of the OARs, identifying key issues for further assessment;
- Assess potential impacts on the following matters of NES:
    - Listed threatened species (Sections 18 and 18A of the Act);
    - Listed migratory species (Sections 20 and 20A of the Act); and
    - The Commonwealth marine area (Sections 23 and 24A of the Act).
- Carry out a detailed impact assessment of issues identified in the risk analysis. This would include:
    - a description of the existing environment;
    - an assessment of potential impacts of all stages of the project, including cumulative impacts, taking all relevant statutory provisions, technical or policy guidelines into consideration;
    - a description of management and mitigation measures including a Monitoring Plan and Environmental Management Plan (EMP).
- Provide a statement of commitments outlining all the proposed environmental management and monitoring measures that would be implemented;
- Justify the project on economic, social and environmental grounds.

1.2 Legislative Context

Under Part 3A of the State *Environmental Planning and Assessment Act 1979 (*EP&A Act*)* the proposal is considered a Major Project and will require approval by the Minister for Planning by Environmental Assessment (EA). Under clause 75B 2(b) of the EP&A Act*,* Part 3A projects include an activity for which the proponent (I&I NSW) is also the determining authority.

In April 2008, the proposal was referred under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) to the Minister of the Environment, Heritage and the Arts. It was determined that the proposal will also require approval under the EPBC Act as the project is considered to have a significant impact on the following matters of National Environmental Significance (NES):

- listed threatened species (Sections 18 and 18A of the Act);
- listed migratory species (Sections 20 and 20A of the Act); and

- the Commonwealth marine area (Sections 23 and 24A of the Act).

The placement and construction of artificial reefs is also regulated under the Commonwealth *Environment Protection* (*Sea Dumping*) *Act 1981* (EP (SD) Act) and requires application for a permit. DEWHA has advised that the guidelines issued for approval under the EPBC Act have been scoped to meet the information requirements of both the EPBC and EP (SD) Acts and so only one set of Commonwealth guidelines have been issued (Appendix 2)

Figure 1 illustrates the assessment and approvals process under the State *EP&A* and Commonwealth EPBC Acts respectively. As can be seen, the processes and requirements are very similar for State and Commonwealth legislation. Requirements for both State and Commonwealth assessment (Appendices 1 and 2) will therefore be addressed in this EA/draft PER document.

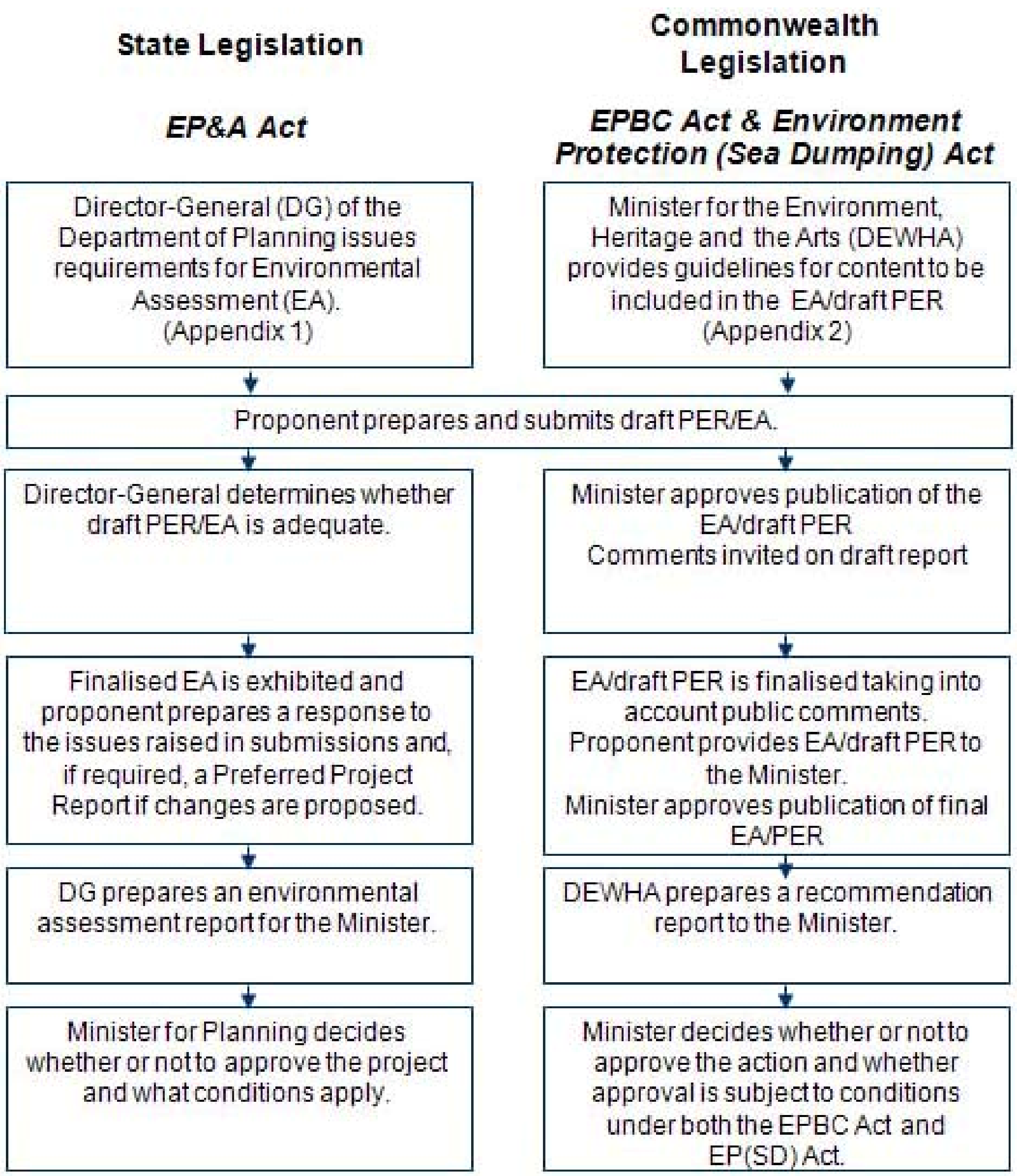


Figure 1: Steps in the assessment and approvals process.

1.3 Project Team

Cardno Ecology Lab has coordinated a team of highly qualified environmental practitioners with extensive experience in ecology, environmental management, oceanography and coastal processes of the NSW coast (Figure 2). Cardno Ecology Lab has been responsible for the preparation of all documentation, stakeholder consultation, risk analysis and specialist flora and fauna investigations. Cardno Ecology Lab has engaged the services of Cardno Lawson Treloar (Coastal, Oceans and Environment Group) to provide expertise in wave behaviour and sediment circulation, navigation and safety, impacts on submerged indigenous heritage and assess environmental impacts associated with the construction, transport and deployment of the structures. Worley Parsons reviewed relevant planning and legislative requirements, contributed to aspects of the risk analysis, provided an overview of the construction and deployment process, assessed impacts associated with the structural stability of the structures and assisted in developing procedures to monitor the structural integrity of the reefs. Worley Parsons also contributed to the Offshore Artificial Reefs 'Location and Constraints Mapping' study (Appendix 1 of Technical Report A), Planning Focus Meetings and the Preliminary Environmental Assessment (Technical Report A). The Department of Environment, Climate Change and Water (DECCW) Waters and Coastal Science Section undertook acoustic seabed surveys and provided maps of habitats in the vicinity of the proposed reef locations. Finally, Cosmos Coroneos Archaeological Consultants provided background information on submerged heritage in the vicinity of the proposed reefs.

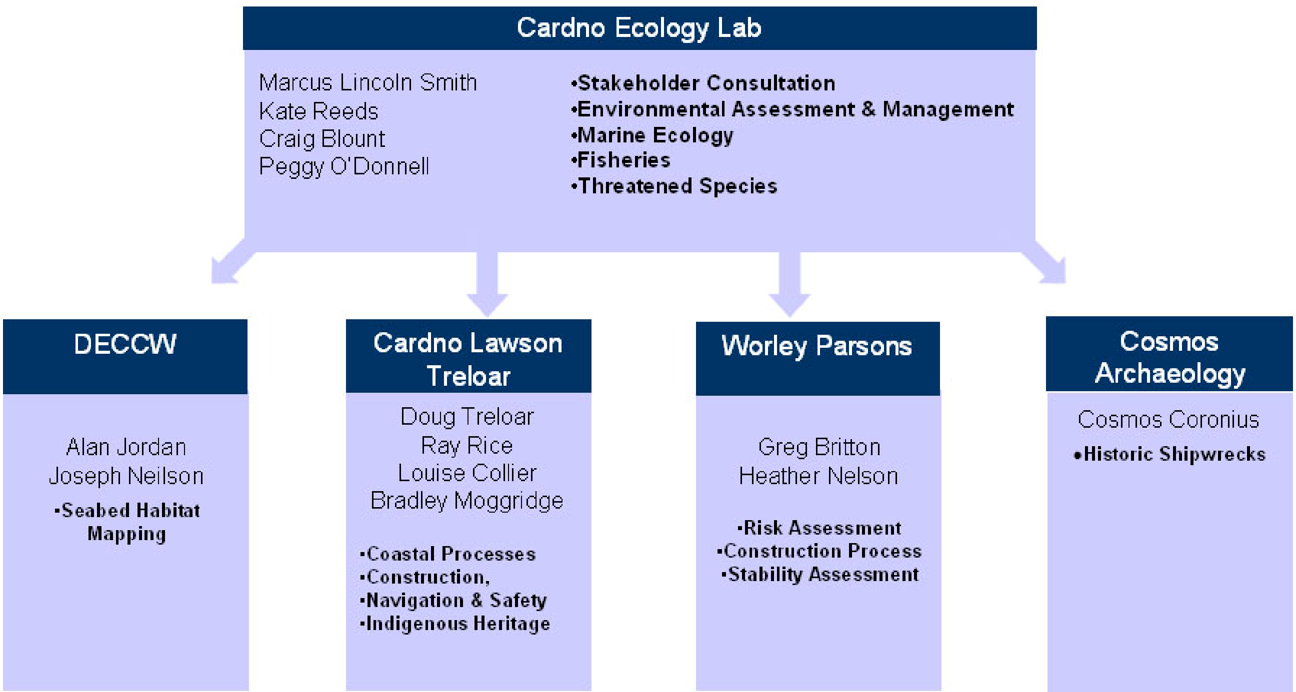


Figure 2: Offshore Artificial Reefs EA/draft PER study team.

2 Review of Existing Information on Artificial Reefs

2.1 Introduction

Artificial reefs have been defined as ‘a submerged structure deliberately placed on the seabed to mimic some characteristics of a natural reef’ (European Artificial Reef Research network 1998). Objectives for the deployment of artificial reefs include the enhancement of recreational and commercial fishing, diving, coastal protection and mitigation of habitat loss and damage (Seaman and Jensen, 2000).

2.2 Artificial Reefs Worldwide

Artificial Reefs have been deployed in up to 40 countries around the world for over three decades in response to problems concerning coastal resources, ecosystems and fisheries (Baine, 2001; Santos and Monteiro 2007). Global trends show that older well-established reef deployment practices have been used to enhance artisanal, commercial and recreational fishing, including some SCUBA diving and spearfishing. Newer practices emerging in the past 10 – 20 years include aquaculture, recreational SCUBA diving, habitat restoration, environmental mitigation and reefs constructed purely for experimental research (Seaman 2002). The two principle goals of these applications are economic/community development and more recently environmental resource conservation (Seaman 2002). In many countries artificial reefs have now become important elements of integrated fisheries management plans (Santos and Monteiro 2007). There has also been a trend towards the use of specifically designed structures as opposed to opportunistic waste materials (Section 2.4).

In the United States (US), greater demand for recreational fishing opportunity and habitat enhancement have been the main drivers for an exponential increase in the number of permitted artificial reefs (Bohnsack 1997). US artificial reefs have also been used for aquaculture, such as oyster culture in Chesapeake Bay (east coast) and restoration of Kelp Beds in San Clemente (west coast). Patented ‘reef ball’ technology using purpose built, moulded concrete modules has been extensively used in almost all coastal States, with approximately 29 projects in Florida alone (Web Reference 1). In South Carolina, permits were given for the continued development of 38 artificial reef construction sites along the coast, located at depths between 3 m to 37 m, ranging from inshore locations to areas as far as 56 km offshore (Web Reference 2). The US National Oceanic and Atmospheric Administration (NOAA) has since developed a National Artificial Reef Plan including practical guidelines for the siting, development and construction of artificial reefs to assist in managing the escalating number of artificial reef projects.

In Europe, the construction of artificial reefs began in the late 1960s and they have since been in deployed in Norway, Poland, Finland, UK, France, Germany, Greece, Turkey, Spain, Italy, Netherlands, Israel, Russia and Portugal. The artificial reef complex of the Algarve (Southern Portugal), deployed for the purpose of restoring and enhancing fisheries resources is currently the largest structure of its kind in Europe, extending over 43.5 km^2 (Ramos *et al*. 2007) and consisting of seven artificial reef systems (Boaventura *et al*. 2006). The large-scale reefs were approved after the success of a 14 year pilot project run by the Portuguese Institute of Marine Research (IPIMAR). In Italy, ten artificial reef sites were developed in the Ligarian Sea over a 30 year period. Extensive research over this period has resulted in the main aims of these reefs (protection against otter trawling and increase in species diversity/biomass) being achieved (Santos and Monteiro 2007). In the UK, artificial reefs have been developed for fisheries enhancement through creation of habitat for lobsters and more recently for recreational diving and surfing. Research on decommissioned gas and oil rigs as artificial reefs has also been undertaken in the North Sea and Adriatic as an alternative to disposal (Baine 2002, Massimo *et al.* 2002, Fabi *et al.* 2004, Løkkeborg *et al.* 2002). Although there have been some increases in total catch and species diversity in and around the platforms, there is a sharp division between stakeholder proponents and opponents and use of decommissioned oil rigs remains controversial in the UK.

Since 1995, the EARRN, a collaboration of over 50 scientists from 36 laboratories, has been active in artificial reef research. The network aimed to promote awareness of artificial reef programs throughout Europe, improve collaboration between projects and help reach a consensus on the direction of future research.

Overexploitation of fisheries and degradation of coastal and marine habitats has prompted extensive development of large-scale artificial reefs in South-East Asia (Pauley and Chua 1988). Artificial reefs have been developed in Malaysia, Thailand, the Philippines, Taiwan, Singapore, Brunei, Indonesia, Hong Kong and Japan. Early reef designs were constructed mainly from car tyres, but also from concrete culverts and scrap vessels. In Asia, many previous artificial reef siting exercises failed through incorrect siting (Chang, 1985 in Kennish *et al.* 2002). Japan and Korea have recently become leaders in research and development of purpose built, large-scale artificial reefs for fisheries enhancement. Long-term monitoring studies have shown that artificial reefs yielded catch volumes 2 – 13 times greater than those of natural reefs (Kim 2001). In 2001, Korea planned to invest over $2 billion (US) in coastal fisheries enhancement projects over a 6 year period. Many of the world's largest reefs have been deployed in Japan, as part of the national fisheries program for enhancement of commercial fish stocks. They include both shallow water reefs targeting shellfish and deeper water reefs for finfish.

2.3 Artificial Reefs in Australia

There have been at least four detailed reviews of artificial reefs in Australia (Pollard and Mathews 1985; Kerr 1992; Branden *et al*. 1994 and Coutin, 2001). Collectively these reviews detail the development of Australian artificial reef design, construction, deployment and monitoring from 1965 to 2001. The first artificial reef was created from concrete pipes laid in Port Phillip Bay (Kerr 1992). Within a few years there were reefs constructed of various materials (tyres, concrete rubble and or car bodies) in NSW, South Australia, Western Australia and Queensland. The main purpose of artificial reefs in Australia is for recreational fishing and diving (Branden *et al,* 1994). Historically, materials of opportunity (waste material) have been the main materials used in their construction (Pollard, 1989; Kerr, 1992).

A number of ex-naval vessels have been scuttled in Australian waters with the purpose of creating artificial recreational dive reefs. Examples include the ex-HMAS *Swan* (off Dunsborough, WA) the ex-HMAS *Hobart* (off Yankalilla Bay, South Australia), the ex-HMAS *Perth* (off King George Sound in Albany, WA) and the ex-HMAS *Brisbane* (off the Sunshine Coast in Queensland). There are currently plans to scuttle the ex-HMAS *Adelaide* offshore from Terrigal, (Central Coast, NSW) in April 2010. The *Adelaide* was decommissioned by the Australian Navy in January 2008 and has been handed over to the NSW Government for the purpose of creating a recreational dive site. Depth and proximity to onshore infrastructure for divers along with investigations into geotechnical, oceanographic and ecological aspects of the area were used to select a placement location approximately 1.67 km offshore of north Avoca Beach (1.51 km south-west of the Skillion). The artificial reef will include a zone of exclusion to fishing called 'The ex-HMAS *Adelaide* Reserve.' Creation of the artificial reef is expected to boost the local economy (particularly from increased dive tourism and hospitality), enhance marine biodiversity in the vicinity of the scuttled ship and provide ongoing research opportunities for the University of Newcastle which is located nearby (The Ecology Lab 2008c).

In NSW, the use of artificial reefs began in 1966, with the deployment of a series of multi-component artificial reefs in Lake Macquarie using car bodies and tyres (Pollard and Mathews 1985; Pollard 1989). Augmentation of these reefs continued in the 1970s with additional reefs constructed in Batemans Bay, Port Stephens and Port Hacking using car tyres (Coutin 2001). Since the 1970s, up to 12 vessels have been scuttled to create single-component artificial reefs in NSW coastal waters, beginning with the retired-ferry the 'Dee Why' in 1976 sunk off Long Reef at a depth of 45 m (Pollard and Mathews1985; Pollard 1989; Coutin 2001). From the mid 1980s a lack of funding and increasingly stringent environmental legislation meant that artificial reef construction in NSW effectively ceased. The introduction of the general recreational fishing fee in 2001, resulted in funding for investigation of the use of artificial structures as a fisheries enhancement tool.

In 2002, a fish aggregating device (FAD) program was established in NSW to provide additional fishing opportunities for sport fishing and game fishers. FADs provide a target location where fast-growing pelagic fish can be targeted by recreational fishers. The FADs consist of a single 600 mm float, moored to the sea-bed at varying depths and distance from the coast. Monitoring of recreational catch composition and factors affecting catch rates of dolphinfish (*Coryphena hippurus*) has been conducted on the FADs (Folpp & Lowry 2006). This project has developed into a long running recreational fisheries enhancement program, with 25 FADs deployed from October to June annually from Tweed Heads to Eden and two trial FADs in the Lord Howe Island Marine Park.

In 2004, I&I began investigations into artificial reefs in coastal estuaries, progressing earlier work done by the Department in the 1970s (Pollard and Mathews, 1985). Using reef ball technology, a number of multi-component artificial reefs were deployed in Lake Macquarie in December 2005, followed by Botany Bay in June 2006, St. Georges Basin in February 2007 and more recently in Merimbula Lake and Lake Conjola. The reef systems vary in size with the largest system in Lake Macquarie consisting of six artificial reef sets (one reef group), utilising a total of 600 Reef Balls, covering an area of more than 3000 m^2 with a volume of 400 m^3. This program is ongoing and additional estuarine reefs are proposed for construction in future. Implementation of the estuarine artificial reefs involved an environmental assessment process and has an associated long-term monitoring program to evaluate their effectiveness. Results indicate that the artificial habitat has been successful in maintaining an increase in fish abundance and diversity and that extensive marine plant growth has occurred on the surface of the reef ball units (Lowry & Folpp, unpublished data). The reefs have also been a success in terms of enhancing recreational fishing opportunities. Eight months after construction, catch abundance, catch diversity, and catch rates of recreational species on the artificial reefs were found to be as good as or better than control sites (naturally occurring reefs) within Lake Macquarie (University of Newcastle, *unpublished data*). I&I NSW has also carried out studies to develop the most efficient and effective techniques for monitoring the artificial reef fish assemblages which involve a combination of underwater visual census (UVC) and baited remote underwater video (BRUV)(Lowry *et al*. 2009). Results of these studies have been presented at international symposia for artificial reefs and habitats. The estuarine artificial reefs project has provided the necessary monitoring and management experience required for the investigation of the potential implementation of large multi-component artificial reefs in NSW coastal waters.

2.4 Materials and Design

Historically, artificial reefs have been created out of a range of opportunistic or secondary (waste) materials (Pollard 1989, Kerr 1992). Examples include decommissioned vessels, car bodies, discarded tyres, railway cars and surplus military equipment (for example). Although the deployment of such opportunistic structures remains the more common option in artificial reef construction, there is a growing trend towards dedicated reef designs (Pickering and Whitmarsh 1997).

Specifically designed and manufactured reef structures are now used in many countries, particularly Japan and Korea. 'Design specific' structures are considered a better alternative to using opportunistic materials as they are more effective in achieving specific fisheries management objectives (Sherman *et al*. 2002). While the use of opportunistic materials may be cheaper initially, mainly due to the lack of design and manufacture cost, a purpose built artificial reef design is preferable over opportunistic materials for the following reasons:

- the proposed manufactured design facilitates long-term planning and budgeting as the project is not dependent on the availability of suitable secondary materials;
- purpose-built designs can be engineered to suit the specific aims and objectives of the artificial reef program targeting specific species, user groups and fishing gears;
- purpose-built designs can also be manufactured to suit a chosen location in terms of depth, oceanographic conditions and substratum type;
- Choice of suitable material can maximise the duration, durability and compatibility of the structure in the marine environment and avoid problems associated with material toxicity or cleaning;
- the overall effectiveness and lifespan of the manufactured design is considered to yield comparatively greater cost-benefits than the use of secondary materials.

A variety of alternative materials have been used to manufacture artificial reefs, designed to enhance fisheries. These include concrete, iron and steel, reinforced concrete (concrete and steel), ceramic, plastic, plastic concrete (concrete mixed with polyethylene, polypropylene sand and iron) and fibre reinforced plastic amongst others (O'Leary *et al.* 2001). Designs include concrete blocks in a variety of shapes (e.g. blocks, cylinders and domes) dimensions and configurations, patented reef balls of varying dimensions and high relief, complex steel structures.

Artificial reefs for fisheries enhancement are now being designed according to the types of target species, as different species of fish respond to hard objects differently (Kim 2008). For example, in Korea the differing ecological needs of porgy and sea bass for shelter, guided the steel and concrete design of box reefs to enhance productivity in marine ranching. The effect of these and other structures on fisheries catch is considered positive (Seaman 2007).

2.5 Benthic Ecology

Factors affecting Benthic Assemblages

Benthic assemblages on hard surfaces (natural or artificial) are strongly influenced by a wide range of environmental variables including water depth (Rule and Smith 2007, Moura *et al*. 2007), orientation in relation to prevailing currents (Baynes and Szmant 1989), orientation of surfaces (Glasby and Connell 2001, Knott *et al*. 2004), complexity of surfaces and structure (Edwards and Smith 2005, Moura *et al*. 2007) and rates of sedimentation (Baynes and Szmant 1989 in Walker *et al*. 2007). Ecological processes such as recruitment (Perko-Finkel and Benayahu 2007) and succession (Nicoletti *et al*. 2007) are also influential.

Comparisons of benthic assemblages on natural and artificial reefs indicate that although they may share many similar taxa, there may be differences in the overall assemblages. Some taxa may be more abundant and diversity may be greater on natural compared to artificial reefs and vice-versa (Edwards and Smith 2005). Diversity of species on new reefs (such as artificial reefs) generally increases through time to a point of relative stability (Ardizzone *et al*. 1989 in Edwards and Smith 2005).

Colonisation

In southern Portugal, small differences in depth (16 m – 20 m) and structure of artificial reefs influenced macrobenthic animals after 6 months of immersion (Moura *et al*. 2007). Three months after immersion more than half the sample area was colonised by macrobenthic species and after 6 months, the entire surface was covered. Sessile encrusting organisms such as barnacles, bryozoans, polychaete worms (family: Serpulidae) and ascidians colonised the reefs with a clear dominance of barnacles (Boaventura *et al*. 2006). These taxonomic groups have been found to colonise artificial reefs in various types of artificial reef structures (Boaventura *et al*. 2006) although the sequence of macrobenthic colonisation appears to vary according to season and location.

Colonisation of sunken vessels by sessile invertebrates has proven to be relatively rapid. For example, the ex-HMAS *Brisbane* (Queensland) became colonised within three months of deployment by red, brown and blue/green algae, limpets and goose barnacles (Queensland EPA 2007). Mobile invertebrates such as crabs, shrimps, crayfish and octopus were recorded within nine months. A diverse assemblage of mobile marine invertebrates including nudibranchs, opisthobranchs, cuttlefish, octopus and starfish have been observed around the wreck of the ex-HMAS *Hobart* (South Australia) following its deployment in November 2002. Sessile sponges, ascidians, polychaete worms and soft corals are now well established. Biological monitoring of the ex-HMAS *Swan* (Western Australia) over a two year period showed that hydroids initially covered approximately 70% – 90% of the area surveyed (Morrison 2001). Algal growth, however, also dominated the encrusting marine life during the summer months, particularly on the upper surfaces. Sessile groups such as sponges, ascidians, anemones and soft corals proliferated on shaded portions of the vessel.

Long-term studies of succession of benthic artificial reef assemblages show that changes still occur after a number of years. Monitoring benthic assemblages on a purpose-built pyramidal artificial reef in Eilat (Israel) over a 10 year period demonstrated a shift in species composition over time from a community dominated by soft corals (up to 2 years) to a sponge dominated community (year 10), Perkol-Finkel and Benayahu (2004). Comparisons with neighbouring natural reefs indicate that the artificial reef assemblages may continue to adapt even after this time. In the Tyrrhenian Sea of Italy, Nicoletti *et al*. (2007) distinguished five different phases in artificial reef colonisation over a 20 year period:

- after 1 month - pioneer species recruitment (hydroids, serpulid polychaetes, barnacles and molluscs);
- after 3 months - mussel dominance (*Mytilus galloprovincialis*);
- after 3 years - mussel regression (increase in soft bottom species), 10 years – mussel absence (a new benthic assemblage characterised by soft bottom species established on the hard surfaces); and finally
- after 20 years - dominance of bryozoans (characterised by bioconstructing bryozoans and a strong increase in diversity of hard and soft bottom species.

The impacts of artificial reefs on surrounding soft bottom habitats have also been investigated (Wilding 2006, Ambrose and Anderson 1990, Davis *et al*. 1982, Fabi *et al* 2002, Steimle *et al*. 2002). Soft bottom assemblages may consist of ‘infauna’ which burrow to depths of about 50 cm into the sediments, and ‘epifauna’ which live on the surface of the sediments. Soft bottom habitats adjacent to artificial reefs may be affected by altered wave field and current patterns which in turn, can influence sediment grain size, scouring and sand ripple patterns (Davis *et al*. 1982). These physical factors appear to affect the composition and abundance of infaunal communities more than biological factors such as predation (Fabi *et al*. 2002). While some studies have found no difference in densities of infaunal and epifaunal assemblages at distances away from an artificial reef (Davis *et al*. 1982) others have shown that densities of some species were enhanced while others were depressed (Ambrose and Anderson 1990). Artificial reefs have potential to alter the trophic structure of nearby fauna by changing the available forage food if some of the species associated with a new artificial reef feed on surrounding soft-bottom habitats. There is evidence that feeding halos can occur around artificial reefs so that abundance and species richness of flora or prey items decreases (Bortone *et al*. 1998). This has potential to affect the food of demersal fish living on soft-bottom habitats and fish of nearby natural reefs.

2.6 Fish Ecology

Factors affecting Fish Assemblages

Size, relief, complexity, location and biological factors can all influence assemblages of fishes on artificial reefs (Bohnsack *et al*. 1994, Kim *et al*. 1994). The types of species that recruit to and colonise the artificial structure is also likely to depend on the time of year that they are deployed.

Reef size and its influence on species abundance is an ongoing debate. Where biomass has been reported in association with large artificial reefs, it may be composed of large but few individuals (Pickering and Whitmarsh 1997). Bohnsack *et al*. (1994) found greater densities of fish on smaller artificial reefs. The relief (or height) of artificial reefs can influence abundance and diversity. In temperate waters, diversity has been shown to be greater on low-relief artificial structures than on natural structures (e.g. Ambrose and Swarbrick 1989) but a study of high-relief reefs found greater diversity on natural reefs than on artificial reefs (Burchmore *et al*. 1985). In tropical waters the effects may be different. A study of low-relief artificial structures did not show the same effect as for temperate waters (e.g. Bohnsack *et al*. 1994) and greater diversity and abundance (relative to natural reefs) has been shown to occur on high-relief structures (Rilov and Benayahu 2000).

It follows that the more complex an environment, the more ecological niches are created. Artificial structures have potential to be complex in terms of their physical makeup and in how they may alter water flow, turbulence and light levels around them. For example, the variety of crevices can contribute significantly to the species composition of artificial reefs (Anderson *et al*. 1989, Carr and Hixon 1997), or small fish, which need a place to rest may prefer the lee side of artificial structures (Dean 1983 in Pickering and Whitmarsh 1997). Regardless, of the number of niches created by an artificial reef, they are likely to be different to natural reefs and for this reason it is not uncommon for assemblages on artificial reefs to be different from those on natural reefs (e.g. Lincoln Smith *et al*. 1988).

The location of an artificial reef can be particularly important to diversity and abundance (Burchmore *et al*. 1985). Some fish, for example, may not occur at particular depths. Burchmore *et al*. (1985) also suggest that the proximity of artificial reefs to existing reefs or the ocean, in the case of estuarine artificial reefs, could increase the chance of recruitment or visitation from neighbouring oceanic areas. Water circulation patterns that provide nutrients or food or substrata that provide sources of food are also likely to be important.

Biological factors can be important. Adult fishes may limit the number of juveniles able to settle (Russell *et al*. 1974) as may other competitors. Encounters with predators have been shown to be less on artificial reefs compared to natural reefs (Sweatman and Robertson 1994) and this may influence mortality (Connell 1997). This effect may be associated with the often isolated nature of artificial reefs.

Colonisation

Initial colonisation of artificial reefs by fish is likely to be rapid. This is due to the behavioural response of fish to hard objects, such as the tendency of certain species to move towards structure, rather than bare, featureless habitat (Brickhill *et al*. 2005). Over time, fish assemblages colonising artificial reefs may become similar in species composition to neighbouring natural reefs (Clynick *et al*. 2008, Santos and Monteiro 2007, Relini *et al.* 2002), although similarities between natural and artificial reefs appear to be dependent on the similarity of structural properties of the reefs (Perkol-Finkel *et al*. 2006, Edwards and Smith 2005).

Species of fish colonising an artificial reef may live permanently on the structure (residents) or be transient visitors. The artificial reef initially provides refuge until colonised by sedentary and attendant organisms which also provide food for the resident fishes. Transient visitors are thought to use the OAR as a temporary refuge, but do not feed there consistently.

Colonisation by fishes of an experimental artificial reef in St. Peter the Great Bay, the Sea of Japan, was generally found to occur within two to six months with final stabilisation occurring after two years with only slight changes thereafter Markevich (2005). The season of deployment was an important factor in determining the type and abundance of species that colonised the artificial reef. Artificial reefs deployed in spring or early summer were more rapidly colonised than those deployed in autumn due to patterns of plankton settlement.

On the wreck of the ex-HMAS *Brisbane,* common hardyhead, yellowtail scad and baitfish (transient visitors) were observed within weeks of the artificial reef being deployed. After three to six months, a number species including batfish, blennies and emporer fish (residents), slimy mackerel, yellowtail kingfish, whiting, sweetlips, amberjack, flounder, flathead, rays, dolphinfish, trevally, leatherjacket and pilchards (transient species) were observed. Within six to nine months, greasy cod, red firefish, scorpion fish, damsel fish guitarfish and spotted wobbegongs were found to be permanent on the wreck. Anglerfish, lionfish, garfish, triggerfish, snapper and bonito (among others) were also observed (Queensland EPA 2007).

Monitoring of the ex- HMAS *Swan* over a two year period showed an increase in average species richness from 2 to 32 species and an increase in abundance from 10 to approximately 1300 individuals relative to a control site. The fish assemblages showed a gradual increase in abundance over the monitoring period and a rapid increase in mean diversity within the first two months of deployment. The assemblage on the wreck showed a rapid shift from omnivorous weed/sand fishes to one dominated by planktivorous and carnivorous reef fishes. The ten most common species found on the wreck were rough bullseye, tarwhine, globe fish, silver trevally, footballer sweep, black-headed puller, long-finned pike, King George whiting, black spotted wrasse and the southern blue-spotted flathead. The species diversity and abundance on the wreck became similar to that of existing natural reefs over time, although the species composition on the vessel remained distinctly different.

Attraction v Production

There is an ongoing debate in the scientific community about whether artificial reefs increase overall production of a defined area (as they provide new habitat in an otherwise saturated environment) or whether they merely attract and aggregate existing fish to a new location i.e. the artificial reef attracts fishes, which would have settled, survived and grown on natural habitats in its absence (Brickhill *et al*. 2005). This has become known as the 'attraction versus production' issue.

Attraction is defined as the net movement of individuals from natural to artificial habitats whereas a simplified definition of production is accumulation of biomass over time (Carr and Hixon 1997). In assessing the effects of artificial reefs on production, it is essential to define explicitly the region or management area in question (Carr and Hixon 1997) as well as the loss of production to habitat that artificial reefs replace. The size of a management area and the spatial distribution of reefs within that area can influence interpretation of the effects of an artificial reef. For example, if no natural reef occurs in a management area containing an artificial reef, then any obligate reef organism on the artificial reef has necessarily enhanced production on reefs within that management area. Clearly, the smaller the management area, then the greater the contribution of the artificial reef to that area will be. However, there may also be a loss of production from the habitat replaced by the artificial reef (usually soft sediment) and this is seldom taken into account.

The question of whether artificial reefs merely redistribute fishes from surrounding areas, or whether they in fact increase production of reef fish is not clear. To increase overall reef productivity, artificial reefs must provide additional habitat which increases carrying capacity. This could be done by:

- providing new substrata for benthic fauna and flora (food sources of fishes);
- providing shelter from predation; recruitment habitat; spawning habitat and/or;
- reducing harvesting pressure on natural reefs (Pickering and Whitmarsh 1997).

In support of the production hypothesis, artificial reefs have been found to increase the local biomass of benthic invertebrates and fishes (Pickering and Whitmarsh 1997). Brickhill *et al*. (2005) report that production is more likely to occur with the addition of more reefs, or more complex reefs and that artificial reefs can also act as nursery areas for economically important species. One theory states that concentrating food resources and/or increasing feeding efficiency by deployment of artificial reefs can increase localised fish productivity in the long-term, through trophic linkages (Leitao *et al*. 2007, 2008b).

This does not however, indicate unequivocally that biomass increases at a regional scale as it is difficult to discern whether:

- fishes that settle or are attracted to artificial reefs would have found suitable habitat if these reefs were not present;
- fishes would have better survival, growth or recruitment on artificial reefs than on natural habitats;
- foraging success and food web efficiencies have improved; or
- habitat is vacated by fishes moving from natural habitats to artificial reefs (Bohnsack *et al.* 1994).

Wilson *et al*. (2001) suggest that both attraction and production are likely to interact in driving artificial-natural reef complexes and that much of the question relates to the role of larval supply and density-dependence driving fish dynamics in general (Hixon 1998, Tupper and Hunte 1998). Osenburg (2002) also considers that attraction and production are not mutually exclusive and can be considered as extremes along a gradient. Furthermore, while artificial reefs may simply attract and aggregate some species, they may promote the production of others and the situation is likely to lie between the two extremes. (Bohnsack 1989 in Leitao *et al.* 2008b).

Species most likely to benefit in terms of increased biomass (a surrogate for production) are reef limited, demersal, philopatric (i.e. those that return to their place of origin to breed), territorial and obligatory reef species. The attraction hypothesis is likely to hold for locations where natural reef habitat is abundant and where species have a high fishing mortality, are recruitment limited, pelagic, highly mobile, partially reef-dependent or opportunists (Bohnsack, 1989), which describes at least some of the species for which the NSW OAR would be designed, e.g. snapper and kingfish.

Overall, and ignoring the concept of which is the dominant factor, there is a body evidence that properly designed and managed artificial reefs, particularly when deployed in less complex or reef-limited habitats, can increase the abundance and in many cases diversity of fish assemblages (in comparison to control locations), making them useful management tools in fisheries enhancement and habitat rehabilitation (Santos and Monteiro 2007, Pollard and Matthews 1985, Golani and Diamant 1999, Terashima *et al*. 2007, Rilov 2000, Chua *et al*. 2004, Markevich 2005, Herrera *et al.* 2002).

Increased Fishing Mortality

A major concern with artificial reefs is that they could potentially make recreationally and commercially important species more easily harvestable by aggregating them in one place, thereby increasing fishing mortality. When reefs are located close to boat ramps and their positions mapped, artificial reefs can increase access, and potentially fishing effort to hard-bottom surfaces in an area (McGlennon and Branden 1994). The problem is exacerbated if new reefs attract fishers who previously did not fish hard-bottom areas due to a prior lack of availability, thus increasing overall fishing effort within a management area. Given that individuals from the same populations or stocks would potentially be caught elsewhere, this may not however, result in increased fishing mortality in the wider study area.

Another potentially adverse effect of artificial reefs is increased predation on fish associated with them that leads to an overall increase in natural mortality (Leitao *et al*. 2008a). This could potentially decrease recruitment to populations if predators and prey are attracted to artificial reefs when the latter may be more vulnerable. It is possible however, that the opposite can occur (i.e. where predators are fewer on artificial reefs compared to natural reefs) as a result of the isolated nature of artificial reefs, or that there is no change in mortality as the prey may only have been consumed at an adjacent natural reef.

2.7 Contamination

Artificial reefs in the marine environment tend to corrode over time, potentially affecting adjacent sediments and water quality. Many organisms can accumulate contaminants from surrounding waters, sediment or their food, which persist within their tissues for long periods of time or are transferred to consumers higher up the food chain i.e. bioaccumulation (Amiard-Triquet *et al*. 1993). Where these organisms also function as habitat (e.g. kelp forests), there is potential for accumulated contaminants to negatively effect associated epifauna (Roberts *et al*. 2008). The ocean has great dispersive properties, but there is potential for accumulations of contaminants to be locally significant. Monitoring of the sediment around the ex-HMAS *Swan* (Dunsborough, WA) after it was scuttled indicated marked increases in aluminium, chromium, copper, iron, lead and zinc concentrations (Morrison 2001). This was attributed to corrosion of the superstructure and leaching from antifouling paints. With the exception of mercury and tin, most of these metals do not generally cause toxicity at low concentrations or accumulate in food chains, (Clark 1997). Some studies have suggested that metal toxicity to organisms attached to metal surfaces can be problematic. For example, some damselfishes (Pomacentridae) prefer artificial substrata for their nests and in doing so expose their larvae to metal toxicity which can reduce the number of viable larvae at hatching (Kerr 1996). It is estimated that a steel structure will corrode at a rate of 1.2 mm per 30 years (Korean design). It is therefore likely this will result in the leaching of iron oxide over time and potentially elevated iron levels within sediments adjacent to the reef. Iron is not however, considered a significant contaminant in the sea and even at elevated levels, would be unlikely to have adverse effects on infaunal assemblages (Clark 1997).

3 Statutory Framework

3.1 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 Act details various planning instruments including State Environmental Planning Policies and Local Environment Plans and specifies which types of developments require development consent.

The objectives of this 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;
- promoting ecologically sustainable development.

Threatened Species Conservation Act 1995 (TSC Act)

In NSW, the TSC Act (administered through the NSW Department of Environment and Climate Change) includes provisions to declare and protect threatened species, populations and ecological communities. Species populations and 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 *Threatened Species Conservation Act* provides for the identification of habitat that is critical to the survival of an endangered species, population or ecological community.

Fisheries Management Act 1994 (FM Act)

Provisions for the protection of fish and marine plants are administered through the Department of Industry and Investment (I&I NSW) under the FM Act. Threatened species populations and 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 (administered by DECCW) 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.

National Parks and Wildlife Act 1974 (NPW Act) and the *National Parks and Wildlife Regulation 2002 (NPWR).*

Under the NPW Act, the Director-General of the National Parks and Wildlife Service 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, karst conservation reserves and regional parks are also administered under the 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 *National Parks and Wildlife Regulation* which came into effect on 1 September 2002, governs various activities under the *National Parks and Wildlife Act 1974*, including:

- the regulation of the use of national parks and other areas administered by the NPWS (Part 2);
- the preservation of public health in Kosciuszko National Park (Part 3);
- licences and certificates (Part 4);
- the protection of fauna (Part 5) including the protection of certain types of marine mammals (Division 3A);
- the exemption of Aboriginal people from the restrictions imposed by various sections of the Act on the hunting of certain animals and the gathering of certain plants (Part 6);
- boards of management and plans of management in relation to Aboriginal land (Part 7); and
- advisory committees constituted under section 24 of the National Parks and Wildlife Act 1974 (Part 8).

The regulation replaces the former *National Parks and Wildlife* (*Land Management*) *Regulation 1995*, the *National Parks and Wildlife* (*Administration*) *Regulation 1995* and the *National Parks and Wildlife* (*Fauna Protection*) *Regulation 2001*.

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 OARs would be located on Crown Land and therefore would require 'land owners consent' through the Department of Lands

Coastal Protection Act 1979

The objectives of this Act 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.

Heritage Act 1977

Under this Act, historic shipwrecks are the remains of any ship (including articles associated with the ship) that has been situated in State waters (within the 3nm 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 Act, a permit is required to move, damage, or destroy any historic shipwreck. The Act does not apply to State waters that are waters to which the Commonwealth's *Historic Shipwrecks Act 1976* applies. There are also provisions within the Act which allow for the declaration of an Interim Heritage Order. The *M24* Japanese submarine wreck, for example, is currently the subject of an Interim Heritage Protection Order.

Maritime Services Act

This Act sets out a range of authorisations for a variety of works in and adjacent to navigable waters.

State Environmental Planning Policy No. 71 – Coastal Protection

The aims of this Policy include to:

- protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast;
- protect and preserve the marine environment of New South Wales; 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 within that zone.

Aboriginal Land Rights Act, 1983

The *Aboriginal Land Rights Act 1983* provides a mechanism for compensating Aboriginal people of NSW for loss of their land. The preamble of the *Land Rights Act*, *1983* 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 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 New South Wales Aboriginal Land Council for the acquisition by the New South Wales Aboriginal Land Council of land on behalf of, or to be vested in, the Local Aboriginal Land Council;
- 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 New South Wales Aboriginal Land Council in respect of such applications;
- 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;
- To promote awareness in the community of the culture and heritage of Aboriginal persons in the Council's area.

Protection of Environment Operations Act, 1997 (*PoEO Act*)

The *Protection of Environment Operations Act (1997)* is administered by the Environment Protection Authority (EPA) within DECCW and ultimately aims to protect, enhance and restore the quality of the environment in New South Wales, to reduce risk to human health and promote mechanisms that minimise environmental degradation through a strong set of provisions and offences. This is relevant to the construction of the OARs. A licence is required from DECCW if any of the activities associated with the proposal are determined to be a Scheduled Activity under Schedule 1 of the Act. At this stage, it is not expected that such a licence will be required.

Environmentally Hazardous Chemicals Act 1985

The *Environmentally Hazardous Chemicals Act (1985)* governs the use and disposal of potentially hazardous chemicals and waste material. Any use and/or removal of hazardous chemicals and material defined under this Act require licensing and must be appropriately declared. At this stage it is not expected that any hazardous chemicals will be present at the construction site.

Contaminated Land Management Act 1997

The Contaminated Land Management Act 1997 outlines the assessment criteria and methodology for the management of contaminated land which poses significant risk to human health or the environment. Under the Act, a person or persons (or a public authority) will be held responsible for allowing land contamination to occur. DECCW is responsible for declaring the land as 'contaminated' and will give notice to end the declaration, once satisfied that the land poses no further risk.

Soil Conservation Act 1938

The *Soil Conservation Act 1938* is associated with the preservation of soils and prevention of erosion within a parcel of land. The appointment of a conservation commissioner is primarily to control and protect; proclaimed works, notified catchment areas, rivers, lakes, dams, creeks, lagoons and marshes form the effects of soil erosion, land degradation, siltation and sedimentation. Notice may be issued if the commissioner is of the opinion that the land holder has done or is likely to do something that will ultimately lead to land degradation.

Water Management Act 2000

The management of water state-wide is governed in accordance with the Water Management Act 2000 which repeals and replaces a number of related Acts. The Water Management Act 2000 has replaced the *Rivers and Foreshore Improvement Act (1948)* and now regulates all construction activities in proximity to waterways.

As the current proposal is being assessed under Part 3A of the EP&A Act, a controlled activity approval under the *Water Management Act* will not be required for undertaking of construction activities on waterfront land. However, principles for water quality management as established within the Act require consideration.

Waste Avoidance and Resource Recovery Act 2001

The *Waste Avoidance and Resource Recovery Act 2001* repeals and replaces the *Waste Minimisation and Management Act 1995*. No permits are required under the Act, though the responsibilities of land occupiers are clearly defined with regards to waste production/ management and natural resource usage. The Act makes reference to 'waste strategies' including minimisation and disposal along with efficient use and disposal of natural resources.

3.2 Relevant Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is administered by the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) 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 national significance; and
- Commonwealth marine areas (this extends from 3 to 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).

It is noted that from 3 February 2009, the eastern Australian population of gemfish (eastern gemfish) and school shark were placed in the 'conservation dependent' category on the national threatened species list. The two species were eligible for the category as they had undergone severe population declines in the past but were currently subject to robust fisheries management measures designed to rebuild their stocks (Web Reference 3).

Environment Protection (Sea Dumping) Act 1981(EP (SD) Act)

Under this Act permits are required to create artificial reefs.

Under the Act, 'artificial reef' means a structure or formation placed on the seabed for the purposes of:

- increasing or concentrating populations of marine plants and animals; and/or
- being used in human recreational activities.

Permit conditions usually require research and monitoring to be undertaken, at the applicants expense for dumping or artificial reef placement. Once a permit is issued, the artificial reef is then charted on maritime maps.

DEWHA has advised that the guidelines issued for the EPBC Act (to address matters of NES) have been scoped to meet the information requirements of the EP (SD) Act and so only one assessment under Commonwealth legislation is required.

Historic Shipwrecks Act 1976

The *Historic Shipwrecks Act 1976* 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 artificial reef unit would be under the jurisdiction of this Act. Under Section 4 of the 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 Act. Other shipwrecks can be declared historic and granted this protection on an individual basis according to their particular merits, such as the M24 Japanese submarine. Under Section 13 of the 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. The SS *Duckenfield* and the *M24* Japanese Submarine are located within declared protected zones. Under Section 17 of the Act persons discovering a shipwreck are legally obligated to notify the appropriate authorities of the discovery. Although this is a Commonwealth Act (administered by DEWHA), the Heritage Office part of the NSW Department of Planning, is the delegated authority for this State.

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 within their claim area.

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 within and between generations;
- 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;
- decisions and actions should provide for broad community involvement on issues which affect them.

3.3 Other Relevant Approvals and Permits

In addition to approval under the EP&A and EPBC Acts, a number of other approvals, concurrences, permits and licences are required for the project to proceed, including:

- lease or licence under Section 34 of the *Crown Lands Act 1989* for the area occupied by the OARs;
- permit for artificial reef placement under Section 19 of the *Environment Protection (Sea Dumping) Act 1981 (Commonwealth)*;
- concurrence, under Sections 6 and 7 of the *Coastal Protection Regulation 2004* to carry out work on the open coast below mean high water mark;
- concurrence under Section 199 of the *Fisheries Management Act* if placement of the OARs is considered reclamation work;
- towing permit from NSW Maritime to transport the OAR structures (depending on whether or not a self-propelling barge is used);
- aquatic licence from NSW Maritime for exclusive use of the waters for the purposes of sinking and/or monitoring the structures;
- authorisation under Section 13T of the *Maritime Services Act 1935* for buoys or moorings associated with the offshore artificial reefs.

Note that under Part 3A some separate approvals, such as those listed below, are not required for an approved project:

- concurrence to carry out /grant consent for work or to use/occupy the coastal zone under Part 3 of the *Coastal Protection Act 1979*;
- permits under sections 201, 205 or 219 of the *Fisheries Management Act 1994.*

3.4 Associated Infrastructure

Any upgrading of boating or navigation facilities that may be required as a result of the offshore artificial reef project would fall under the following legislation and policies.

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

Under the Standard Template (introduced in 2005) for Council Local Environmental Plans (LEPs), boat launching ramps and jetties in “Working Waterfront” zones require development consent under Part 4 of the Act. Water recreation structures in “Natural Waterway” and “Recreational Waterway” zones may or may not require development consent, depending on individual LEPs. Work on unzoned land requires development consent.

Lake Macquarie, Waverley and Wollongong councils have not as yet prepared new LEPs. Under the current LEPs (which pre-date the Standard Template), work on unzoned land requires development consent, as does work in Lake Macquarie’s “Lakes and Waterways” zone.

State Environmental Planning Policy (Infrastructure) 2007

Under this SEPP, navigation facilities installed by a public authority do not require consent.

Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005

Under the REP, public boat launching ramps and water recreational facilities require consent. The consent authority for land-based development and land/water interface development is generally the council of the local government area closest to where the development is proposed. The consent authority for water-based development is generally NSW Maritime. Note that this plan is currently under review (including development controls) and will become a State Environmental Planning Policy.

4 Description of the Proposal

4.1 Need for the Project

I&I NSW manages recreational fishing in ocean waters off NSW under the *Fisheries Management Act 1994* (FM Act) and Offshore Constitutional Settlement.

The primary objective of the FM Act is 'to conserve, develop and share the fishery resources of the State for the benefit of present and future generations'. Further objects under the Act include promoting 'ecologically sustainable development, including the conservation of biological diversity' and promoting 'quality recreational fishing opportunities'. The deployment of artificial reefs as a fisheries enhancement tool is consistent with these objectives.

Recreational fishing is an important leisure activity for approximately 17 % of the NSW population (approximately 1 million people) and provides significant social and economic benefits (Henry and Lyle 2003). In NSW, approximately 30 % of the total fishing effort takes place between the shoreline and 5 km offshore (Web Reference 28). The creation of new, high quality fishing areas through the deployment of artificial reefs will enhance fishing opportunity by creating, high relief, complex fish habitat. OARs would provide additional fishing locations and an alternative to heavily fished natural reefs. They also have the potential to increase the abundance and productivity of some demersal and reef species that would be found there.

The proposed offshore artificial reefs project would complement existing recreational fishing enhancement projects such as fish aggregating devices (FADs) and estuarine artificial reef (EAR) programs which have proven successful over the past 7 years.

The consequence of not proceeding with the proposal would result in continued pressure being put on groups of fish that inhabit existing natural reefs. Where natural reefs are overfished, this may lead to a local decline in numbers. OARs may help relieve this pressure. Not proceeding with the proposal is likely to cause conflict of interest between recreational fishing and the need for marine parks that may restrict recreational fishing activity in certain parts. OARs would help balance these interests. The proposed OAR would be the first of its kind that has been designed specifically for recreational fishing in NSW and nationwide, as opposed to those which have been created for the purpose of recreational diving. Not proceeding with the initial Sydney deployment would result in the loss of valuable research opportunity and would be likely to impede progress in future research and development into the use of OARs for improving recreational fishing opportunity and habitat restoration.

4.2 Structure Design

The design for a single artificial 'reef unit' is based on designs used for large-scale artificial reefs deployed in Korea (Figure 3, a and b). These types of design have arisen through extensive research and development undertaken in Korea and Japan where artificial reefs have been used to enhance commercial fisheries for over 30 years. The following key factors have been considered in the development of the final offshore artificial reef design;

- Function - the reefs have been specifically developed to suit the target species and the type of fishing gear intended for recreational fishing. Reef height, volume, void space, weight, profile, surface area and strength are major design features that affect the function of the artificial reefs and the attraction of species (Kim *et. al.* 2007, USNOAA 2007). Steel (proposed for the current design) has proven a suitable habitat for the settlement of attached epifauna (such as encrusting algae, bryozoans, barnacles and sponges) important for the success of the reefs. The steel plates provide a substratum for the settlement of attached organisms, shading and create eddies which are a stimuli to fish. H-beams and steel legs are fabricated within two metre intervals, considered to be the distance of visual perception for fish (Kim 2008). The steel members (H beams) are designed to create eddies or a turbulent wake behind the structure which causes fluctuations in water pressure and a stimulus to the acoustic sense of fish (Kim 2008).
- Stability – The proposed design has been refined to suit the type of bottom sediment, currents and prevailing sea conditions at the deployment locations (Section 4.3). This is necessary to ensure that the structure maintains stability against sliding or overturning even in extreme weather events.
- Durability – Steel material has been selected for its resistance to chemical and physical forces. The structures are intended to remain functional for a minimum of 30 years.

- Environmental Risk – Materials have been selected that will result in minimal leaching of chemicals in order to reduce potential for uptake by attached marine organisms or impact on water quality. These materials will be fabricated to meet Australian standards. Durability of the design is also intended to prevent risk of deterioration and therefore minimise potential hazards to navigation and safety and degradation through potential contact with fishing gear.
- Cost – Although initial investments may be higher in purpose built structures than using secondary materials, the overall effectiveness and lifespan of the manufactured design is likely to yield comparatively greater cost-benefits.

a)

b)

Figure 3: Examples of individual offshore artificial reef units deployed in Korea. The dimensions of the units are13.6 m x 11 m x 11m (height, length and width) and 10 m x 12 m x 12 m (height, length and width) in (a) and (b) respectively.

An existing Korean design, as shown in Figure 3a, was initially proposed for the OAR project. As part of the EA/PER process, stability assessments were carried out by Worley Parsons to determine whether such designs would suit the oceanographic conditions at the proposed study regions. Calculations indicated that the Korean steel reef designs would not be capable of resisting the overturning and sliding forces which could be experienced in extreme storm events at the proposed locations and therefore did not meet Australian safety requirements. Details of the stability assessments are given in Section 6.3.2.1.

A new concept design, based on the Korean designs, has therefore been developed to suit the oceanographic conditions at the proposed OAR locations and meet the required safety standards. This concept design will be used for the OAR project. The concept design aims to retain the functionality of the Korean reef designs, while maintaining structural integrity, durability and stability.

The concept design has a base of 15 m x 12 m and a total height of 12 m, with the main bulk of the unit reaching a height of 4 m (Figure 4). This gives the structure greater stability from a lower centre of gravity than the previous Korean designs. Dimensions of the OAR may vary pending the finalisation of the technical design specifications that will be used for the units manufacture/fabrication, transport and deployment. The structures will be manufactured from steel beams and plates, weigh approximately 35 tonnes (dry weight) and will sit directly on the seabed without the need for additional anchorage, other than the weight of the unit itself.

Detailed specifications of the concept design are given in Section 6.3.2.2 and Appendix 8. The concept design will require verification by a structural marine engineer before it may be finalised.

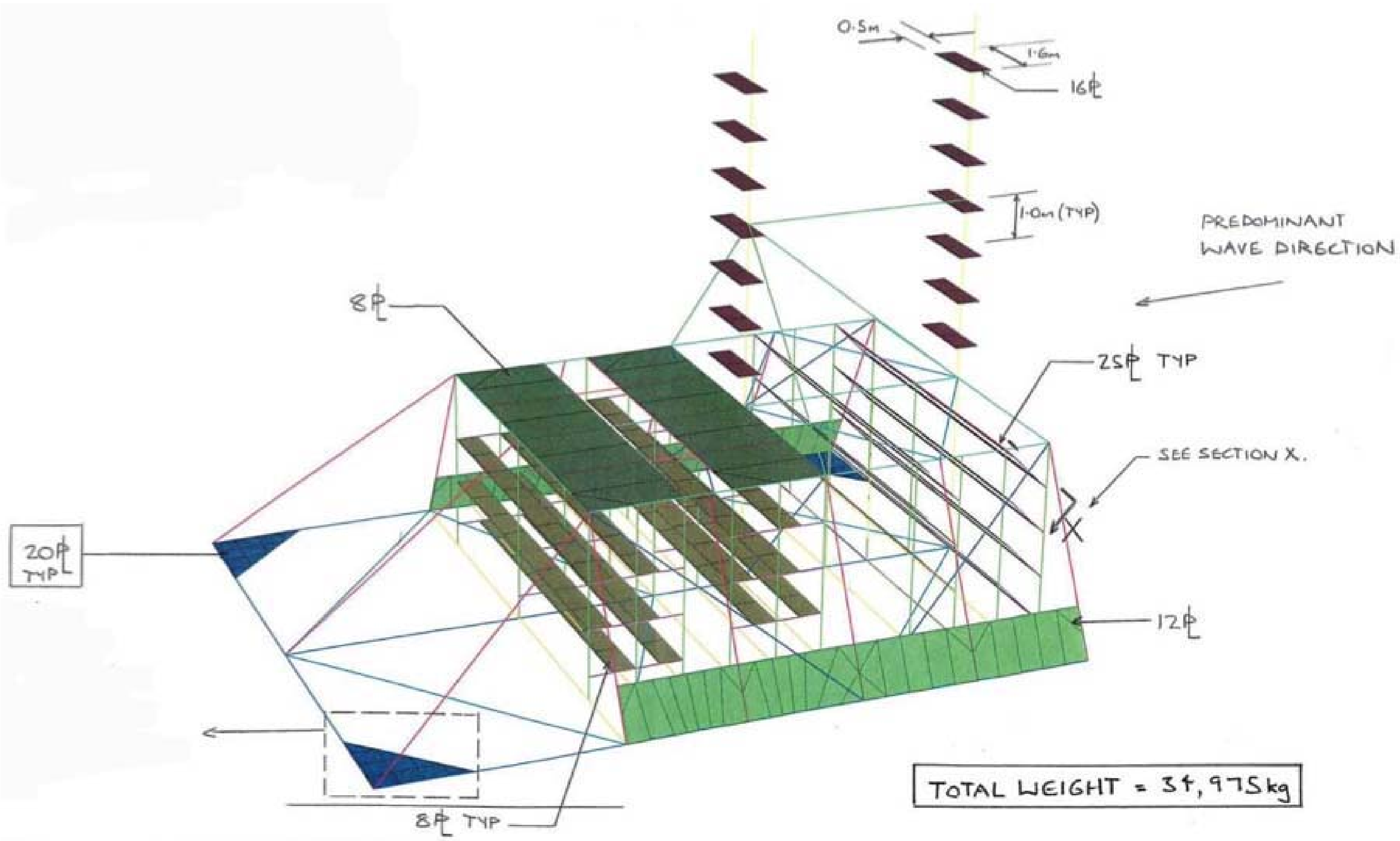


Figure 4: OAR concept design developed by Worley Parsons that will be used for the OAR project.

4.3 Locations and Configuration

Constraints Mapping and Site Selection

Location selection is considered critical to the success of an artificial reef (USNOAA 2007, O'Leary *et al*. 2001) and constraint mapping techniques are commonly used in site selection studies to bring together biological, physical and social factors in an overall context (Gordon 1994; Heaps *et al*. 1997; Kennish *et al*. 2002). Location selection and constraints mapping was carried out in relation to the current proposal by The Ecology Lab (Appendix 1 of Technical Report A). The study investigated the following issues within the Newcastle, Sydney and Wollongong study regions:

- Exclusion zones, including:
    - AMCA cable exclusion zones;
    - deepwater ocean outfalls;
    - commercial fishing areas (e.g. trawl and trap);
    - designated commercial shipping lanes/port restrictions;
    - marine protected areas (State and Commonwealth);
    - mining exploration leases;
    - historical ship wrecks;
    - spoil grounds.
- Other restricting features e.g;
    - FADS (Fish Aggregation Devices);
    - desalination plants.
- Depth (bathymetry).
- Distribution of substrata and suitability of substrata to support reef structures.
- Distribution of habitats, flora and fauna (including critical habitats for threatened species e.g. grey nurse sharks)
- Threatened species issues, including fish, invertebrates, marine mammals and marine reptiles.
- Coastal and oceanographic processes.

The elimination of major constraining features (e.g. unsuitable substratum and designated exclusion zones) led to the prioritisation of potential areas (sub regions) within each of the study regions. Based on results of the initial constraints mapping study (Appendix 1 of Technical Report A), I&I NSW identified potential offshore artificial reef sites within the recommended sub-regions.

The constraints mapping exercise also identified gaps in available information that would need to be addressed as part of a detailed environmental assessment before the suitability of selected sites could be confirmed. This included the need for site-specific information on the seabed, particularly for the Newcastle and Wollongong regions where data is sparse, details of commercial fishing activities and site-specific information on coastal and oceanographic processes. Sampling of demersal fish and assemblages of benthic macrofauna plus sediment particle size was also recommended to provide a baseline against which future monitoring may be compared.

Proposed Locations and Configuration

Four individual 'reef units' (i.e. a reef set) are proposed to be deployed at a depth between 30 m and 40 m offshore in the vicinity of Newcastle, Sydney and Wollongong (Figure 5). Initially, one of the three locations will be selected for OAR deployment and deployments at the remaining locations will depend on the success of the first. From here on, each region (Newcastle, Sydney and Wollongong) will be referred to as the 'study region'.

GPS positions for each of the OAR units were initially provided by I&I NSW which were used as the basis for the EA/draft PER (Table 1). It was initially proposed that OAR units will be configured in a diamond arrangement spaced approximately 600 m apart (Figures 6, 7 and 8, indicated by red dots). These are the locations that were assessed for the EA/draft PER.

Final Locations and Configuration

As a result of issues identified in the assessment process, adjustments were made to the proposed locations/configuration and alternatives selected (Section 9). The alternative locations and configuration will be used as the final locations and configuration for the OAR project (Figures 6, 7 and 8, indicated by blue dots). The final configuration will be in a line, spaced approximately 200 m apart and placed into areas of bare sand a minimum of 0.5 km from the nearest natural reef. The final OAR locations that will be used for the OAR project are as follows:

- Newcastle study region (Swansea). Approximately 3.6 km offshore from Blacksmiths Beach and the entrance to Swansea Channel, configured in a line, at a depth of approximately 28 m. The depth of water over the structures will be approximately 16 m (Figure 6 indicated in blue).
- Sydney study region (South Sydney). Approximately 1.2 km off The Gap and 1.9 km south-east of South Head, configured in a line, at a depth between 36 m – 38 m. The depth of water over the structures will be a minimum of approximately 24 m (Figure 7 indicated in blue).
- Wollongong study region (Port Kembla). Approximately 2.4 km offshore from Perkins Beach, and 2.5 km south of the Five Islands Nature Reserve, configured in a line, at a depth of approximately 34 m. The depth of water over the structures will be approximately 22 m (Figure 8 indicated in blue).

The final GPS positions for each of the OAR units are given in Table 2.

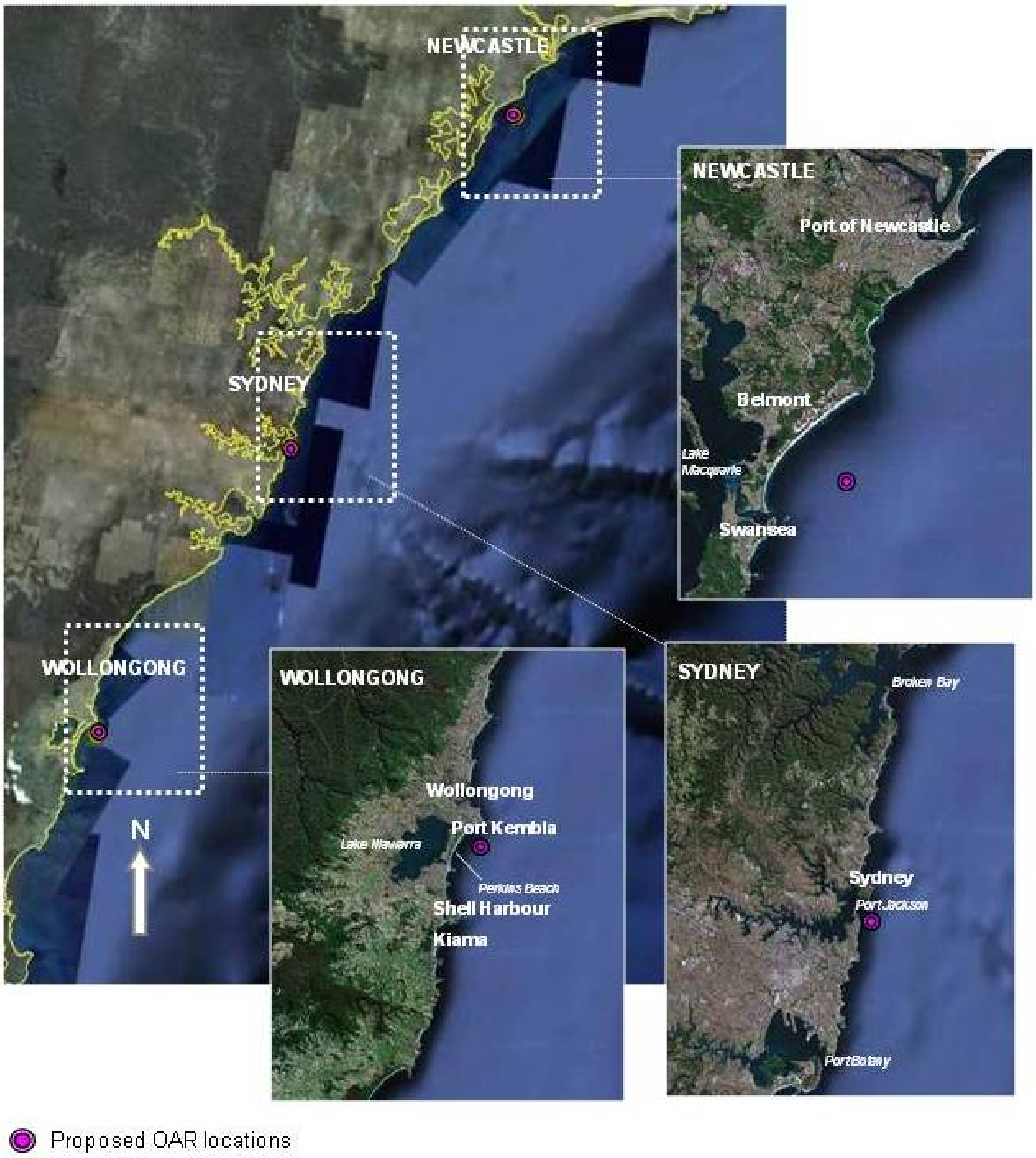


Figure 5: Broad-scale map of the proposed offshore artificial reef locations.

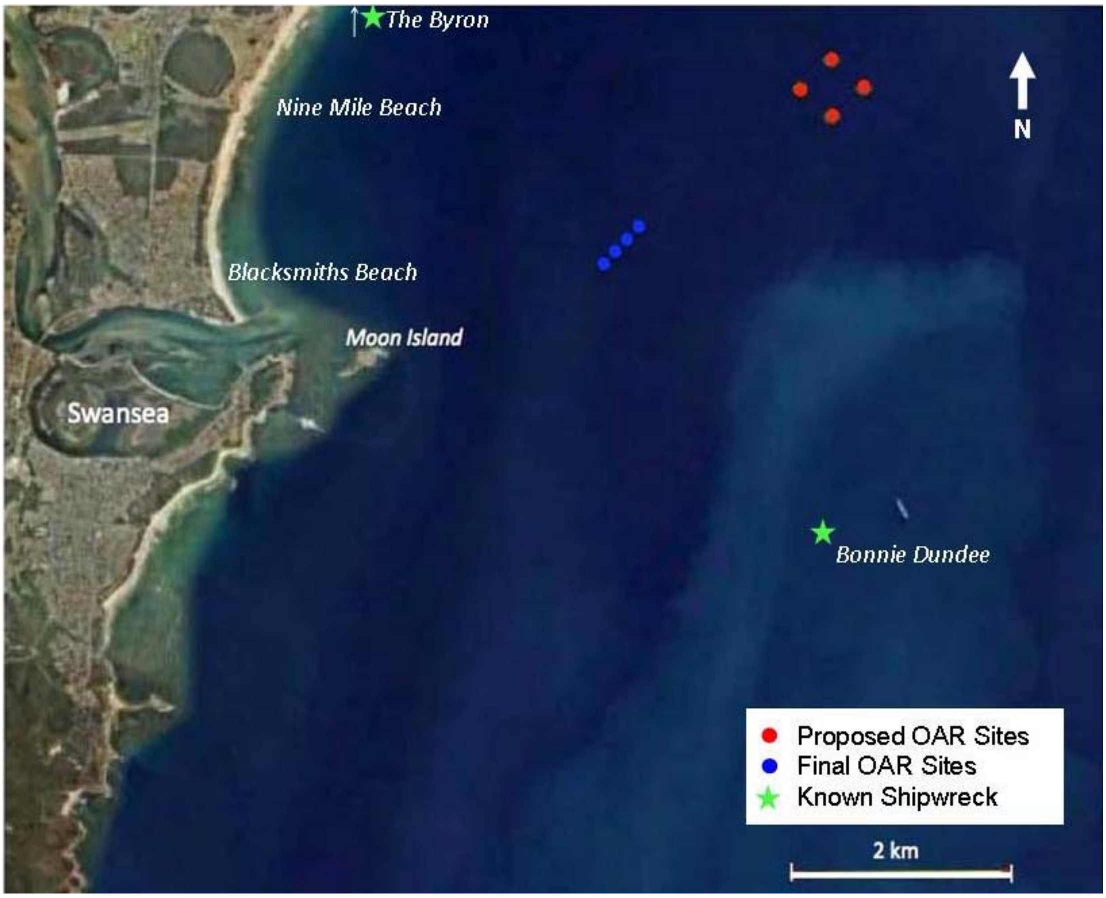


Figure 6: Map of the proposed and final artificial reef unit locations within the Newcastle study region.

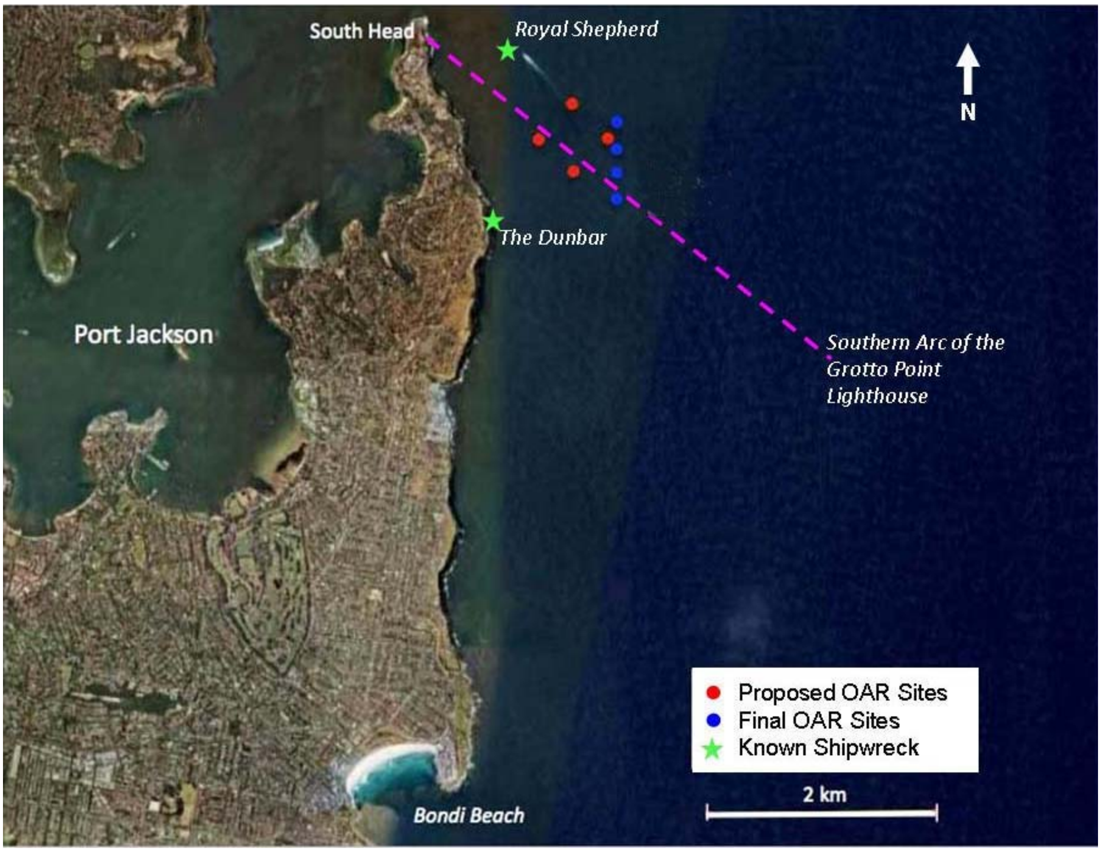


Figure 7: Map of the proposed and final artificial reef unit locations within the Sydney (South) study region.

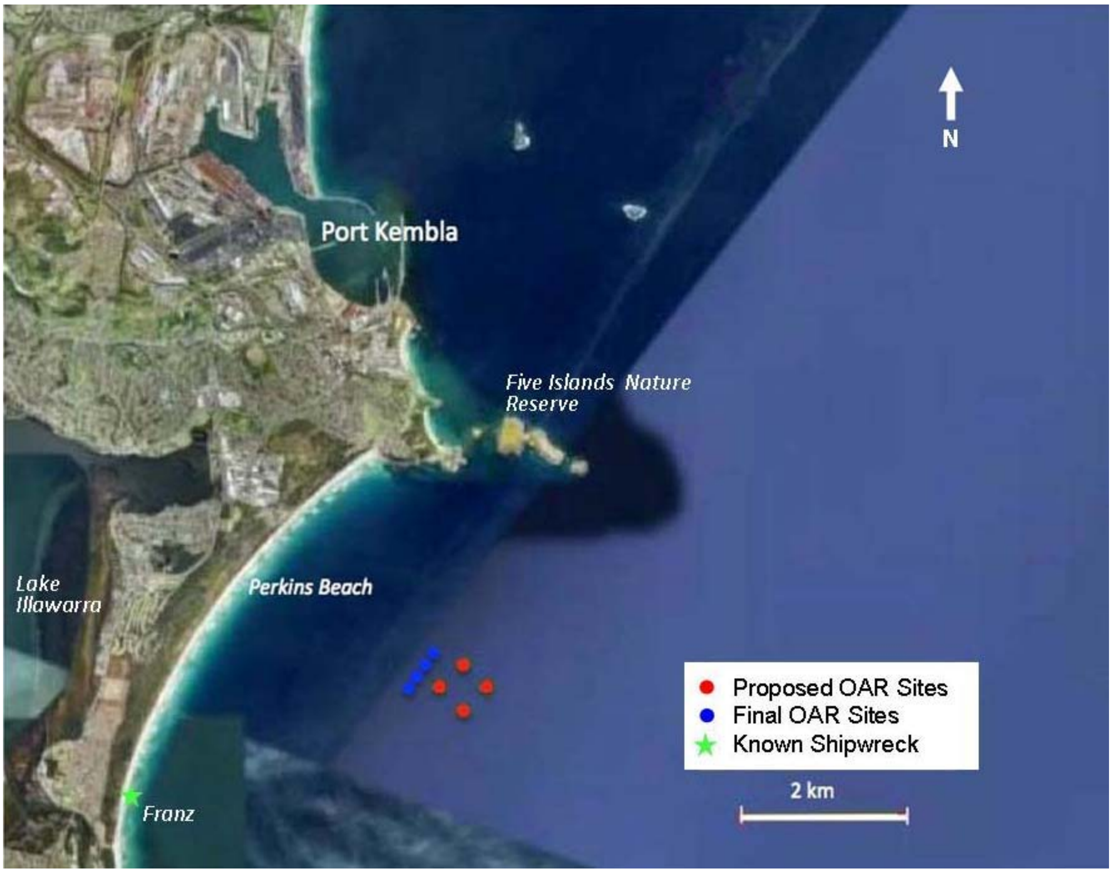


Figure 8: Map of the proposed and final artificial reef unit locations within the Wollongong (Port Kembla) study region.

Table 1: GPS positions (WGS84) of the initially proposed OAR unit locations within the Newcastle, Sydney and Wollongong study regions.

Study Region	Location	GPS Position (WGS84)	
Newcastle (Swansea)	Proposed OAR Unit Location	Latitude (S)	Longitude (E)
	Site 1 (North)	33°03.543' S	151°43.227' E
	Site 2 (East)	33°03.703' S	151°43.424' E
	Site 3 (South)	33°03.866' S	151°43.230' E
	Site 4 (West)	33°03.706' S	151°43.038' E
Sydney (South Sydney)	Proposed OAR Unit Location	Latitude (S)	Longitude (E)
	Site 1 (North)	33°50.368' S	151°17.735' E
	Site 2 (East)	33°50.529' S	151°17.929' E
	Site 3 (South)	33°50.692' S	151°17.733' E
	Site 4 (West)	33°50.532' S	151°17.535' E
Wollongong (Port Kembla)	Proposed OAR Unit Location	Latitude (S)	Longitude (E)
	Site 1 (North)	34°31.037' S	150°55.308' E
	Site 2 (East)	34°31.200' S	150°55.500' E
	Site 3 (South)	34°31.361' S	150°55.308' E
	Site 4 (West)	34°31.199' S	150°55.110' E

Table 2: GPS positions (WGS84) of the final OAR locations within the Newcastle, Sydney and Wollongong study regions.

Study Region	Location	GPS Position (WGS84)	
Newcastle (Swansea)	Final OAR Unit Location	Latitude (S)	Longitude (E)
	1(South)	33°04.574' S	151°41.733' E
	2	33°04.492' S	151°41.829' E
	3	33°04.408' S	151°41.925' E
	4 (North)	33°04.324' S	151°42.022' E
Sydney (South Sydney)	Final OAR Unit Location	Latitude (S)	Longitude (E)
	1(South)	33°50.797' S	151°17.988' E
	2	33°50.689' S	151°17.990' E
	3	33°50.581' S	151°17.993' E
	4 (North)	33°50.473' S	151°17.995' E
Wollongong (Port Kembla)	Final OAR Unit Location	Latitude (S)	Longitude (E)
	1(South)	34°31.176' S	150°54.776' E
	2	34°31.084' S	150°54.863' E
	3	34°30.992' S	150°54.950' E
	4 (North)	34°30.901' S	150°55.036' E

4.4 Construction and Staging of the Project

Subject to approval, it is expected that one contractor would be appointed to undertake and oversee all stages of the project. This would include:

- selection of an appropriate site for the fabrication of the structures;
- pre-construction inspection and planning;
- fabrication (5 – 6 months);
- loading and transportation (this would take place over a 2 month period);
- deployment (minimum 1 – 4 days);
- decommissioning of the land-based construction site.

Site Selection

There are a number of options for the location of the fabrication/construction site depending on the contractor and what facilities are available during pre-construction planning. There is a port facility located near each of the OAR sites. If a waterside location could be found at the port, the units could be constructed and loaded directly on to cargo barges for transportation to the offshore site. The contractor could lease space from the port authority for the duration of the works. Construction at a port based facility is the preferred option, however, should a waterside location not be available at the relevant port, it would be necessary to find an alternate private site with waterside facilities. Due to the size of the units it would not be possible to transport the units by road. The units would therefore need to be fabricated at the relevant port or private waterside facility and then be transported along the coast by cargo barge to the deployment site. The chosen fabrication site should include reasonable transport links, power, water, fuel, security, storage (including undercover storage), a site office, staff facilities (seating, toilets, parking) and IT and communications. A crane and crane storage area, scaffolding (for working at height) and tools for welding and steel fabrication would also be required. It is estimated that a site of 100 m x 100 m (10,000 m^2) would be necessary to carry out the works and accommodate the associated facilities.

Given that construction at a port based facility is the preferred option three potential sites have been identified for the OAR construction:

- Newcastle Port – Dyke Point (Figure 9);
- Sydney Port – White Bay; (Figure 10); and

- Port Kembla – Outer Harbour, adjacent to Jetty #6 (Figure 11).

Figure 9: Proposed construction locations Port of Newcastle.

Figure 10: Proposed construction locations Sydney

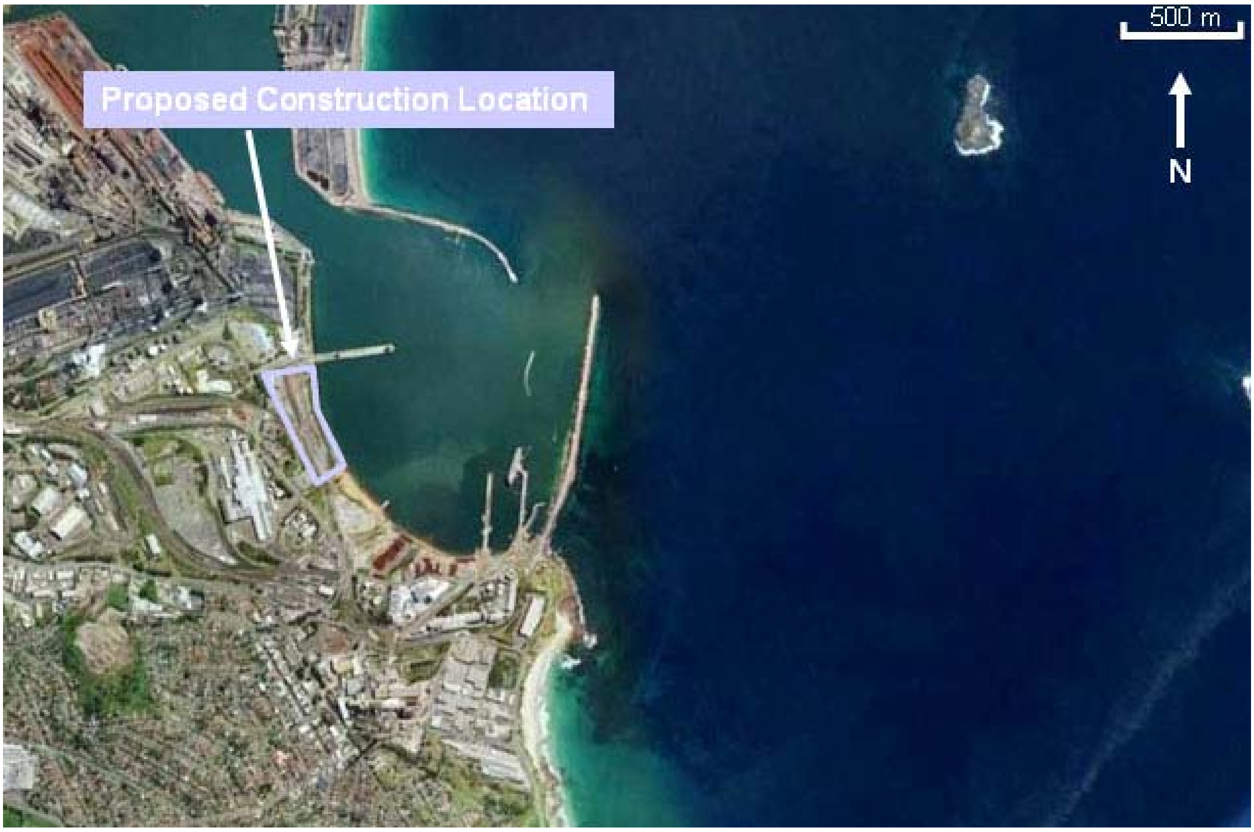


Figure 11: Proposed construction location (Port Kembla).

Based on professional experience and knowledge of the existing port facilities, these locations are considered to meet the requirements for construction locations. Furthermore, it is understood that these ports have the available space (10,000 m^2) required to undertake the construction operations.

Fabrication

It is estimated that the fabrication stage would take approximately 5 to 6 months to complete. The necessary steel would be delivered to the site. The contractor would unload the steel using the onsite crane and place it in the designated storage area. The units would be built in layers from the bottom up. The steel members would be welded together with butt and fillet weld by experienced and qualified welders in accordance with the drawings and technical specification. To ensure adequate quality of the welding, a weld quality control plan would need to be prepared to outline the extent of mechanical and non-destructive testing and inspection required before final certification of the works. As the structure rises from the base, scaffolding would be required giving construction and inspection access to the structure.

Once the units are fabricated, a final inspection would be conducted prior to transferring the units to barges for transportation to the offshore site.

Loadout

Once fabrication and certification are complete, the units would be loaded on to barges for transportation to the offshore location. This operation is referred to as loadout. The method of loadout shall be at the contractor's discretion and the contractor would be fully responsible for the structural integrity of the structures during this process.

The most likely loadout method for moving the unit to the barge is by crane lifting. A cargo barge of adequate dimensions would be required to accommodate the 12 m x 15 m x 12 m structure. The barge would be moored at the wharf at the waterside fabrication site or if no wharf is available, it would be positioned with the aid of anchors and tugs at a suitable location. The mooring arrangement would ensure the barge is stable and not moving to allow the units to be transferred with minimal disruption. The contractor's would prepare a Loadout Plan to include barge ballasting requirements and a step-by-step schedule of the loadout process. Allowances for actual tidal changes and current shall be included in the Plan. To accommodate the units the barges may require some strengthening works where large stresses would occur.

Once the unit is in place on the barge, it would be sea-fastened to ensure it is secure and ready for transportation. The contractor would be responsible for ensuring the unit is secure for all potential weather and sea conditions which may arise during the transportation to the site. Once the units are secured the supervisor would inspect the fastening prior to transporting the units to the offshore site. Following loadout, the contractor shall ballast the cargo barge to its design trim and draft for tow.

It is estimated that the loadout and subsequent transportation and deployment of the units would occur over a two month period, depending on weather conditions. If the units are located within 20 km of the site, it is feasible that once loadout is completed, the units could be transported and installed within three to four days.

Transportation

The contractor would consult the weather forecast for NSW coastal waters to ensure weather conditions are suitable for deployment. Deployment of the units would not be permitted unless the current sea state and its direction is less than the maximum safe values determined by the transport stability analysis and unit lift analysis. Before moving from the fabrication site, notification would need to be acquired from the relevant port authority that it is safe to proceed and that no large shipping movements would interfere within the proposed transport route. Motion analysis and stability analysis for the transportation of the units would also be required to ensure the barge can safely reach the site in a 1 year event storm without damaging the units. This would also help the contractor selecting the correct barge and towing tug for the operations. Once the units have reached the offshore location, the units would be inspected to ensure no damage has occurred prior to deployment. If any damage has occurred it may be necessary to return the units to shore to carry out repairs or, alternatively minor repairs could be conducted on board the barge.

Deployment

Once the units have reached the reef site the barge would be anchored in position at the required coordinates using GPS and an anchor handling tug. Once the barge is secured in position, the units would be lifted by crane and lowered into the sea to the final resting position on the seabed. A dive inspection would then be carried out to ensure the units are in the required position and orientation allowing the cable to be retracted. During the lifting procedure appropriate temporary navigational aids would be provided on the structure and surrounding vessel. Anchor buoys would also be positioned at the anchor locations.

Decommissioning of the Construction Site

Following completion of the project, the construction site would need to be decommissioned. This would involve evacuating all areas, clean up and restoration of the site to its original state, disposal of excess construction materials, removal of temporary construction facilities and archiving of any site-based hard or soft files.

4.5 Feasible Alternatives

Structure design and materials

The alternative to using a specifically designed and manufactured artificial reef, as described in Section 4.2, would be to use secondary or scrap material. As described in Section 2.4, a manufactured artificial reef has a number of advantages over the use of opportunistic materials. Overall, a specifically manufactured artificial reef would be more effective and be likely to have a greater long-term cost-benefit. The preferred manufactured design would have minimal risk of contamination (if any) and maximum stability. The environmental risks to the receiving environment would be considerably greater by using scrap materials.

A range of different materials are used for specifically manufactured artificial reefs including concrete, ceramic, iron and steel, among others. Steel is the preferred option for the proposed OARs as it is strong, durable, cost-effective and can be fabricated according to the preferred design specification. Steel is also preferable for open structures with large internal volume, whereas concrete is better suited to solid face structure with small internal volume. A specifically designed and manufactured steel reef is likely to have comparatively less potential impact (if any) on the receiving marine environment and matters of NES.

Locations and configurations

A diamond configuration with units spaced 600 m apart was initially proposed for the OAR project (Figure 12,a), but other line or zig-zag configurations were also considered as part of the EA/draft PER (Figures 12, b and c). Following consultation with recreational and commercial fishermen, a line configuration was considered to have practical advantages by potentially allowing utilisation by more vessels at any one time and to allow drift fishing with the prevailing current (generally running north to south at all locations). Commercial operators that were consulted also indicated that a line configuration would be preferable to navigate past. As indicated in section 4.3 and Section 9 it is proposed that the final OAR configuration would be in a line running approximately north to south with units spaced approximately 200 m apart.

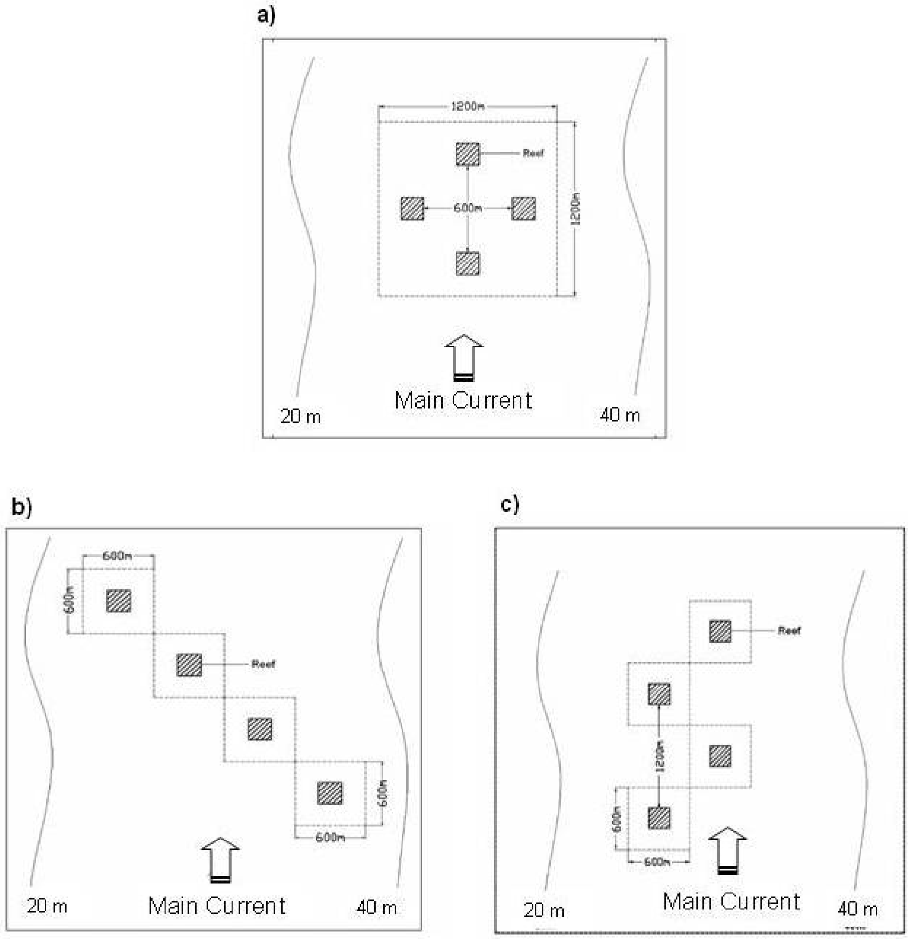


Figure 12: a) Proposed configuration for a single reef set (composed of four single artificial reef units). b) and c) alternative configurations for a single reef set (composed of four artificial reef units). Source: Kim 2008.

Construction

The preferred option for the construction of the artificial reefs would be at a port based waterside facility (see Section 4.4). A port based, waterside construction site is preferable because transit time to the deployment sites, for all study regions, would be faster and less weather dependent than if located a significant distance away. Transport links and infrastructure are also likely to better at a port based facility. Given that a port based waterside facility cannot be guaranteed, it is feasible that the OARs would require construction at a private waterside facility either locally or potentially greater than 20 km from the deployment location. The environmental impacts would be comparatively similar for the alternative options, although transport related costs and emissions would increase with transit distance.

4.6 Related Actions

The current OAR proposal has relevance to other actions taking place in the direct Sydney study area and the wider Wollongong study area. None of the actions identified in the Newcastle study region are likely to be of relevance to the current proposal.

In December 2008 the National Parks Association (NPA - an independent non-government organisation) released a proposal called the *Torn Blue Fringe* (Winn 2008) for more marine parks and sanctuaries in NSW. The proposal is currently being reviewed by the NSW Government. Priorities for conservation outlined in the proposal relevant to the current proposal include:

- proposal for a Sydney Marine Park (103,150 ha);
- proposal for a Five Islands Aquatic Reserve (3,723 ha); and
- proposal for a Bass Point Aquatic Reserve (2,307.5 ha).

The proposed Sydney OAR would overlap with the proposal for a Sydney Marine Park (Figure 13). All fishing activities within marine parks are generally regulated by zoning and operational plans, which are developed in consultation with all interest groups, and the community in general. There would therefore be scope for integration of an artificial reef within the marine park.

The proposed Wollongong OAR would be located approximately 2.4 km south of the proposed Five Islands Aquatic Reserve and 6 km north of the proposed Bass Point Aquatic Reserve (Figure 14). Given the distance of the proposed OAR locations from the boundaries of the proposed Aquatic Reserves, this is not considered to be an issue. The NPA's opinions on the proposed OAR locations are included in Section 5.2 of this document.

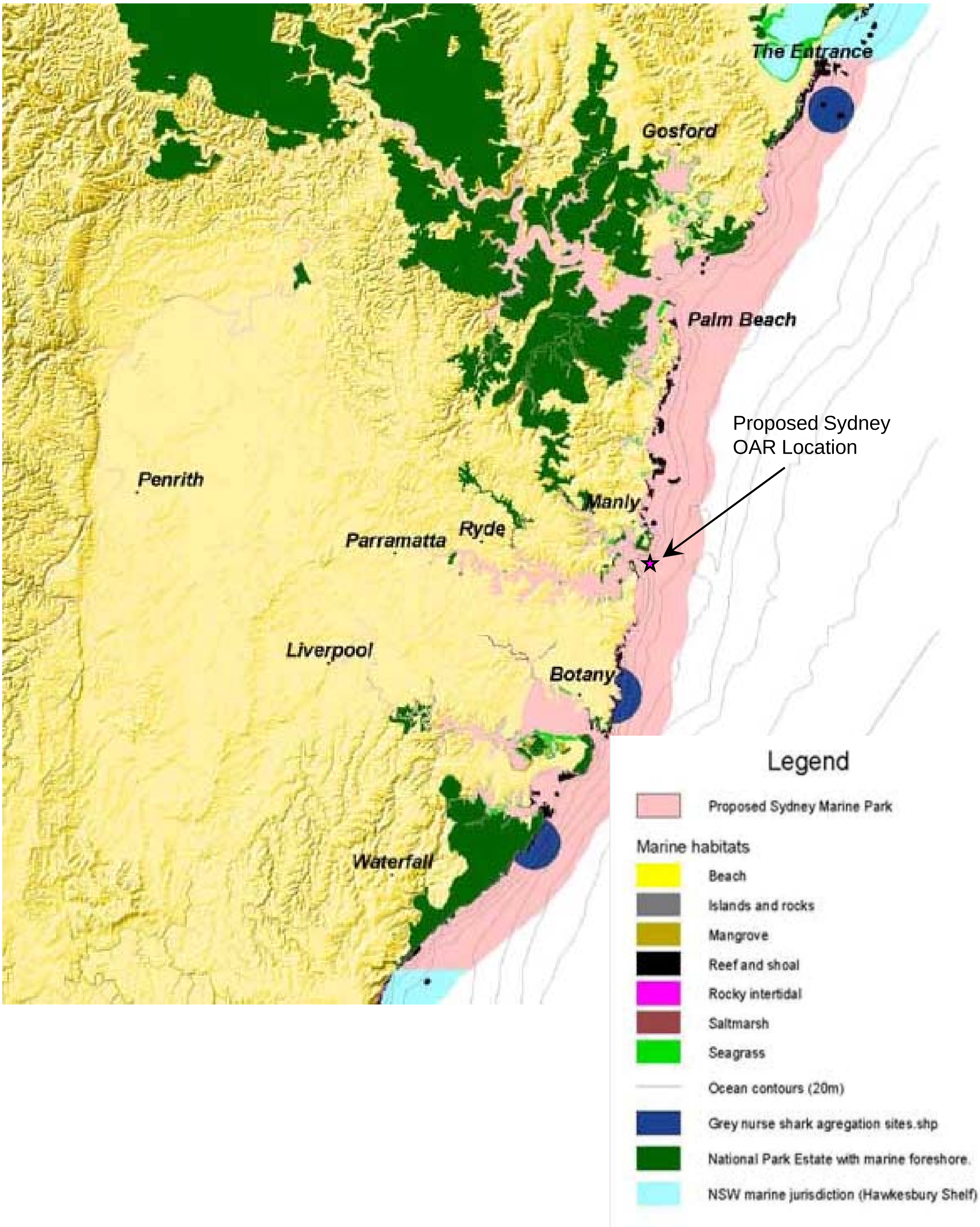


Figure 13: Proposed Sydney Marine Park Hawkesbury Shelf Marine Bioregion, Central Section. Source: NSW National Parks Association (NPA) Torn Blue Fringe Report (Winn 2008).

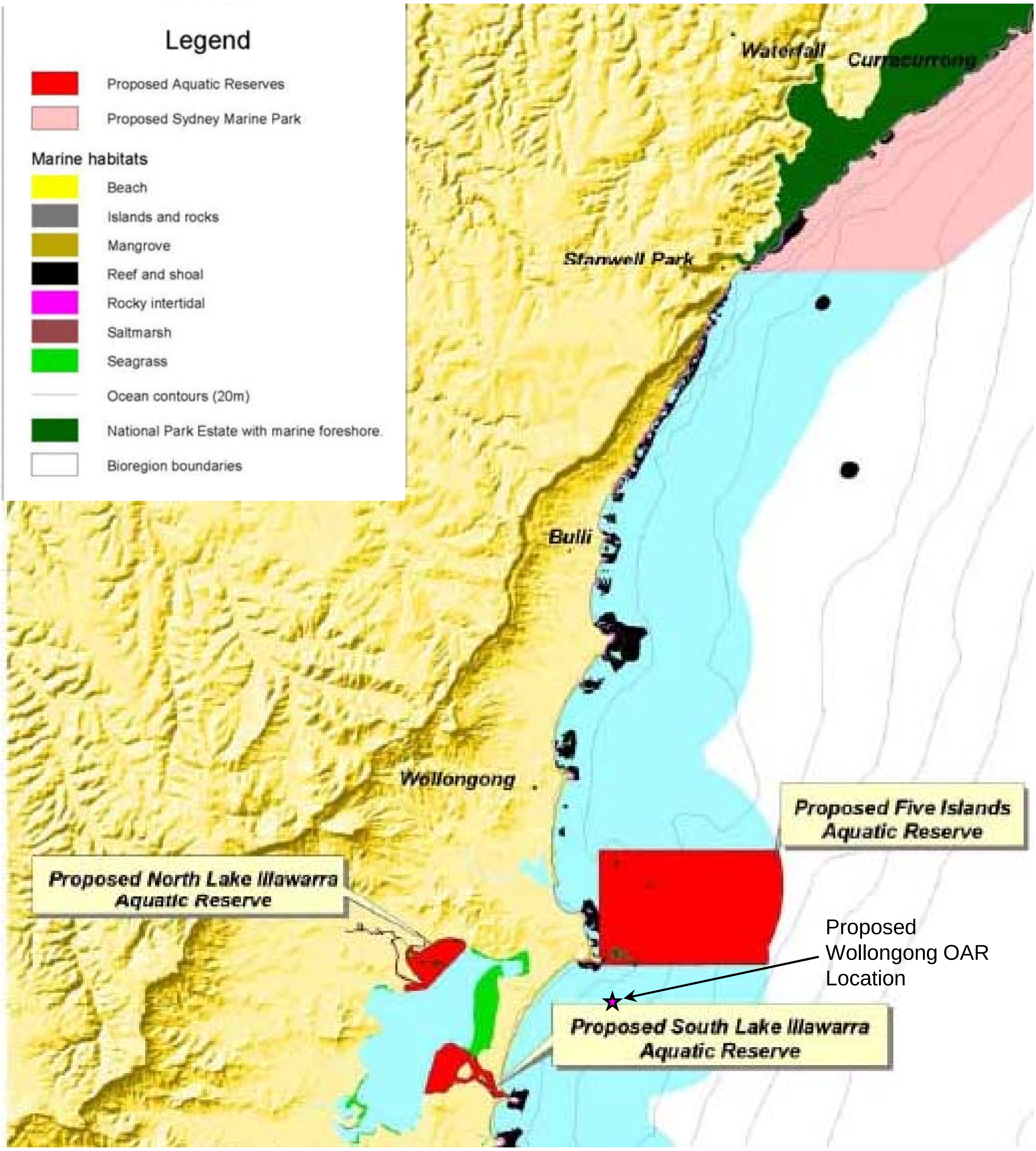


Figure 14: Proposed Aquatic Reserves, Hawkesbury Shelf Marine Bioregion, Southern Section. Source: NSW National Parks Association (NPA) Torn Blue Fringe Report (Winn 2008).

4.7 Decommissioning

The nominal operational lifespan of the OAR units is estimated to be 30 years. It is likely, however, that the structures would remain operational for longer than this. The current design does not allow for removal of the structures intact at the end of the 30 year lifespan as it is uncertain whether they would be structurally sound enough to be lifted from the seabed and transported to a disposal site. Whether the units are removed intact or dismantled would depend on the outcome of structural inspections prior to removal. The following options for decommissioning would be considered:

- Option A – Provided the structures are verified to be structurally sound for removal, the units would be lifted intact by crane to a barge and transported to a waterside location, where the units would be cleaned, dismantled and disposed of at an appropriate land-based facility.
- Option B – If it is not feasible for the units to be removed intact, then the units would be dismantled by commercial divers in-situ, sections craned onto a barge and transported to a waterside facility where the pieces would be cleaned and disposed of at an appropriate land-based facility.
- Option C – Structures would remain in-situ on the sea-bed and be allowed to gradually break-down over time. Monitoring of the structures would continue.

These options would provide a contingency for decommissioning at any stage during the operational life of the OAR if required, although the option of removing the units intact is unlikely to be feasible towards the end of the operational lifespan. In the event that unacceptable impacts to the environment were detected during monitoring of the first (Sydney) deployment then ‘Option A’ would be the most likely method of decommissioning. In the event that removal of the OAR structures or partial removal is required, a decommissioning plan will be submitted to DEWHA and the NSW Department of Planning for approval.

It is likely that the main impact of removing the structures (options A or B) would be a significant loss of attached flora and fauna and a loss of fish habitat, however, the overall environmental impact would depend on which option for decommissioning was considered most appropriate and the length of time the units had been in place. Removal of the units (Options A or B) would therefore be subject to a separate environmental assessment as well as preparation of safe work method statements for their removal.

5 Consultation

I&I NSW, Cardno Ecology Lab and Worley Parsons began the consultation process with relevant stakeholders as part of the initial location and constraints mapping study. Consultation carried out to-date has included:

- December 2007: Consultation with relevant Ports Authorities and NSW Maritime relating to location and constraints mapping;
- February 2008: Exhibition of a Preliminary Environmental Assessment (PEA);
- February 2008: Planning Focus Meeting (PFM);
- September 2008: Discussions between I&I NSW and commercial fishing operators;
- November 2008: Stakeholder engagement via email, post and telephone;
- November/December 2008: Stakeholder consultation meetings held by Cardno Ecology Lab and I&I NSW at venues in the Newcastle, Sydney and Wollongong study regions;
- January 2009: Further meetings and correspondence with relevant Port Authorities and NSW Maritime in relation to navigation and safety issues;
- February 2009: Meetings with indigenous land councils;
- March 2009: Meeting with commercial fishing representatives in the Sydney study region;
- April 2009: Further consultation with conservation groups.

Details of all stakeholders engaged during the course of the project are listed in Appendix 3. A list of attendees and summary of issues raised at stakeholder consultation meetings (November/December 2008) is given in Appendix 4.

5.1 Statutory Authorities

Application for the current proposal was referred to the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). Issues raised during the consultation and where in the EA/draft PER these issues are addressed are listed in Table 3a below.

Table 3a: Consultation issues - DEWHA

Issue	Assessment and Conclusion
▪ potential impacts on threatened and protected species (including migratory species);	Section 8.1.9 and 8.2.3.4
▪ potential impacts on Commonwealth marine areas;	Section 8.2.3.6
▪ proximity to habitats critical to the survival of the critically endangered grey nurse shark (*Carcharias taurus*) in the Newcastle and Sydney study regions;	Section 8.2.3.7, Appendix 6 and 7
▪ proximity to aggregation sites significant to the vulnerable Great White Shark (*Carcharodon carcharias*).	Appendix 7 (species profile for the great white shark)

NSW Department of Planning, NSW Department for Environment, Climate Change and Water (DECCW) and NSW Department of Lands were consulted during a Planning Focus Meeting held at The Department of Planning in February 2008. No significant issues were raised other than those to be specified in the DGR's requirements (Appendix 1) and requirements outlined under the Commonwealth EPBC Act (Appendix 2).

Extensive consultation has been undertaken in accordance with the DECCW *Interim Community Consultation Requirements for Applicants* (2004). The guidelines suggest that consultation with the Aboriginal Community is conducted over the duration of the project.

DECCW was consulted in relation to potential impacts on areas of heritage significance. No items of cultural heritage have been registered at the proposed OAR sites within NSW. Consultation with the manager of north Sydney Harbour concluded that the proposed Sydney OAR is not located within the boundary of the Sydney Harbour National Park and is therefore not an issue. It is understood that the Newcastle and Illawarra reef locations do not fall within any environmental protection or exclusion zones of heritage significance.

NSW Department of Aboriginal Affairs

A search for the Registered Aboriginal Owners was obtained from the Office of the Registrar on 20 February 2009. There are no registered owners pursuant to *Division 3* of the *Aboriginal Land Rights Act, 1983*. Furthermore, it was recommended that consultation be undertaken with Bahtabah, La Perouse and Illawarra Local Aboriginal Land Council's in reference to the project. Correspondence received from the Office of the Registrar in relation to the proposal is included in the Aboriginal Cultural Heritage Assessment (Technical Report B).

Local Aboriginal Land Councils (LALCs)

Local Aboriginal Land Council's were the main point of contact with the aboriginal community in relation to the proposal. There are three main LALCs which govern the land adjacent to the proposed Newcastle, Sydney and Wollongong reef locations. These include, Bahtabah, La Perouse and Illawarra LALCs respectively.

Bahtabah Local Aboriginal Land Council is located to the south of Newcastle at Swansea and covers the coastal regions to the north of the Metropolitan LALC. Discussions held with Michael Green (CEO) in February 2009 indicated that there are no objections to the proposed artificial reef, nor is it likely that any items of Aboriginal cultural heritage would be impacted as a result of its deployment or passive operation. Information provided to Bahtabah LALC on the proposal was passed on to the local board members and community groups as required. Bahtabah LALC do not object to the placement of artificial reefs offshore between Redhead and Moon Island.

A meeting with Ros Field (Acting CEO) of the La Perouse LALC (February 2009) aimed to identify the potential Aboriginal cultural constraints which would be associated with the proposed Sydney OAR. As a result of the meeting it was understood that the La Perouse Local Aboriginal Land Council has no objection to the proposed establishment of the OAR. Furthermore, it was considered highly unlikely that the deployment and passive operation of the proposed OAR would have any significant affects on Aboriginal cultural heritage within the area including artefacts and spiritual (dreaming) stories. Details of the meeting have been passed on to the La Perouse LALC board for review accompanied by the Preliminary Environmental Assessment undertaken by The Ecology Lab (Technical Report A). Despite efforts to contact La Perouse LALC no formal response had been provided at the time of preparation of this report.

The Illawarra LALC governs a vast area to the south of the Tharawal and La Perouse LALC. Consultation was initially undertaken with Sharralyn Robinson (CEO) and correspondence was subsequently passed on to relevant board members and community groups within the area. The Illawarra LALC has outlined two issues with regards to the proposed OAR at Wollongong (Table 3b).

Table 3b: Consultation issues - LALCs

Issue	Assessment and Conclusion
▪ The Five Islands Group, located to the south east of Port Kembla (Figure 8) has significant spiritual meaning and heritage within the local Aboriginal community. The islands form a part of the spiritual significance through the Dreaming stories "Oola-boola-woo" (see Technical Report B). It is understood that there is concern visual amenity associated with the area would be impacted as a result of clustering of recreational fishing vessels above the proposed artificial reef and that this could potentially detract from the spiritual significance of the Five Islands Group.	Section 8.2.8.2
▪ Indigenous Fisheries Consultants in their letter to the Illawarra LALC in March 2009 have indicated that the proposed location of the reef may conflict with the development of a Fin Fish Aquaculture site.	Following discussions to obtain further information, it is understood that no specific details are available as yet and no formal application has been submitted to Industry and Investment NSW.

Local Councils

Local councils were sent background information, contacted by phone and email and invited to attend stakeholder consultation workshops for the relevant study regions. Of the twelve contacted six did not respond, four had no comments and two (Wollongong and Lake Macquarie) attended a stakeholder consultation meeting.). Issues raised during the consultation and where the EA/draft PER addresses these issues are listed in Table 3c.

Table 3c: Consultation issues – local councils.

Issue	Assessment and Conclusion
▪ production versus attraction, i.e. whether the OARs are likely to increase actual productivity, or draw fish away from other areas, particularly natural reefs;	Section 8.2.3.3
▪ potential to encourage pest species;	Section 8.2.3.5
▪ potential conflict with minerals exploration licenses and seismic survey work in the Newcastle region due to commence in 2009 (Lake Macquarie Council).	The licence area for the exploration of marine minerals is beyond the 3 nm limit of State waters which is a significant distance from the proposed Newcastle OAR and at the time of preparation is not expected to conflict with the proposal. I&I NSW would, however, subject to the projects approval, I&I NSW would be committed to check the NSW minerals licence database for new offshore minerals exploration licences.
▪ naming of the OARS. Lake Macquarie Council was concerned that 'Newcastle' offshore artificial reef was misleading and that it should be named according to the specific geographic region.	I&I NSW would consider naming of the reefs pending approval.

5.2 Other Non – Statutory Organisations

Non-statutory organisations were sent background information, contacted by phone and email and invited to attend stakeholder consultation workshops for the relevant study regions (Appendix 3). Six of the nine organisations approached responded. Oceanwatch representatives and Fishcare volunteers also attended stakeholder meetings. Production versus attraction was again considered the main issue of concern.

The NSW National Parks Association (NPA) was consulted in relation to the overlap of the proposed OAR locations with NPA's submission to the NSW government for Marine Protected Areas within the Hawkesbury Shelf marine bioregion.

NPA believes that locations for artificial reefs for fishing purposes should not overlap with those waters currently proposed for marine protected areas, but that both artificial reefs and marine protected areas could potentially coexist "given more scientific certainty that they contribute to environmental and fish habitat enhancement". Current views of the NPA are that marine protected area planning must take precedence over proposals for improved fishing opportunities and that there should not be any commitment to create artificial reefs within the waters identified in The Torn Blue Fringe as priority marine protected areas. The extent of the proposed marine parks (in relation to the proposed OAR locations) are given in Figures 13 and 14. Comments received from the NPA via email are included in Appendix 5.

5.3 Port Corporations and NSW Maritime

Newcastle Ports Corporation (NPC)

Mr Tim Turner (Harbour Master) advised that the OAR should not be located within the 3 nm Port Limit off Nobbys Head, and also should not be within the Newcastle recommended anchorage area which is south of 32°58' latitude (Little Redhead Point) and not closer than 3 nautical miles (5.55 km) to the coastline (at a depth of approximately 40 m relative to Chart Datum). With this considered, the main issue relating to the proposed OAR site was the proximity of the proposed OAR site to the Port of Newcastle's anchorage area. Provided that the OAR is clear of the areas specified and marked on maritime charts (to provide a suitable warning to shipping), the proposal was not considered to be an issue with NPC.

Sydney Ports Corporation (SPC)

Discussions were held with Captain Robin Heath (Harbour Master until early Feb 2009) and subsequently with Mr Richard Lorraine (Interim Harbour Master). Mr Robin Heath advised that consideration may be given to the placement of artificial reefs within the Port Limits (Port Jackson), provided they would not considered to be a risk to vessel traffic. It was also advised that offshore anchorage zones are not part of Sydney Ports Corporation's management policy, as vessels are anchored inside the harbours. In the unlikely event that a vessel is queuing for berth space, vessels generally position themselves well offshore and are therefore unlikely to be a significant risk to the proposal.

SPC specified that a minimum clearance of 20 m from the uppermost part of the OAR at LAT (Lowest Astronomical Tide) is required if the OAR were to be located in the area between Dunbar Head and South Head. Based on the present configuration and location this would require that the proposed Sydney location is moved into deeper water towards the SSE. Initially it was required that the units also be located south of the southernmost arc of the Grotto Point Lighthouse, outside the no anchorage zone, referred to as 'Area B' (Figure 7). However, after further discussions with Mr. Richard Lorraine, this is no longer considered to be a significant issue provided the minimum 20 m clearance is observed. SPC also requested that they be advised of the timing of deployment and final locations to ensure ports and RAN hydrographic surveyors are notified so they can issue a notice to mariners.

Port Kembla Ports Corporation (PKPC)

Port Kembla Port Corporation was not supportive of any proposed artificial reef locations within the Port Limit which extends from Red Point, just south of the port entrance, up to Bulli Point in the north. Mr Kell Dillon (General Manager, Marine & Port Operations) also advised that the OAR should be located clear of any vessel approach to Port Kembla. PKPC confirmed that the proposed location does not pose any great issue with them, provided the appropriate notifications are made to the Australian Hydrographic Office so the location can be charted.

NSW Maritime

Mr Brett Moore (General Manager, Recreational & Regional Services), advised that the Newcastle and Wollongong locations do not present any navigational issues. In the Sydney study region, NSW Maritime initially required the units to be located south of the southernmost arc of the Grotto Point Lighthouse, outside the no anchorage zone, referred to as 'Area B' (Figure 7). However, after further discussions with Mr. Brett Moore, location of the units within Area B was approved provided that the minimum of 20 m clearance is observed and fishing vessels give way to the movement of commercial vessels in the shipping channel.

5.4 Commercial Fishing Operators

Commercial trawl fishing operators from the Newcastle, Sydney and Wollongong study regions were contacted via phone and/or email and invited to attend the relevant stakeholder consultation meetings, prior to the selection of specific locations for the OAR units. Representatives from the commercial fishing industry and professional fishermen also attended stakeholder consultation meetings. Issues raised during the consultation and where the EA/draft PER addresses these issues are listed in Table 3d.

Table 3d: Consultation issues – commercial fishing.

Issue	Assessment and Conclusion
▪ Need for alternative recreational fishing reefs. Local commercial fishing representatives questioned the need for expenditure on developing new structures when artificial structure (such as scuttled ships, wrecks etc.) already exists in the Sydney region. It was also pointed out that there is a significant amount of existing natural reef present in the Sydney/Wollongong regions.	Justification for specifically designed artificial reefs is given in Section 2.4 OARs would be located a significant distance away from existing natural reef to create additional habitat.
▪ Obstruction to trawling. Professional fishermen (Richard and Paul Bagnato) are opposed to the location of the proposed Newcastle OAR as it conflicts with regular trawling activity in the area. Richard and Paul Bagnato represent commercial fishing operators from seven trawling vessels based at Port Jackson including the Maybelle, Francesca, Arakiwa, Immacolata, Lisa Ann, Carmello, Kirrawa and Seaport (Sydney Fish Markets).	Section 8.2.4
▪ Vandalism to commercial gear. Trap and line fisherman Dennis Brown, was concerned that deployment of an offshore artificial reef at the proposed Wollongong location would prove popular and encourage interference to commercial trap gear. However, a proposed distance of 1 km between the proposed OAR and natural reef (where traps are set) was considered a reasonable distance to prevent vandalism.	No further action required.
▪ Proximity to anchored vessels in the Newcastle study area. Commercial operators suggested that reef units should be located on the 35 m contour (rather than 40 m) to avoid this potential hazard with anchored vessels.	Final OAR locations would be located within the 35 m contour therefore no further action is required.
▪ Configuration. Trawl operators indicated a preference for a line arrangement as it would be easier for trawlers to navigate past.	Sections 8.2.6.2 and Section 9

5.5 Recreational Fishing Associations/Clubs

Comments have been received via mail and email from recreational fishing associations in response to the distribution of project information in November 2008 and in relation to the stakeholder consultation meetings held in November/December 2008 (Appendix 5). The issues summarised in Table 3e are based on correspondence and feedback during stakeholder consultation meetings.

Table 3e: Consultation issues – recreational fishing.

Issue	Assessment and Conclusion
▪ Cost. Concerns were raised over the relatively high costs of manufacturing new artificial reefs as opposed to using secondary materials.	Justification for specifically designed artificial reefs is given in Section 2.4
▪ SCUBA Diving. Recreational fishing groups were strongly against utilisation of the reefs by SCUBA divers and have requested that the reefs be 'SCUBA diver free zones'. This was due to safety and because SCUBA divers do not contribute to the recreational fishing license fee.	Section 8.2.4. Scuba diving in the vicinity of the OARs would be strongly recommended against but not excluded.
▪ Conflict with Commercial Fishing. 'NSW Ecofishers' recreational fishing organisation recommend that OARs are designated 'Commercial fishing free zones' under Section 8 of the FM Act (Closures).	Section 8.2.4. Commercial fishing would not be excluded from the OARs.

Table 3e Continued: Consultation issues – recreational fishing.

Issue	Assessment and Conclusion
▪ Charter Fishing. 'NSW Ecofishers' recreational fishing organisation recommend that OARs are designated 'charter fishing free' zones' as charter vessels are larger and able to work the traditional and wider offshore grounds in most weathers and greater safety'. Charter fishing organisations were in favour of the proposed OARs.	Section 8.2.4. Charter vessels would not be excluded from OARs.
▪ Location. Distance offshore should be suitable for small craft to access.	Section 9
▪ Configuration. A line configuration orientated north to south or zig – zag configuration (e.g. Figure 12, b and c) were preferred.	Section 9
▪ Anchoring. NSW Ecofishers recreational fishing organisation, suggest that anchoring in the OAR area be prohibited and limited to trolling and drift fishing only.	Section 8.2.6. Anchoring in the vicinity of the OARs would be strongly advised against.
▪ Spearfishing. Spearfishing was generally considered to be compatible with recreational fishing. A plan of management to integrate the two user groups was suggested.	No action required.
▪ Potential for increased hazards from shipping on completion of the Port Botany Expansion Project in 2011.	This is unlikely to be an issue in future, given the proposed location of the Sydney OAR therefore no action required.
▪ Safety. Representatives from the Underwater Skin Divers and Fisherman's Association (USFA formerly the AUF), were confident that a number of free divers are capable of diving to depths in the OAR range (in excess of 25 m) and that the associated safety risks should be considered.	Section 8.2.4
▪ Accessibility. The OARs are not considered to be accessible to the majority of spearfishers at the currently proposed depths. It has been suggested that one of the four reef units (per location) be placed at a depth accessible to the majority of spear fishers (to prevent user conflict and for safety).	This would be difficult to achieve due to stability and navigation issues that arise at shallower depths.
▪ Management. Allocation of access times for different user groups was suggested as a measure to reduce user conflict.	Section 8.2.4 Conflict would be managed through a code of conduct.

6 The Existing Coastal Environment

6.1 Existing Information

The three study regions lie within the Hawkesbury Shelf marine bioregion which extends from the Hunter River at Stockton, south to Shellharbour. Hawkesbury sandstone is a dominant feature of the coastline and has been eroded to create vertical cliffs, intersected by drowned river valleys such as Sydney Harbour and the Hawkesbury River that minimise potential for coastal sedimentation. The bioregion features around 24 estuaries, also including barrier estuaries such as Lake Macquarie, coastal lakes such as Wamberal and Dee Why lagoons and a large embayment, Botany Bay. Approximately 2000 km^2 of oceanic and estuarine waters occur within the bioregion. Ocean water depths typically reach between 40 m – 60 m within the 3 nm limit of State waters, although depths of nearly 120 m are found off Botany Bay (Breen *et al.* 2005).

6.1.1 Coastal Processes

A detailed description of wave climate, currents, water levels, winds and sediment transport at the three proposed study regions is provided in the coastal processes report (Technical Report C). Relevant information has been summarised in the following Sections.

6.1.1.1 Wave Climate

The wave climate of the study area can be considered to be similar throughout, and reasonably well defined. Wave data has been recorded offshore from and within Botany Bay by Sydney Ports Corporation (SPC), and its predecessor bodies, since 1971. The principal location is offshore in a depth of about 80 m using a Datawell Waverider buoy that transmits a signal onshore for processing and data storage. In the early 1970s this was done using paper tape and records were taken about four times a day. Continuous records are taken now, thereby providing a better definition of peak storm wave parameters. Offshore wave direction is an important parameter as well, but has not been recorded at this site. Other offshore wave data for the Sydney region has been recorded by Manly Hydraulics Laboratory at Long Reef to the north of Botany Bay. That installation includes recorded wave direction and data recorded from 1992 onwards. Comparison between the analysed offshore Long Reef and Botany Bay wave databases show that 'actual' offshore wave directions (Long Reef) are more southerly, on a probability of occurrence basis, than has been estimated from synoptic charts for the offshore Botany Bay data by Lord and Kulmar (2001). Other wave climate investigations undertaken in the Port Kembla and Newcastle areas by Cardno Lawson Treloar have demonstrated good correlation between waves recorded at Long Reef and those recorded at Port Kembla and Newcastle. Extreme wave height and wave periods for 1 – 250 ARIs (Average Recurrence Intervals) are given in Technical Report C.

Based on all data collected at the Sydney and Port Kembla buoys to the end of 2004, it is evident that the average significant wave height (H_s) offshore of the study area is about 1.6 m. Storm conditions with H_s exceeding 4.5 m occurred for less than 1 % of the time. Also, the average peak wave period (T_p) is about 9.7 seconds, with about 60 % of T_p values between 8 seconds and 12 seconds and about 90 % of T_p values between 6 seconds and 14 seconds (Kulmar *et al*. 2005).

Kulmar *et al*. (2005) predicted that the 100 year average recurrence interval (ARI) H_s exceeded for a duration of 1 hour and 6 hours offshore of Sydney was 9.5 m and 8.5 m respectively. These values are applicable to all study regions. The predominant wave direction offshore from the study regions is from the SSE. Based on all data collected at the directional Sydney Waverider buoy to the end of 2004, Kulmar *et al*. (2005) found that about 31 % of waves were from the SSE, 19 % from the S, and 16 % from the SE. Furthermore, the SSE direction is dominant for larger waves.

As waves approach the shore from deep water, they may be transformed by the processes of refraction, shoaling, diffraction, attenuation, reflection and breaking. At the proposed water depths for placement of the artificial reefs of around 30 m, the dominant wave transformation processes would be refraction and shoaling, unless islands or other obstructions affect the wave climate and cause sheltering, diffraction and/or reflections. Any potential effects would only be significant in areas offshore of sandy beaches with development at threat due to coastline hazards.

Waves also generate orbital velocities and accelerations in the water column below. At a particular location, the maximum horizontal velocity in the direction of wave propagation occurs at the wave crest, while the maximum horizontal velocity in the opposite direction to wave propagation occurs at the wave trough. In between, velocities vary through all directions between vertical and horizontal.

Knowledge of velocities and accelerations allows the calculation of hydrodynamic wave forces (drag and inertial forces), which are important to consider in the design of the OAR units. It is necessary to ensure that the proposed design would be stable under storm wave conditions.

6.1.1.2 Currents

Water movements in the study areas may be caused by a variety of physical processes, including:-

- tides;
- winds;
- density flows;
- coastal trapped waves ;
- East Australia Current;
- nearshore wave processes;

The Astronomical Tide

Because the tide ranges and phases are very similar along much of the NSW coastline, tidal currents are low along the coastline, except near the entrances to Lake Macquarie, Port Jackson and Botany Bay.

Wind

Wind forcing is applied to the water surface varies with wind speed. Momentum from the wind is gradually transferred down through the water column by vorticity, the maximum depth of this effect being termed the Ekman depth. At the surface, wind induced currents, are in the direction of the wind, but in the southern hemisphere they gradually turn to the left of the wind direction until they flow in the opposite direction at the Ekman depth. Water depths at the three sites are generally too shallow for this condition to develop fully as wind driven currents are affected by the seabed boundary layer. Wind driven currents diminish with depth. Because wind forcing is applied at the water surface, the relative effect is greater in shallow water where there is less water column volume per unit plan area. Wind driven currents are therefore greater in more shallow areas. Maximum surface current speed is in the order of 1 % to 3 % of the wind speed, depending on water depth. Where water is piled up against a coastline by wind forcing, a reverse flow develops near the seabed. Wind-driven currents are likely to be the most important physical process at the three reef sites.

Density Flows

Density currents may be caused by freshwater inflows for example, when the Hunter River is in flood. The freshwater is more buoyant and tends to spread across the sea surface until mixing with the ambient seawater occurs.

Coastal Trapped Waves

Coastal Trapped Waves (CTW) are long period wave phenomena that propagate northward along the continental shelf. Their origin is not fully understood, but they are believed to originate from the passage of successive high and low pressure meteorological systems across southern Australia. These systems have arrival times varying from 3 to 7 days, typically, and these are the periods of observed CTW. These waves are irregular and cause approximate coast parallel currents and variations in water levels. They are trapped on the continental shelf of NSW and will affect observed water levels at all three sites. These currents may be in the order of 0.5 m/s and generally lower than currents caused by strong storm winds.

East Australia Current

The East Australia Current (EAC) transports warmer waters from the Coral Sea southwards into the Tasman Sea. Although the EAC is strong and persistent offshore of northern NSW, it sometimes separates from the continental shelf around Seal Rocks (about 90 km north of the Newcastle study region). The EAC can also spawn large warm or cold core eddies that break away from the main EAC and move slowly southward. A typical EAC structure cannot therefore be defined. Roughan and Middleton (2004) noted that although currents upstream of the separation point are generally southward and strong, downstream currents are highly variable in both strength (generally lower speed than upstream) and direction. Encroachment of the EAC upon the coast was noted by Roughan and Middleton (2004) to have a profound effect on the coastal waters, accelerating the southward (alongshore) currents and decreasing the temperature in the bottom boundary layer by up to 5°C. The EAC is generally strongest in summer, peaking in February, and weakest, by as much as half the flow, in winter (CSIRO Marine Research 2000). The Australian Hydrographic Service charts (AUS808 and AUS809) available for the study area indicate that the EAC is up to 2.1 m/s (applicable to the entire study area).

Nearshore Wave Processes

The propagation of ocean waves (swell) into the nearshore region leads to wave breaking and energy dissipation. Where waves propagate obliquely to the shoreline this process leads to the generation of a longshore current in the surf zone, and to some extent seaward of that line.

6.1.1.3 Water Levels

The main factor that contributes to still water level movement offshore of the study regions is astronomical tide, which is the regular rise and fall of sea level in response to the gravitational attraction of the sun, moon and planets, and the rotational effect due to the spin of the earth on its axis. Tides along the NSW coastline are semi-diurnal, with high and low water approximately equally spaced in time and occurring twice daily (that is, on average, there are two high tides and two low tides in any 24 hour period). There is significant diurnal inequality in NSW coast tides, that is a difference in height of the two high waters or the two low waters of each tidal day. Astronomical tide typically varies between about –1 m AHD (Lowest Astronomical Tide) and 1 m AHD (Highest Astronomical Tide) along the NSW coast, with 0 m AHD close to mean sea level. There are only small differences in tidal characteristics between the three study regions (Table 2.1 of Technical Report C). Barometric pressure changes also affect oceanic water levels amongst other oceanographic effects.

General scientific consensus predicts that, under enhanced climate change conditions, sea levels will rise in response to isothermic expansion and melting of polar ice shelves. Predictions of global sea level rise due to the climate change vary considerably and are linked to greenhouse gas emission scenarios. It is impossible to state conclusively by how much the sea may rise, and no policy yet exists regarding the appropriate provision that should be made in the investigation of coastal processes under those conditions, other than to examine a range of cases (DECC 2009). In February 2009, the NSW Government released a draft sea-level rise policy statement which predicts sea-level rise of up to 0.4 m by 2050, and 0.9 m by 2100 compared to the 1990 mean sea level (DECC 2009). Although shorelines down-wave from the three proposed reef sites may be affected by possible future mean sea level rises and changes in climate, the change in impacts arising from the reefs, in water depths of about 30 m, would not be identifiable. Hence climate change issues are not considered further in this study.

6.1.1.4 Winds

Wind affects both the wave and current climates at the proposed study sites. Wind data has been recorded at Sydney Airport since 1939, Monypenny and Middleton (1997). There is little reliable data from other sites, except for Newcastle (Nobbys Light-house) and Norah Head near The Entrance. However, none of these data has been analysed in the same detail as has the Sydney Airport data. The wind speeds are however, considered to be very similar at all three reef sites with the most extreme wind speeds occurring from the south (Table 2.5 of Technical Report C).

6.1.1.5 Sediment Transport

Sediment transport is caused by the water particle motions of waves and currents that lead to a shear stress on the seabed sediment particles. Generally, sediment motion commences when the seabed shear stress exceeds a threshold value, which depends on particle size and density. Sediment may be transported as bed load or suspended load. Bed load transport is affected as a series of saltations or hops. Suspended sediment transport occurs when the turbulent mixing of the flow counteracts the fall velocity of the finer sediment particles that disperse upward from the seabed; principally under wave action. Where a seabed is disturbed, and where the threshold condition for sediment movement is exceeded, wave and current caused sediment transport may act to restore the pre-condition of the seabed. At shoreline locations sediment transport may be alongshore and/or onshore/offshore. Where waves break obliquely to the shoreline, a longshore current may cause longshore transport. Offshore transport normally occurs during a storm, with a longer term onshore transport following storm abatement.

The majority of sediment transport along the NSW coast is inshore from the depths under consideration in the current proposal. Onshore/offshore (also known as cross-shore) sand movement is caused by natural variations in wave climate and water level. The offshore movement of sand is usually referred to as storm erosion. This onshore/offshore movement of sand results in short-term fluctuations in the width of the beach profile. During storms with relatively large waves, beach sand moves offshore to form bars. This process typically occurs over a period of hours to days. When extended periods of calmer waves occur, the material held in these bars migrates onshore to re-build the beach. Depending on the magnitude of the preceding storm, this beach building process can occur over a time scale of days to years.

The sediment in and around the study area at depths between about 25 m and 75 m is generally, medium to fine grained, moderately sorted, quartzose marine sand with variable shell content and up to about 20% mud content (Nielsen 1994).

Sand waves evident in the study area between 25 m and 75 m depth are consistent with the general south-flowing current structure. Wave-generated ripples are found on the seabed to depths of about 60 m, causing reworking of the seabed surface to depths of about 0.2 m on a daily basis at 25 m depth, and for about 25 % of the time at 60 m depth (Nielsen 1994). However, Nielsen (1994) found that there was negligible net sediment transport beyond 35 m depth.

6.1.2 Flora and Fauna

6.1.2.1 Soft Sediment Environment

Offshore Artificial Reefs are considered to be most effective when placed in bare sandy 'habitat limited' environments. Selection of OAR sites has therefore focused on areas known or likely to consist of sandy substratum away from areas of naturally occurring reef. Soft sediment habitats can support extremely diverse macrofaunal assemblages. Macrofauna (organisms > 1.0 mm) generally comprise polychaetes, crustaceans and molluscs (Hutchings 1998 1999, Snelgrove 1999). Additional taxa recorded include worm-like invertebrates such as nemerteans, echiurids, phoronids and sipunculids and other groups such as echinoderms, sponges, cnidarians and tunicates. Benthic assemblages are found to vary considerably with depth but less so with latitude. Benthic macrofauna are also considered to be good indicators of environmental conditions as they are relatively sedentary, diverse and abundant (Warwick 1993).

In general, the benthic environment off the Newcastle study region consists of proportionally less area of natural rocky reef habitat and greater expanses of uninterrupted bare sand than in the Sydney and Wollongong study regions. Surveys carried out by The Ecology Lab Pty Ltd (2001 and 2003 investigated benthic assemblages and sediment characteristics of sites in the vicinity of the Newcastle Harbour spoil ground using benthic grabs and ROV (Remote Operated Vehicle). In the 2001 survey, control sites at depths of 18 m and 28 m were sampled offshore of South Stockton Beach and offshore from Red Head Point. ROV observations at both sites showed that the seafloor appeared clean except for shells and shell fragments in ripples. Sea urchin tests (skeletons) and small starfish were also observed at some locations. Assemblages of benthic invertebrates consisted mainly of polychaete worms (family Cirratulidae), amphipod crustaceans (family Phoxocephalidae), isopod crustaceans (family Anthuridae) and bivalve molluscs (family Veneridae). Sediment particle size composition was similar at both control sites and consisted of approximately 98 % sand and the remainder gravel. In 2003, dominant families were again isopod crustaceans, amphipod crustaceans, polychaete worms and bivalve molluscs, although the composition was slightly different. In general, larger numbers of individuals were found in sediments at greater depths. Sediments at the control sites were characterised as 'natural shelf sediments' and were again composed mainly of sand with a small amount of gravel. A small proportion of rock fragments and quartz were also found at some locations. Overall, the benthic assemblage was typical of that expected in sandy offshore habitats.

As there are detailed, seabed maps available for the Sydney study region (Public Works Department 1989), broad areas of sand and rocky reef habitat are easily identified. The substratum within the proposed Sydney study area consists of fine to medium grained, golden coloured sand with 10 % shell from the rocky reef shoreline, seaward to a depth of approximately 60 m. Sandy habitats off Sydney have been found to support diverse and abundant assemblages of macroinvertebrates. Major changes occur in these assemblages with increasing depth, even over a relatively narrow range (e.g. between 20 m - 30 m). The invertebrates within shallower areas (e.g. 20-25 m), have been shown to be capable of rapid recolonisation if disturbed and to show detectable responses to storm activity, even at depths of 65 m (The Ecology Lab 1993). This suggests that these assemblages are resilient to physical disturbance.

Soft sediments in the Wollongong study region offshore from Belambi Point and to the north of Bellambi were investigated by The Ecology Lab (2001). Sediment consisted mainly of fine to medium brown sand, with some samples containing a small percentage of silt and some gravel (as broken shells). No significant differences in grain size were detected between these locations and it is expected that a similar sediment composition exists throughout this study area, except the spoil grounds located outside the entrance of Port Kembla and areas adjacent. The benthic infauna associated with the sandy sediments consisted of amphipod crustaceans, polychaetes and a high number of gastropod molluscs of the family Trochidae. Significant differences in assemblages were found among the three depths investigated.

In NSW a few common groups make up the fish fauna of sandy areas (Connell and Lincoln Smith 1999). The elasmobranchs are often represented by Urolophid and Rhinobatid rays. There may also be many small planktivorous fishes. Other common and commercially important groups are the flatheads (Platycephalidae), which are voracious predators and whiting (Sillaginidae), which are benthic feeders. It would be expected that these groups are abundant across the three study regions.

6.1.2.2 Rocky Reef Environments

The location of rocky reef habitat in relation to the proposed OAR sites is an important factor to be considered in achieving the project objectives. The site selection process focussed on sites consisting of bare sand with adequate separation from existing natural reef (The Ecology Lab 2008b). This is for three main reasons:

- so that the artificial reefs provide new alternative fishing locations to relieve pressure on existing natural reef;
- to avoid attraction of adult fish from existing reefs (i.e. draw-down effects);
- provision of a stable substratum.

The recommendation for adequate separation varies broadly depending on the relative sizes of the natural and artificial reefs under consideration. Investigations of fish assemblages inhabiting artificial reefs have shown that the local area of influence of an artificial reef may range from 5 m to 50 m, depending on the local environmental conditions and the reef size (Fabi and Sala 2002, Continental Shelf Associates 1982, Gerlotto *et al*. 1989 Fabi *et al*. 1999).

Rocky reefs support very different communities to the sandy habitats. This is because:

- they have solid substrata which provide points of attachment for sessile organisms such as macroalgae, sponges and corals; and
- they provide organisms with a variety of microhabitats including vertical and horizontal surfaces, crevices and overhangs (The Ecology Lab 1993).

Rocky reef assemblages also show some degree of 'zonation', with turfing macroalgae and kelp occurring in shallower waters, bare rock (which is actually covered by encrusting red algae) in intermediate areas and 'sponge gardens' in deeper water (Underwood *et al.* 1991). These habitats are structured by a variety of physical and biological processes. Reef habitat is likely to be less resilient to disturbance than sandy habitat and is also heavily utilised by humans.

Subtidal rocky reefs harbour fishes that depend on this habitat for food, shelter and/or spawning sites at some stage during their lives. Many species are affected by the topography of the reef and are more abundant in areas of greater physical complexity. Some reef fishes may be very active, including wrasses and leatherjackets, and can traverse large areas of reef. There are also many less mobile, reef associated, species, which spend most of their time on or near the bottom and cryptic species that remain within caves, overhangs and crevices. Bottom dwelling fish include Serranidae and Scorpaenidae while species which inhabit caves and crevices include Pempheridae, Moridae and Muraenidae. Rocky reefs also support a range of highly mobile fishes which visit these reefs but range over a much greater area. Examples include Carangidae and Carcharhinidae (Cardno Ecology Lab 2009).

The near-shore sub-tidal marine reef and soft sediment maps produced by DECCW show no near-shore reefs located in the direct study area of the proposed Newcastle OAR. The closest area of mapped reef is located approximately 4 km south west of the proposed OAR location.

In the Sydney direct study area, a significant outcrop of subtidal reef (Dunbar Head) is located less than 0.5 km south of the proposed artificial reef location. There are also shipwrecks in the area that function as artificial reefs, often supporting similar assemblages of fish and invertebrates. Fish have been surveyed on natural reef occurring within the wider Sydney study area at Cabbage Tree Bay Aquatic Reserve (The Ecology Lab 2006). The reserve is located approximately 4.2 km north of the proposed Sydney OAR and extends from south Manly to the headland north of Cabbage Tree Bay. Mado (*Atypichthys strigatus*), were the most abundant species recorded over a 2 year period contributing to 35 % to 45 % of relative abundance. Other numerically dominant species included one-spot puller

(*Chromis hypselepis*), southern batfish (*Schuettea scalaripinnis*) and yellowtail scad (*Trachurus novaezelandiae*) which were often observed forming dense schools. Luderick (*Girella tricuspidata*), a commercially important species, was also common (contributing to 6 % relative abundance). Several species protected in NSW under the FM Act were also observed including blue groper (*Achoerodus viridis*), elegant wrasse (*Anampses elegans*) and blue devil fish (*Paraplesiops bleekeri*). Species such as the grey nurse shark and black cod could also be expected to be found in the area around Cabbage Tree Bay.

According to near-shore sub-tidal marine reef and soft sediment maps, the rocky reef habitat which forms the Five Islands Nature Reserve is located approximately 2.4 km north of the proposed Wollongong study region. Anecdotal evidence (Brown, D 2008 Pers. Comm) suggests that there are areas of subtidal reef north, east and south of the Wollongong (Port Kembla) direct study area.

The EPA (1992) carried out surveys of rocky reef habitat within the Five Islands area, outside of Port Kembla. Depths between 20 m - 22 m were characterised by a diverse assemblage of encrusting flora and fauna including sponges, bryozoans, cnidarians ascidians and algae. The Ecology Lab (2001) found that sub-tidal rocky reef assemblages in the Port Kembla area consisted of sponges, ascidians, encrusting and foliose algae. Weedy seadragons have also been sampled north of Wollongong Harbour and on the northern side of Big Island, with sites on the interface of reef and sand (depth 15 m – 20 m) appearing to be their favoured habitat (The Ecology Lab, 1999). A total of 64 weedy seadragons were observed during the study with distribution appearing variable between locations. In 2007 The Ecology Lab carried out fish transect surveys in the Wollongong study region in relation to the Illawarra Waste Water Strategy. Control sites (located over reefs approximately 8 km north of the direct study area) were compared with the Wollongong outfall site (located offshore of Port Kembla) approximately 6 km north of the direct study area. Results of the surveys indicated that fish abundance and diversity at the outfall site (post-commissioning) was greater than at nearby rocky reefs but that the fish assemblages at the outfall were different to that of rocky reefs (The Ecology Lab 2007a). Twenty species of fish were recorded at the outfall site compared to an average of 15.6 at the three control sites. It is likely that the structure of the outfall (which was colonised by algae and other organisms) was a factor in attracting fish due to additional artificial habitat and food availability. The difference in assemblages between the control and outfall site is likely to be a result of structural and morphological differences in habitat. Bullseye (*Pempheris* spp.), silver sweep, mado and silver trevally were the most numerically abundant species at the outfall site. Hula fish (*Trachinops taeniatus*), crimson banded wrasse (*Notolabrus gymnogenis*), maori wrasse (*Opthalmolepis lineolatus*), white ear (*Parma microlepis*) and mado were numerically abundant at control locations. Commercially and recreationally important species observed at the outfall site included yellowtail scad, red morwong (*Cheilodactylus fuscus*), silver trevally and snapper. Red morwong, black reef leatherjacket (*Eubalichthys bucephalus*), silver trevally and yellowtail were also observed at control sites but overall abundance was greater at the outfall site.

6.1.2.3 Pelagic Environment

The pelagic environment includes the water mass between the surface and the seabed and is inhabited by a diverse range of organisms including plankton, fishes and marine mammals and reptiles.

Plankton is made up of two general groups: meroplankton, which spend part of their life in the plankton, usually as larvae; and holoplankton, which spend their entire life in the plankton (Kingsford 1995). A number of biotic and abiotic factors are important in determining the taxonomic composition and relative abundances of individual planktonic taxa present in the water column (Gray and Miskiewicz 2000), including seasonal differences in the East Australian Current and spawning times. The ocean currents impinging on the OARs would form a wake or zone of flow disturbance in the lee of the structures (e.g. Rissik *et al*. 1997). In deep water, flow disturbance can uplift cool, nutrient-rich water in eddies, which in turn, can lead to production of phytoplankton and the zooplankton that feed on them (Rissik *et al*. 1997). Although the OARs would be unlikely to increase nutrient levels by this process because of their location and depth, there would be potential to create small eddies that may act as retention zones, trapping water and particulates behind the structures for significant periods of time that may facilitate increased concentrations of plankton. Although this phenomenon has been reported only for large island masses (e.g. Hernandez-Leon 1991) the structures may have a smaller scale, but similar effect. Planktivorous fishes may congregate where concentrations of plankton are greater (as has potential to occur at the OARs) as they can feed more successfully in these areas (Rissik and Suthers 2000). Such concentrations of fishes on the OARs (which may be prey to some species) are likely to attract, larger pelagic predatory fish, such as yellowtail kingfish (*Seriola lalandii*), Australian bonito (*Sarda australis*) and tailor (*Pomatomus saltatrix*).

Marine turtles and marine mammals live in the pelagic environment and may pass close by to shore where the OARs would be situated. Some of these have potential to occur in the study regions all year round (i.e. marine turtles, seals and dolphins) while others such as the much larger baleen whales (e.g. humpback whale, *Megaptera novaeangliae*) and southern right whale, *Eubalaena australis*) are seasonal.

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

State legislation relevant to threatened and protected species, populations and ecological communities are the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the NSW *Fisheries Management Act 1994* (FM Act) and the *National Parks and Wildlife Act 1974.*

The NSW government 'BioNet' database (Web Reference 11) and the DECCW threatened species database (Web Reference 25) were searched for threatened species, populations and communities listed under relevant Schedules of the TSC Act, FM Act and NP&W Act that are likely or predicted to occur in the three study regions. The search was carried out in February 2009 and included species of marine fish, marine mammals, marine reptiles, marine algae/vegetation, marine invertebrates and seabirds. The 'BioNet' searches covered the Hunter/Central Rivers, Sydney Metro and Southern Rivers Catchment Management Authorities (CMAs). DECCW database searches were carried out according to the relevant marine zone CMA sub-regions. This allowed a broad-scale assessment of all threatened and protected species that could potentially occur in the study regions. The results of the database searches for each of the CMAs/ marine zone CMA sub-regions are listed in Tables 4, 5 and 6 for Newcastle, Sydney and Wollongong respectively.

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

- the 'presumed extinct' green sawfish (*Pristis zijsron);*
- the 'critically endangered' east coast population of grey nurse shark (*Carcharias taurus);*
- the 'endangered' blue whale (*Balaenoptera musculus);*
- the 'endangered' dugong (*Dugong dugon);*
- the 'endangered' southern bluefin tuna (*Thunnus maccoyii);* and
- the 'endangered' loggerhead turtle (*Caretta caretta*).
- nine species were also listed as vulnerable and 50 species identified as 'protected' under the FM Act, (mainly syngnathiforms i.e. seahorses, pipefish, pipehorses, ghost pipefish, seamoths and seadragons).

Species protected under the TSC/FM Act potentially occurring in the Sydney metro search area, included:

- the 'critically endangered' east coast population of grey nurse shark (*Carcharias taurus);*
- the 'endangered' blue whale (*Balaenoptera musculus);*
- the 'endangered' dugong (*Dugong dugon);*
- the 'endangered' southern bluefin tuna (*Thunnus maccoyii);* and
- the 'endangered' loggerhead turtle (*Caretta caretta*).
- nine 'vulnerable' and 42 'protected' species were also listed under the TSC/FM Act.

Species protected under the TSC/FM Act potentially occurring in the Southern Rivers search area, included:

- the 'critically endangered' east coast population of grey nurse shark (*Carcharias taurus);*
- the 'endangered' blue whale (*Balaenoptera musculus);*
- the 'endangered' dugong (*Dugong dugon);* and
- the 'endangered' southern bluefin tuna (*Thunnus maccoyii)*.
- nine 'vulnerable' species and 64 'protected' species were also listed.

Searches for seabirds likely to forage offshore and in the direct study areas occurring in the relevant CMAs/marine zone CMA sub-regions were carried out separately. Intertidal and wading birds such as sandpipers, curlews and plovers, for example, were excluded from the assessment as they are unlikely to be affected by the proposal. The main groups of seabirds that were found to occur in the three study regions included albatrosses, petrels, shearwaters, terns, skuas, gulls, gannets and the endangered population of little penguins (*Eudyptula minor*) at Manly.

In the Hunter/Central Rivers CMA/NRMR, 30 species of seabirds were listed as 'protected', four listed as 'endangered' and 16 species listed as' vulnerable'(Table 4). In the Sydney Metro CMA/NRMR 46 species of seabirds were listed as 'protected', four listed as 'endangered' and 13 species listed as' vulnerable'(Table 5). In the

Southern Rivers CMA/NRMR, 43 species of seabirds were listed as 'protected', four listed as 'endangered' and 14 species listed as' vulnerable'(Table 6).

Only threatened species (from the initial search) that were known or considered likely to occur in the wider study areas (based on general species distribution databases) and/or known to utilise habitat in the study areas, were considered for further Assessment of Significance. These species were assessed according to DECCW/I&I threatened species assessment guidelines (DECC 2007, DEC 2004, DPI 2008). It should be noted that this does not include 'protected' or 'conservation dependent' species, which do not require an Assessment of Significance. All seabirds were assessed collectively, except for the little penguin which was assessed individually.

Assessments of Significance (State)

Individual species assessments are given in Appendix 6. Overall, five species of fish, three species of marine turtle, four species of cetacean, two pinnipeds and one sirenian (the dugong) were assessed according to DECCW/I&I threatened species assessment guidelines (DECC 2007, DEC 2004). A generic assessment was undertaken for seabirds, apart from the little penguin, which was assessed individually due to the endangered population occurring at Manly.

Fish

Species of threatened fish under the FM Act considered likely to occur within the wider Newcastle, Sydney and Wollongong study areas are:

- the *critically endangered* east coast population of grey nurse shark (*Carcharias taurus*);
- 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 issues which could occur, or be exacerbated by the proposed OARs on fish were identified as:

- the potential for increased fishing mortality through incidental capture;
- the potential to increase the impact of key threatening process namely:
    - 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act);
    - 'hook and line fishing in areas important to the survival of a threatened fish species (FM Act).

The proposal was not considered to have a significant impact on any of the species identified above, hence Species Impact Statements (SIS) were not necessary (Appendix 6).

In the case of the southern bluefin tuna and great white shark, this was mainly due to the transient nature of the species, which means they are unlikely to remain in the vicinity of the OARs long enough to be vulnerable to the potential impacts identified.

As the last sighting of the green sawfish was in 1972 from the Clarence River in Yamba, it is highly unlikely that the species would occur in any of the proposed study areas.

The grey nurse shark is known to aggregate at discreet locations within the wider study areas, including known critical habitats such as Magic Point (Maroubra) approximately 12.5 km from the Sydney OAR site, and Bass Point approximately 8 km south of the Wollongong OAR site. Given the distance from known aggregation areas, the proposal would not directly affect grey nurse shark habitat. It is however, possible that individuals could occasionally forage within the direct OAR study areas. Although this species is most frequently sighted in or near sand-bottomed gutters or rocky caves, the fish are thought to be partly migratory and may occasionally forage outside of aggregation sites over open sandy habitat (Smale 2005). This considered, it is possible that the grey nurse shark could be at risk of incidental capture as a result of the proposal. Even if sharks are returned to the water, capture related injuries can lead to early mortality due to infection and/or by affecting feeding efficiency. Given that the sharks are only likely to forage within any of the direct study areas on occasion, it is unlikely that potential impacts associated with the OARs would affect the life cycle of a viable local population to such an extent that the species is placed at the risk of extinction. Furthermore, providing that fishing activities in the direct OAR study areas are properly managed and monitored, potential risks would be minimised or addressed before they become problematic.

Marine Turtles

Species of marine turtle considered likely to occur within the wider Newcastle, Sydney and Wollongong study areas are:

- the *vulnerable* green turtle (*Chelonia mydas*);
- the *vulnerable* leatherback turtle (*Dermochelys coriacea*); and
- the *endangered* loggerhead turtle (*Caretta caretta*).

The loggerhead turtle is only known to occur in the Newcastle and Sydney study regions.

Potential issues which could occur, or be exacerbated by the proposed OARs on marine turtles were identified as:

- increased risk of boat strike in the direct study areas; and
- the potential to increase the impact of a key threatening process namely, 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act).

For both species, the proposal was not considered to have a significant impact such that a Species Impact Statement (SIS) would be necessary. This was mainly due to the transient nature of the species and absence of important nesting, mating or feeding areas within any of the wider study areas.

Cetaceans

Species of cetacean (protected under State legislation) considered likely to occur within the wider Newcastle, Sydney and Wollongong study areas are:

- the *vulnerable* 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 all study regions. The sperm whale is only known or likely to occur in the Sydney and Wollongong study areas and the blue whale is only considered likely to occur in the Sydney study area. Blue whales occur right around Australia and whilst they are unlikely to spend much if any time in the waters of the OAR, they could occur in the wider study areas.

Potential issues which could occur, or be exacerbated by the proposed OARs on cetaceans were identified as:

- increased risk of acoustic disturbance (from boat noise) in the direct study areas;
- increased risk of boat strike in the direct study areas and;
- the potential to increase the impact of a key threatening process namely, 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act).

The proposal was not considered to have a significant impact on any species of cetacean, such that a Species Impact Statement (SIS) would be necessary. This was mainly due to the transient nature of the species and that important, mating, feeding or resting areas would not be affected by the proposal.

Pinnipeds and Sirenians

Species of pinniped and sirenian (protected under State legislation) considered likely to occur within the wider Newcastle, Sydney and Wollongong study areas are:

- 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 and New Zealand fur-seal were considered likely to occur within all the wider study areas, however, the dugong is only reported to occur in the wider Newcastle and Wollongong study areas. Potential issues which could occur, or be exacerbated by the proposed OARs on pinnipeds and sirenians were identified as:

- increased risk of acoustic disturbance (from boat noise) in the direct study areas;
- increased risk of boat strike in the direct study areas (only applicable to the dugong) and;
- the potential to increase the impact of a key threatening process namely; 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act).

Although pinnipeds and sirenians (particularly seals) could forage within the wider study areas, the proposal was not considered to have a significant impact, such that a Species Impact Statement (SIS) would be necessary.

Seabirds

Seabirds likely to forage offshore in the vicinity of the study areas were assessed collectively. Protected species known to roost or breed on land nearby to the direct study areas include:

- the *vulnerable* sooty oyster catcher (*Haematopus fuliginosus*) - Moon Island (Newcastle study region) and Five Islands Nature Reserve (Wollongong study region);
- the *protected* wedge-tailed shearwater (*Puffinus pacificus*) - Moon Island (Newcastle study region) and Five Islands Nature Reserve (Wollongong study region);
- the *protected* short-tailed shearwater (*Puffinus tenuirostris*) - Five Islands Nature Reserve (Wollongong study region);
- the *protected* Kelp gull (*Larus dominicanus*) - Moon Island (Newcastle study region);
- the *protected* White bellied sea eagle (*Haliaeetus leucogaster*) - Five Islands Nature Reserve (Wollongong study region);
- the *endangered* wandering albatross (*Diomedea exulans*) - North Head (Sydney study region);
- the *endangered* southern giant petrel (*Macronectes giganteus*) - North Head (Sydney study region).

The Five Islands Nature Reserve, Moon Island Nature Reserve and North Head are located 2.4 km, 4 km and 1.7 km respectively from the proposed OAR locations. Potential issues which could occur or be exacerbated by the proposed OARs on seabirds were identified as:

- incidental capture by commercial or recreational fishing activity;
- the potential to increase the impact of a key threatening process namely; 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act).

The proposal was not considered to have a significant impact on any species of seabird, such that a Species Impact Statement (SIS) would be necessary, but it is recommended that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement) in the vicinity of the OARs. The OARs should also be monitored for occurrence and/or interactions of the species with fishing activity.

Endangered Population – Little Penguins at Manly

An endangered population of the little penguin (*Eudyptula minor*) is known to occur within the wider Sydney study area. The proposal has the potential to increase the impact of a key threatening process on the little penguin population Manly, by 'entanglement or ingestion of anthropogenic debris in marine and estuarine environments' (TSC/FM Act).

The endangered population at Manly is the only 'mainland' breeding colony of little penguins and occurs approximately 3.7 km northwest of the proposed Sydney OAR site. Although the species could potentially forage in the direct study area, no area of critical habitat would be directly affected and the proposal was not considered to have a significant impact, such that a Species Impact Statement (SIS) would be necessary.

Table 4: Species known or predicted to occur in the Hunter/Central Rivers CMA/NRMR (Newcastle study region) as listed under the NSW *Fisheries Management Act* (FM Act), the NSW *Threatened Species Conservation Act* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act* (EPBC Act). PE = presumed extinct, CE = critically endangered, E = endangered, V = vulnerable, CD= Conservation Dependant, M = migratory, L = listed, Cet = cetacean and P = protected. Source: NSW 'Bionet' database and the EPBC Database environmental reporting tool (accessed February 2009). Note: All native birds, reptiles, amphibians and mammals in NSW are protected by the *National Parks and Wildlife Act* (NP&W Act).

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
1. Marine Mammals:				
Cetaceans				
Balaenoptera acutorostrata	Dwarf minke whale	P	Cet	~
Balaenoptera musculus	Blue whale	E	Cet, E, M	
Balaenoptera bonaerensis	Antarctic minke whale	P	Cet, M	
Balaenoptera edeni	Bryde’s whale	P	Cet, M	~
Caperea marginata	Pygmy right whale	P	Cet, M	~
Delphinus delphis	Common dolphin	P	Cet	✓
Dugong dugon	Dugong	E	Cet, M	✓
Eubalaena australis	Southern right whale	V	Cet, E, M	✓
Feresa attenuata	Pygmy killer whale		Cet	
Globicephala melas	Short-finned pilot whale	P	Cet	
Globicephala macrorhyncus	Long-finned pilot whale	P	Cet	
Grampus griseus	Risso's dolphin	P	Cet	~
Kogia breviceps	Pygmy sperm whale	P	Cet	
Lagenorrhycus obscurus	Dusky dolphin		Cet, M	~
Lissodelphis peronii	Southern right whale dolphin		Cet	
Mesoplodon bowdoini	Andrews beaked whale		Cet	
Megaptera novaeangliae	Humpback whale	V	Cet, V, M	✓
Mesoplodon grayi	Gray's beaked whale	P	Cet	✓
Mesoplodon layardii	Strap-toothed beaked whale	P	Cet	
Mesoplodon mirus	True's beaked whale		Cet	
Orcinus orca	Killer whale		Cet, M	~
Peponocephala electra	Melon-headed whale	P	Cet	
Pseudorca crassidens	False killer whale	P	Cet	
Physeter macrocephalus	Sperm whale	V	Cet, M	
Stenella coeruleoalba	Striped dolphin	P	Cet	
Stenella attenuata	Spotted dolphin	P	Cet	✓
Stenella longirostris	Long snouted spinner dolphin		Cet, M	
Steno bredanensis	Rough toothed dolphin	P	Cet	
Tursiops aduncus	Long-beaked bottle nosed dolphin	P	Cet, M	✓
Tursiops truncatus	Bottlenose dolphin	P	Cet	~
Ziphius cavirostris	Cuvier's beaked whale		Cet	
Pinnipeds				
Arctocephalus pusillus doriferus	Australian fur-seal	V	L	~
Arctocephalus forsteri	New Zealand fur-seal	V	L	~
Arctocephalus tropicalis	Sub-Antarctic fur seal	P		

Continued

Table 4: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
1. Marine Mammals:				
Hydrurga leptonyx	Leopard seal	P		✓
Pinnipeds				
Neophoca cinerea	Australian sea lion	P		
2. Fish				
Carcharodon carcharias	Great white shark	V	V, M	✓
Carcharias taurus (East Coast)	Grey nurse shark	CE	CE	✓
Epinephelus coioides	Estuary cod	P		
Epinephelus daemelii	Black cod	V		
Epinephelus lanceolatus	Giant Queensland groper	P		
Girella cyanea	Bluefish	P		
Galeorhinus galeus	School shark		CD	~
Paraplesiops bleekeri	Bleekers devil fish	P		✓
Pristis zijsron	Green sawfish	PE		✓
Rexea solandri	Eastern gemfish		CD	
Thunnus maccoyii	Southern bluefin tuna	E		
Rhincodon typus	Whale shark		M, V	~
Pipefish (Sygnathiformes)				
Phyllopteryx taeniolatus	Weedy seadragon	P	L	✓
Acentronura tentaculata	Hairy pygmy pipehorse	P	L	~
Festucalex cinctus	Girdled pipefish	P	L	~
Filicampus tigris	Tiger pipefish	P	L	~
Heraldia nocturna	Upside-down pipefish	P	L	~
Hippichthys heptagonus	Madura pipefish	P	L	
Hippichthys penicillus	Beady pipefish	P	L	~
Hippocampus abdominalis	Eastern potbelly seahorse	P	L	~
Hippocampus whitei	White's seahorse	P	L	~
Histiogamphelus briggsii	Briggs' crested pipefish	P	L	~
Lissocampus runa	Javelin pipefish	P	L	~
Maroubra perserrata	Sawtooth pipefish	P	L	~
Notiocampus ruber	Red pipefish	P	L	~
Solegnathus dunckeri	Duncker's pipehorse	P	L	
Solegnathus spinosissimus	Spiny pipehorse	P	L	~
Solenostomus cyanopterus	Blue-finned ghost pipefish	P	L	~
Solenostomus paradoxus	Harlequin Ghost pipefish	P	L	~
Stigmatopora argus	Spotted pipefish	P	L	~
Stigmatopora nigra	Wide-bodied pipefish	P	L	~
Syngnathoides biaculeatus	Double-ended pipehorse	P	L	~
Trachyrhamphus bicoarctatus	Short-tailed pipefish	P	L	~
Urocampus carinirostris	Hairy pipefish	P	L	~
Vanacampus margaritifer	Mother-of-pearl pipefish	P	L	~

Continued

Table 4: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
3. Marine Reptiles				
Marine Turtles				
Caretta caretta	Loggerhead turtle	E	E,M	✓
Chelonia mydas	Green Turtle	V		✓
Eretmochelys imbricata	Hawksbill turtle	P		✓
Dermochelys coriacea	Leatherback turtle	V	E, M	~
Natator depressus	Flatback turtle	P	V, M	✓
Seasnakes				
Hydrophis elegans	Elegant seasnake		L	
Pelamis platurus	Yellow-bellied seasnake		L	
4. Seabirds				
Apus pacificus	Fork-tailed swift	P		~
Calonectris leucomelas	Streaked shearwater	P	M	~
Catharacta skua	Great skua		L	~
Chlidonias hybridus	Whiskered tern	P		~
Chlidonias leucopterus	White-winged black tern	P		~
Diomedea exulans	Wandering albatross	E	V, M	~
Diomedea exulans amsterdamensis	Amsterdam albatross		E, M	~
Diomedea exulans antipodensis	Antipodean albatross	V	V, M	~
Diomedea exulans exulans	Tristan albatross		E, M	~
Diomedea exulans gibsoni	Gibsons albatross	V	V, M	~
Fregata ariel	Lesser frigatebird	P		~
Fregetta grallaria grallaria	White-bellied storm-petrel	V	V	~
Gygis alba	White tern	V		~
Haematopus fuliginosus	Sooty oystercatcher	V		✓
Haematopus longirostris	Pied oystercatcher	V		~
Haliaeetus leucogaster	White-bellied sea-eagle	P	M	~
Larus dominicanus	Kelp gull	P		✓
Larus novaehollandiae	Silver gull	P	L	✓
Macronectes giganteus	Southern giant petrel	E	E, M	~
Macronectes halli	Northern giant petrel	V	V, M	~
Morus serrator	Australasian gannet	P		~
Pachyptila turtur	Fairy prion	P	V, M	~
Pelecanus conspicillatus	Australian pelican	P		✓
Pelagodroma marina	White-faced storm petrel		L	~
Phalacrocorax carbo	Great cormorant	P		~
Phalacrocorax melanoleucos	Little pied cormorant	P		~
Phalacrocorax sulcirostris	Little black cormorant	P		~
Phalacrocorax varius	Pied cormorant	P		~
Phoebtria fusca	Sooty albatross	V	V,M	~
Pterodroma externa	Juan fernandez petrel	P		~
Pterodroma leucoptera leucoptera	Gould's petrel	E	E, M	~
Pterodroma neglecta neglecta	Kermadec petrel	V	V	~

Continued

Table 4: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
4. Seabirds				
Pterodroma nigripennis	Black-winged petrel	V		~
Pterodroma solandri	Providence petrel	V		~
Puffinus assimilis	Little shearwater	V		~
Puffinus carneipes	Flesh-footed shearwater	V		~
Puffinus gavia	Fluttering shearwater	P		~
Puffinus griseus	Sooty shearwater	P	M	~
Puffinus pacificus	Wedge-tailed shearwater	P	M	✓
Puffinus tenuirostris	Short-tailed shearwater	P	M	~
Sterna albifrons	Little tern	E	M	~
Stercorarius parasiticus	Arctic jaeger	P		~
Stercorarius pomarinus	Pomarine jaeger	P		~
Sterna bergii	Crested tern	P	L	~
Sterna caspia	Caspian tern	P		~
Sterna fuscata	Sooty tern	V		~
Sterna hirundo	Common tern	P		~
Sterna nilotica	Gull-billed tern	P		~
Sterna paradisaea	Arctic tern	P		~
Sterna striata	White-fronted tern	P		~
Sula dactylatra	Masked booby	V		~
Thalassarche cauta	Shy albatross	V	V, M	~
Thalassarche chlororhynchos	Yellow-nosed albatross	P	M	~
Thalassarche chrysostoma	Grey-headed albatross	P		~
Thalassarche melanophris	Black-browed albatross	V	V, M	~
Thalassarche bulleri	Bullers albatross		V, M	~
Thalassarche cauta salvini	Salvins albatross		V, M	~
Thalassarche cauta steadi	White-capped albatross		V, M	~
Thalassarche cauta eremita	Chatham albatross		E, M	~
Thalassarche melanophris impavida	Campbell albatross		V, M	~

Table 5: Species known or predicted to occur in the Sydney Metro CMA/NRMR (Sydney study region) as listed under the NSW *Fisheries Management Act* (FM Act), the NSW *Threatened Species Conservation Act* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act* (EPBC Act). PE = presumed extinct, CE = critically endangered, E = endangered, V = vulnerable, CD= Conservation Dependant, M = migratory, L = listed, Cet = cetacean and P = protected. Source: NSW 'Bionet' database and the EPBC Database environmental reporting tool (accessed February 2009). Note: All native birds, reptiles, amphibians and mammals in NSW are protected by the *National Parks and Wildlife Act* (NP&W Act).

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
1. Marine Mammals:				
Cetaceans				
Balaenoptera acutorostrata	Dwarf minke whale	P	Cet	✓
Balaenoptera musculus	Blue whale	E	Cet, E, M	~
Balaenoptera bonaerensis	Antarctic minke whale	P	Cet, M	~
Balaenoptera edeni	Bryde’s whale	P	Cet, M	~
Berardius arnuxii	Arnoux's beaked whale		Cet	~
Caperea marginata	Pygmy right whale	P	Cet, M	~
Delphinus delphis	Common dolphin	P	Cet	✓
Dugong dugon	Dugong	E	Cet, M	✓
Eubalaena australis	Southern right whale	V	Cet, E, M	✓
Grampus griseus	Risso's dolphin	P	Cet	✓
Kogia breviceps	Pygmy sperm whale	P	Cet	✓
Kogia simus	Dwarf sperm whale	P	Cet	✓
Lagenorrhycus obscurus	Dusky dolphin		Cet, M	~
Lobodon carcinophagus	Crab-eater seal	P		✓
Megaptera novaeangliae	Humpback whale	V	Cet, V, M	✓
Mesoplodon layardii	Strap-toothed beaked whale	P	Cet	~
Mirounga leonina	Southern elephant seal	P		✓
Orcinus orca	Killer whale		Cet, M	✓
Pseudorca crassidens	False killer whale	P	Cet	✓
Physeter macrocephalus	Sperm whale	V	Cet, M	✓
Stenella coeruleoalba	Striped dolphin	P	Cet	✓
Stenella attenuata	Spotted dolphin	P	Cet	✓
Tursiops truncatus	Bottlenose dolphin	P	Cet	✓
Pinnipeds				
Arctocephalus pusillus doriferus	Australian fur-seal	V	L	✓
Arctocephalus forsteri	New Zealand fur-seal	V	L	✓
Arctocephalus tropicalis	Sub-Antarctic fur seal	P		✓
Hydrurga leptonyx	Leopard seal	P		✓
Neophoca cinerea	Australian sea lion	P		✓
2. Fish				
Anampses elegans	Elegant wrasse	P		✓
Carcharodon carcharias	Great white shark	V	V, M	✓
Carcharias taurus (East Coast)	Grey nurse shark	CE	CE	✓
Epinephelus daemelii	Black cod	V		✓

Continued

Table 5: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
2. Fish				
Galeorhinus galeus	School shark		CD	~
Girella cyanea	Bluefish	P		~
Hoplostethus atlanticus	Orange roughy		CD	~
Paraplesiops bleekeri	Bleekers devil fish	P		✓
Pristis zijsron	Green sawfish	PE		✓
Rexea solandri	Eastern gemfish		CD	~
Thunnus maccoyii	Southern bluefin tuna	E		~
Rhincodon typus	Whale shark		M, V	~
Pipefish (Sygnathiformes)				
Phyllopteryx taeniolatus	Weedy seadragon	P	L	~
Acentronura tentaculata	Hairy pygmy pipehorse	P	L	~
Festucalex cinctus	Girdled pipefish	P	L	~
Filicampus tigris	Tiger pipefish	P	L	~
Heraldia nocturna	Upside-down pipefish	P	L	~
Hippichthys penicillus	Beady pipefish	P	L	~
Hippocampus abdominalis	Eastern potbelly seahorse	P	L	~
Hippocampus whitei	White's seahorse	P	L	~
Histiogamphelus briggsii	Briggs' crested pipefish	P	L	~
Lissocampus runa	Javelin pipefish	P	L	~
Maroubra perserrata	Sawtooth pipefish	P	L	~
Notiocampus ruber	Red pipefish	P	L	~
Solegnathus spinosissimus	Spiny pipehorse	P	L	~
Solenostomus cyanopterus	Blue-finned ghost pipefish	P	L	~
Solenostomus paradoxus	Harlequin Ghost pipefish	P	L	~
Stigmatopora argus	Spotted pipefish	P	L	~
Stigmatopora nigra	Wide-bodied pipefish	P	L	~
Syngnathoides biaculeatus	Double-ended pipehorse	P	L	~
Trachyrhamphus bicoarctatus	Short-tailed pipefish	P	L	~
Urocampus carinirostris	Hairy pipefish	P	L	~
Vanacampus margaritifer	Mother-of-pearl pipefish	P	L	~
3. Marine Reptiles				
Caretta caretta	Loggerhead turtle	E	E, M	✓
Chelonia mydas	Green turtle	V	M, V	✓
Dermochelys coriacea	Leatherback turtle	V	E, M	✓
Seasnakes				
Pelamis platurus	Yellow-bellied seasnake		L	✓
Hydrophis elegans	Elegant seasnake		L	✓
4. Seabirds				
Eudypula minor	Little penguin	Endangered Population	L	✓
Anous minutus	Black noddy		L	~
Anous stolidus	Common noddy		M	~

Continued

Table 5: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
4. Seabirds				
Apus pacificus	Fork-tailed swift	P		~
Calonectris leucomelas	Streaked shearwater	P	M	~
Catharacta skua	Great skua		L	~
Chlidonias hybridus	Whiskered tern	P		~
Chlidonias leucopterus	White-winged black tern	P		~
Daption capense	Cape petrel	P		~
Diomedea exulans	Wandering albatross	E	V, M	~
Diomedea exulans amsterdamensis	Amsterdam albatross		E, M	~
Diomedea exulans antipodensis	Antipodean albatross	V	V, M	~
Diomedea exulans exulans	Tristan albatross		E, M	~
Diomedea gibsoni	Gibsons albatross	V	V,M	✓
Fregata ariel	Lesser frigatebird	P		~
Fregatta grallaria grallaria	White-bellied storm-petrel	V	V, M	~
Fulmarus glacialoides	Southern fulmar	P		~
Garrodia nereis	Grey-backed storm-petrel	P		~
Gygis alba	White tern	V		~
Haematopus fuliginosus	Sooty oystercatcher	V		~
Haematopus longirostris	Pied oystercatcher	V		~
Haliaeetus leucogaster	White-bellied sea-eagle	P	M	~
Larus dominicanus	Kelp gull	P		~
Larus novaehollandiae	Silver gull	P		~
Larus pacificus	Pacific gull	P		~
Larus pipixcan	Franklin's gull	P		~
Macronectes giganteus	Southern giant petrel	E	E, M	~
Macronectes halli	Northern giant petrel	V	V, M	~
Morus serrator	Australasian gannet	P		~
Pachyptila belcheri	Slender-billed prion	P		~
Pachyptila desolata	Antarctic prion	P		~
Pachyptila turtur	Fairy prion	P	V, M	~
Pelagodroma marina	White-faced storm-petrel	P		~
Pelecanoides urinatrix	Common diving-petrel	P		~
Pelecanus conspicillatus	Australian pelican	P		✓
Phalacrocorax carbo	Great cormorant	P		~
Phalacrocorax melanoleucos	Little pied cormorant	P		~
Phalacrocorax sulcirostris	Little black cormorant	P		~
Phalacrocorax varius	Pied cormorant	P		~
Phoebetria fusca	Sooty albatross	V	V,M	✓
Procelsterna cerulea	Grey ternlet	V		~
Pseudobulweria rostrata	Tahiti petrel	P		~
Pterodroma inexpecta	Mottled petrel	P		~
Pterodroma lessonii	White-headed petrel	P		~
Pterodroma leucoptera leucoptera	Gould's petrel	E	E, M	✓

Continued

Table 5: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
4. Seabirds				
Pterodroma macroptera	Great-winged petrel	P		~
Pterodroma mollis	Soft-plumaged petrel	P		~
Pterodroma neglecta neglecta	Kermadec petrel	V	V	✓
Pterodroma nigripennis	Black-winged petrel	V		✓
Pterodroma solandri	Providence petrel	V		✓
Puffinus assimilis	Little shearwater	V		✓
Puffinus carneipes	Flesh-footed shearwater	V		✓
Puffinus gavia	Fluttering shearwater	P		~
Puffinus griseus	Sooty shearwater	P	M	~
Puffinus huttoni	Hutton's shearwater	P		~
Stercorarius longicaudus	Long-tailed jaeger	P		~
Stercorarius parasiticus	Arctic jaeger	P		~
Stercorarius pomarinus	Pomarine jaeger	P		~
Sterna albifrons	Little tern	E	M	✓
Sterna bergii	Crested tern	P	L	~
Sterna caspia	Caspian tern	P		✓
Sterna fuscata	Sooty tern	V		~
Sterna hirundo	Common tern	P		~
Sterna nereis	Fairy tern	P		~
Sterna nilotica	Gull-billed tern	P		~
Sterna paradisaea	Arctic tern	P		~
Sterna striata	White-fronted tern	P		~
Sula leucogaster	Brown booby	P		~
Thalassarche bulleri	Bullers albatross		V, M	~
Thalassarche cauta	Shy albatross	V	V, M	✓
Thalassarche cauta eremita	Chatham albatross		E, M	~
Thalassarche cauta salvini	Salvins albatross		V, M	~
Thalassarche cauta steadi	White-capped albatross		V, M	~
Thalassarche chlororhynchos	Yellow-nosed albatross	P	M	~
Thalassarche chrysostoma	Grey-headed albatross	P		~
Thalassarche melanophris	Black-browed albatross	V	V, M	✓
Thalassarche melanophris impavida	Campbell albatross		V, M	~

Table 6: Species known or predicted to occur in the Southern Rivers (Wollongong study region) as listed under the NSW *Fisheries Management Act* (FM Act), the NSW *Threatened Species Conservation Act* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act* (EPBC Act). PE = presumed extinct, CE = critically endangered, E = endangered, V = vulnerable, CD= Conservation Dependant, M = migratory, L = listed, Cet = cetacean and P = protected. Source: NSW 'Bionet' database and the EPBC Database environmental reporting tool (accessed February 2009). Note: All native birds, reptiles, amphibians and mammals in NSW are protected by the *National Parks and Wildlife Act* (NP&W Act)

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
1. Marine Mammals				
Cetaceans				
Balaenoptera acutorostrata	Dwarf minke whale	P	Cet	✓
Balaenoptera musculus	Blue whale	E	Cet, E, M	✓
Balaenoptera bonaerensis	Antarctic minke whale	P	Cet, M	
Balaenoptera edeni	Bryde's whale	P	Cet, M	✓
Berardius arnuxii	Arnoux's beaked whale		Cet	
Caperea marginata	Pygmy right whale	P	Cet, M	~
Delphinus delphis	Common dolphin	p	Cet	✓
Dugong dugon	Dugong	E	Cet, M	✓
Eubalaena australis	Southern right whale	V	Cet, E, M	✓
Globicephala melas	Short-finned pilot whale	P	Cet	✓
Globicephala macrorhyncus	Long-finned pilot whale	P	Cet	
Grampus griseus	Risso's dolphin	P	Cet	~
Hyperooodon planifrons	Southern bottlenose whale	P	Cet	
Kogia breviceps	Pygmy sperm whale	P	Cet	✓
Kogia simus	Dwarf sperm whale	P	Cet	
Lagenorrhycus obscurus	Dusky dolphin		Cet, M	~
Lissodelphis peronii	Southern right whale dolphin		Cet	
Megaptera novaeangliae	Humpback whale	V	Cet, V, M	✓
Mesoplodon bowdoini	Andrews beaked whale		Cet	✓
Mesoplodan densirostris	Blainvilles beaked whale	P	Cet	✓
Mesoplodon gingodens	Ginko-toothed whale	P	Cet	
Mesoplodon grayi	Gray's beaked whale	P	Cet	✓
Mesoplodon hectori	Hectors beaked whale		Cet	
Mesoplodon layardii	Strap-toothed beaked whale	P	Cet	✓
Mesoplodon mirus	True's beaked whale		Cet	
Orcinus orca	Killer whale		Cet, M	~
Pseudorca crassidens	False killer whale	P	Cet	✓
Physeter macrocephalus	Sperm whale	V	Cet, M	✓
Stenella attenuata	Spotted dolphin	P	Cet	✓
Stenella coeruleoalba	Striped dolphin	P	Cet	✓
Steno bredanensis	Rough toothed dolphin	P	Cet	✓
Tursiops aduncus	Long-beaked bottle nosed dolphin	P	Cet, M	~
Tursiops truncatus	Bottlenose dolphin	P	Cet	✓
Ziphius cavirostris	Cuvier's beaked whale		Cet	
Pinnipeds				
Arctocephalus pusillus doriferus	Australian fur-seal	V	L	✓

Continued

Table 6: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
1. Marine Mammals				
Arctocephalus forsteri	New Zealand fur-seal	V	L	✓
Arctocephalus tropicalis	Sub-Antarctic fur seal	P		✓
Hydrurga leptonyx	Leopard seal	P		✓
2. Fish				
Carcharodon carcharias	Great white shark	V	V, M	~
Carcharias taurus (East Coast)	Grey nurse shark	CE	CE	~
Epinephelus coioides	Estuary cod	P		
Epinephelus daemelii	Black cod	V		
Epinephelus lanceolatus	Giant Queensland groper	P		✓
Galeorhinus galeus	School shark		CD	~
Girella cyanea	Bluefish	P		
Hoplostethus atlanticus	Orange roughy		CD	
Paraplesiops bleekeri	Bleekers devil fish	P		✓
Pristis zijsron	Green sawfish	PE		~
Rexea solandri	Eastern gemfish		CD	
Thunnus maccoyii	Southern bluefin tuna	E		
Rhincodon typus	Whale shark		M, V	~
Pipefish (Sygnathiformes)				
Phyllopteryx taeniolatus	Weedy seadragon	P	L	✓
Acentronura tentaculata	Hairy pygmy pipehorse	P	L	~
Cosmocampus howensis	Lord Howe pipefish	P	L	
Festucalex cinctus	Girdled pipefish	P	L	~
Filicampus tigris	Tiger pipefish	P	L	~
Heraldia nocturna	Upside-down pipefish	P	L	~
Hippichthys penicillus	Beady pipefish	P	L	~
Hippocampus abdominalis	Eastern potbelly seahorse	P	L	~
Hippocampus breviceps	Short-head seahorse	P	L	
Hippocampus minotaur	Bullneck seahorse	P	L	
Hippocampus whitei	White's seahorse	P	L	~
Histiogamphelus briggsii	Briggs' crested pipefish	P	L	~
Histiogamphelus cristatus	Rhino pipefish	P	L	
Hypselognathus rostratus	Knife-snouted pipefish	P	L	
Kaupus costatus	Deep-bodied pipefish	P	L	
Kimblaeus bassensis	Trawl pipefish	P	L	
Leptoichthys fistularius	Brushtail pipefish	P	L	
Lissocampus runa	Javelin pipefish	P	L	~
Maroubra perserrata	Sawtooth pipefish	P	L	~
Mitotichthys semistriatus	Half-banded pipefish	P	L	
Mitotichthys tuckeri	Tucker's pipefish	P	L	
Notiocampus ruber	Red pipefish	P	L	~
Solegnathus robustus	Robust spiny pipehorse	P	L	

Continued

Table 6: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
2. Fish				
Solegnathus spinosissimus	Spiny pipehorse	P	L	~
Solenostomus cyanopterus	Blue-finned ghost pipefish	P	L	~
Solenostomus paradoxus	Harlequin Ghost pipefish	P	L	~
Stigmatopora argus	Spotted pipefish	P	L	~
Stigmatopora nigra	Wide-bodied pipefish	P	L	~
Stipecampus cristatus	Ring-backed pipefish	P	L	
Syngnathoides biaculeatus	Double-ended pipehorse	P	L	~
Trachyrhamphus bicoarctatus	Short-tailed pipefish	P	L	~
Urocampus carinirostris	Hairy pipefish	P	L	~
Vanacampus margaritifer	Mother-of-pearl pipefish	P	L	~
Vanacampus phillipi	Port Phillip pipefish	P	L	
Vanacampus poecilolaemus	Long-snouted pipefish	P	L	
3. Marine Reptiles				
Marine Turtles				
Chelonia mydas	Green turtle	V	M, V	~
Eretmochelys imbricata	Hawksbill turtle	P		✓
Natator depressus	Flatback turtle	P	V, M	
Dermochelys coriacea	Leatherback turtle	V	E, M	~
4. Seabirds				
Eudypula minor	Little penguin	Endangered Population	L	✓
Apus pacificus	Fork-tailed swift	P		~
Calonectris leucomelas	Streaked shearwater	P	M	~
Chlidonias hybridus	Whiskered tern	P		~
Chlidonias leucopterus	White-winged black tern	P		~
Daption capense	Cape petrel	P		~
Diomedea epomophora	Southern royal albatross		V, M	~
Diomedea epomophora sanfordi	Northern royal albatross		E, M	~
Diomedea exulans	Wandering albatross	E	V, M	~
Diomedea exulans amsterdamensis	Amsterdam albatross		E, M	~
Diomedea exulans antipodensis	Antipodean albatross	V	V, M	~
Diomedea exulans exulans	Tristan albatross		E, M	~
Diomedea exulans gibsoni	Gibsons albatross	V	V, M	~
Eudyptes pachyrynchus	Fjordland penguin	P		~
Fregata ariel	Lesser frigatebird	P		~
Fregatta grallaria grallaria	White-bellied storm-petrel	V	V	✓
Fregetta tropica	Black bellied storm petrel	P		~
Fulmarus glacialoides	Southern fulmar	P		~
Gygis alba	White tern	V		~
Haematopus fuliginosus	Sooty oystercatcher	V		✓
Haematopus longirostris	Pied oystercatcher	V		~

Continued

Table 6: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
4. Seabirds				
Haliaeetus leucogaster	White-bellied sea-eagle	P	M	✓
Halobaena caerulea	Blue petrel		V	~
Larus dominicanus	Kelp gull	P		✓
Larus novaehollandiae	Silver gull	P		✓
Larus pacificus	Pacific gull	P		~
Macronectes giganteus	Southern giant petrel	E	E, M	~
Macronectes halli	Northern giant petrel	V	V, M	~
Pachyptila belcheri	Slender-billed prion	P		~
Pachyptila desolata	Antarctic prion	P		~
Pachyptila turtur	Fairy prion	P	V, M	~
Pelagodroma marina	White-faced storm-petrel	P		✓
Pelecanoides urinatrix	Common diving-petrel	P		~
Pelecanus conspicillatus	Australian pelican	P		✓
Phalacrocorax carbo	Great cormorant	P		~
Phalacrocorax fuscesans	Black-faced cormorant	P		~
Phalacrocorax melanoleucos	Little pied cormorant	P		~
Phalacrocorax sulcirostris	Little black cormorant	P		~
Phalacrocorax varius	Pied cormorant	P		~
Phoebetria fusca	Sooty albatross	V		~
Procellaria aequinoctialis	White chinned petrel	P		~
Procellaria parkinsoni	Black petrel	P		~
Pterodroma inexpecta	Mottled petrel	P		~
Pterodroma lessonii	White-headed petrel	P		~
Pterodroma leucoptera leucoptera	Gould's petrel	E	E, M	~
Pterodroma macroptera	Great-winged petrel	P		~
Pterodroma neglecta neglecta	Kermadec petrel	V	V	~
Pterodroma nigripennis	Black-winged petrel	V		~
Pterodroma solandri	Providence petrel	V		~
Puffinus assimilis	Little shearwater	V		~
Puffinus carneipes	Flesh-footed shearwater	V		~
Puffinus gavia	Fluttering shearwater	P		~
Puffinus griseus	Sooty shearwater	P	M	~
Puffinus huttoni	Hutton's shearwater	P		~
Puffinus pacificus	Wedge-tailed shearwater	P	M	✓
Puffinus tenuirostris	Short-tailed shearwater	P	M	✓
Sterna albifrons	Little tern	E	M	~
Sterna bergii	Crested tern	P	L	✓
Sterna caspia	Caspian tern	P		~
Sterna fuscata	Sooty tern	V		~
Sterna hirundo	Common tern	P		~
Sterna nereis	Fairy tern	P		~
Sterna nilotica	Gull-billed tern	P		~
Sterna paradisaea	Arctic tern	P		~

Continued

Table 6: Continued

Scheduled Species	Common Name	Status under *TSC/FM Act*	Status under *EPBC Act*	Species known (✓) or likely (~) to occur in the direct or wider study area
4. Seabirds				
Sterna striata	White-fronted tern	P		~
Thalassarche cauta cauta	Shy albatross	V	V, M	~
Thalassarche cauta eremita	Chatham albatross		E, M	~
Thalassarche cauta salvini	Salvins albatross		V, M	~
Thalassarche cauta steadi	White-capped albatross		V, M	~
Thalassarche chlororhynchos	Yellow-nosed albatross	P	M	~
Thalassarche chrysostoma	Grey-headed albatross	P		~
Thalassarche melanophris	Black-browed albatross	V	V, M	~
Thalassarche melanophris impavida	Campbell albatross		V, M	~

6.1.2.5 Matters of National Environmental Significance (Commonwealth Legislation)

In April 2008, the proposal was referred under the EPBC Act to the Minister for the Environment, Heritage and the Arts according EPBC Act Policy Statement 1.1 (Significant Impact Guidelines) as the proposal was considered likely to have an impact on matters of national environmental significance (NES). It was subsequently determined that the proposal requires approval under the EPBC Act, as it is considered to have a significant impact on the following matters of NES.

- listed threatened species (sections 18 and 18A of the EPBC Act);
- listed migratory species (sections 20 and 20 A of the EPBC Act); and
- the Commonwealth marine area (sections 23 and 24 A of the EPBC Act).

Listed Threatened and Migratory Species

The DEWHA EPBC Act database (Web Reference 10) and the NSW government 'BioNet' database (Web Reference 11) were searched for listed threatened and migratory species, populations and communities listed in relevant Schedules of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that are likely or predicted to occur in the three study regions. Note that threatened species assessed under the EPBC Act include only those listed as 'extinct in the wild', 'critically endangered', 'endangered', 'vulnerable' or 'migratory'.

The search was carried out in February 2009 and included marine species of fish, mammals, reptiles, algae/vegetation, invertebrates and seabirds. Searches covered areas defined by CMA (Bionet) or by the relevant Natural Resource Management Region (NRMR) i.e. the Hunter/Central Rivers, Sydney Metro and Southern Rivers CMA's/NRMR's (DEWHA threatened species database) (Tables 4, 5 and 6). This allowed a broad-scale assessment of all threatened and protected species that could potentially occur in the study regions. The following species protected under the EPBC Act could occur in the Hunter/Central Rivers search area:

- the 'critically endangered' grey nurse shark (*Carcharias taurus*);
- the 'endangered' blue whale (*Balaenoptera musculus)*;
- the 'endangered' southern right whale (*Eubalaena australis);*
- the 'endangered' loggerhead turtle *(Caretta caretta);*
- the 'endangered' leatherback turtle (*Dermochelys coriacea*);
- the 'vulnerable' whale shark (*Rhincodon typus);*
- the 'vulnerable' great white shark (*Carcharodon carcharias)*;
- the 'vulnerable' humpback whale (*Megaptera novaeangliae);*
- the 'vulnerable' green turtle *(Dermochelys coriacea);*
- the 'vulnerable' flatback turtle *(Natator depressus*);
- the 'conservation dependent' eastern gemfish (*Rexea solandri);* and
- the 'conservation dependent' school shark (*Galeorhinus galeus)*;
- thirty one species were also identified as 'cetaceans', 18 species identified as 'migratory' and 27 species identified as 'listed' (including syngnathiformes, pinnipeds and marine reptiles).

Note that species may be classed as both a cetacean and migratory species in addition to its protected status, for example, the southern right whale (*Eubalaena australis*) which is listed as 'endangered', but is also protected as a migratory cetacean.

Species protected under the EPBC Act that may potentially occur in the Sydney Metro search area, included:

- the 'critically endangered' grey nurse shark (*Carcharias taurus*);
- the 'endangered' blue whale (*Balaenoptera musculus*);
- the 'endangered' southern right whale (*Eubalaena australis);*
- the 'endangered' loggerhead turtle *(Caretta caretta);*
- the 'endangered' leatherback turtle (*Dermochelys coriacea*);
- the 'vulnerable' whale shark (*Rhincodon typus);*
- the 'vulnerable' great white shark (*Carcharodon carcharias)*;
- the 'vulnerable' humpback whale (*Megaptera novaeangliae);*
- the 'vulnerable' green turtle *(Chelonia mydas*);
- the 'conservation dependent' eastern gemfish (*Rexea solandri);*
- the 'conservation dependent' orange roughy *(Hoplostethus atlanticus);* and
- the 'conservation dependent' school shark *(Galeorhinus galeus).*

Fifteen migratory species, 21 species listed as 'cetaceans and 25 'listed' species (mainly syngnathiformes, pinnipeds and marine reptiles) were also identified in the Sydney Metro search area.

Species protected under the EPBC Act that could occur in the Southern Rivers search area, included:

- the 'critically endangered' grey nurse shark (*Carcharias taurus*);
- the 'endangered' blue whale (*Balaenoptera musculus*;
- the 'endangered' southern right whale (*Eubalaena australis);*
- the 'endangered' leatherback turtle (*Dermochelys coriacea*);
- the 'vulnerable' whale shark (*Rhincodon typus);*
- the 'vulnerable' great white shark (*Carcharodon carcharias)*;
- the 'vulnerable' humpback whale (*Megaptera novaeangliae);*
- the 'vulnerable' green turtle *(Chelonia mydas);*
- the 'vulnerable' flatback turtle *(Natator depressus*);
- the 'conservation dependent' eastern gemfish (*Rexea solandri);*
- the 'conservation dependent' orange roughy *(Hoplostethus atlanticus);* and
- the 'conservation dependent' school shark *(Galeorhinus galeus).*

Fifteen migratory species, 34 species listed as 'cetaceans and 37 'listed' species (including syngnathiformes, pinnipeds and marine reptiles) were also identified.

Searches for seabirds likely to forage offshore and in the direct study areas occurring in the relevant CMAs/marine zone CMA sub-regions were carried out separately. Intertidal and wading birds such as sandpipers, curlews and plovers (for example) were excluded from the assessment as they are unlikely to be affected by the proposal. The main groups of seabirds found to occur in the three study regions were albatrosses, petrels, shearwaters, terns, skuas, gulls, gannets and the endangered population of little penguins (*Eudyptula minor*) at Manly. In the Hunter/Central Rivers CMA/NRMR, five species were listed as 'endangered', five listed as 'vulnerable', seven listed as 'migratory' and four just as 'listed' (Table 4). In the Sydney Metro CMA/NRMR, five species were listed as 'endangered', 10 listed as 'vulnerable', five listed as 'migratory' and two just 'listed' (Table 5). In the Southern Rivers CMA/NRMR, seven species were listed as 'endangered', 11 listed as 'vulnerable', seven as 'migratory' and one just 'listed' (Table 6).

Only threatened species that were known or considered likely to occur in the wider study areas (on the basis of their geographical distributions) and/or known to utilise habitat in the study areas, were considered for further impact assessment:

The following species are considered likely to occur within the wider Newcastle, Sydney and Wollongong study areas:

Fish

- the '*critically endangered'* grey nurse shark (*Carcharias taurus*);
- the '*vulnerable'* great white shark (*Carcharodon carcharias*); and
- the '*vulnerable'* whale shark (*Rhincodon typus*).

Contextual information on the above species is provided in Appendix 7.

Marine Turtles

- the '*vulnerable'* green turtle (*Chelonia mydas*);
- the '*endangered'* leatherback turtle (*Dermochelys coriacea*);
- the '*vulnerable'* flatback turtle (*Natator depressus);* and
- the '*endangered'* loggerhead turtle (*Dermochelys coriacea*).

Contextual information on the above species is provided in Appendix 7.

Cetaceans

- the '*vulnerable'* southern right whale (*Eubalaena australis*);
- the '*vulnerable'* humpback whale (*Megaptera novaeangliae*);
- the '*migratory* 'sperm whale (*Physeter macrocephalus*);
- the '*endangered* 'blue whale (*Balaenoptera musculus*);
- the '*migratory'* brydes whale (*Balaenoptera edeni*);

- the '*migratory'* pygmy right whale (*Caperea marginata*);
- the '*migratory'* dusky dolphin (*Lagenorrhycus obscurus*);
- the '*migratory'* killer whale (*Orcinus orca*); and
- the '*migratory'* Antarctic minke whale (*Balaenoptera bonaerensis*).

Contextual information on the above species is provided in (Appendix 7).

Pinnipeds and Sirenians

- the *endangered* dugong (a sirenian).

Contextual information on the dugong is provided in (Appendix 7).

Seabirds

- the 'vulnerable' wandering albatross (*Diomedea exulans*);
- the 'vulnerable' shy albatross (*Thalassarche cauta*);
- the 'migratory' yellow-nosed albatross (*Thalassarche chlororhynchos*);
- the 'vulnerable'black-browed albatross (*Thalassarche melanophris*);
- the 'vulnerable' bullers albatross (*Thalassarche bulleri*);
- the 'vulnerable' salvins albatross (*Thalassarche cauta salvini*);
- the 'vulnerable' white-capped albatross (*Thalassarche cauta steadi*);
- the 'endangered' Chatham albatross (*Thalassarche cauta eremite*);
- the 'vulnerable' campbell albatross (*Thalassarche melanophris impavida*);
- the 'vulnerable'southern royal albatross (*Diomedea epomophora*);
- the 'endangered' northern royal albatross (*Diomedea epomophora sanfordi*);
- the 'endangered' Amsterdam albatross (*Diomedea exulans amsterdamensis*);
- the 'vulnerable' antipodean albatross (*Diomedea exulans antipodensis*);
- the 'endangered' tristan albatross (*Diomedea exulans exulans*);
- the 'vulnerable' gibsons albatross (*Diomedea exulans gibsoni*);
- the 'vulnerable' white-bellied storm-petrel (*Fregetta grallaria grallaria*);
- the 'endangered'southern giant petrel (*Macronectes giganteus*);
- the 'vulnerable' northern giant petrel (*Macronectes halli*);
- the 'vulnerable' kermadec petrel (*Pterodroma neglecta neglecta*);
- the 'vulnerable'blue petrel (*Halobaena caerulea*);
- the 'endangered' goulds petrel (*Pterodroma leucoptera leucoptera*);
- the 'vulnerable' fairy prion (*Pachyptila turtur*);
- the 'migratory' sooty shearwater (*Puffinus griseus*);
- the 'migratory' wedge-tailed shearwater (*Puffinus pacificus*);
- the 'migratory' short-tailed shearwater (*Puffinus tenuirostris*);
- the 'migratory' streaked shearwater (*Calonectris leucomelas*);
- the 'migratory' little tern (*Sterna albifrons*);
- the 'migratory' common noddy (*Anous stolidus*); and
- the 'migratory' white-bellied sea-eagle (*Haliaeetus leucogaster*).

Contextual information on the above species is provided in (Appendix 7).

No critically endangered or endangered ecological communities are known to occur within the proposed study areas.

The Commonwealth Marine Area

The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters. The Commonwealth marine area stretches from 3 to 200 nautical miles from the coast (Web Reference 26).

The proposed Newcastle, Sydney and Wollongong OARs are located within State waters approximately 1.2 km (0.7 nm), 2.36 km (2.4 nm) and 2.5 km (1.4 nm) west of the 3 nm limit, respectively.

6.1.2.6 Key Threatening Processes

The following Key Threatening Processes (KTPs) have been identified as potentially relevant to the proposal:

- Hook and line fishing in areas important for the survival of threatened fish species (FM Act).

- Entanglement or ingestion of anthropogenic debris in marine and estuarine environments (TSC Act).
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (EPBC Act).

Hook and line fishing in areas important for the survival of threatened fish species

Hook and line fishing refers to the use of a combination of lines and hooks for catching fish, including lines composed of microfilament, wire and cord, with attached lures, hooks and jigs. Hand – lines, set lines, rod and reel fishing, trolling, lure fishing and fly fishing are all included in the activities identified as a key threatening process. This definition includes catch and release, not just the 'taking' of fish (FSC 2003). Areas that are used for feeding and breeding are considered important for the survival of a threatened species and with the exception of grey nurse shark, such areas are poorly defined, if at all, for the majority of threatened species considered in these assessments. Following identification, some of these areas may be declared as critical habitat, such as 10 of the grey nurse shark aggregation sites along the NSW coast. The grey nurse shark, green sawfish and black cod are considered particularly vulnerable to this KTP (Web Reference 12). Even when accidentally captured, hooks caught in fishes mouths can result in damage that can impact on feeding behaviour and success. The effects of fish hooks can be more serious over a longer time if retained in the mouth, throat and stomach of fishes and sharks, and ultimately can lead to death (FSC 2003). It is recognised that listing all hook and line fishing throughout NSW waters as a KTP would be unpractical and unwarranted. However, where known aggregation sites, spawning areas, important juvenile habitats and feeding areas are concerned, activities that could kill or adversely affect threatened fish species should be considered a threatening process and managed accordingly. A threat abatement plan is yet to be developed for this KTP.

Entanglement or ingestion of anthropogenic debris in marine and estuarine environments (TSC Act)

The NSW Scientific Committee has declared entanglement in or ingestion of anthropogenic debris in marine and estuarine environments to be a 'key threatening process' in NSW. Marine debris is mostly comprised of fishing gear, packaging materials, convenience items and raw plastics. The major sources of marine debris are from ship waste, recreational activities, aquaculture industry and both urban and rural discharges into rivers, estuaries and coastal areas (Web Reference 13). Marine debris, particularly plastics, can become entangled around or be ingested by marine animals. This can lead to a number of lethal or detrimental impacts for example:

- strangulation;
- increased drag;
- potential poisoning by polychlorinated biphenyls (PCBs);
- blockage and/or perforation of an individual's digestive system;
- wounds caused by line or net and subsequent infection;
- gastric impaction by plastic bodies.

Even sub-lethal effects of entanglement or ingestion of marine debris may reduce an individual's fitness and ability to successfully reproduce, catch prey and avoid predation. Records kept by the NSW National Parks & Wildlife Service and Taronga Zoo databases show that entanglement in monofilament line, presence of hooks in the mouth and/or gut, net/line wounds and gastric impaction of plastic bodies are the main reasons for injury or mortality in marine wildlife (Web Reference 14).

A number of threatened marine species including marine turtles, seals, cetaceans and a number of marine birds have been found entangled in marine debris or to have ingested marine debris.

Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' (EPBC Act)

This KTP is similar to the above KTP, but applies to vertebrate marine life protected under Commonwealth legislation (Web Reference 14). DEWHA has developed a draft Threat Abatement Plan to address the impacts of this KTP (DEWHA 2008).

6.1.2.7 Areas of Conservation Significance

For the purpose of this study, areas of conservation significance include areas declared as critical habitats under the NSW FM and TSC Acts and Marine Protected Areas (which includes Marine Parks, Aquatic Reserves and Nature Reserves). Distances of areas of conservation significance in relation to the proposed OARs are listed in Table 7.

Table 7: Distances of OARs to areas of conservation significance.

Area of Conservation Significance	Designation	Nearest OAR site	Distance to nearest OAR site (km)
Port Stephens Great Lakes	Marine Park	Newcastle (Swansea)	45.0
Moon Island	Nature Reserve	Newcastle (Swansea)	4.0
North Sydney Harbour	Aquatic Reserve	Sydney (South)	2.0
Cabbage Tree Bay	Aquatic Reserve	Sydney (South)	4.2
Bronte-Coogee	Aquatic Reserve	Sydney (South)	7.0
Magic Point	GNS Critical Habitat	Sydney (South)	12.5
Little Manly	Little Penguin Critical Habitat	Sydney (South)	3.0
Five Islands Nature Reserve	Nature Reserve	Wollongong (Port Kembla)	2.4
Bass Point	GNS Critical Habitat	Wollongong (Port Kembla)	8.0

Marine parks are areas of marine waters and lands permanently set aside to protect the biological diversity of our marine plants and animals, and to provide protection for unique and representative areas. Marine parks are zoned for multiple-uses such as fishing and recreation (Web Reference 15). Aquatic reserves have been established to protect biodiversity and provide representative samples of marine life and habitats. Aquatic reserves are generally small compared with marine parks, but play a significant role by protecting important habitat, nursery areas and vulnerable and threatened species and have research and educational roles (Web Reference 16). Nature reserves are areas of predominantly untouched land in a natural condition and are considered to have high conservation value. Their primary purpose is to protect and conserve outstanding, unique or representative ecosystems, native plant and animal species or natural phenomena (Web Reference 17). Nature reserves are generally terrestrial, but there are some with associated marine components.

Newcastle

The Port Stephens – Great Lakes Marine Park extends from Birubi Beach Surf Life Saving Club (North Stockton Beach), north, to Cape Hawke Surf Life saving Club (near Forster). As the Marine Park is located over 45 km from the proposed Newcastle OAR site, the proposal is not likely to cause any adverse impacts to species or habitats of the marine park and it is not therefore considered further (Figure 15).

Moon Island Nature Reserve is part of the Lake Macquarie State Conservation Area and located off the coast at the entrance to Lake Macquarie (Swansea Heads) approximately 4 km south west of the proposed Newcastle OAR site. It is an important breeding and roosting habitat for seabirds including wedge tailed shearwater (*Puffinus pacificus*), little penguins (*Eudyptula minor*), kelp gull (*Larus dominicanus*), sooty oyster catcher (*Heamatopus unicolour*) and crested tern (*Sterna bergii*). The kelp gull is considered rare in Australia and the crested tern is an international migratory bird (Web Reference 18). There is thought to be one breeding pair of sooty oyster catchers and around 15 breeding pairs of little penguins (NSW NPWS 2005a) occurring within the reserve. According to the Pulbah Island and Moon Island Nature Reserve Plan of management (NSW NPWS 2005a) the specific objectives for the Reserve include protection of visual and aesthetic values; and conservation of biodiversity, with emphasis on protection of seabird nesting and roosting habitat.

Sydney

In the Sydney study region, there are a total of 10 Aquatic Reserves located between Barrenjoey Head (Briken Bay) and Shiprock (Port Hacking). Only the North Sydney Harbour Aquatic Reserve, Cabbage Tree Bay Aquatic Reserve and the Bronte-Coogee Aquatic Reserve are considered of relevance to the current proposal. North (Sydney) Harbour Aquatic Reserve lies between an imaginary line from the headlands at North Head and Grotto Point and another line joining Little Manly Point, Manly Point and Forty Baskets Beach. The reserve extends from the seabed at these outer boundaries up to the mean high water mark between them and covers an area of approximately 260 hectares (Web Reference 19). Within the reserve, line fishing is allowed only for finfish, but the collection or disturbance of marine life or habitat is prohibited. This includes collecting shellfish, pumping for worms, spearfishing and collecting dead or empty shells. The southern limit of North Harbour Aquatic reserve is located approximately 2 km from the proposed Sydney OAR site. The Cabbage Tree Bay Aquatic Reserve includes the whole foreshore of the bay from Manly Surf Life Saving Club to the northern end of Shelly Beach Headland, and encompasses all of Cabbage Tree Bay. The reserve is an important sanctuary for the weedy sea dragon, elegant wrasse, black rock cod and the blue groper amongst others (Web Reference 20) and is located approximately 4.2 km north of the direct study area.

Bronte-Coogee Aquatic Reserve on Sydney's eastern beaches includes the whole foreshore from the southern end of Bronte Beach to the rock baths at Coogee Beach, a distance of four kilometres. This reserve extends 100 m seaward from mean low water. Line fishing is permitted in the reserve, together with the collection of rock lobster, sea lettuce and baitweed, but recreational fishing competitions require a permit (Web Reference 21). The taking of groper by any fishing method is prohibited. The northern limit of the Bronte-Coogee Aquatic Reserve is approximately 7 km from the proposed Sydney OAR site.

Magic Point at south Maroubra is a critical habitat for the grey nurse shark (*Carcharias taurus*) (Figure 16). Grey nurse shark observations recorded by Otway and Parker (2000) and Otway *et al*. (2003) have been mapped by the Natural Heritage Trust as part of the 'Broadscale Biodiversity Assessment of the Hawkesbury Shelf Marine Bioregion'. Maps showed that South Maroubra (Magic Point) was a significant aggregation site with sharks observed on 50 % of survey occasions in numbers representing 3.5 % of the total observed population. The area of critical habitat includes a 200 m area off Magic Point with an 800 m buffer zone extending beyond the critical habitat. The Magic Point Critical habitat is situated approximately 12.5 km south of the proposed Sydney OAR site.

The endangered population of the Little Penguin (*Eudyptula minor*) is known to occur from just north of Smedley's Point to Cannae Point, North Sydney Harbour, Manly and is the only known breeding population on 'mainland' NSW (NSW NPWS 2000). The area has been declared a critical habitat and has a 50 m restriction zone extending outwards from the shoreline. The proposed Sydney OAR is located approximately 3 km south of the southern boundary of the little penguin critical habitat.

Wollongong

Within the wider Wollongong study region, one nature reserve and one critical habitat are considered relevant to the proposal. The Five Islands Nature Reserve located approximately 2.4 km north of the proposed Wollongong OAR site includes five small islands clustered off the coast of Port Kembla, immediately south of the city of Wollongong. The islands are clustered between approximately 0.5 km and 3.5 km off the coast (NSW NPWS 2005b). The five islands, Flinders Islet, Bass Islet, Martin Islet, Big Island and Rocky Islet, together cover an area of approximately 26 hectares. Rocky and Martin Islets and Big Island are tightly clustered to the mainland off Red Point while Flinders and Bass Islets are more distant. The reserve is a significant habitat for a number of migratory marine birds including the sooty oyster catcher (*Heamatopus unicolour*), wedge-tailed shearwater (*Puffinus pacificus*), short-tailed shearwater (*Puffinus tenuirostris)* and white-bellied sea-eagle (*Haliaeetus leucogaster*). The Australian fur-seal (*Arctocephalus pusillus doriferus)* and leopard seal (*Hydrurga leptonyx*), both of which are protected under NSW legislation, also occur on the islands. According to the Five Islands Nature Reserve Plan of Management (NSW NPWS 2005b) specific objectives for the Reserve are that the islands remain important breeding sites for seabirds of conservation significance.

Bass Point is a grey nurse shark critical habitat within Bushrangers Bay Aquatic Reserve, approximately 4 km south of Shellharbour (Figure 17). The area is approximately 8 km south of the proposed Wollongong OAR site. Outside the critical habitat there is a 1 km buffer zone within which recreational fishing (other than with wire trace line) is permitted.

Figure 15: Location of grey nurse shark critical habitat and aggregation sites in relation to the Newcastle OAR study area.

Figure 16: Location of grey nurse shark critical habitat and aggregation sites in relation to the Sydney OAR study area.

Figure 17: Location of grey nurse shark critical habitat and aggregation sites in relation to the Wollongong OAR study area.

6.1.3 Recreational and Commercial Fishing

6.1.3.1 Recreational Fishing

Recreational fishing generally includes spearfishing, sports fishing, charter boat fishing and game fishing. Spearfishing takes place mainly in coastal marine waters, often near rocky headlands and targets species such as red morwong (*Cheilodactylus fuscus*), rock blackfish (*Girella elevata*), leatherjackets (Monacanthidae), luderick (*Girella tricuspidata*) and kingfish (*Seriola lalandi*) (Lincoln Smith *et al.* 1989). Sports fishing uses hook and line to target demersal reef species such as yellowfin bream (*Acanthopagrus australis*), silver trevally (*Pseudocaranx dentex*), mulloway (*Agyrosomus hololepidotus*), snapper (*Pagrus auratus*) and kingfish (*Seriola lalandi*) on offshore reefs and species such as leatherjackets (Monacanthidae) and flathead (Platycephalidae) over sand. Because of its proximity to densely populated areas and its inexpensiveness, the sportfish fishery is estimated to cater to over 150,000 anglers and catch in excess of 1000 t of fish per annum (Web Reference 4). The charter boat fishery operates in fresh and marine waters with species caught varying accordingly. There are approximately 200 charter vessels actively operating along the NSW coast. The gamefish fishery occurs mainly in deeper waters adjacent to the edge of the continental shelf, where billfish (black, blue and striped marlin), tuna (albacore, yellowfin, striped) and sharks (whalers, mako and blue) are targeted. Gamefishing has a strong and well-organised club component and fishing activities under the auspices of angling clubs involve an increasing emphasis on the tagging and release of caught fish, rather than their retention. Recreational fishing in NSW is managed by catch controls (bag and size limits), restrictions on the type of gear (no fish traps or nets), closed areas and seasons and protected species.

Newcastle

Recreational fishing in the Newcastle study region is popular, with three I&I listed charter vessels operating out of the Hunter (Web Reference 9) and a number of other vessels operating from the surrounding suburbs (National Oceans Office, 2004). It should be noted however that I&I-listed vessels (those wishing to be listed) represent approximately 70% of all registered vessels operating in the area so the actual figure is likely to be greater.

Popular offshore fishing spots in the wider study area (south of the Port of Newcastle) include spots known as Middle Reef and North Reef offshore from the port entrance where bream, mulloway and teraglin are targeted and the dumping ground around Nobby's Head and reefs south of Nobby's Head, which are thought to be good locations for snapper and mulloway. Directly south of Nobby's Head and east of Redhead are several sections of reef productive for a mixture of reef fish. The wreck of the Bonnie Dundee, approximately 5 km offshore from Swansea, is a favoured spot for mulloway and baitfish (McEnally and McEnally 2004). Surveys of offshore recreational fishing carried out at Norah Head (between Sydney and Newcastle) from March 2007 to February 2008 by I&I NSW (Web Reference 30) indicated that the top ten species caught by anglers were: silver trevally, *Pseudocaranx dentex* (19.3 %), eastern blue-spotted flathead, *Platycephalus caeruleopunctatus* (10.4 %), blue morwong, *Nemadactylus douglasii* (9.5 %), snapper, *Pagrus auratus* (9.2 %), chinaman leatherjacket *Nelusetta ayuraudi* (8.4 %), silver sweep, *Scorpis lineolata* (4.1 %), tailor, *Pomatomus saltatrix* (3.5 %), nannygai, *Centroberyx affinis* (3.3 %), yellowfin bream, *Acanthopagrus australis* (3.1 %) and yellowtail *Trachurus novaezelandiae* (3.0 %). The 37 other species recorded in the survey accounted for 26.3 % of the catch.

Sydney

Recreational fishing from boats occurs throughout the Sydney study region. There are 39 I&I-listed chartered fishing boats operating in the study region including those listed in the Hawkesbury, Port Jackson, Port Botany and Port Hacking (Web Reference 8). Trolling for pelagic species such as tailor (*Pomatomus saltatrix*) and kingfish is also common (McEnally and McEnally 2004). Game fishing for pelagic fish, including sharks, tunas, billfish, bonito, frigate mackerel, tailor and Australian salmon generally takes place off the Sydney coastline towards the edge of the continental shelf, although they may be found anywhere beyond the estuaries (The Ecology Lab 1993)

Spearfishing and lobster gathering is popular on headlands and reefs. In NSW, these activities are permitted using snorkel (i.e. no SCUBA or surface air supply) and are generally restricted to waters of 20 m depth or less. Surveys of offshore recreational fishing carried out at Long Reef (approximately 10 km north of the Sydney study area) from March 2007 to February 2008 by I&I NSW (Web Reference 31), indicated that the top ten species caught by anglers were: silver trevally (15.2 %), eastern blue-spotted flathead (14.8 %), snapper (10.2 %), tailor, (8.9 %), chinaman leatherjacket (8.5 %), silver sweep (7.0 %), yellowtail (5.5 %), slimy mackerel (4.4 %), kingfish (3.6 %) and blue morwong (3.5 %). The 46 other species recorded in the survey accounted for 18.3 % of the catch.

Wollongong

In the Wollongong study region, drift fishing for flathead is thought to be productive along the entire stretch of coast. Offshore from Wollongong Harbour (between 1.5 km and 2.5 km) and west of Big Island, patches of gravel substratum and reef provide good fishing for snapper. The Five Islands, offshore from Port Kembla, are known for kingfish, snapper and mulloway, with bream, tailor and salmon occurring in shallower waters. (Ross 1998). Surveys of offshore recreational fishing carried out at Port Kembla (immediately north of the Wollongong study area) from March 2007 to February 2008 by I&I NSW (Web Reference 32), indicated that the top ten species caught by anglers were: eastern blue-spotted flathead (19.1 %), snapper (11.6 %), yellowtail (9.5 %), silver trevally (7.8 %), silver sweep (5.4 %), slimy mackerel (5.0 %), chinaman leatherjacket (4.8 %), blue morwong (4.5 %), tailor (2.8 %) and six-spined leatherjacket, *Meuschenia freycineti* (2.6 %). The 67 other species recorded in the survey accounted for 26.9 % of the observations.

6.1.3.2 Commercial Fishing

Commercial fisheries potentially affected by the proposal are those that can operate in State waters. These include those under the jurisdiction of the State of NSW and also those under the jurisdiction of the Commonwealth of Australia that may operate within the 3 nm limit under a Section 37 permit (The Ecology Lab 2007b).

The Ocean Hauling Fishery

The Ocean Hauling Fishery targets approximately 20 finfish species using commercial hauling and purse seine nets from sea beaches and in ocean waters within 3 nautical miles of the NSW coast. On average 3,500 t of fish, mainly including sea mullet (*Mugil cephalus*), luderick (*Girella tricuspidata*), yellowtail scad (*Trachurus novaezelandiae*), blue mackerel (*Scomber australasicus*), pilchards (*Sardinops neopilchardus*) and sea garfish (*Hyporhamphus melanochir*) is taken by the whole fishery each year (Web Reference 5). Purse seining for garfish, yellowtail scad and blue mackerel occasionally occurs within the proposed study areas but the majority of this fishery takes place from ocean beaches and is therefore unlikely to be affected by the proposal.

The Ocean Trap and Line Fishery

The Ocean Trap and Line Fishery is a multi-method, multi-species fishery targeting demersal and pelagic fishes along the NSW coast (NSW DPI 2006). Snapper (*Pagrus auratus*), spanner crabs (*Ranina ranina*), yellowtail kingfish (*Seriola lalandii*), leatherjackets (Monacanthidae), bonito (*Sarda australis*) and silver trevally (*Pseudocaranx dentex*) form the bulk of the commercial catch (Web Reference 6). Blue morwong (*Nemadactylus douglasi*), blue-eye (*Hyperoglyphe antarctica*), gummy shark (*Mustelus antarcticus*), bar cod (*Epinephalus septemfasciatus*) and yellowfin bream (*Acanthopagrus australis*) are also key species. The fishery uses a variety of methods, most commonly involving a line with hooks, or traps. Trap and line fishing usually occurs along the edge of reef and sand. As the placement locations are on bare sand it is unlikely that fishers would currently be active in the direct study areas but are likely to operate within the wider study areas (particularly in the Wollongong study region). Handlining for schooling baitfish such as yellowtail could also occur in the direct study areas. Consultation with local trap and line fishermen suggests that none of the proposed OAR locations are particularly important for the trap and line fishery. It is, however, likely that some traps would be set in the vicinity of the OAR units.

The Ocean Trawl Fishery

There are two sectors to the NSW Ocean Trawl Fishery, the prawn trawl sector and the fish trawl sector. Both sectors use similar gear (e.g. the otter trawl net) and many of the fishers endorsed for fish trawling are also endorsed for prawn trawling. Endorsements for the fish trawl sector are divided into the ocean fish trawl (north) and ocean fish trawl (south). Endorsements for the prawn trawl sector are further divided into the inshore, offshore and deepwater sectors, whereby the offshore sector would be most relevant to the current proposal.

The fish trawl sector targets a large number of species, including silver trevally, tiger flathead (*Platycephalus richardsoni*), redfish (*Centroberyx gerrardi*), john dory (*Zeus faber*) and numerous species of sharks and rays. Total catches reported by fish trawl operators from NSW managed waters in 2000/01 were 1,171 t, valued at $4 million at first point of sale (Web Reference 7). The commercial fishers operating in the study regions consulted in relation to the proposed OAR locations did not raise any issues in relation to the proposed Sydney and Wollongong OAR locations, but did indicate that the proposed Newcastle OAR location would interfere with areas frequently trawled by the Sydney groups. Anecdotal evidence also suggests that most commercial fishing in the Wollongong study region takes place in deeper shelf waters well beyond the limit of the suitable OAR depth range.

The prawn trawl sector, the most valuable fishery in NSW, is worth around $32 million at first point of sale each year (Web Reference 8). In 2000/01 the total catch for the fishery was 3,411 t with 1,739 t of that being prawns only. Prawn trawlers use trawl nets to target prawns on soft sediments. Incidental catches of other species of fish may also be landed. The main species harvested include school prawns and eastern king prawns. As for the fish trawl sector, it is only the Newcastle study area which is considered likely to interfere with prawn trawling.

The Lobster Fishery

The NSW Lobster Fishery is a small but valuable fishery. Eastern rock lobster (*Jasus verreauxi*) is the main species harvested but occasionally, southern rock lobster, *Jasus edwardsii*, and tropical rock lobster, *Panulirus longipes* and *Panulirus ornatus*, are also caught. The Fishery extends from the Queensland border to the Victorian border and includes all waters under the jurisdiction of NSW to around 80 miles from the coast. There are inshore and offshore sectors, whereby inshore fishers use small beehive or smaller square traps in waters up to 10 m in depth whilst the offshore fishers use large rectangular traps (Web Reference 34). It is unlikely that lobster fishing occurs in the proposed OAR locations, as the offshore sector operates in much deeper water. No issues were raised in relation to the proposal by the Lobster Fishery MAC.

6.1.4 Navigation and Safety

The proposed OAR locations are adjacent to the three major population centres of NSW and therefore may impinge on the recreational and commercial vessel operations. Each location is situated near to one of three major commercial ports in NSW, namely:

- Newcastle Port: Operated by Newcastle Port Corporation (NPC) is a major coal port, exporting approximately 90 million tonnes per annum.
- Sydney Ports (Port Jackson & Port Botany): Operated by Sydney Ports Corporation (SPC), is a major commercial port. It handles nearly one-third of Australia's containerised trade, and 17 million mass tonnes per annum.
- Port Kembla: Operated by Port Kembla Port Corporation (PKPC). The port handles bulk goods such as coal, steel and grain (export), and imports of cars, iron ore and goods. Total trade is over 27 million tonnes.

6.1.5 Infrastructure

Newcastle

There are 30 boat ramps in the Newcastle study region located at the Port of Newcastle, Swansea and Lake Macquarie (Figure 18, Table 8). The five nearest boat ramps, situated between 7.4 km and 10.2 km from the proposed Newcastle OAR are located in the Swansea Channel between the Heads and Pelican Point. They are all of sealed concrete construction with either 2 or 3 access lanes. There are few facilities at the boat ramps e.g. barbeques, toilets, kiosks or pump out facilities, although most facilities are available in the town of Swansea. The Boat ramps within the Port of Newcastle are located between 18.5 km and 20. 5 km of the proposed OAR site. Three of these boat ramps are of good condition with 2 -3 lanes and concrete construction.

Sydney

There are nine boat ramps in the Sydney study region, five of which are within a 10 km range of the proposed OAR site (Figure 19a and 19b, Table 8). These are located in Port Jackson (including North Harbour and Middle Harbour), Botany Bay and one at Long Reef. The five closest boat ramps (between 4.5 km and 9.5 km distance) to the proposed OARs are all located within Port Jackson. Condition of the boat ramps varies between poor and excellent. Three of the five closest boat ramps (Little Manly, Cammeray and Rose Bay) are of excellent or good condition. Two of the five closest boat ramps (Milson's Point and McMahon's Point) are of poor condition and only have single lane access. Boat ramps located within Botany Bay are situated between 22.8 km and 27 km from the proposed OAR site and are of good condition with 1 – 4 access lanes. Facilities vary among locations but all have toilet facilities and most have lighting. One of the closest ramps has disabled access.

Wollongong

There are nine boat ramps in the Wollongong study region located at Wollongong Harbour and Port Kembla, Windang and within Lake Illawarra (Figures 20a and 20b, Table 8). All ramps are of good to excellent condition with the exception of Wollongong Harbour which is of average condition. All the ramps (with the exception of the Wollongong Harbour ramp) are located within 10.5 km of the proposed OAR site, with the closest ramp being approximately 5 km away. Facilities at all boat ramps are good but type of facilities varies among locations. Six of the nine boat ramps have disabled access (including the closest ramp at Fern Street, Windang).

Table 8: Boat ramps and infrastructure at the Newcastle, Sydney and Wollongong study regions. Refer to Figures 18 - 20.

1. Newcastle study region

Map number	Distance from OAR Site (km)	Street name	Area	Owner	Construction	Condition	Disabled access	No. lanes	Wash down	Lighting	Fish cleaning	Fuel	Kiosk	BBQ	Toilets	Pump Out
1	7.4	Ungala Road	Swansea	Council	Concrete	Good	N	3	Y	Y	Y	N	N	N	N	N
2	8.8	Wallarah Street	Swansea	Council	Concrete	Good	N	2	N	y	Y	N	N	N	N	N
3	9	Dobinson Drive	Swansea	Unknown	Concrete	Average	Unknown	3	N	N	N	N	N	N	N	N
4	9.4	Makoro Street	Pelican	Council	Concrete	Excellent	N	2	N	N	N	N	N	N	N	N
5	10.2	Naru Road	Marks Point	Unknown	Concrete	Good	Unknown	2	N	N	Y	N	N	N	N	N
6	21	Booth Street	Stockton	Council	Concrete	Good	N	2	N	Y	Y	Y	Y	N	Y	N
7	18.5	Wharf Road	Newcastle	Other	Sand	Poor	N	1	N	N	N	N	N	N	N	N
8	19.5	Punt Road	Stockton	Council	Concrete	Good	N	2	Y	Y	Y	Y	Y	N	N	N
9	20.5	Tully Street	Carrington	Other	Concrete	Good	N	3	N	Y	N	N	N	N	N	N

Note: There are a further 21 boat ramps within Lake Macquarie

2. Sydney study region

Map number	Distance from OAR Site (km)	Street name	Area	Owner	Construction	Condition	Disabled access	No. lanes	Wash down	Lighting	Fish cleaning	Fuel	Kiosk	BBQ	Toilets	Pump Out
1	4.2	Craig Ave	Little Manly	Council	Concrete	Excellent	N	1	N	Y	N	N	Y	Y	Y	N
2	8.2	Brothers Ave	Cammeray	Council	Concrete	Excellent	Y	2	N	Y	Y	N	N	N	Y	N
3	6.5	New South Head R	Rose Bay	Unknown	Concrete	Good	N	2	N	Y	N	N	N	Y	Y	N
4	8.8	McDougall St	Milsons Point	Unknown	Concrete	Poor	N	1	N	Y	N	N	N	N	Y	N
5	12.5	Anzac Ave	Long reef	Unknown	Concrete	Average	Unknown	1	Unknown	Y	Y	N	N	Y	Y	N
6	9.5	Railway Ave	McMahons Point	Unknown	Concrete	Poor	N	1	N	Y	N	N	N	N	Y	N
7	23.4	Penryn Rd	Banksmeadow	Council	Concrete	Good	N	2	Y	Y	Y	N	Y	N	Y	N
8	22.8	Prince Charles Pde	Kurnell	Council	Concrete	Good	N	1	N	N	N	N	N	N	Y	N
9	27	Mutch Ave	Kyeemah	Council	Concrete	Good	Y	4	N	Y	N	N	N	N	Y	N

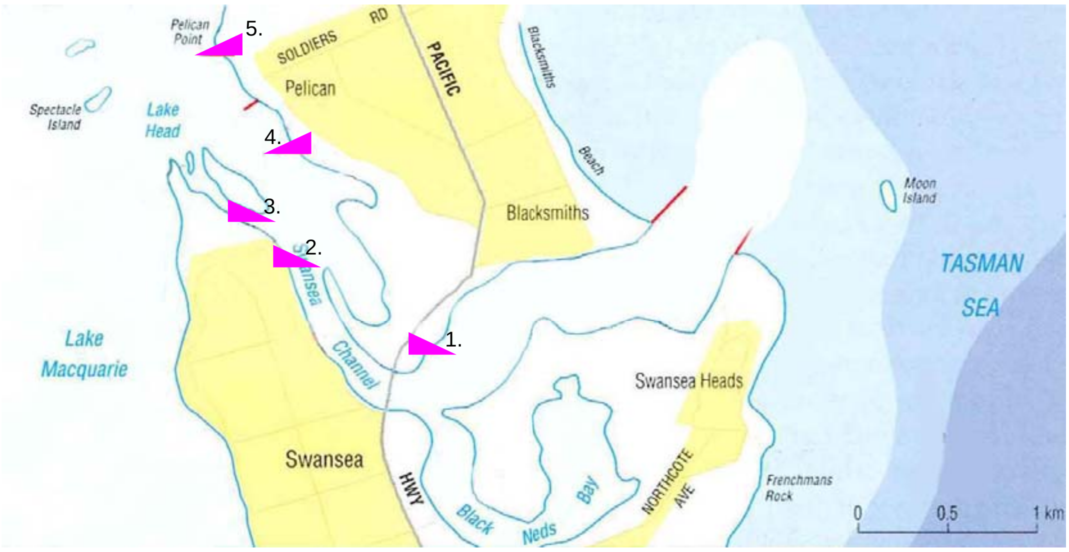
Continued

Table 8: Continued

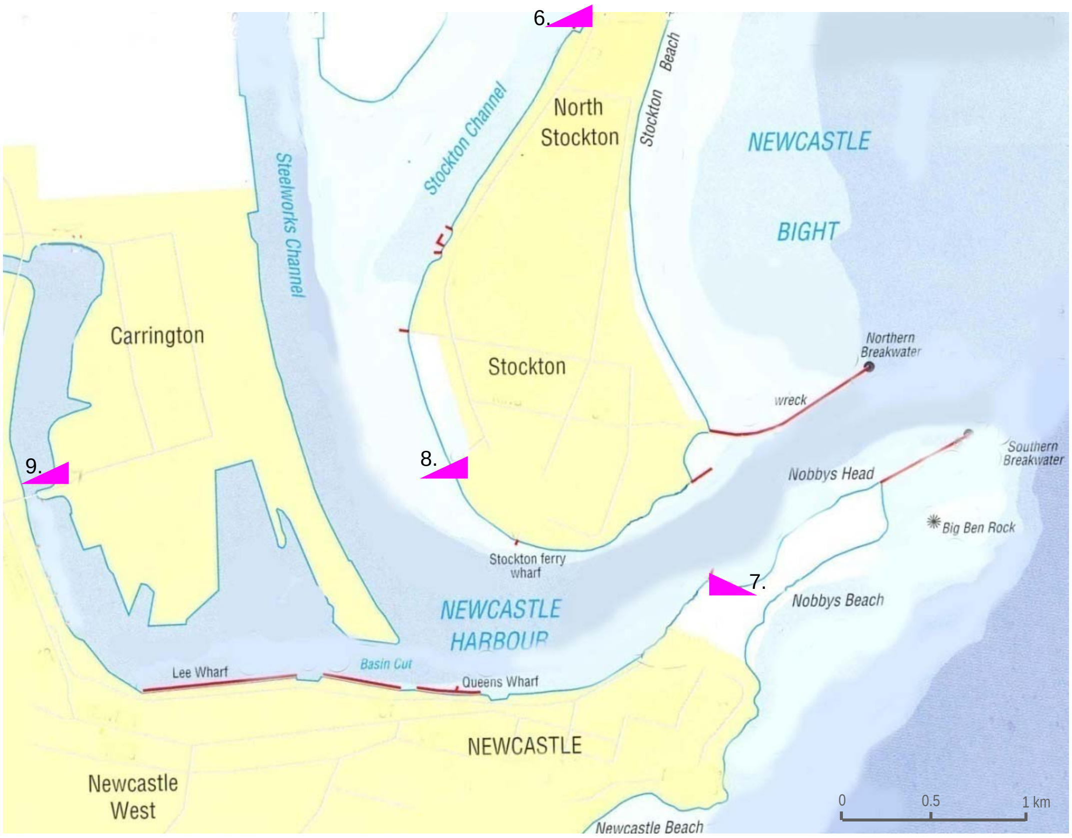
3. Wollongong study region

Map number	Distance from OAR Site (km)	Street name	Area	Owner	Construction	Condition	Disabled access	No. lanes	Wash down	Lighting	Fish cleaning	Fuel	Kiosk	BBQ	Toilets	Pump Out
1	17.2	Endevour Rd	Wollongong Harbour		Concrete/sand	Average	N	1	N	Y	N	N	N	N	N	N
2	8.9	Foreshore Shore R	Port Kembla	Other	Concrete	Excellent	N	3	Y	Y	Y	Y	N	N	Y	N
3	5.1	Fern St	Windang	Other	Concrete	Good	Y	2	Y	Y	Y	Y	Y	Y	Y	N
4	5.6	Reddel Pde	Windang	Other	Concrete	Good	N	1	N	Y	N	Y	Y	Y	Y	N
5	7.5	Towns St	Shellharbour	Council	Concrete	Good	Y	2	Y	Y	Y	Y	Y	Y	Y	N
6	12.1	King St	Lake Illawarra	Other	Concrete	Good	Y	2	N	N	N	Y	N	Y	N	Y
7	11.1	Northcliffe Dr	Lake Illawarra	Council	Concrete	Good	Y	2	Y	Y	Y	Y	Y	N	N	Y
8	10.5	Kanahooka Rd	Lake Illawarra	Council	Concrete	Good	Y	2	Y	Y	N	Y	N	Y	N	Y
9	10.5	The Esplanade	Lake Illawarra	Council	Concrete	Good	Y	1	Y	Y	N	Y	N	Y	N	Y

a) Swansea



b) Port of Newcastle



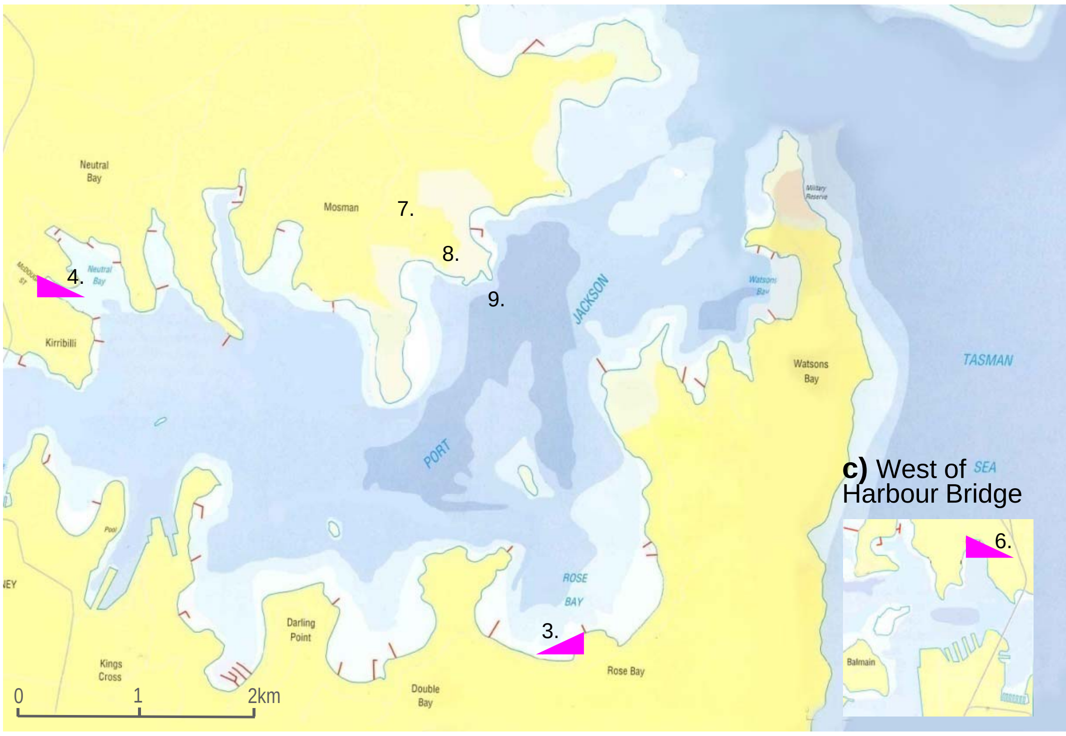
1. Boat ramp

Wharf or jetty

Figure 18: Boat Ramps in the Newcastle study region located at **a)** Swansea and **b)** the Port of Newcastle. Information on infrastructure at each numbered boat ramp is in Table 7.

a) Middle Harbour

b) Port Jackson



1. Boat ramp

Wharf or jetty

Figure 19a: Boat ramps in the Sydney study region located at **a)** Middle Harbour, **b)** Port Jackson and inset **c)** west of the Sydney Harbour Bridge. Information on infrastructure at each numbered boat ramp is in Table 7.

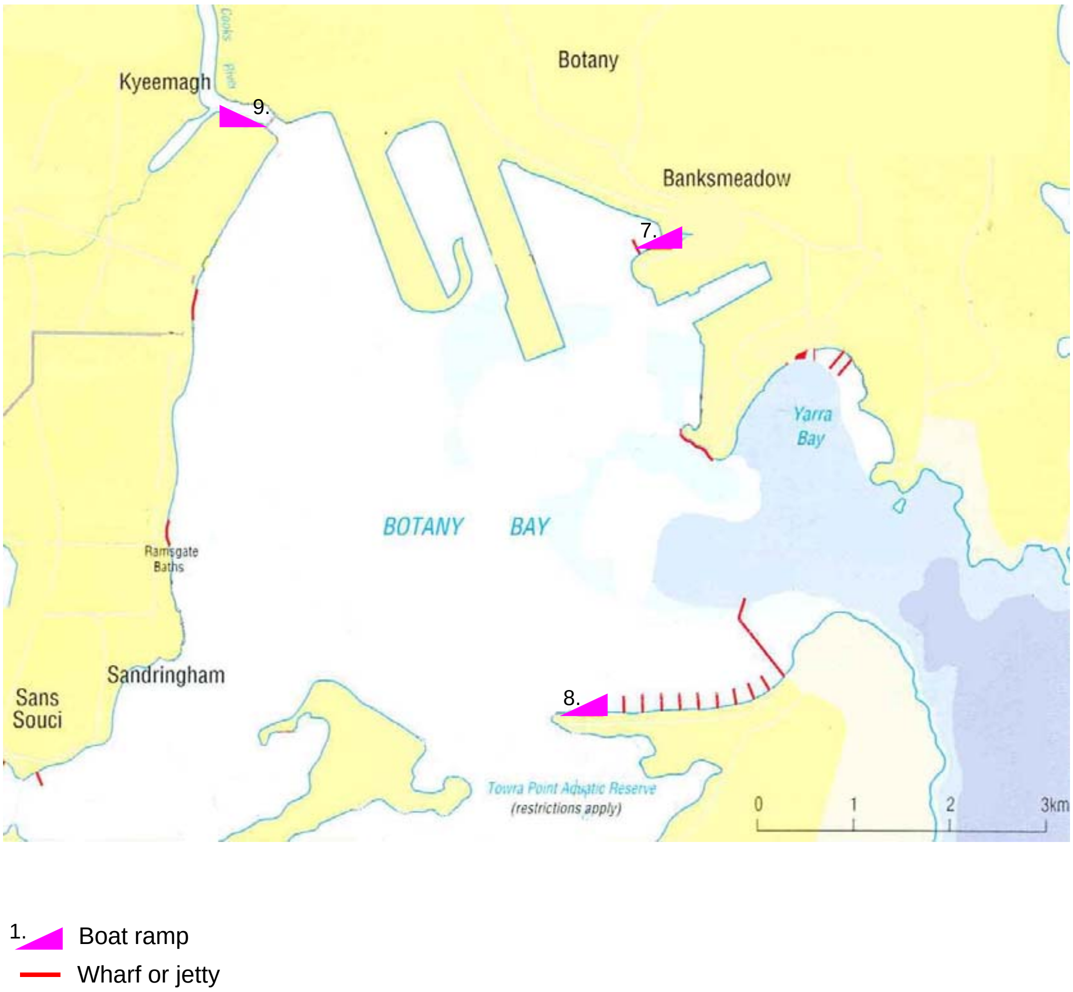
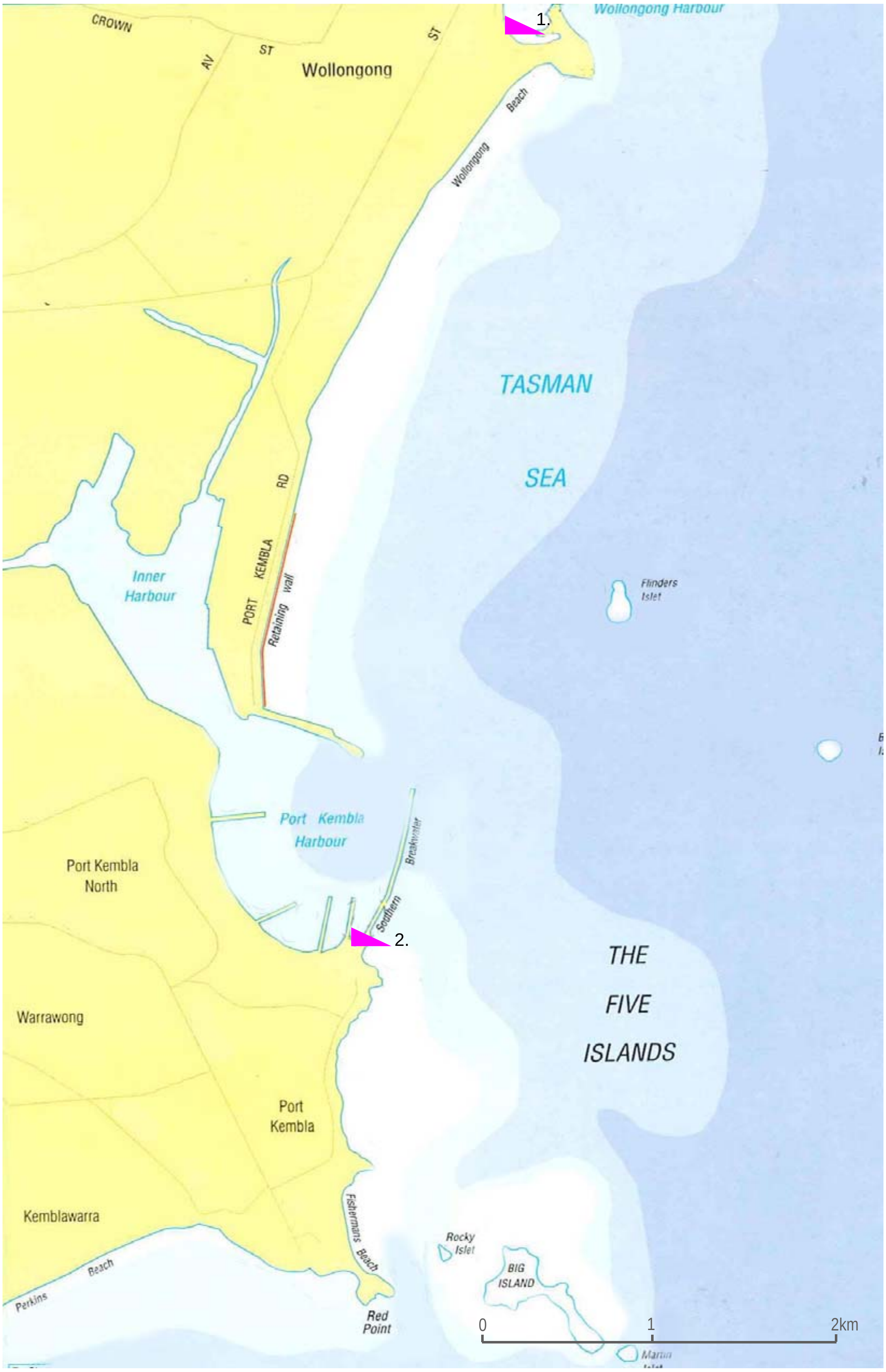


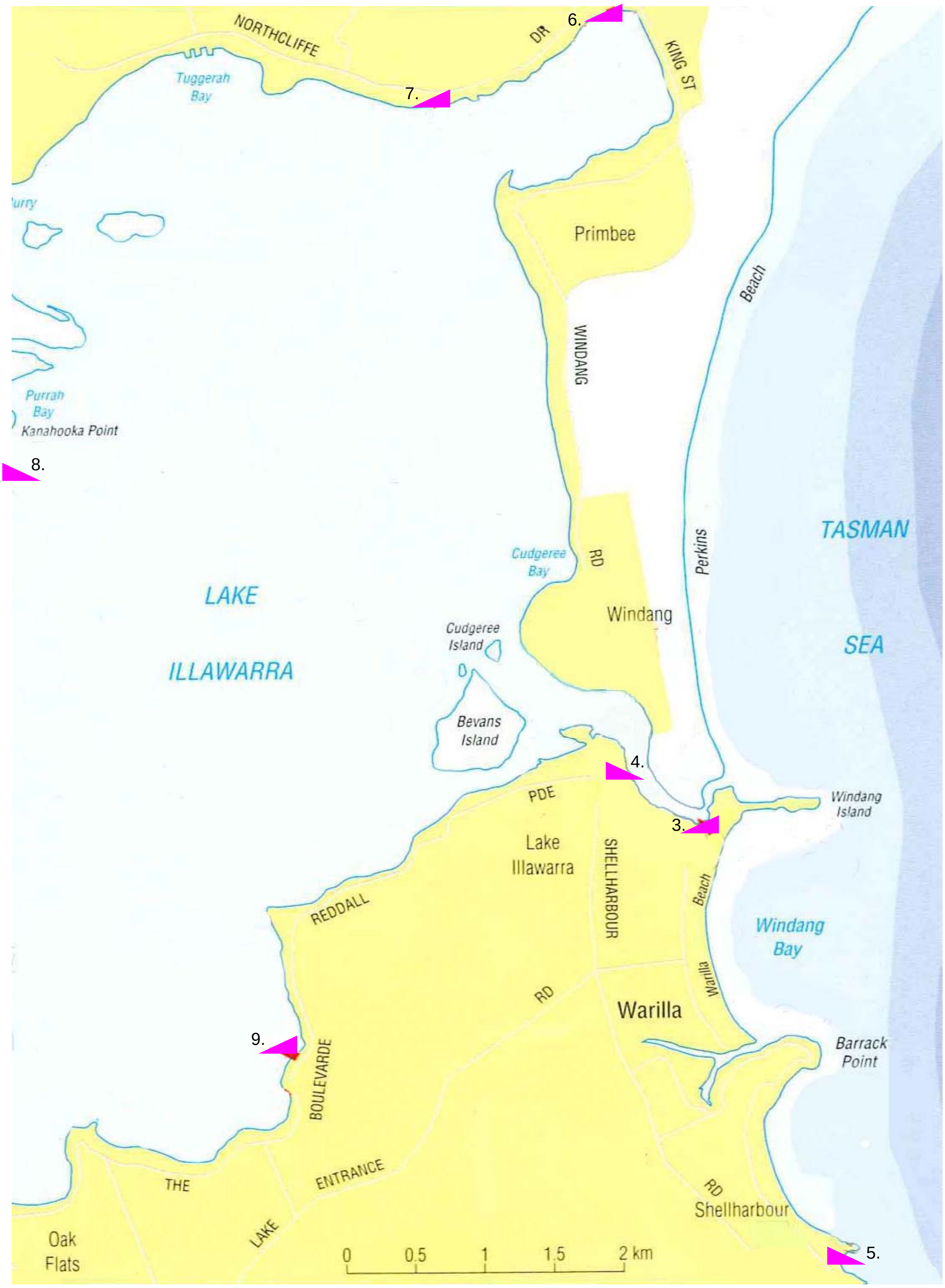
Figure 19b: Boat ramps in the Sydney study region located at Botany Bay. Information on infrastructure at each numbered boat ramp is in Table 7.



1. Boat ramp

Wharf or jetty

Figure 20a: Boat ramps in the Wollongong study region located at Port Kembla. Information on infrastructure at each numbered boat ramp is in Table 7.



1. Boat ramp

Wharf or jetty

Figure 20b: Boat ramps in the Wollongong study region located between Port Kembla and Shellharbour. Information on infrastructure at each numbered boat ramp is in Table 7.

6.1.6 Heritage

6.1.6.1 Historic Shipwrecks

A desktop review of shipwrecks known or potentially occurring in the direct study areas was carried out in November 2008 (Technical Report D). Information was sourced from the NSW Historic Shipwrecks Database (Web Reference 23), the Shipwreck Atlas of NSW (Heritage Office 1995), Auschart 808, the Australian Hydrographic Service (Web Reference 24), unpublished data (Riley 1988) and the Offshore Artificial Reefs, Location Selection and Constraints Mapping report (The Ecology Lab 2008b).

Newcastle

There are two known shipwreck sites located within 4.6 km of the proposed Newcastle OAR. These are *Bonnie Dundee*, located to the south of the study area, and the *Bryon,* located to the north-northeast of the proposed OAR location (Figure 6 and Table 9). Both of these wrecks are considered to be well outside of the direct study area.

An additional five shipwrecks are believed to occur in the wider Newcastle study region. It is, however, considered unlikely or almost impossible that any of these five would occur within the direct study area.

Sydney

A formal vessel disposal area located to the south-southeast of the proposed OAR site has been in use for most of the 20th century Although it is a considerable distance from the proposed Sydney OAR site, vessels being towed to the disposal grounds passed over the area and it is well documented that vessels and other material was deposited outside the designated zone. There are two known shipwrecks located within 0.74 km of the proposed OAR off Sydney. Approximately 0.74 km west-northwest from the proposed location of the northern unit is the wreck of the *Royal Shepherd*; and 0.88 km southeast of the southernmost OAR unit is the wreck of the *Dunbar* (Figure 7 and Table 9). The wrecks of the *Dunbar* and of the *Royal Shepherd* are protected under both the *Historic Shipwrecks Act 1976* and the *NSW Heritage Act 1977*, and the wreck of the *Dunbar* is also listed as a State Significant site by the Heritage Branch, NSW Department of Planning. The *Dunbar* was wrecked in 1857 on the rocks south of South Head when the ship missed the opening into Port Jackson due to thick fog. The wrecking event occurred on the rocky cliffs where the *Dunbar* struck, with the ship breaking up almost immediately in only 11 m of water. Material from the *Dunbar* would have floated and spread during the wrecking event, as well as afterwards during high activity wave and current action over the site. The extent to which material from the *Dunbar* or the debris from the wreck has spread is not known for certain, however, it can be predicted to have been within the immediate area of the initial incident and scattered further along the cliff line. The *Royal Shepherd* sank in 1890 after a collision with the collier *Hesketh,* approximately 1 km east of South Head. The vessel which sank almost immediately lies at a depth of 27 m. As the shipwreck is located in relatively shallow water, it is expected that debris from the wreck would have spread away from the wreck site to the northwest, pushed along by the prevailing SE swells/surge.

In addition to the location of known shipwrecks, 15 shipwrecks are yet to be found in the wider Sydney study region. It is however, considered unlikely or highly improbable 12of the 15 would occur within the direct study area. It is, however, possible that two vessels (the *Sisters* and *Snowy*) could occur within the direct study area. The *Snowy*'s engine exploded 0.9 km off Sydney Heads and the *Sisters* sprang a leak in a gale and sunk 2.3 km east of Sydney Heads (Web Reference 23). Both vessels were wooden although the *Snowy* had an engine.

In most cases the hulls of such wrecks would have disappeared. If the wreck rests on a sandy bottom, some sections of the hull may have been preserved under the sand. The engine components of such wrecks would be visible on sandy bottoms and would be detected with sidescan sonar.

Wollongong

There are no identified shipwrecks in the vicinity of the proposed OAR south of Wollongong. The closest known shipwreck is that of the *Franz*, a wooden schooner wrecked in a gale at Windang, approximately 4.6 km southwest of the proposed OAR site (Figure 8 and Table 9). This site is not considered further in this assessment.

No ships are believed to have been lost off Perkins Beach, Lake Illawarra, Windang Island, North of Port Kembla or south of the immediate Wollongong area. It is therefore extremely unlikely that any undiscovered/unreported shipwreck occurs within close proximity of the proposed Wollongong OAR.

Table 9: Submerged shipwrecks known to occur within the wider study regions.

Name	Date Lost	Latitude	Longitude	Source	Approximate distance to study area (nm)
Newcastle					
Bonnie Dundee	1879	Not stated	Not stated	HO wreck dbase	2.5
Byron	1896	Not stated	Not stated	HO wreck dbase	2.5
Sydney					
Dunbar	1857	33.85013	151.2858	HO wreck dbase	0.4
Royal Shepherd	1890	33.83728	151.2869	HO wreck dbase	0.4
Wollongong					
Franz	1879	34.53334	150.8736	HO wreck dbase	2.5

6.1.6.2 Cultural Heritage

It is widely accepted that Aboriginal people have inhabited the Australian landscape for the past 50,000 years. During that time variations in climatic conditions would have exposed and inundated low lying areas, such as the east coast of Australia. The sea level over the past 50,000 years has fluctuated in response to atmospheric temperatures and carbon dioxide concentrations. At its lowest point over the past 50,000 years, sea levels were approximately 120 m below current heights therefore corresponding to the exposure of approximately 20 km beyond the current shoreline (NSW Coastline Management Manual 1990). As such, there is potential for items of Aboriginal cultural heritage to have been deposited during periods of low water levels and submerged under rising sea levels.

Database searches were conducted to identify any documented cultural heritage issues pertaining to the three offshore reef locations and surrounding areas which may be affected by the proposed works. DECCW indicated that a search of the 'Aboriginal Heritage Information Management System (AHIMS) would not be required as no items of cultural heritage have yet been registered offshore within NSW. A search of the 'National Native Title Tribunal' database (Web Reference 22) showed that there are currently 470 applications listed for NSW, none of which are related to the direct study areas. There are 31 determinations currently listed for NSW of which one identified that Native Title exists. This determination also does not directly correspond with any of the proposed study areas.

Spiritual and dreamtime stories also contribute significantly to Aboriginal cultural heritage. These stories define cultural ties with the land and therefore must be accounted for when considering the overall impacts of the proposal. No such stories have been identified for the Sydney or Newcastle study regions, however, there are two dreamtime stories that require consideration within the Wollongong region:

- 'Gang-man-gang' – the story of Windang Island; and
- 'Oola-Boola-Woo' – Five Islands Group.

Both of these stories describe creation and have local cultural significance. Whale dreaming and migration stories are also of regional significance to numerous Aboriginal tribes along the east coast of NSW. Further details of Oola-Boola-Woo are outlined in Technical Report B.

6.2 Gaps in Information

Coastal Processes

No long-term current data has been collected at the locations of the proposed OARs. These data are required to undertake hydrodynamic current modelling that will assist in assessment of local sediment transport (i.e. erosion and scouring) around the base of the OARs (Section 8.2.1).

Structural Integrity and Stability

Initial stability calculations indicated that the preferred two-storey octagonal steel reef design would be stable at the proposed deployment depths of 30 m – 45 m (Kim 2008). Upon review, these calculations were not considered to be sufficient in terms of their methodology or design assumptions for the following reasons:

- The calculations were based on an average wave height of 9.9 m in 25 m depth which is significantly smaller than the Australian standards for this type of structure (AS4997) which specify a 100 year design wave for maximum (not average) wave height.
- A linear wave theory used to calculate the theoretical velocities and accelerations on the structure is considered to be inappropriate for the design wave.
- The calculations did not account for forces generated by vertical velocities and accelerations on the structure, which tend to reduce the structures capacity to resist overturning.
- The calculations were based on the vertical area of one external face only and did not account for the effect of the entire structure.
- The calculations did not account for load increases associated with marine growth on the structure.

Further detailed assessment was therefore required using appropriate calculations, methodology and design wave that conforms to Australian standards for the proposed type of structure (6.3.2).

Habitats

Existing spatial datasets do not describe habitat type or the physical characteristics of the seafloor at a scale relevant for planning considerations. A detailed knowledge of seafloor conditions, particularly the distribution of sand and rocky reef is necessary, so that the suitability of the proposed sites can be adequately assessed. Swath habitat mapping was therefore carried out by the NSW Department of Environment, Climate Change and Water (DECCW) HABMAP team (Section 6.3.3).

Flora and Fauna

Existing information relating to flora and fauna assemblages is mostly broad-scale or based on areas where other studies have been carried out. In order to adequately assess potential impacts associated with the proposal, it is essential that ecological investigations are carried out in the areas that would be directly affected by the proposal. This will provide additional information to assist with risk and impact assessment and to establish baseline conditions for which future monitoring studies may be compared. Additional studies on species assemblages (fish and benthos), together with environmental conditions (sediment type, water quality and contaminants), were therefore undertaken within the direct OAR study areas (Section 6.3.4).

Sediments and Water

Baseline data on existing water quality and sediment contamination is required to assess impacts of contaminants potentially leaching from the steel OAR structures. Information on sediment contamination is also important as deployment of the structures could mobilise contaminants present in the surface sediment, if any. Baseline data could also be used as a reference for future monitoring (Section 6.3.5).

Heritage

A significant amount of information has been compiled on the locations of shipwrecks that are known or likely to occur within the direct and wider study areas. However, few of the sites have accurate positions and even wrecks marked on recently published maritime charts may be inaccurate as it is not known how their positions were originally recorded (e.g. sextant or GPS) and information is often transferred from older charts to recent charts without verification. Wrecks may also be fragmented and scattered over a large area of seabed. No wrecks are known to occur within any of the direct study areas. It is, however, possible that two wrecks could occur within the direct Sydney study area. Swath habitat mapping carried out by DECCW would not only provide full coverage information on the nature of the seabed in the direct study areas but would also identify any obstructions to be avoided or anomalies requiring further investigation for potential historic or cultural significance (Section 6.3.3).

6.3 Additional Studies

In order to bridge the knowledge gaps identified in the previous section and to provide the level of detail necessary for the EA/draft PER, further field and desktop studies were carried out.

6.3.1 Coastal Processes

Currents were measured at each of the three proposed artificial reef sites in January 2009 using a Teledyne RD Instruments 300 kHz Acoustic Doppler Current Profiler (ADCP). The ADCP was mounted over the side of the vessel facing vertically down in the water. In this configuration, the ADCP uses four acoustic beams to measure the Doppler shift and time of return of the acoustic echoes in order to resolve the vessel velocity and water current velocities over the full depth profile. Field investigations were carried out at the Newcastle site on 14 January 2009, the Sydney site on 21 January 2009 and the Wollongong site 23 January 2009. On each of these days, currents were recorded at the four proposed artificial reef sites and four reference sites. The current measurements showed generally low, depth-averaged current speeds and differing current directions at each of the three locations. The depth averaged currents during the measurement periods were as follows:-

- Newcastle – under 0.25 m/s flowing to the south-west;
- Sydney – under 0.1 m/s flowing to the south-east; and
- Wollongong – approximately 0.1 m/s flowing to the north.

Currents were not observed to vary greatly in speed or direction over the depth profile at any of the locations; nor did the currents vary greatly amongst the four measurement sites at each of the three locations. Details of this investigation are presented in Technical Report C.

6.3.2 Structural Integrity and Stability

6.3.2.1 Background

Stability assessments were carried out on the proposed two-storey octagonal steel reef (Figure 3, a) which was designed and developed for use in Korea. Calculations were carried out in accordance with Australian standards for similar offshore structures with a 30 year design life. The model for the stability assessment was based on the following parameters:

- water depth of 35 m;
- a 100 year average recurrence interval (ARI) design wave (Hmax) in the primary wave direction (19.6 m);
- a 100 year ARI design wave period (Tmax) of 14 seconds;
- a minimum Factor of Safety (FOS) of 1.15 for overturning; and
- load increase associated with marine growth.

Calculations based on the above parameters and conditions indicated that the two-storey octagonal steel reef design would not be capable of resisting the overturning forces exerted in 100 year ARI event and would therefore not meet the required FOS.

A series of further models were run to assess the stability at greater depth (as wave driven forces decrease with depth) and also by sequentially removing levels and plates to reduce the drag coefficient on the structure. Results showed a significant improvement in resistance to overturning with increased water depth and by reducing the height of the structure, however, as the FOS for overturning became more acceptable with a reduction in height, a new issue arose, which was the sliding of the structure, due to the reduction in weight. It was determined that a suitable FOS against both overturing and sliding could not be achieved with the current design. The potential for anchoring the structure to the seabed was therefore considered as an alternative, but due to the associated labour and additional equipment costs, it was not feasible within the budget of the proposal. Anchoring the structure to the seabed would also require strengthening of the steel beams due to increased structural loads, which was also considered to be costly.

Given that the required FOS could not be met with the two-storey octagonal steel reef design, the model was re-run using an alternative existing Korean design (Figure 3, b) provided by I&I NSW. Although the alternative design was slightly lower in height (12 m x 12 m x 10 m) and had a lower centre of gravity, it also failed to meet the required FOS for both overturning and sliding under the specified conditions.

It was recommended that a new concept design be developed to ensure that the proposed OAR structure is capable of resisting overturning and sliding under the given conditions with adequate factors of safety. Details of the concept design are given in Section 6.3.2.2 below.

6.3.2.2 Concept Design

On 21 July 2009, Worley Parsons was engaged by Cardno Ecology Lab Pty Ltd to investigate and develop a new OAR concept design that would be used for the OAR project (Figure 4). The design specification is provided in full in Appendix 8. The new concept design has a base of 15 m x 12 m and a total height of 12 m, with the main bulk of the unit reaching a height of 4 m. This gives the structure greater stability from a lower centre of gravity than the previous Korean designs. Dimensions of the OAR may vary pending the finalisation of the technical design specifications that will be used for the units manufacture/fabrication, transport and deployment. The new concept design aims to retain the functionality of the Korean reef designs, while maintaining structural integrity, durability and stability. The design developed was based on the following parameters:

- depth of 35 m;
- a maximum wave height (Hmax) of 19.6 m in the primary direction and 12.8 m in the adjacent direction;
- a 100 year ARI event (note that other directional values may also be critical);
- a minimum safety factor of 1.15 for both sliding and overturning;
- marine growth thickness of 20 mm at the structure base increasing linearly to 70 mm at the top of the structure;
- maximum structure mass of 35 tonnes.

Based on the above parameters, the new design aims to:

- maximise the surface area (and habitat complexity) of the structure;
- minimise drag forces on the main structural components by utilising a more efficient structural section;
- increase the sliding resistance of the structure by mobilizing passive soil pressure at its base;
- maximize the height of the structure while maintaining adequate safety factors in sliding and overturning;
- incorporate plates at optimum angles and positions within the structure to provide overturning resistance; and additional habitat complexity.

Proposed Structure Section Types

Previous designs were constructed completely from steel beam sections. The new design would utilise a combination of square hollow sections (SHS) and rectangular hollow sections (RHS) which have drag coefficients approximately 25 % less than universal beam sections of equivalent width. SHS and RHS have drag coefficients approximately 25% greater then tubular sections (which can reduce drag by up to 50 %), however, the connections between SHS and RHS members are less costly than connections incorporating tubular sections and were therefore incorporated into the current design.

It should be noted that the section sizes selected in the proposed design (Appendix 8) are based on conservative hand calculations and not on a detailed frame analysis. Consequently, the member sizes will require final verification during the detailed design process. Additional stiffening plates may also be required to satisfy fatigue related requirements at connection points.

Sliding Resistance

It has been demonstrated that the sliding load case is more critical than the overturning load case in the artificial reef design. Sliding resistance is achieved by the mass of the structure and its frictional resistance on the seabed. Sliding resistance, however, can be significantly increased by mobilizing the passive soil resistance underneath the structure. In order to mobilise the passive soil pressure beneath the structure, vertical plates would be attached to the base of the structure at the corners (Appendix 8). The plates would be of a maximum thickness and width to ensure that they would embed into the sand under the self weight of the structure during installation. By embedding into the sand, the plates would mobilise passive soil pressure in sliding. As the maximum passive resistance is dictated by a ‘wedge’ failure within the soil, the actual embedment depth of the plates would be critical. Preliminary design calculations suggest that a nominal penetration depth of 30 cm is sufficient to engage adequate sliding resistance within the required factor of safety, however a maximum of one metre will be allowed for. Detailed design work would confirm the required plate dimensions. Prior to deployment, I&I NSW will ensure that additional bed penetration surveys are carried out at the final OAR locations to ensure there is sufficient sand depth for embedment of the resistance plates.

These tests will be carried out by one of two possible methods:

- CHIRP sub-bottom profiler: This technique uses seismic echo-sounders to give a high-resolution profile of the seabed. Penetration from a few metres, up to 50 m (depending on the sediment consolidation) can be achieved.

- Diver probing: Commercial divers use probes (approximately 3 m length) of plastic tubing attached to compressed air which allows the probes to penetrate into the sand layer. The depth into which the probes penetrate can provide a relatively accurate profile of depths within the survey area. Diver probing is considered to be the most cost-effective option to meet the requirements of the study.

Structure Height

To maximise the effectiveness of the artificial reef in attracting pelagic fish, it is desirable to provide a structure with height. Providing a high density of structural material at higher areas within the structure, however, creates more significant overturning forces. The proposed design achieves the maximum structure self weight and also achieves an overturning safety factor close to the minimum value required, indicating that it is an efficient design. Further optimisation may be possible during detailed design.

Orientation

The new structure has been designed to be effective when positioned with the front (vertical face) orientated into the predominant (critical) wave direction. Based on directional wave buoy data (Kulmar *et al*. 2005) this would mean units would be orientated into the south-south east direction at the three proposed OAR locations.

Plates

The optimum angle and position of plates within the structure was considered in terms of overturning resistance. An analysis focusing on maximising these benefits was performed to obtain the most efficient plate angles and positions within the structure. For plates angled downwards at 40 to 45 degrees at the front of the structure (i.e. the end closest to the critical wave direction) there is a tendency for the hydrodynamic forces to drive the front of the structure downwards and create an additional restoring moment at the point of maximum load on the structure. The success of this relies on the directionality of the wave, as while the plate creates a restoring moment for water velocities in the primary wave direction, the effect is reversed for water velocities in the reverse direction which do occur as part of a wave cycle. The effect of angled plates varies with height. In general, the higher the plate position, the less effective it will be in reducing overturning moments. Calculations suggest that angled plates should be located within the lowest 4 m of height to achieve the maximum effectiveness. Apart from providing additional drag forces, horizontal plates have minimal effect on overturning and sliding forces. Uplift forces are generated at horizontal plates through vertical water velocities and through 'added mass' effects combined with wave accelerations. Added mass effects are minimized by providing plates with one relatively short dimension. As the effects of horizontal plates are small relative to other components within the structure, horizontal plates have been utilised on towers extending above the main structure to provide additional surface area and shaded areas that have a minimal overturning effect on the structure. During the detailed design stage, it may be possible to provide additional plates (shaded areas) and habitat complexity within the structure to utilise all residual capacity.

6.3.3 Seabed Habitat Mapping

Seabed habitat mapping within the Newcastle and Sydney study regions was carried out during December 2008 and within the Wollongong study region in March 2009 by the DECCW HABMAP team (Technical Report E). The aim of the survey was to provide a complete description of the physical characteristics of the seafloor within the direct study areas highlighting the presence of unsuitable substratum (i.e. reefs), obstructions, or items of heritage significance (such as shipwrecks). Complete swath acoustic surveys, using sidescan sonar, were carried out to provide bathymetry, backscatter, slope, and aspect data for the direct study area (at least of 4 km² of seafloor) surrounding the proposed OAR locations. Towed underwater video surveys were also carried out to assist interpretation of swath acoustic data and provide a visual record of the seafloor in the immediate vicinity of proposed reef sites.

A total of 5.91 km² of seafloor was surveyed and mapped at the proposed Newcastle location at depths between 30 m and 38 m. The seafloor in the survey area was relatively homogenous, sandy, and sloped gently to the south-east. No reef was observed (Figure 21). Depth (AHD) at the proposed location of the four reef units was: north: 32.7 m, east: 33.4 m, south: 33.5 m, west: 32.1 m. Towed video footage from immediately nearby the proposed reef locations showed that the sand was coarse grained, and contained shell grit and has well defined sand waves and troughs. No reef or cobbles were observed along any of the video transects.

In the Sydney study region a total of 4.36 km² of seafloor at depths between 8 m and 56 m was surveyed and mapped. The seafloor in the immediate vicinity of the proposed reef units was sandy and sloped gently to the east. Steep, complex nearshore rocky reef, approximately 5 m in vertical relief was present 390 m to the south and south-west of the southernmost proposed reef unit (Figure 22). Depth (AHD) at the proposed locations of the four reef units was: north: 34.1 m, east: 37.6 m, south: 33.4 m, west: 29.9 m. Towed video footage from nearby the proposed reef locations showed that the sand was fine grained, bioturbated, had small (< 5 cm) surface ripples, and patchy areas of shell grit.

In the Wollongong study region 4.92 km² of seafloor at depths between 25 m and 51 m was surveyed and mapped. The seafloor in the immediate vicinity of the proposed reefs was sandy and sloped gently to the south-east. Acoustic data indicated that there were extensive areas of high-relief rocky reef nearby the proposed reef locations. Reef was found 870 m to the south and south-west, 60 m to the east south-east, and 30 m to the north-east of the closest proposed OAR units (Figure 23). Depth (AHD) at the proposed locations of the four reef units was: north: 38.8 m, east: 43.5 m, south: 43.2 m, west: 38.4 m. Towed video footage from immediately nearby the proposed reef locations showed that the sand appeared to be fine grained with small (< 5 cm) surface ripples and patchy sections of shell grit. Bioturbation was evident in some sandy areas.

No anomalous features were observed from the swath mapping or towed video surveys that warranted further investigation for historic or cultural significance at any of the direct study areas. Note that the wreck of the Royal Shepherd is known to occur just outside the north-west extent of the mapped Sydney area was not detected in the survey.

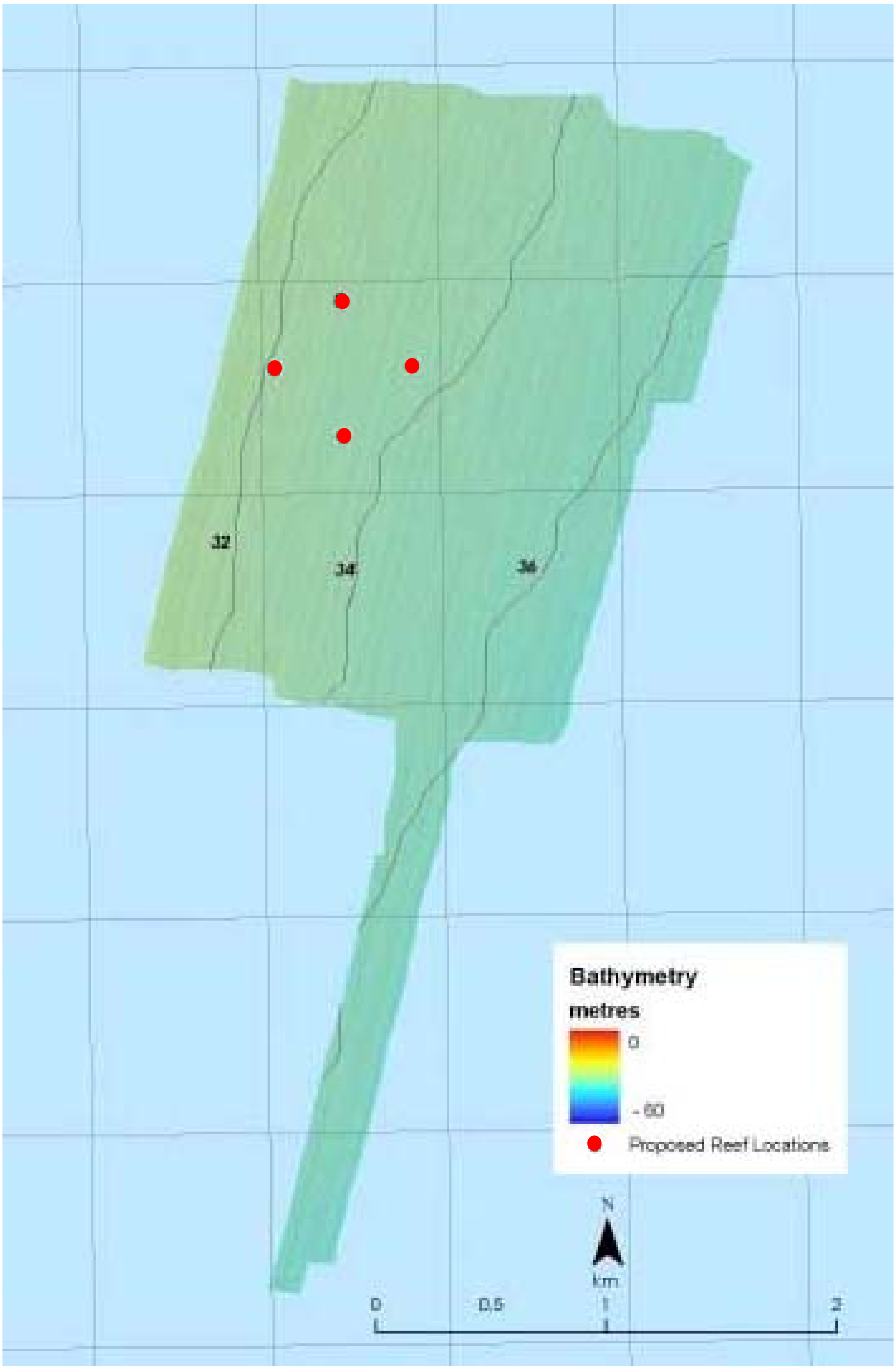


Figure 21 : Bathymetry with hillshaded relief at the Newcastle study area. Depths shown along contour lines are in metres AHD.

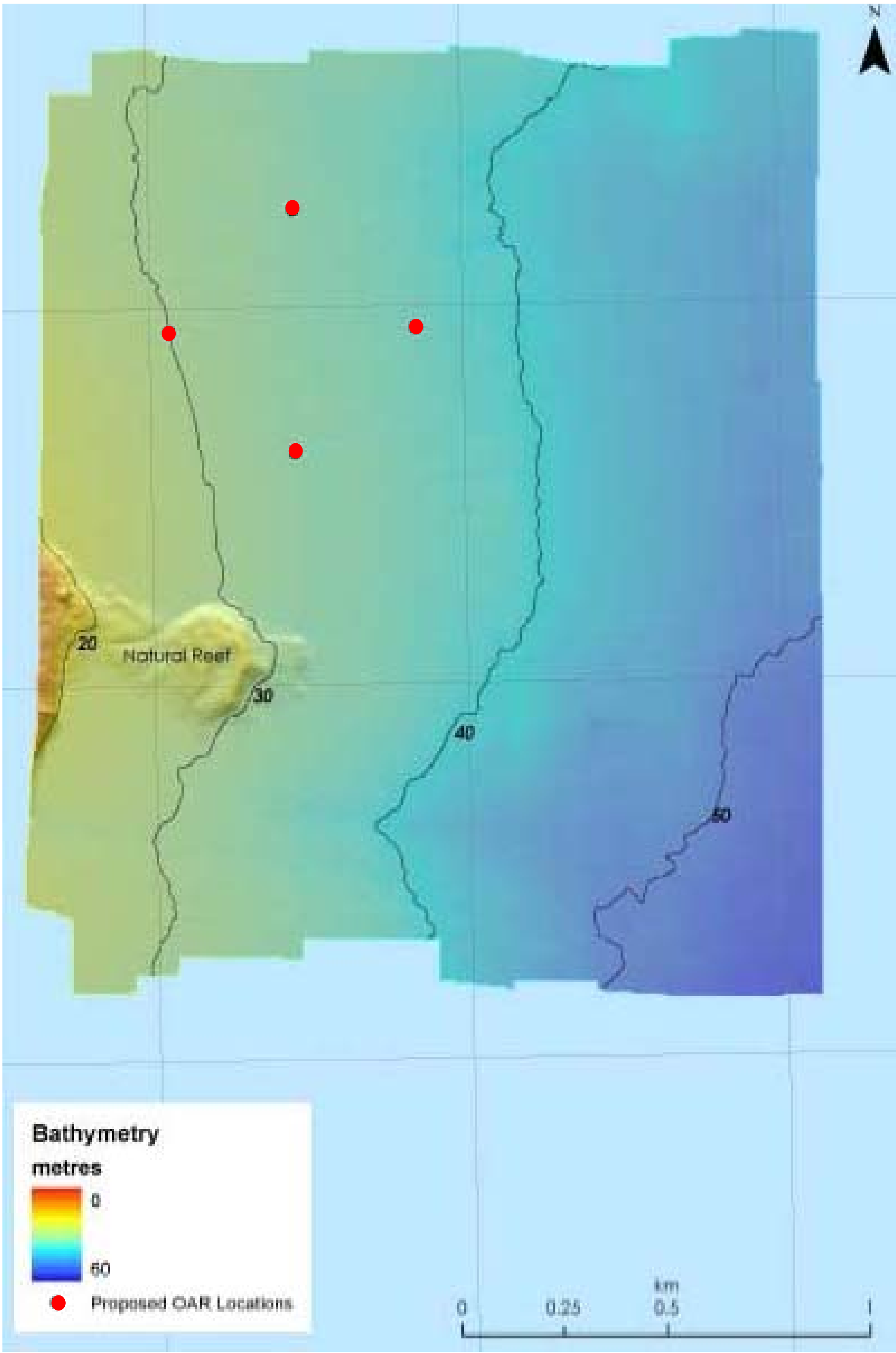


Figure 22: Bathymetry with hillshaded relief at the Sydney study area. Depths shown along contour lines are in metres AHD.

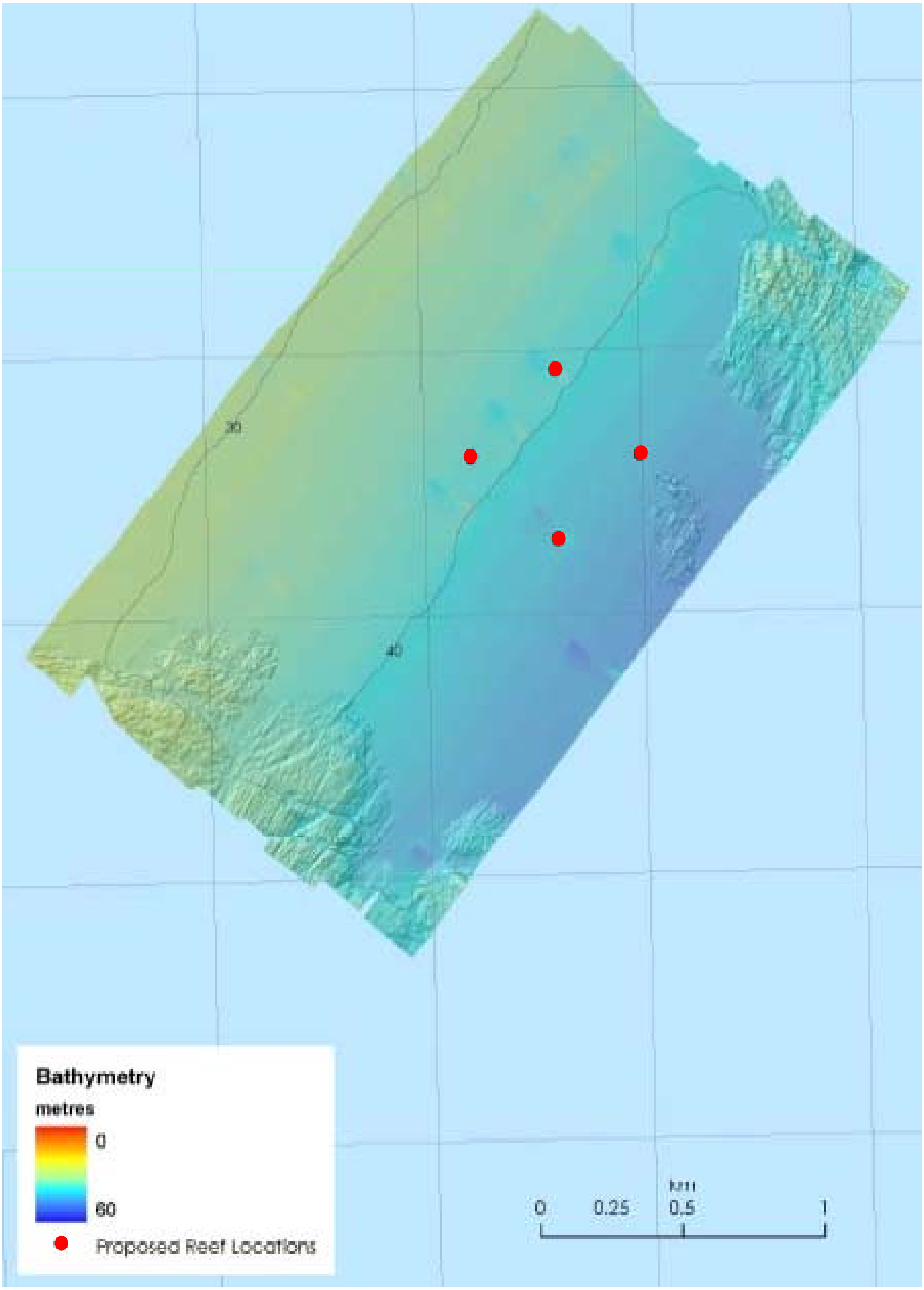


Figure 23: Bathymetry with hillshaded relief at the Wollongong study area. Depths shown along contour lines are in metres AHD.

6.3.4 Flora and Fauna

Fish and benthos associated with soft sediments were surveyed as part of marine ecological field investigations carried out by Cardno Ecology Lab in January 2009 (in each of the three metropolitan regions) (Technical Report F).

In each study region (Newcastle, Sydney and Wollongong), replicate samples were collected from four sites within the proposed OAR location and four from a control location which would serve as a reference for future monitoring designed to assess the impact of the OARs (Figures 1b and c of Technical Report F). A total of 96 benthic samples and 30 fish (video) samples were taken during the survey.

Samples for analysis of benthic macroinvertebrate assemblages were collected by deploying a Ponar benthic grab from a boat, while fish were sampled using 'Baited Remote Underwater Video Stations' (BRUVS).

The habitat was similar at the proposed OAR locations, consisting of relatively flat, sandy substratum with shell grit deposited between sand waves (or in patches) and evidence of polychaete tubes. The benthic assemblages in these study regions were diverse and characterised by high numbers of crustaceans and polychaetes with relatively few representatives of other phyla. The structure of the assemblages differed among study regions, locations and sites. The results were similar to those observed in earlier studies carried out in the three study regions and suggest that assemblages at the proposed OAR locations are fairly typical of those expected in sandy offshore habitats.

Fish assemblages consisted predominantly of demersal species commonly associated with sandy habitat, although some partly pelagic and reef associated species were also observed. These assemblages also differed among regions and locations (within regions). A total of 22 species and 14 families of fish were identified from the three study regions surveyed. The greatest number of fish (667) was recorded in the Newcastle study region, 592 individuals were recorded in the Sydney study region and the least number of individuals (208) was recorded in the Wollongong study region. Although considerably greater numbers of fish were recorded at the Newcastle study region, this was the least diverse. Sydney had the most diverse fish assemblage. The most abundant species across the entire survey was the chinaman leatherjacket (*Nelusetta ayraudi*). Long-spine flathead *(Platycephalus longispinus*), silver trevally (*Pseudocaranx dentex*) and clupeids (herrings, sardines and pilchards) were also abundant throughout the survey. No threatened or protected species were observed during the surveys.

6.3.5 Sediments and Water

The sediment particle size distribution (PSD), concentrations of heavy metals and water quality was also surveyed at each of the three study regions in January 2009 (Technical Report F). The sampling design was the same as that described in Section 6.3.4 except that a total of 48 PSD samples, 24 heavy metal samples and 96 water quality readings were taken. Sediment samples were collected by deploying a Ponar benthic grab from a boat. Water quality was measured with a Yeokal 611 water quality probe. Sediment samples were sent to an NATA accredited laboratory for analyses of particle size distribution and heavy metal contaminants. Sediments collected from the three study regions were similar, consisting of a high percentage of sand (particle size between 0.06 mm – 2 mm) and a negligible percentage of gravel (particle size > 2 mm). Coarser fractions were due to shell grit and occasional large shell fragments.

In the Newcastle study region, the sediment consisted of 95 % to 99 % fine, golden sand with shell grit and polychaete tubes. At the Sydney sites the sediment consisted of 85 % to 99 % sand. Shell grit, shell fragments and polychaete tubes were also observed during sample collection. The sediment samples collected from the Wollongong study region were noticeably darker than those from other study regions, but were of similar composition, consisting on average of between 95 % and 99 % sand. Occasional pockets of black, anoxic mud, shell grit, shell fragments and polychaete tubes were also observed. The average median grain size was generally 0.15 mm larger at the Newcastle study region compared with the Sydney and Wollongong study regions. Within each region, sediment grain size was similar at the proposed OAR locations and the controls which is useful for future monitoring.

Concentrations of heavy metals within the sediments were well below the ANZECC/ARMCANZ interim sediment quality guidelines (ISQG) lower trigger values for marine systems at all locations. Water quality was similar in all regions, with percentage saturation of dissolved Oxygen (DO) slightly below ANZECC/ARMCANZ recommended guidelines (Technical Report F). It should be noted that water quality sampling was not replicated over time and is therefore limited to providing a snapshot of conditions at that time.

6.4 Synthesis

Coastal Processes

- The wave climate appears to be similar throughout the study area and is reasonably well defined. The 100 year average recurrence interval (ARI) H_s exceeded for a duration of 1 hour and 6 hours offshore of Sydney was 9.5 m and 8.5 m respectively. These values are applicable to all study regions. The predominant wave direction offshore from the study regions is from the SSE.
- Currents were not observed to vary greatly in speed or direction over the depth profile at any of the locations, nor did the currents vary greatly amongst the four measurement sites at each of the three locations. Measurements at the three locations were fairly typical for the time of year and conditions.
- The main factor that contributes to still water level movement offshore of the study regions is astronomical tide.
- Long-term wind data suggests that conditions are very similar at all three proposed OAR sites.
- The majority of sediment transport along the NSW coast occurs between where waves break and the shoreline that is inshore of the depth limits of the proposed OARs.

Structural Integrity and Stability

- Stability assessments carried out on the originally proposed two-storey octagonal steel reef showed that the design fails to meet the stability requirements required under Australian standards.
- The new OAR concept design prepared by Worley Parsons would maintain the functionality, the structural integrity and stability requirements of the artificial reef in the given conditions.

Seabed Habitat

- Habitat at the proposed OAR unit locations consisted mainly of bare, relatively flat or rippled fine to coarse-grained sand, with some shell grit that gently slopes to the east/south-east.
- Areas of steep, nearshore rocky reef was present approximately 400 m to the south and south-west of the southernmost OAR unit at the proposed Sydney location. Extensive areas of high relief rocky reef were present to the east south-east and south south-west of the proposed Wollongong OAR unit locations. No reef was observed within the direct Newcastle study area.
- Results of the habitat mapping are consistent with ground truthing and sediment particle size analyses carried out as part of the marine ecology investigations.

Flora and Fauna

- Benthic assemblages in all study regions were diverse and characterised by large numbers of crustaceans and polychaetes with few representatives of other Phyla. Benthic assemblages differed among regions and sites within locations. These results are similar to those from earlier studies carried out in the three study regions and indicate that the assemblages of the proposed OAR locations were typical of those in sandy offshore habitats.
- Fish assemblages consisted predominantly of demersal species commonly associated with sandy habitat, although some pelagic and reef-associated species were also observed. Variation among study regions and also among locations was evident.
- Implications for future monitoring are that each geographical region (Newcastle, Sydney and Wollongong) should be treated separately (due to large-scale geographical variation) and that additional control locations within each study region would be required to account for the variation within study regions.
- A number of threatened or protected species are known or likely to occur within the three study regions. Further assessment by means of a Species Impact Statement (SIS), was not, however, necessary for any of the species identified. It was recognised that the proposal had potential to exacerbate Key Threatening Processes (KTPs) namely harm or injury from entanglement in discarded fishing gear or anthropogenic debris.

Sediments and Water

- Sediments collected from the three study regions were similar, consisting of a high percentage of sand and a negligible percentage of gravel. Coarser fractions were due to shell grit and occasional large shell fragments observed during sample collection. Average median grain size was generally 0.15 mm larger at the Newcastle study region compared with the Sydney and Wollongong study regions which is consistent with the results of the habitat mapping survey.

- Water quality was similar in all regions and complied with recommended ANZECC/ARMCANZ guidelines for all parameters sampled except for percentage saturation of dissolved oxygen (DO) which was slightly below ANZECC/ARMCANZ recommended guidelines at all locations.
- Levels of heavy metal contaminants within the sediments were well within the recommended ANZECC/ARMCANZ guidelines for marine systems.

7 Risk Assessment

7.1 Introduction

As part of the Preliminary Environmental Assessment, a risk analysis workshop attended by representatives of I&I NSW, Cardno Ecology Lab and Worley Parsons, was held on 17 January 2008. The aim of the workshop was to identify potential issues/hazards associated with the Offshore Artificial Reefs program, to assess the likelihood of occurrence of these hazards and the consequence to key receptors if these hazards eventuated.

The initial risk analysis considered potential impacts relating to coastal processes and oceanography, ecosystem processes, contamination, climate change, fisheries (commercial and recreational) and interference with existing coastal infrastructure, obstructions and exclusion zones (Technical Report A). The Constraints Mapping process (Appendix 1 of Technical Report A) sought to minimise or eliminate a number of potential risks associated with existing infrastructure, obstructions and exclusion zones (such as deepwater ocean outfalls, port restrictions, spoil grounds and historical shipwrecks), by selecting locations away from such areas. This process also minimised potential risks associated with threatened species by avoiding critical habitats and marine protected areas. Risks associated with stability were reduced by selecting areas consisting predominantly of sand/coarse sand and avoiding known reef habitats, although this has required further survey work due to a lack of fine-scale seabed habitat information.

The current risk assessment focuses on issues identified in the DGRs requirements and potential impacts on relevant matters of NES.

7.2 Methods

Environmental or ecological risk assessment has become an important means for identifying the likelihood and relative consequence of potential hazards associated with human activities. It is also now being widely advocated as beneficial for fisheries management (Fletcher 2005). The following risk assessment was based on the principles of Australian Standards for Risk Management 4360:2004 and Fletcher (2005).

Typically, assessment of risk entails the identification of a potential <u>hazard</u> (i.e. some aspect of the activity that could affect the environment), a judgment of the <u>likelihood</u> that the hazard has of occurring and a judgement of the <u>consequence</u> of that hazard, if it did result from the proposed activity. Frequently, scientists and managers also consider those aspects of the environment that might be subject to the hazard; such aspects are often referred to as <u>receptors</u>.

Key points that need to be recognised in relation to the general risk assessment:

- The risk assessment benefited greatly from the initial site selection and constraints mapping (The Ecology Lab 2008b) which resulted in avoidance of major biological constraints, such as areas of natural reef and areas of conservation significance, navigational hazards and exclusion zones.
- The risk assessment was done at a generic level, that is, without particular emphasis to any of the three study areas. Impacts on specific study areas are discussed in the following section.
- Risk is often scale-dependent, therefore the risk assessment considered the potential effects of the artificial reefs in the direct study area (4 km^2) and the wider study area (4 km^2 – 10 km^2).
- The risk analysis methodology deals mainly with impacts on the environment, however, the methodology has also been used to analyse relevant health and safety issues (such as construction related activities).
- The risk analysis (and environmental assessment) is based on the new OAR concept design as given in Section 6.3.2.2.

Figure 24 gives the rationale for scoring probability/likelihood of a hazard occurring and of the consequence if the hazard eventuated. Scores of likelihood and consequence may then be combined into a matrix to provide a subjective judgement of significance. Based on this, each hazard/risk is identified as low, medium or high significance. This does not mean that the project should not proceed (i.e. if the level of risk is high) or that an issue should be ignored if the level of risk is considered low, but rather that the issue may need greater or less effort in management/mitigation or that further research on the receiving environment is required. Note that health and safety impacts are assessed on a different scale to environmental impacts (Figure 24).

a)

Probability/Likelihood			
A	Almost certain	Happens often	>1/month
B	Likely	Could readily happen	>1/yr
C	Possible	Could happen and has occurred elsewhere	1 to 10 yrs
D	Unlikely	Has not happened but could	10 to 100 yrs
E	Rare	Conceivable in extreme circumstances	</100 yrs
Consequence (Environmental)			
1	Extreme environmental harm (widespread catastrophic impact)		
2	Major serious harm (widespread substantial impact)		
3	Serious environmental harm (widespread significant impact)		
4	Moderate environmental harm (localised and significant harm)		
5	Minimal environmental harm (interference or likely interference)		
Consequence (Health and Safety)			
1	Catastrophic (single or multiple fatalities)		
2	Major (major or multiple injuries)		
3	Moderate (serious injury)		
4	Minor (minor injury e.g. medical treatment required)		
5	Insignificant (first aid case)		

b)

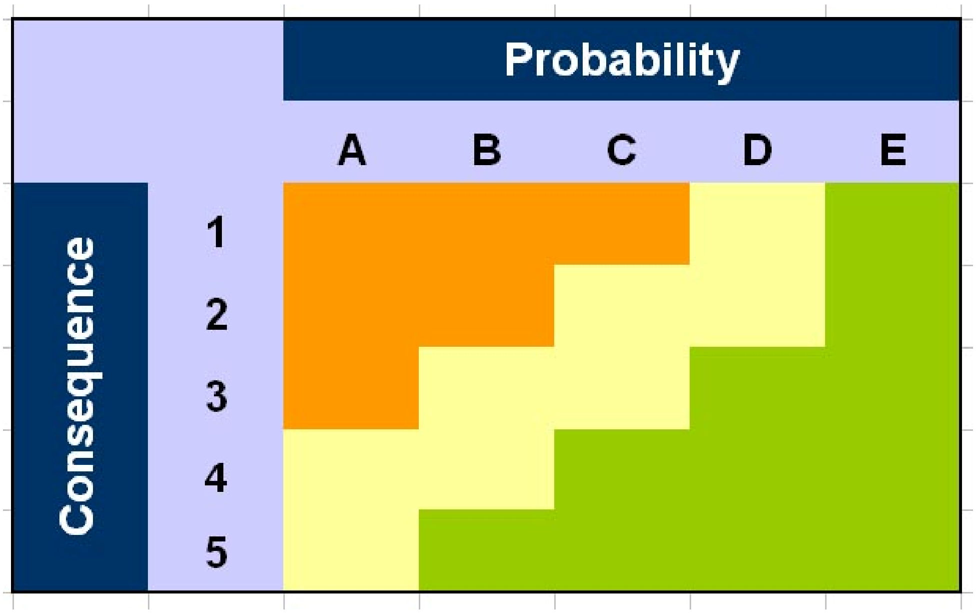


Figure 24: Risk analysis methodology a) rationale for likelihood and consequence b) significance assessment matrix.

7.3 Results

Results of the risk assessment are presented in Table 10 and summarised below. These issues are then addressed in the impact assessment and where necessary, appropriate mitigative or management action has been identified (Section 8).

Risks Associated with Manufacture, Construction and Deployment

Issues of High Significance:

- conflict with shipping and/or other waterway users;
- health and safety during construction, transport and deployment.

Issues of Moderate Significance:

- noise pollution from construction activities;
- increased turbidity during deployment;
- risk of damage to structures during deployment;
- incorrect positioning/orientation resulting in instability of units;
- inadequate temporary work facilities resulting in poor OH & S.

Risks Associated with Long-Term Operation

Impacts of High Significance:

- increased mortality of fish (from aggregation);
- incidental capture of threatened or protected species;
- aggregation of threatened or protected species;
- injury or drowning (spear fishing);
- insufficient clearance for navigation;
- injury or loss of life during diver maintenance or monitoring inspections;

Issues of Moderate Significance:

- local scouring/deposition around units;
- loss of structural integrity e.g. from corrosion or excessive marine growth;
- change to local sedimentary characteristics;
- changes to community structure;
- increased predation by fishes from the OAR on benthos;
- changes to benthic assemblages;
- change to fish assemblages;
- loss of habitat (benthic species);
- attraction/aggregation;
- increased fishing effort;
- harm from marine debris and pollution (KTPs) – (All threatened species);
- interruption of movement corridors (cetaceans);
- increased predation – fish only;
- loss of habitat – (benthic or demersal species dependent on sandy habitat);
- impacts on Nature Reserves.

Table 10: Risk analysis matrix. L = Likelihood of risk occurring, C = Consequence of risk occurring. See Figure 24 for methods and rational for the risk assessment criteria. Asterisk (*) indicate that the scale for health and safety consequences was used (not environmental consequences).

High significance = (orange)
Moderate significance = (yellow)
Low significance = (green)

A. Risks Associated with Construction, Transport and Deployment

Receptor/Issue	Hazard/Negative Impact	Scale: Small (≤1 km) L	Small (≤1 km) C	Large (1-10 km) L	Large (1-10 km) C
1. Noise					
	Noise pollution from construction activities	A	5	B	4
2. Sediments and Water					
	Reduction in water quality in waterway adjacent to construction area (stormwater run - off)	B	5	D	4
	Increased turbidity during deployment	A	5	E	5
	Mobilisation of contaminated sediments during deployment	B	5	E	5
3. Air Quality					
	Reduction of local air quality	B	5	D	4
4. Waste					
	Generation of harmful waste materials	E	5	E	5
5. Traffic					
	Increase in traffic volume	D	5	E	4
	Parking congestion	C	4	E	4
6. Soil					
	Soil contamination/erosion	E	5	E	4
7. Structural Integrity and Stability					
	Risk of damage to structures during deployment	B	4	N/A	N/A
	Incorrect positioning/orientation resulting in instability of units	C	3	N/A	N/A
8. Navigation & Safety					
	Conflict with shipping and/or other water users	B	2	B	2
	Damage to cargo barge during transport/deployment	D	4	D	4
9. Flora and Fauna					
	Disruption to migratory marine mammals	D	4	E	4
10. Occupational Health and Safety					
	Inadequate temporary work facilities resulting in poor OH &	D*	2*	N/A	N/A
	Health and safety matters resulting in injury or loss of life during deployment	C*	1*	N/A	N/A

Continued

Table 10: Continued

B. Risks Associated with Long-Term Operation

Receptor/Issue	Hazard/Negative Impact	Scale Small (≤1 km) L	Scale Small (≤1 km) C	Scale Large (1-10 km) L	Scale Large (1-10 km) C
1. Coastal Processes & Oceanography:					
Nearshore coastal	Inshore wave climate	D	5	D	4
	Change to beach erosion/deposition	N/A	N/A	D	3
Local Seabed	Local scouring/deposition around units	A	5	N/A	N/A
2. Structural Integrity and Stability					
	Loss of structural integrity e.g. from corrosion or excessive marine growth	C	2	N/A	N/A
	Risk of sliding or overturning	E	3	N/A	N/A
3. Flora and Fauna					
Benthos	Direct loss of habitat	A	4	E	4
	Change to sedimentary characteristics	A	4	B	4
	Changes to benthic assemblages	A	4	C	4
	Increased predation by fishes from the OAR on benthos	A	4	C	4
	Commercial trawling in areas not previously trawled	B	5	E	4
Proximal natural reef	Changes to benthic assemblages	C	3	B	3
	Change to fish assemblages	B	3	D	3
Pelagic Environment					
Plankton	Concentration of plankton	B	5	E	5
Fish	Loss of habitat (benthic species)	A	5	E	5
	Attraction/aggregation	A	4	B	4
	Increased fishing effort	B	4	C	4
	Increased mortality (from aggregation)	A	3	B	3

Continued

Table 10: Continued

Receptor/Issue	Hazard/Negative Impact	Scale: Small (≤1 km) L	Small (≤1 km) C	Large (1-10 km) L	Large (1-10 km) C
Threatened and protected species					
Fish	Incidental capture	B	2	C	2
	Aggregation of threatened or protected species	B	2	C	2
	Harm from marine debris and pollution (KTPs)	C	2	C	2
	Interruption of movement corridors (e.g. GNS)	D	3	D	3
	Increased predation	C	4	D	4
	Loss of habitat	A	5	E	5
	Introduction of harmful marine pests	D	3	D	3
Marine Turtles	Harm from marine debris and pollution (KTPs)	C	2	C	2
	Incidental capture	C	2	C	2
	Boat strike	C	2	C	2
	Acoustic disturbance	C	5	E	5
	Interruption of movement corridors	D	3	D	3
	Loss of habitat	D	4	E	4
	Introduction of harmful marine pests	E	2	E	2
Cetaceans	Harm from marine debris and pollution (KTPs)	C	2	C	2
	Incidental capture	C	2	C	2
	Boat strike	C	2	C	2
	Acoustic disturbance	B	4	B	4
	Interruption of movement corridors	C	4	C	4
	Loss of habitat	E	2	E	2
	Introduction of harmful marine pests	E	2	E	2
Pinnipeds and	Harm from marine debris and pollution (KTPs)	C	2	C	2
	Incidental capture	D	2	D	2
	Boat strike (sirenians only)	D	2	D	2
	Acoustic disturbance	D	4	E	4
	Interruption of movement corridors	E	2	E	2
	Loss of habitat	E	2	E	2
	Introduction of harmful marine pests	E	2	E	2
Seabirds	Harm from marine debris and pollution (KTPs)	C	2	C	2
	Incidental capture	C	2	C	2
Invasive Marine Pests					
	Introduction of invasive marine pests	C	4	E	3
The Commonwealth Marine Environment					
	Impact on and activities within Commonwealth Marine	N/A	N/A	E	3
Areas of Conservation Significance	Impacts on Nature Reserves	C	2	C	2
	Impacts on Aquatic Reserves	E	2	E	2
	Impacts on Critical Habitats	E	2	E	2

Table 10: Continued

Receptor/Issue	Hazard/Negative Impact	Scale Small (≤1 km) L	C	Large (1-10 km) L	C
4. Recreational and Commercial fishing					
	Loss of commercial fishing ground	A	4	N/A	N/A
	Conflict between user groups	A	4	A	4
	Risk OAR does not achieve goals	D	3	D	3
	Gear hook-up	A	4	N/A	N/A
	Collision from crowding	C	3*	E	3*
	Impacts on commercial fish stocks	E	3	E	2
	Increased encounters with dangerous marine animals	C	5*	E	5*
	Injury or drowning (spear fishing)	C	1*	N/A	N/A
5. Sediments and Water					
	Leaching of contaminants	A	4	E	4
6. Navigation and Safety					
	Clearance	B	2	B	2
	Anchor fouling	B	3	N/A	N/A
	Increased vessel traffic				
7. Infrastructure					
	Conjestion/crowding at boat ramps	B	5	B	5
	Lack of amenties	D	5	D	5
8. Heritage					
	Impacts on historic shipwrecks	E	4	N/A	N/A
	Impacts on submerged aboriginal deposits	E	4	E	4
	Conflict with areas of spiritual significance/dreamings	B	4	D	3
	Negative impacts on aesthetic amenity	C	4	C	4
9. Occupational Health and Safety					
	Injury or loss of life during diver maintenance or monitoring inspections	C	1*	C	1*

7.4 Productivity Susceptibility Analysis (PSA)

The initial risk assessment indicates that increased fishing mortality, associated with the aggregation of target species, is an issue of high significance in relation to the proposal. This is, however, expected, as the aim of the proposal is to promote fishing opportunity. In order for the proposal to meet its objectives, fishing mortality must therefore occur. This is balanced by two mitigating factors:

- if the OAR increases production of fish, the additional mortality related to fishing would not reduce the population size at existing levels; and
- not all species are equally vulnerable to fishing mortality so species are likely to be affected differently.

In fisheries management, productivity susceptibility analysis (PSA) is commonly used as part of a process to determine how vulnerable different species, communities or components of a habitat are to impacts from certain fisheries and to assess the sustainability of a fishery. This approach has been adapted from Stobutzki *et al*. (2001) and Hobday *et al*. (2004) to provide a general assessment of the vulnerability of species likely to occur in the OAR study areas to fishing mortality.

The PSA approach assumes that vulnerability depends on both the susceptibility of a species to capture on the OARs and the productivity of a species, which will determine the rate at which the population can recover from fishing mortality. Susceptibility to fishing mortality on the OARs is considered to depend upon behavioural factors such as:

- attraction to artificial structures and habitat preference;
- site fidelity (i.e. whether a species is resident or transient); and
- depth range (i.e. whether there is overlap of the species depth range with the OAR depth range).

For example, species that are attracted to the structure and are likely to occur within the depth range for the proposed OAR units are likely to be more susceptible to fishing mortality than those that do not have a habitat preference for reef or structure and generally occur outside the OAR depth range. For the purpose of the assessment, it has been assumed that existing populations of resident (or territorial) reef species are less likely to occur on the OAR than transient species. This is assuming that the units are positioned a sufficient distance away from the natural reefs to prevent overlap of existing populations. Territorial reef species are thus less likely to occur on the OARs and will be less susceptible to fishing mortality (on the OAR) than to transient species. This does not apply to the susceptibility of territorial reef species that may recruit to the OAR as larvae and remain in the vicinity, which would then become susceptible to fishing mortality. In this case, fishing mortality of resident reef species could potentially be mitigated by the increase in productivity from new recruits (if they were not prevented from recruiting to natural reefs). In summary, site-attached species occurring on natural reef are less likely to move to the OAR than transient species. This hypothesis can be tested readily by monitoring the species and their size distribution in the period following deployment of the reef units. Larval fishes are typically much more abundant than post-settlement fishes. It would generally be expected that there would be an over supply of larval fishes and suitable settlement habitat would be limiting. On this basis, surplus larvae would be available to colonize the OARs, without limiting recruitment to natural reef.

Other factors related to susceptibility and species vulnerability are:

- the recreational or commercial importance of a species (i.e. a non-target species is more likely to be returned to the water after capture and avoid mortality than a targeted species); and
- the species exploitation status (i.e. populations that are heavily exploited and suppressed from overfishing are likely to be more at risk than those that are moderately or lightly fished). The species exploitation status was classified according to the NSW DPI Status of Fisheries Resources (Scandol *et al.* 2008).

Productivity depends on life history traits, with long lived, late maturing and slower growing species with low fecundity likely to have relatively low productivity and therefore be more vulnerable to fishing mortality.

Table 11 lists the criteria used to assess the productivity and susceptibility of the species likely to be affected by the proposal and explains the rationale for ranking each attribute. The analysis was carried out on the 48 species most likely to occur in the study areas based on:

- fisheries catch statistics (Web Reference 28);
- surveys of line fishers and spearfishers carried out from March 2007 to February 2008 (Web Reference 30-32); and
- results of BRUVS surveys carried out from the current OAR study.

The ten most frequently caught recreational species and top 20 commercially targeted species (based on reported gross tonnes) were included from the survey data. The ten most abundant species from the current survey also were included. In addition, species not represented but considered likely to occur on the OARs were included. The list of species included in the PSA is not exhaustive, but aims to represent the main recreationally and commercially important species likely to be affected by the proposal.

Species information relating to the relevant criteria was collated from the NSW DPI Status of Fisheries Resources in NSW 2006/2007 (Scandol *et al*. 2008), Fishbase (Web Reference 33) and from the relevant literature. For each species, criteria were ranked from 1 to 3, whereby 1 indicated low susceptibility and high productivity (low risk) and 3 indicated high susceptibility and low productivity (high risk). Rankings for each species are listed in Table 12. The average productivity and susceptibility scores for each species (48 in total) were then plotted on a 2D PSA graph (Figure 25). Each data point is numbered (from 1- 48) and corresponds to an ID listed in Table 12.

The overall risk value (or measure of vulnerability) is the Euclidean distance from the origin of the graph (Hobday *et al*. 2004) to each respective point. The plot is divided into equal thirds representing three risk categories (high, medium and low). The cut–offs for each category are thirds of the total distribution of all possible risk values.

Limitations of this approach occur where there is uncertainty or missing data values (Hobday *et al*. 2004). In such circumstances, a more conservative rank was assigned (i.e. a high risk category was used). Units with missing scores therefore had a more conservative overall risk value than those species with fewer missing attributes. Stobutzski *et al*. (2001) recommends that in situations where attributes are strongly correlated only one of them should be included in the PSA. This is because two or more criteria explaining the same factor can over emphasize their effect. Correlations between the criteria indicated that there was little redundancy among the criteria suggesting that each criterion contributed unique information. The only exception was the correlation between maximum length (L_{max}) and length at maturity (L_{mat}) for which r = 0.87. The criterion maximum length was therefore removed from the analysis as length at maturity is likely to be more reliable than maximum length.

Of the 48 species assessed, 12 were considered to be at relatively high risk, five at low risk and the majority (17 species) at moderate risk to fishing mortality as a result of the proposal (Figure 25).

The high risk group included wobbegong sharks (*Orectolobus* spp.), shovelnose ray (*Aptychotrema rostrata*), long-fin pike (*Dinolestes lewini*), sergeant baker (*Aulopus purpurissatus*), silver trevally (*Pseudocaranx dentex*), kingfish (*Seriola lalandi*), mulloway (*Argyrosomus japonicus*) and moray eel (*Gymnothorax prasinus*). The cartilaginous fishes (wobbegongs and shovelnose ray) were grouped as high risk because they produce few offspring, are vivaporous and grow to a large size, which result in a low productivity ranking. Silver trevally and kingfish and are in the higher risk group mainly because they are targeted recreational species that are likely to occur on the reefs. Mulloway is also in the higher risk group as it is targeted and is vulnerable to exploitation through overfishing. The blue grouper (*Achoerodus viridis*), also has a low productivity ranking. These species should therefore be considered a high priority within the impact assessment and for the future monitoring and management of the artificial reefs. It is, however, important to consider that existing populations of territorial reef species such as wobbegongs and blue grouper are only likely to be at high risk if drawn away from natural reef to the OAR. Locating the OARs a sufficient distance away from natural reef would minimise the likelihood of this occurring.

Long-fin pike, sergeant baker and moray eel are also potentially at high risk as they are recreationally caught and likely to occur on the OARs, however, gaps in life-history data may have resulted in an over-conservative productivity ranking for these species, in which case they are more likely to belong in the moderate risk group.

The moderate risk group included sawtail (*Prionurus microlepidotus*), tarwhine (*Rhabdosargus sarba*), (leatherjackets (Monocanthidae), snapper (*Pagrus auratus*), red and blue morwong (Cheilodactylidae), nannygai (*Centroberyx affinis*), fiddler ray (*Trygonorrhina fasciata*), yellowfin bream (*Acanthopagrus australis*), Australian salmon (*Arripis trutta*) and silver sweep (*Scorpis lineolata*) among others.

Although this group is considered less vulnerable to fishing pressure overall, many of the species are of high commercial and recreational importance and are likely to be targeted on the OARs. Therefore consideration in the proposal's long-term management and monitoring strategy (particularly for target species) is recommended.

Species at low risk include those predominantly associated with sandy habitat with high productivity rankings such as flatheads (Platycephalidae) and pelagic species found further offshore, such as clupeids (herrings, sardines, pilchards) and blue mackerel (*Scomber australasicus*). These species may be recorded as part of the ongoing monitoring but should be considered of low priority. There would be some loss of habitat for these sand dwelling species as a result of the unit placement, although this would be relatively insignificant in relation to the amount of similar habitat.

It is recommended that all threatened or protected species of fish should be considered to be of high vulnerability. The only exceptions to this would be most groups of syngnathiformes which are unlikely to be at risk of incidental capture even if occupying the proposed OARs.

Table 11: Productivity Susceptibility Analysis (PSA) attributes for target recreational and commercial species. Methodology for the PSA was sourced from Hobday *et al*. 2004.

1. Productivity attributes

				Productivity Ranking	
Productivity attribute	Rationale for attribute	Action in the case of multiple values	High (1)	Moderate (2)	Low (3)
Age at maturity	Later maturing species tend to have lower natural mortality, they are threrefore less productive and tend to show a greater decrease in abundance with fishing.	Average of male, female and no-gender minimum age at maturity.	< 3 yrs	3 yrs - 4 yrs	> 4
Approx. lifespan	Longer lived species tend to be slow growing, later maturing and have lower natural mortality, they are therefore less productive and tend to show a greater decrease in abundance with fishing.	Average of male, female and no-gender maximum longevity.	< 10 yrs	10 yrs - 20 yrs	> 20 yrs
Fecundity (estimated as geometric mean)	Species with fewer offspring are less productive.	N/a	> 500, 000	200 - 500,000 or unknown for broadcast spawners	< 200
Max size (L_{max})	Larger species tend to be slow growing and have lower natural mortality, they are therefore less productive and tend to show a greater decrease in abundance with fishing.	Average of male, female and no-gender upper limit of maximum size.	< 50 cm	50 cm - 99 cm	100 cm and greater
Length at maturity (L_m)	Late maturing species tend to be slow growing and have lower natural mortality, they are therefore less productive and tend to show a greater decrease in abundance with fishing.	Average of male, female and no-gender upper limit of maximum size.	< 25 cm	25 - 45 cm	> 45 cm
Reproductive strategy	Species with fewer offspring are considered less productive.	N/a	Broadcast spawner	Demersal spawner, brood or guard young	Live bearer

Continued

Table 11: Continued

2. Susceptibility attributes

		Susceptibility Ranking		
Susceptibility attribute	Rationale for attribute	Low (1)	Moderate (2)	High (3)
Target Group	Target group indicates the relative likelihood of surviving capture. Target species are retained, thus non-target species are likely to be returned to the water. Recreationally targeted species will be most vulnerable. Species targeted only by commercial fishing are considered less vulnerable.	Commercially targeted species	Recreationally targeted species	Recreationally and commercially targeted species
Habitat Preference	Species prefering reef habitat are more likely to aggregate at the OARs and therefore be more vulnerable to fishing.	Sand	Reef and/or sand	On or near reef
Site fidelity	Existing populations of transient or transient/territorial species are likely to be more susceptible than territorial reef species.	Territorial	Transient	Both
Exploitation Status	Species that are 'overfished' are more vulnerable to overexploitation. (The exploitation status of species is taken from the Status of Fisheries Resources in NSW, 2006/2007).	Lightly - moderately fished	Fully fished	Recruitment overfished, overfished, growth overfished or status uncertain/undefined
Depth Range	Species with a narrow depth range are more likely to occur on the OARs than species with a broad depth range.	Outside 20 m - 40 m OAR range	Broad depth range 0 m - 500 m	Narrow depth range 0 m - 100 m

Table 12: Productivity Susceptibility Analysis (PSA) rankings for target recreational and commercial species. Ranking of species with respect to criteria that reflect their susceptibility to fishing and productivity.

1. Productivity Attributes

ID	Family	Common Name	Scientific Name	Age at maturity	Length at maturity (Lmat)	Approx. lifespan	Fecundity	Reproductive strategy	Ave. Productivity
1	Rhinobatidae	Shovelnose ray*	*Aptychotrema rostrata*	1	3	2	3	3	**2.4**
2	Rhinobatidae	Fiddler ray*♦	*Trygonorrhina fasciata*	1	3	2	3	3	**2.4**
3	Orectolobidae	Spotted wobbegong♥	*Orectolobus maculatus*	3	3	3	3	3	**3.0**
4	Orectolobidae	Banded wobbegong♥	*Orectolobus halei*	3	3	3	3	3	**3.0**
5	Orectolobidae	Ornate wobbegong♥	*Orectolobus ornatus*	3	3	3	3	3	**3.0**
6	Clupeidae	Herrings, sardines, pilchards*♦	*Clupeidae*	2	1	1	2	1	**1.4**
7	Muraenidae	Moray eel♥	*Gymnothorax prasinus*	3	3	3	2	1	**2.4**
8	Aulopidae	Sargeant baker♥	*Aulopus purpurissatus*	3	2	3	2	1	**2.2**
9	Berycidae	Nannygai †	*Centroberyx affinis*	3	2	3	2	1	**2.2**
10	Zeidae	John dory♥	*Zeus faber*	2	2	2	2	1	**1.8**
11	Scorpaenidae	Red rock cod♥	*Scorpaena cardinalis*	3	1	2	2	1	**1.8**
12	Platycephalidae	Eastern blue-spotted flathead*†	*Platycephalus caeruleopunctatus*	2	2	2	1	1	**1.6**
13	Platycephalidae	Long-spine flathead*†	*Platycephalus longispinus*	1	1	1	1	1	**1.0**
14	Platycephalidae	Dusky flathead♦	*Platycephalus fuscus*	1	3	2	1	1	**1.6**
15	Platycephalidae	Tiger flathead♦	*Platycephalus richardsoni*	1	2	1	1	1	**1.2**
16	Dinolestidae	long-fin pike♥	*Dinolestes lewini*	3	3	3	2	1	**2.4**
17	Sillaginidae	School whiting♦	*Sillago bassensis*	1	1	2	2	1	**1.4**
18	Pomatomidae	Tailor †	*Pomatomus saltatrix*	2	3	2	1	1	**1.8**
19	Rachycentridae	Cobia♥	*Rachycentron canadum*	1	3	2	2	1	**1.8**
20	Carangidae	Silver trevally*♦	*Pseudocaranx dentex*	3	2	3	2	1	**2.2**
21	Carangidae	Yellow-tail scad*♦	*Trachurus novaezelandiae*	2	1	3	2	1	**1.8**
22	Carangidae	Kingfish †♦	*Seriola lalandi*	3	3	3	1	1	**2.2**
23	Coryphaenidae	Common dolphinfish♥	*Corypheana hippurus*	1	3	1	2	1	**1.6**
24	Arripidae	Australian salmon♦	*Arripis trutta*	2	2	1	2	1	**1.6**
25	Sparidae	Snapper*♦	*Pagrus auratus*	3	3	3	1	1	**2.2**

Continued

Table 12: Continued

ID	Family	Common Name	Scientific Name	Age at maturity	Length at maturity (Lmat)	Approx. lifespan	Fecundity	Reproductive strategy	Ave. Productivity
26	Sparidae	Tarwhine♦	*Rhabdosargus sarba*	3	1	3	2	1	**2.0**
27	Sparidae	Yellow-fin bream†♦	*Acanthopagrus australis*	2	1	2	1	1	**1.4**
28	Gerreidae	Silver biddy♦	*Gerres subfasciatus*	1	1	1	2	1	**1.2**
29	Sciaenidae	Mulloway♥	*Argyrosomus japonicus*	3	3	3	1	1	**2.2**
30	Girellidae	Luderick♦	*Girella tricuspidata*	2	2	2	2	1	**1.8**
31	Girellidae	Black drummer♥	*Girella elevata*	3	2	2	2	1	**2.0**
32	Scorpididae	Silver sweep†	*Scorpis lineolata*	1	1	3	2	1	**1.6**
33	Cheilodactylidae	Blue morwong†	*Nemadactylus douglasii*	2	1	3	2	1	**1.8**
34	Cheilodactylidae	Red morwong♥	*Cheilodactylus fuscus*	3	2	3	2	1	**2.2**
35	Latrididae	Bastard trumpeter♥	*Latridopsis forsteri*	1	2	2	2	1	**1.6**
36	Mugilidae	Sand mullet♦	*Myxus elongatus*	1	1	2	2	1	**1.4**
37	Sphyraenidae	Striped sea pike♥	*Sphyraena obtusata*	1	1	1	2	1	**1.2**
38	Labridae	Maori wrasse†	*Opthalmolepis lineolata*	1	1	2	2	1	**1.4**
39	Labridae	Blue grouper♥	*Achoerodus viridis*	3	3	3	2	1	**2.4**
40	Scombridae	Blue mackerel♦	*Scomber australasicus*	1	2	1	2	1	**1.4**
41	Scombridae	Australian bonito♦	*Sarda australis*	2	3	2	1	1	**1.8**
42	Istiophoridae	Striped marlin♥	*Tetrapturus audax*	1	3	1	1	1	**1.4**
43	Acanthuridae	Sawtail♥	*Prionurus microlepidotus*	2	2	2	2	1	**1.8**
44	Monocanthidae	Yellow-finned leatherjacket*	*Meuschenia trachylepis*	2	1	2	1	1	**1.4**
45	Monocanthidae	Chinaman leatherjacket*♦	*Nelusetta ayraudi*	2	3	2	1	1	**1.8**
46	Monocanthidae	Six-spined leatherjacket†	*Meuschenia freycineti*	3	2	3	1	1	**2.0**
47	Loliginidae (Cephlapoda)	Southern calamari♥	*Sepioteuthis australis*	1	1	1	2	2	**1.4**
48	Teuthida (Cephlapoda)	Arrow squid♥	*Nototodarus gouldi*	3	2	1	2	2	**2.0**

Continued

Table 12: Continued

2. Susceptibility Attributes

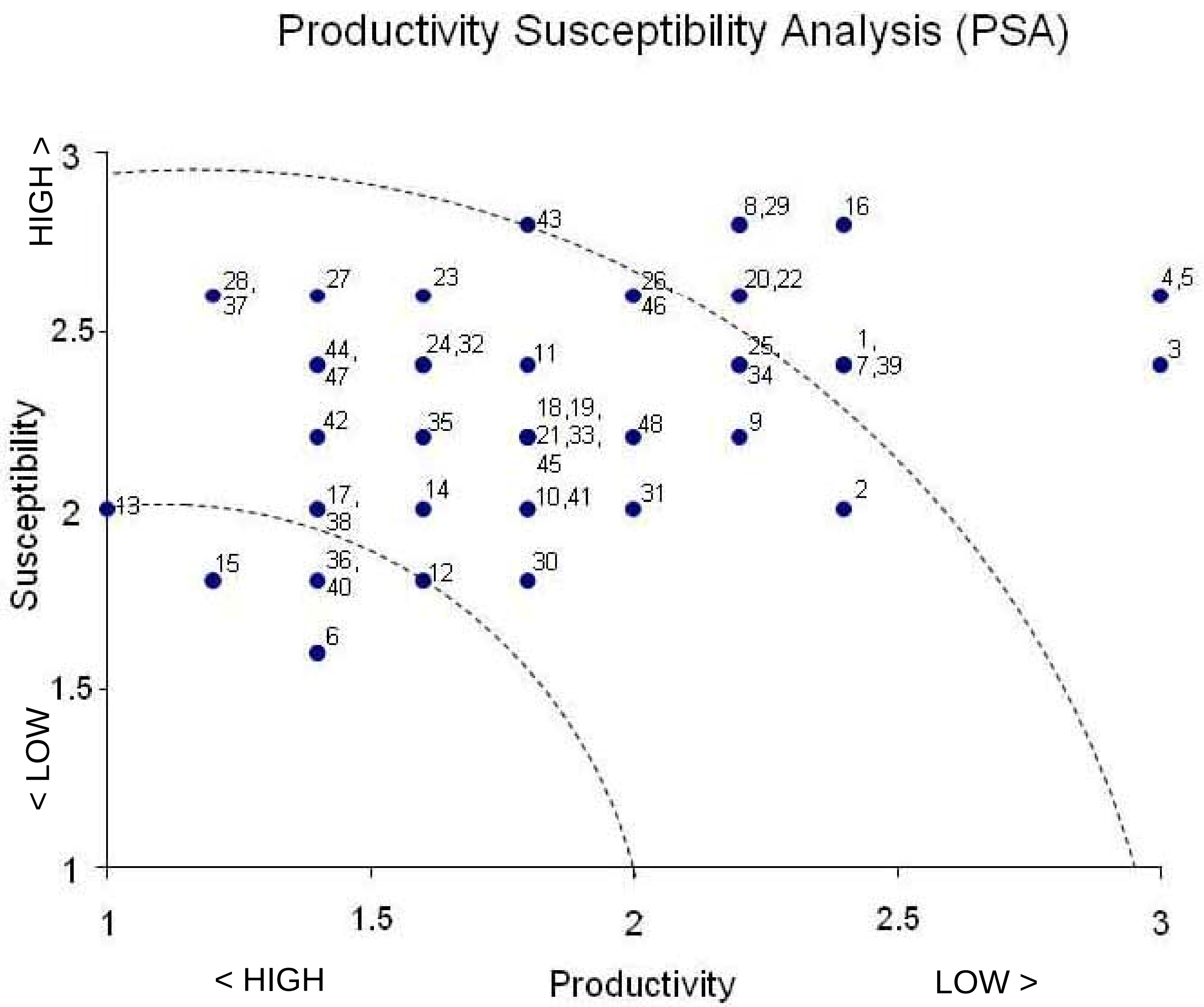
ID	Family	Common Name	Scientific Name	Target Group	Habitat preference (adults)	Site fidelity	NSW DPI Exploitation status	Depth range	Ave Susceptibility
1	Rhinobatidae	Shovelnose ray*	*Aptychotrema sp.*	3	1	2	3	3	**2.4**
2	Rhinobatidae	Fiddler ray*♦	*Trygonorrhina fasciata*	1	1	2	3	3	**2.0**
3	Orectolobidae	Spotted wobbegong♥	*Orectolobus maculatus*	3	2	1	3	3	**2.4**
4	Orectolobidae	Banded wobbegong♥	*Orectolobus halei*	3	3	1	3	3	**2.6**
5	Orectolobidae	Ornate wobbegong♥	*Orectolobus ornatus*	3	3	1	3	3	**2.6**
6	Clupeidae	Herrings, sardines, pilchards*♦	Clupeidae	1	2	2	1	2	**1.6**
7	Muraenidae	Moray eel♥	*Gymnothorax prasinus*	2	3	1	3	3	**2.4**
8	Aulopidae	Sargeant baker♥	*Aulopus purpurissatus*	2	3	3	3	3	**2.8**
9	Berycidae	Nannygai †	*Centroberyx affinis*	2	3	1	3	2	**2.2**
10	Zeidae	John dory♥	*Zeus faber*	2	2	2	2	2	**2.0**
11	Scorpaenidae	Red rock cod♥	*Scorpaena cardinalis*	2	3	1	3	3	**2.4**
12	Platycephalidae	Eastern blue-spotted flathead*†	*Platycephalus caeruleopunctatus*	3	1	1	2	2	**1.8**
13	Platycephalidae	Long-spine flathead*†	*Platycephalus longispinus*	2	1	1	3	3	**2.0**
14	Platycephalidae	Dusky flathead♦	*Platycephalus fuscus*	3	1	1	2	3	**2.0**
15	Platycephalidae	Tiger flathead♦	*Platycephalus richardsoni*	3	1	1	2	2	**1.8**
16	Dinolestidae	Long-fin pike♥	*Dinolestes lewini*	2	3	3	3	3	**2.8**
17	Sillaginidae	School whiting♦	*Sillago bassensis*	3	1	1	2	3	**2.0**
18	Pomatomidae	Tailor †	*Pomatomus saltatrix*	2	2	1	3	3	**2.2**
19	Rachycentridae	Cobia♥	*Rachycentron canadum*	2	2	2	3	2	**2.2**
20	Carangidae	Silver trevally*♦	*Pseudocaranx dentex*	3	1	3	3	3	**2.6**
21	Carangidae	Yellow-tail scad*♦	*Trachurus novaezelandiae*	3	3	1	2	2	**2.2**
22	Carangidae	Kingfish †♦	*Seriola lalandi*	3	3	2	3	2	**2.6**
23	Coryphaenidae	Common dolphinfish	*Corypheana hippurus*	3	2	2	3	3	**2.6**
24	Arripidae	Australian salmon♦	*Arripis trutta*	3	2	1	3	3	**2.4**
25	Sparidae	Snapper*♦	*Pagrus auratus*	3	2	2	3	2	**2.4**

Continued

Table 12: Continued

ID	Family	Common Name	Scientific Name	Target Group	Habitat preference (adults)	Site fidelity	NSW DPI Exploitation status	Depth range	Ave Susceptibility
26	Sparidae	Tarwhine♦	*Rhabdosargus sarba*	3	2	3	2	3	**2.6**
27	Sparidae	Yellow-fin bream†♦	*Acanthopagrus australis*	3	2	3	2	3	**2.6**
28	Gerreidae	Silver biddy♦	*Gerres subfasciatus*	1	1	3	1	3	**1.8**
29	Sciaenidae	Mulloway♥	*Argyrosomus japonicus*	3	2	3	3	3	**2.8**
30	Girellidae	Luderick♦	*Girella tricuspidata*	3	3	1	1	1	**1.8**
31	Girellidae	Black drummer♥	*Girella elevata*	2	3	1	3	1	**2.0**
32	Scorpididae	Silver sweep†	*Scorpis lineolata*	3	3	1	2	3	**2.4**
33	Cheilodactylidae	Blue morwong†	*Nemadactylus douglasii*	2	3	1	2	3	**2.2**
34	Cheilodactylidae	Red morwong♥	*Cheilodactylus fuscus*	2	3	1	3	3	**2.4**
35	Latridae	Bastard trumpeter♥	*Latridopsis forsteri*	3	1	2	3	2	**2.2**
36	Mugilidae	Sand mullet♦	*Myxus elongatus*	1	1	1	3	3	**1.8**
37	Sphyraenidae	Striped sea pike♥	*Sphyraena obtusata*	2	3	3	3	2	**2.6**
38	Labridae	Maori wrasse†	*Opthalmolepis lineolata*	2	3	1	3	1	**2.0**
39	Labridae	Blue grouper♥	*Achoerodus viridis*	2	3	1	3	3	**2.4**
40	Scombridae	Blue mackerel†	*Scomber australasicus*	3	2	2	1	1	**1.8**
41	Scombridae	Australian bonito♦	*Sarda australis*	3	1	2	3	1	**2.0**
42	Istiophoridae	Striped marlin♥	*Tetrapturus audax*	3	1	2	3	2	**2.2**
43	Acanthuridae	Sawtail♥	*Prionurus microlepidotus*	2	3	3	3	3	**2.8**
44	Monocanthidae	Yellow-finned leatherjacket*	*Meuschenia trachylepis*	3	2	2	2	3	**2.4**
45	Monocanthidae	Chinaman leatherjacket*♦	*Nelusetta ayraudi*	3	2	2	2	2	**2.2**
46	Monocanthidae	Six-spined leatherjacket†	*Meuschenia freycineti*	2	3	3	2	3	**2.6**
47	Loliginidae (Cephlapoda)	Southern calamari♥	*Sepioteuthis australis*	3	1	3	3	2	**2.4**
48	Teuthida (Cephlapoda)	Arrow squid♥	*Nototodarus gouldi*	3	1	3	3	1	**2.2**

(*) = recorded in January 2009 fish survey
(†) = recorded in top ten observed recreational and spearfishing catches 2007/2008 (Web Reference 23)
(♦) = recorded in top 20 commercially caught species (estimated by weight in tonnes) 2006/2007 (Web Reference 24)
(♥) = Other species considered likely to occur



1	Shovelnose ray	17	School whiting	33	Blue morwong
2	Fiddler ray	18	Tailor	34	Red morwong
3	Spotted wobbegong	19	Cobia	35	Bastard trumpeter
4	Banded wobbegong	20	Silver trevally	36	Sand mullet
5	Ornate wobbegong	21	Yellow-tail scad	37	Striped sea pike
6	Herrings, sardines, pilchards	22	Kingfish	38	Maori wrasse
7	Moray eel	23	Common dolphinfish	39	Blue grouper
8	Sargeant baker	24	Australian salmon	40	Blue mackerel
9	Nannygai	25	Snapper	41	Australian bonito
10	John dory	26	Tarwhine	42	Striped marlin
11	Red rock cod	27	Yellow-fin bream	43	Sawtail
12	Eastern blue-spotted flathead	28	Silver biddy	44	Yellow-finned leatherjacket
13	Long-spine flathead	29	Mulloway	45	Chinaman leatherjacket
14	Dusky flathead	30	Luderick	46	Six-spined leatherjacket
15	Tiger flathead	31	Black drummer	47	Southern calamari
16	long-fin pike	32	Silver sweep	48	Arrow squid

Figure 25: Productivity Susceptibility Analysis (PSA) of recreationally and commercially important species likely to occur at the proposed OAR study regions.

8 Assessment of Impacts

The following impact assessment has been divided into the two main stages of the project:

- Construction, transportation and deployment.
- Long-term operation.

The construction, transportation and deployment stages of the project would be the responsibility of a contractor that would be appointed by I&I NSW subject to the projects approval. Long-term operation, maintenance and monitoring would be the responsibility of I&I NSW.

8.1 Construction, Transport and Deployment

8.1.1 Noise

8.1.1.1 Assessment of Impacts

There is potential for noise to be generated in conjunction with the proposed construction of the artificial reef structures. When assessing the impact of noise generated by the construction of the OARs, consideration of the following factors is required:

- existing land uses and ambient noise levels;
- noise source level, mode of operation, duration of operation;
- location of noise receptors in relation to construction works and the presence of noise softening measures (e.g. barriers in the form of buildings or variations in topography) between the source and receptor; and
- sensitivity of the receiving environment.

The EPA, which is incorporated within DECCW, is responsible for the regulation of noise-related issues, primarily through the enforcement of requirements outlined in the *Protection of the Environment Operations Act* 1997 (*PoEO Act*). Guidelines to manage the impacts of construction-related noise are set out in the *NSW Construction Noise Guideline* (DECC 2008), and guidelines for vibration are set out in *Assessing Vibration: a Technical Guideline* (DECC 2006). The DECC (2008) *Draft NSW Construction Noise Guideline* specifies the typical maximum 'at source' sound power levels (L_w) for the types of equipment likely to be used as follows:

- diesel Generator 84 dB;
- mobile Crane 78 dB;
- truck 107 dB; and
- handheld Welder 73 dB;

Other equipment used during the construction of the artificial reefs is likely to include hand tools and small power tools. There is some potential for noise to be generated and received by the broader region through the movement of heavy vehicles delivering construction materials. However, due to the amount of material required and the relatively small-scale of the works, it is considered unlikely that significant noise will be generated through vehicle movements at any of the proposed construction sites.

Considering that appropriate construction locations have not yet been finalised a qualitative assessment has been undertaken to determine the likely impact of noise within the general vicinity of the Port of Newcastle, Port Jackson (Sydney) and Port Kembla.

The Newcastle Port area is dominated by industrial berths where vessels such as coal tankers load and unload large amounts of goods on a daily basis. These operations contribute significantly to the background noise levels within the area and therefore the noise from reef construction is considered to be insignificant in comparison. Based on the level, type and duration of noise generated by the construction works, the magnitude of impact is estimated to be 'moderate' whilst the sensitivity of receptor (i.e. shipping berths and operations facilities) is considered to be 'minor'. Consequently, the likely impact of the construction works affecting receptors within the Newcastle Ports region is considered to be minor (Table 13). Within the Sydney Ports region, there is greater residential development and therefore the sensitivity of receptor (i.e. is considered to be 'high' and the likelihood of noise from construction works significantly affecting receptors would be high (Table 13). At Port Kembla, the sensitivity of receptor (i.e. industrial premises) is considered to be 'minor' and consequently, the likely risk of the construction works significantly affecting receptors within the Port Kembla region is considered to be minor (Table 13).

Given the relatively short-term nature of the works, the proposed construction methodology and assumed locations, it is considered unlikely that noise levels would significantly impact local sensitive receptors during the construction of the artificial reefs. It is however, recommended that this assessment be reviewed once the location for construction is finalised.

Table 13: Noise impact assessment criteria. Magnitude of impact is based on the level, type and duration of noise impact. Residential receptors are considered to have very high sensitivity, conversely a highly industrialised receptor would be considered to have minimal sensitivity.

Magnitude of Impact	Sensitivity of Receptor: Very High	High	Moderate	Minor	Minimal
Very High	Very High	Very High	High	High	Moderate
High	Very High	High	High	Moderate	Moderate
Moderate	High	High	Moderate	Minor	Minor
Minor	High	Moderate	Minor	Minor	Minimal
Minimal	Moderate	Moderate	Minor	Minimal	Minimal

A further site-specific assessment has also been carried out based upon the three potential construction locations identified in Section 4.4 (Figures 9, 10 and 11). Straight-line hemispherical noise calculations, using the highest expected noise generating source (i.e. a truck) at 107 dB, indicated that the received noise levels by the closest sensitive locations would be in the order of 45 dB, 49 dB and 59 dB at Newcastle, Sydney and Port Kembla respectively. According to DECC (2008) guidelines, the $L_{Aeq\ (15\ min)}$ for industrial and commercial premises is 75 dB. The calculated noise generated by the construction activity at the three sites would therefore not significantly impact local receptors (Technical Report G).

8.1.1.2 Recommendations and Mitigation

As best practise, the following measures to minimise noise are recommended:

- Specific noise mitigation measures including all viable methods to maintain/reduce duration and intensity of noise output should be identified and included in a Construction Environmental Management Plan (CEMP) to be prepared by the contractor. Due to the potential of the works to impact local receptors, hours of operation during the construction stage should be designated as follows:
    - Monday to Friday 7am to 6pm;
    - Saturday 7am to 1pm;
    - Sunday or Public Holidays No construction work to take place.
- Noise levels should not exceed the LAeq (15 mins) for industrial and commercial premises.
- It is recommended that further assessment be undertaken to fully determine the likely impact of noise and establish appropriate mitigation measures once locations for the works are finalised.

8.1.2 Sediments and Water

8.1.2.1 Assessment of Impacts

Stormwater run-off

The construction of the artificial reef structures is to be undertaken on waterfront/port-side land in order to facilitate transportation via barge. As such, there is potential for runoff generated by rainfall events to transport pollutants and/or fine particulates into the adjacent waterbodies. Construction is likely to take place within an industrialised or urbanised port, the affect of surface run-off from the OAR construction works would therefore be relatively insignificant in comparison to background pollution levels. Considering the relatively limited nature of the proposed works and the absence of significant sources of potential pollutants, it is considered unlikely that water quality within in any of the three harbours would be significantly affected by stormwater run-off.

Increased turbidity

Initial deployment of the OAR units is likely to cause localised disturbance and re-suspension of sandy sediment at the site where the units are installed. This may result in a short-term and localised increase in turbidity, which could cause mobile macroinvertebrates and fish temporarily to move out of the area. As the effects of this impact will be short-term and localised within the direct study areas mitigative action is not considered necessary.

Disturbance of contaminated sediments

It is possible that sediment disturbance during deployment could result in the mobilisation of contaminants, if present in the surface sediments. The results of the field studies (Section 6.3.5) indicate that mobilisation of heavy metal contaminants (which can be harmful to fish and invertebrates) would be highly unlikely. Initial constraints mapping (Appendix 1 of Technical Report A) also highlighted spoil grounds and dumping areas that would be avoided in OAR site selection. It is therefore not considered that action to mitigate this potential impact would be required.

8.1.2.2 Recommendations and Mitigation

Overall impacts on water quality during the construction, transport and deployment stage are considered to be negligible however, as best practise it is recommended that:

- The contractor prepares a Water Quality Management Plan (WQMP) as a component of the CEMP. As a minimum this plan should include provisions for the capture, storage, testing, treatment and release of stormwater runoff from the construction site. Further details are outlined in the Environmental Management Plan (Appendix 9).
- The quality of water discharged from the construction areas is maintained generally in accordance with ANZECC/ARMCANZ (2000) guidelines and the *Protection of Environment Operations Act 1997* (PoEO Act).
- The disposal of liquid waste materials into the waters is limited to salt or fresh water and other materials that have been adequately treated for the removal of oil or other constituents that may be harmful to aquatic life or property. Other non-liquid waste materials that may be harmful or hazardous to life or property, or that result in an unsightly appearance, are not be disposed of into the waters.
- Prior to loadout, the structures should be cleaned of all slag, rust, water, oil, paint and other material and inspected prior to deployment.
- As the site location is yet to be determined it is recommended that this assessment is reviewed once the final site locations are determined and that the WQMP outlines site specific mitigation measures.

8.1.3 Air Quality

8.1.3.1 Assessment of Impacts

The primary concern relating to air quality associated with the construction of the artificial reef structures is the creation of dust and emissions from the use of machinery and hand tools. This would comprise exhaust emissions from machinery and emissions resulting from the use of welding equipment (i.e. burning Oxy-acetylene). Furthermore, exhaust emissions created by the movement of vehicles transporting materials to and from site also has the potential to impact local air quality. There is also potential for fine particles associated with construction materials and sediments to become airborne during periods of high winds. However, as construction only requires the assembly of materials, the risk of aeolian transport is considered to be minimal. Due to the relatively limited scale and duration of the proposed construction works in relation to the ongoing industrial practices within the port regions, it is considered very unlikely that the construction of the artificial reef structures will significantly contribute to a local reduction in air quality.

8.1.3.2 Recommendations and Mitigation

Impacts on local air quality during the construction works would be negligible, however, as best practice, measures to minimise potential impacts on air quality are outlined below:

- Local air quality should be maintained generally in accordance with The National Ambient Air Quality Standards – under the National Environment Protection Council (NEPC).
- An Air Quality Management Plan (AQMP) should be prepared as a component of the CEMP to minimise potential impacts to local air quality. The following mitigation measures should be included in the plan:

- adequate covering of material being transported by trucks to minimise dust pollution generated;
- in instances where extreme wind conditions are experienced (greater than 40km/h), works should cease immediately;
- regular maintenance of plant and equipment should be conducted to ensure that they are in proper working order, thus minimising the exhaust emissions from such vehicles; and
- correct specification, storage, and preparations of raw material to prevent or minimise the requirements for shot blasting or further cleaning.

8.1.4 Waste

8.1.4.1 Assessment of Impacts

During the construction of the artificial reef structures there is potential for waste to be generated and for construction waste (i.e. material off-cuts) to contribute to on-site waste production. However, any waste generated would be of a small volume and would not be potentially harmful to humans or the surrounding environment. It is understood that the relatively limited scale of the works would ensure that any waste produced is localised to the immediate construction site and that it would be disposed of at an appropriate facility or reused where possible. Furthermore, prefabrication of construction material would assist in minimising potential waste.

8.1.4.2 Recommendations and Mitigation

Impacts of waste production during the construction stage would be minimal however, as best practice measures to minimise waste are outlined below:

- Prior to construction, the contractor should seek to minimise the total amount of waste required for disposal through appropriate planning and ordering of materials where feasible.
- The contractor should develop and implement a Waste Management Plan (WMP) as a component of the CEMP. This plan should be written in accordance with the framework outlined in the Waste Avoidance and Recovery Strategy, (DECC 2007a) and the relevant local government Development Control Plans for the respective works location. As a minimum the WMP should include the following:
    - identification of potential sources of waste during the construction works;
    - outline of the measures and strategies to be implemented to minimise the waste generated by the works;
    - outline the handling and disposal of waste during construction;
    - identification of opportunities to reuse and recycle waste material and if necessary, treat and dispose of in accordance with the EPA guidelines on the Assessment, Classification and Management of Liquid and Non-Liquid Waste;
    - ongoing monitoring of waste generation throughout the duration of the construction works.
- Due to the nature of the construction works, it is not anticipated that any hazardous waste will be generated. However, should it be identified prior to or during the works, that waste may be potentially harmful to humans or the surrounding environment (i.e. toxic liquid/chemical waste), an appropriate means of disposal and disposal facility should be nominated.

8.1.5 Traffic

8.1.5.1 Assessment of Impacts

Construction workers entering and leaving the construction site will increase traffic volumes slightly, but this impact is perceived as negligible as the scale of the works will not require significant numbers of construction workers. Truck movements associated with the movement of construction materials would be spread throughout the day (i.e. normal working hours) and would not significantly affect local traffic conditions at any of the proposed locations. Furthermore, it is expected that a large portion of the required materials would be transported to site during the early stages of construction therefore the frequency of vehicle movements would decline during the latter stages of construction.

Vehicle access into the Newcastle Ports area has already been established for industrial operations associated with steel manufacturing and shipping. The area is currently accessed via Newcastle's major road network and provides sufficient space for the parking of construction generated traffic and the manoeuvre of large vehicles. Sydney Ports facilitates numerous commercial and industrial areas and therefore accommodates the movements of associated traffic. It is not perceived that any additional road infrastructure would be required as a consequence of the construction works within the Sydney Ports area. Parking for traffic generated by the construction works should be immediately adjacent to the construction site. Port Kembla, specifically the Outer Harbour is perceived to have sufficient infrastructure to accommodate the movement of construction generated traffic. The area is linked by Five Islands Drive which is a major collector road.

8.1.5.2 Recommendations and Mitigation

A contractor to carry out the construction, transport and deployment of the structures has not yet been appointed and as such, a waterside construction location has not yet been finalised. It is unlikely that OAR construction will have a significant impact on local traffic conditions if constructed within the three recommended port locations, however, as best practice, measures to minimise traffic are outlined below:

- A detailed Traffic Management Plan (TMP) should be developed and implemented by the contractor in accordance with the RTA (2002) *Guide to Traffic Generating Developments*. The TMP would form a component of the CEMP and should include provisions for:
    - truck parking and manoeuvring,
    - construction zones,
    - crane usage,
    - truck and construction traffic routes,
    - general parking zones for other construction traffic.
- If required during the proposed works, signage would be erected to warn motorists of traffic entering and leaving the works site at each location.
- The contractor would be responsible for maintaining all traffic management procedures to ensure safety within the site and for public road users and pedestrians.
- Stabilised access points should be established as required to minimise damage to the surrounding environment.
- All vehicles carrying materials to and from the site should have their loads covered where possible.
- The movements of construction vehicles should be limited to general construction work hours in order to comply with noise regulations.

8.1.6 Soil

8.1.6.1 Assessment of Impacts

It is understood that the proposed construction of the artificial reef structures will be undertaken at sites which have previously been utilised for industrial and/or commercial purposes. Existing flat and even hardstand areas will provide a suitable surface for works to be undertaken. It is therefore considered unlikely that there will be any effect on soils within or surrounding the work sites. As there is no requirement for excavation of soils or the importation of fill material/loose sediment associated with the construction works the requirement for erosion and sediment control measures to be implemented is considered to be minimal.

8.1.6.2 Recommendations and Mitigation

As best practise, erosion and sedimentation issues should be addressed in an Erosion and Sediment Control Plan prepared in accordance with the Managing Urban Stormwater – Soils and Construction (Department of Housing, 2004) guidelines. This plan would be prepared as a component of the CEMP and should focus management and minimisation of the risk of soil erosion during the proposed construction works by implementing measures to:

- minimise disturbance;
- conserve topsoil;
- control water; and
- stabilise/rehabilitate all disturbed surfaces.

8.1.7 Structural Integrity and Stability

8.1.7.1 Assessment of Impacts

Damage to structures during transportation and deployment

During the transport and deployment process, there is potential for the units to become damaged if they have been incorrectly loaded or not properly secured. Damage to the units has the potential to effect the long-term structural integrity, design life and performance of the OARs.

Incorrect positioning/orientation resulting in instability

The proposed OAR concept design requires that the units are orientated into the critical wave direction. If not properly deployed and installed according to the design specification, there is a risk that the units could slide or overturn. This could compromise the design life and functionality of the reef and also result in them becoming a navigational hazard.

8.1.7.2 Recommendations and Mitigation

Risks during transportation and deployment that have potential to compromise the structural integrity of the units would be addressed by ensuring that a suitably qualified contractor is appointed. The contractor would be responsible for carrying out lift analyses to ensure that barges and vessels are stable during the loading transportation and deployment process. DGPS positioning and diver inspections would ensure that the units have been deployed into the correct location and orientation. A specific deployment procedure would be required for each of the loading, transportation and deployment stages. The recommended procedures for these stages are outlined in detail in the EMP (Appendix 9). Provided that these procedures are followed as outlined, no significant impacts would be expected.

8.1.8 Navigation and Safety

8.1.8.1 Assessment of Impacts

Conflict with shipping and/or other water users

Depending on the location of the construction site, it may be necessary for the units to be transported by cargo barge, potentially more than 20 km from the deployment site. Once loaded onto the cargo barge it is possible that transportation and deployment may be completed in only a few days depending on the weather and sea conditions. Transiting to and from the fabrication site may interfere with other commercial shipping movements.

Damage to cargo barge during transport and deployment

Stability of the units is an issue during the loadout, transportation and deployment stages. If not properly secured throughout the process, there is risk of damage to the units or cargo barges.

8.1.8.2 Recommendations and Mitigation

Risks to navigation and safety during the transportation and deployment phases would be mitigated and managed provided the contractor carries out procedures as outlined in the EMP (Appendix 9). This primarily involves checking the sea state and weather conditions, communication of the proposed timing and location of the works to the relevant Port Authority, obtaining clearance from the relevant Ports Authority and the use of temporary navigational markers within the deployment area. Procedures to secure and check the structures during transit would also be carried out. Provided these procedures are followed as outlined, no significant impacts to navigation and safety would be expected.

8.1.9 Flora and Fauna

8.1.9.1 Assessment of Impacts

It is conceivable that the transport and deployment stages of the proposal could result in the disruption of migratory species, particularly whales through noise, vibration or physical obstruction. It is more likely however, that migratory species present in the vicinity of the deployment operation would move away from the disturbance, hence the risk to these species is considered very low. Furthermore, shipping and boating activity at the three potential deployment locations would already be relatively high as they are close to large ports and metropolitan centres.

8.1.9.2 Recommendations and Mitigation

To avoid any potential impacts on migratory species during transportation and deployment, deployment should not proceed if there are reports of migratory marine mammals (particularly whales) within the vicinity of the deployment area. Operations should also be temporarily stopped if migratory marine mammals are observed within 300 m of the deployment site, until it is safe to proceed.

8.1.10 Occupational Health and Safety

8.1.10.1 Assessment of Impacts

There are inherent occupational health and safety (OH & S) risks associated with construction work and deployment operations carried out at sea. The majority of OH & S risks would be the responsibility of the contractor that is appointed to carry out the works and would be addressed as part of a Construction Environmental Management Plan (CEMP) and OH & S plan.

8.1.10.2 Recommendations and Mitigation

It should be ensured that the temporary construction area is adequate in terms of OH & S. A health and safety management plan and operational protocols would be drawn up and implemented for the construction, transport and deployment stages. An outline of these procedures and plans is given in the EMP (Appendix 9). Provided the appropriate OH & S and management plans are developed and implemented and a suitably qualified contractor is appointed to carry out the works, occupational health and safety risks during, construction, transportation and deployment are considered to be acceptable and no significant impacts would be expected.

8.2 Long-Term Operation

8.2.1 Coastal Processes

8.2.1.1 Assessment of Impacts

The existing environment in relation to coastal processes is described in detail in Section 6.1.1 and includes the local wind and wave climate, prevailing currents, water levels and processes that affect sediment transport. Information on the existing sediment characteristics within the direct and broad study areas is given in Sections 6.3.3 and 6.3.5. Impacts relating to coastal processes are listed and discussed below.

Impacts on Nearshore Coastal Processes

The majority of sediment transport along the coast occurs inshore of the depth limits of the proposed OARs. Emplacement of the reef units has potential to transform waves, causing a directional shift and influence wave patterns, particularly refraction, which could indirectly affect nearshore coastal processes. Only sandy shorelines inshore of the direct study areas i.e. Nine Mile Beach (Newcastle study region) and Perkins Beach (Wollongong study region), could potentially be affected. The extent to which the OAR emplacement would affect inshore wave climate was investigated using the SWAN model. An outline of data and methodology used for the assessment is outlined in Technical Report C. A comparison between pre and post-deployment conditions was made by considering the potential change in weighted mean wave direction and consequent net longshore transport along sandy beaches.

The comparison of pre and post-deployment conditions (Figures 26, 27 and 28) shows that the placement of the OAR structures has no discernible influence on the inshore wave climates at the three study regions and would not affect the erosion of sandy shoreline areas that lie landward of them. Note that these investigations were initially carried out for a structure 11 m x 11 m x 13.6 m. These dimensions are significantly smaller than the typical offshore wave length which is in the order of 100 m or greater. The dimensions of the OAR concept design prepared by Worley Parsons are 15 m x 12 m x 12 m. These dimensions are also much smaller than the typical wave length and hence the same outcome can be assumed. The placement of the units at their proposed depths would have no discernible influence on inshore wave climates, so no further recommendations or modifications are required beyond what is proposed.

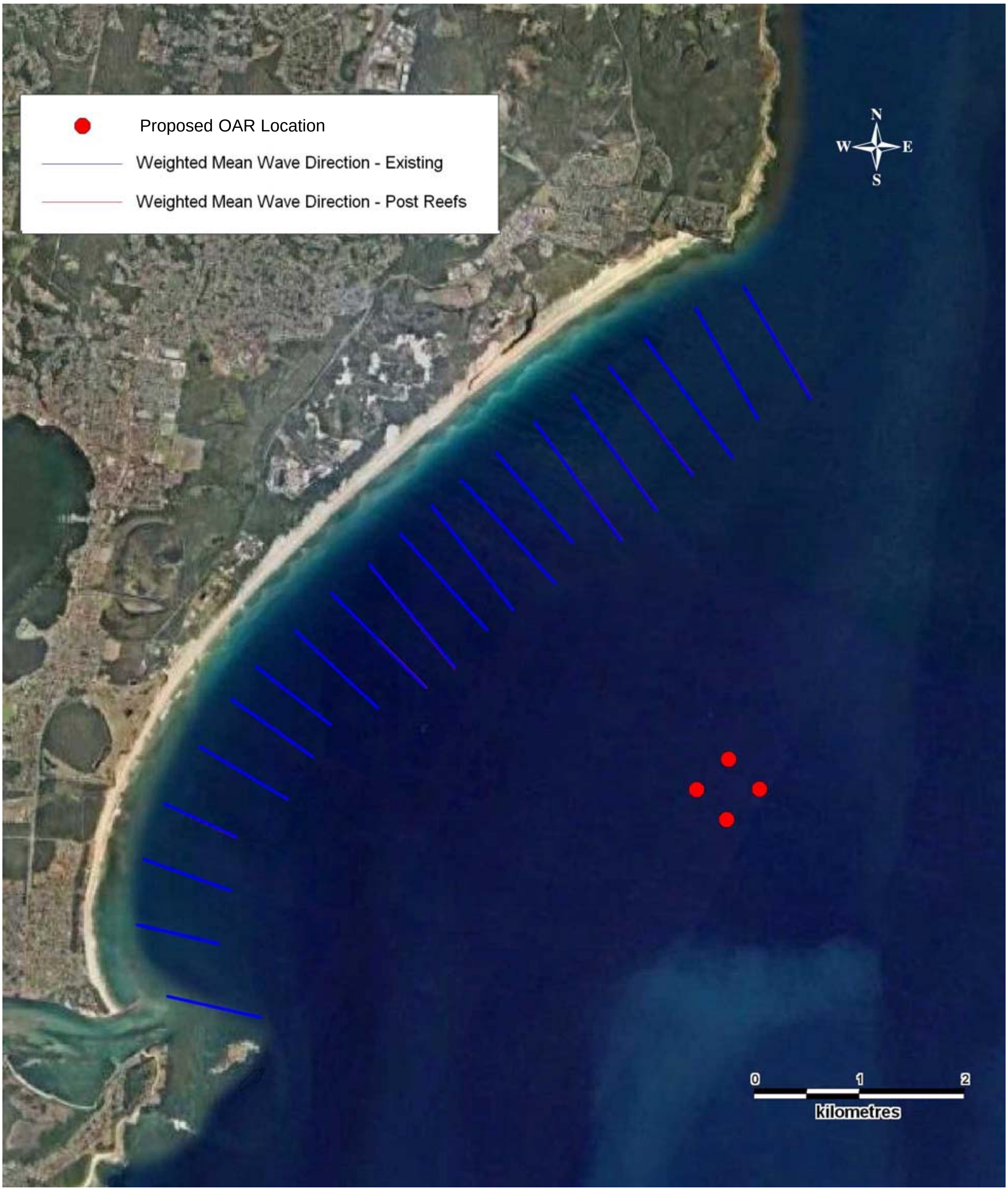


Figure 26: Weighted mean wave direction (Newcastle study region). Source: Cardno Lawson Treloar.

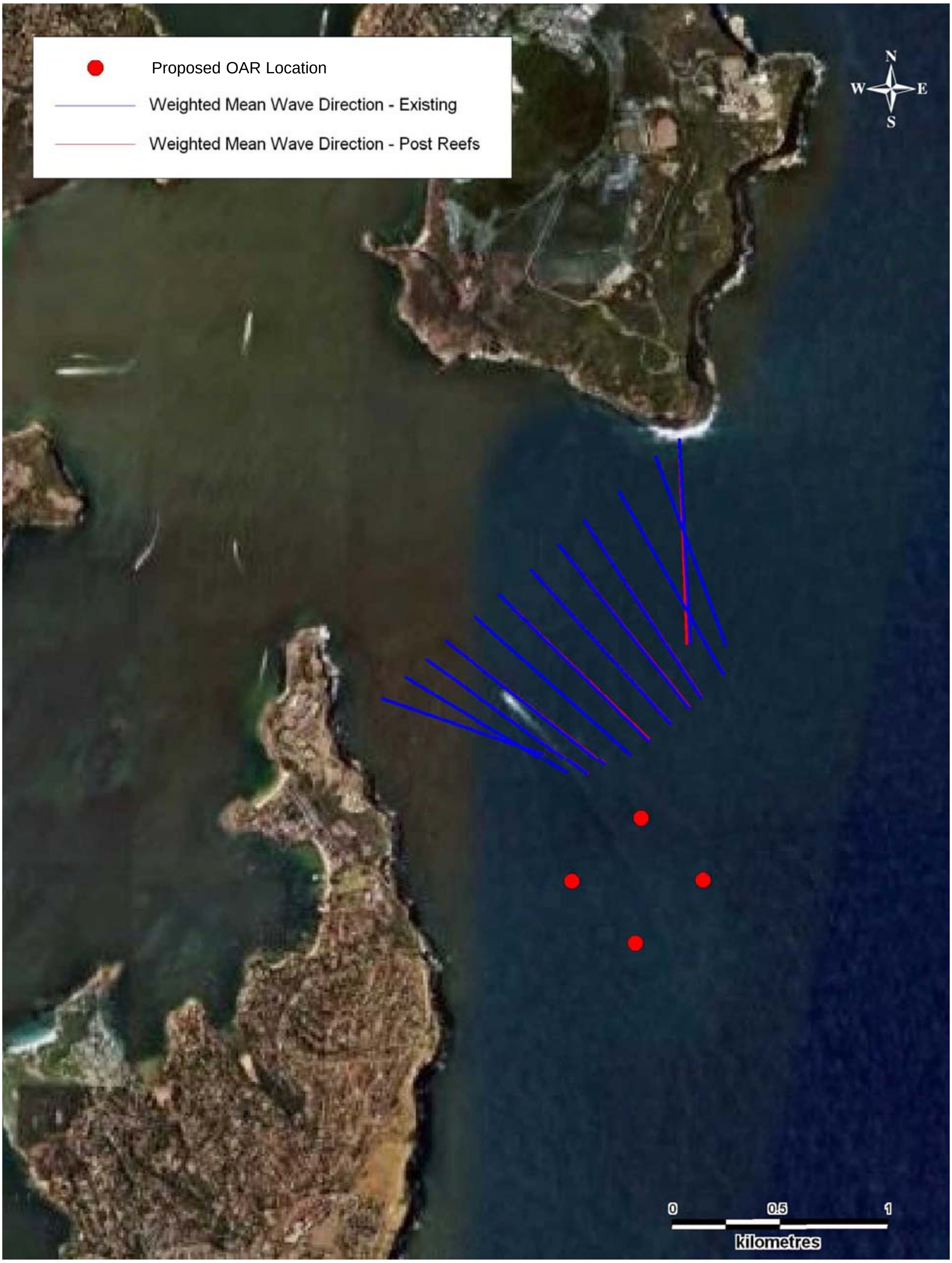


Figure 27: Weighted mean wave direction (Sydney study region). Source: Cardno Lawson Treloar.

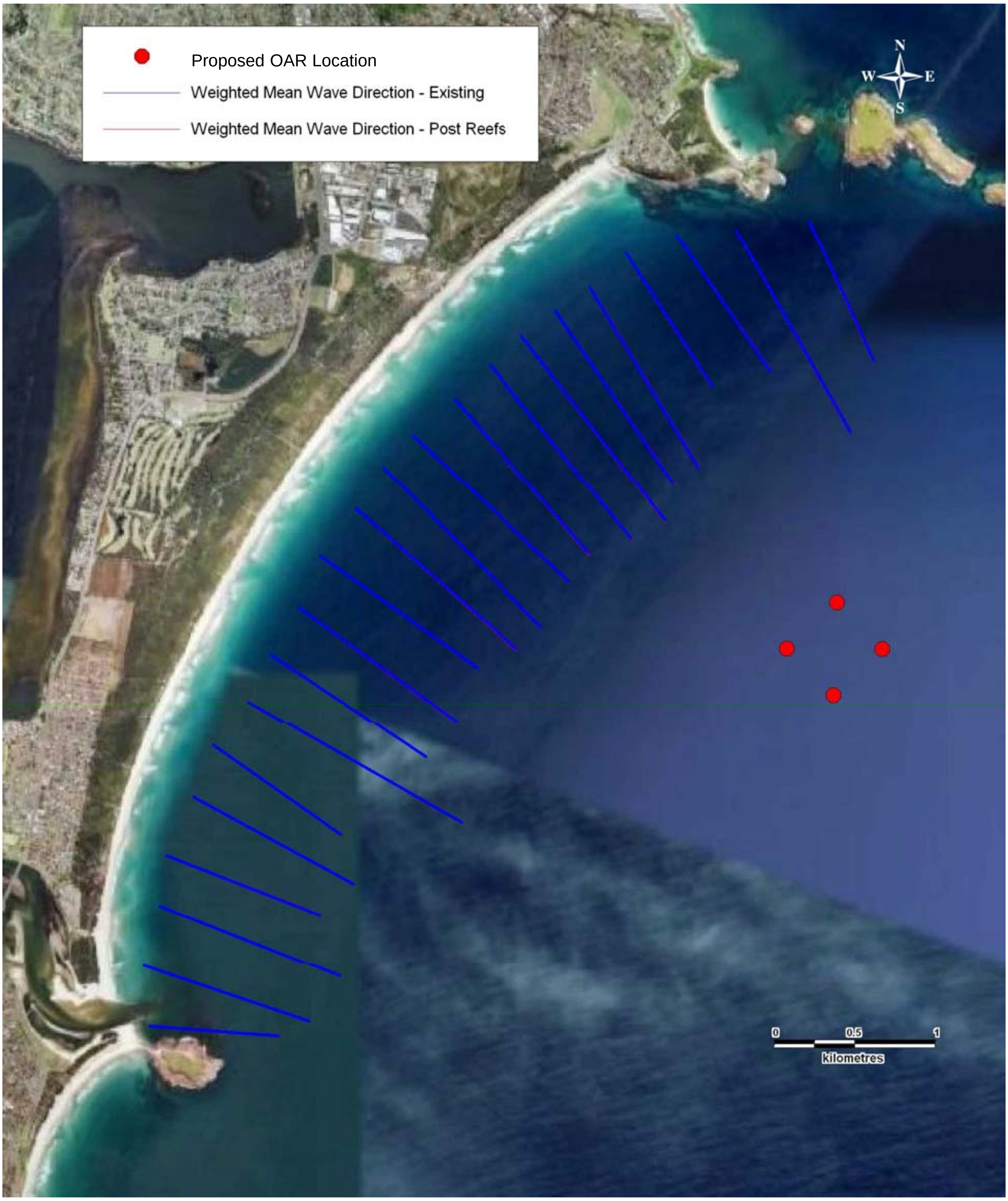


Figure 28: Weighted mean wave direction (Wollongong study region). Source: Cardno Lawson Treloar.

Impacts on the Local Seabed

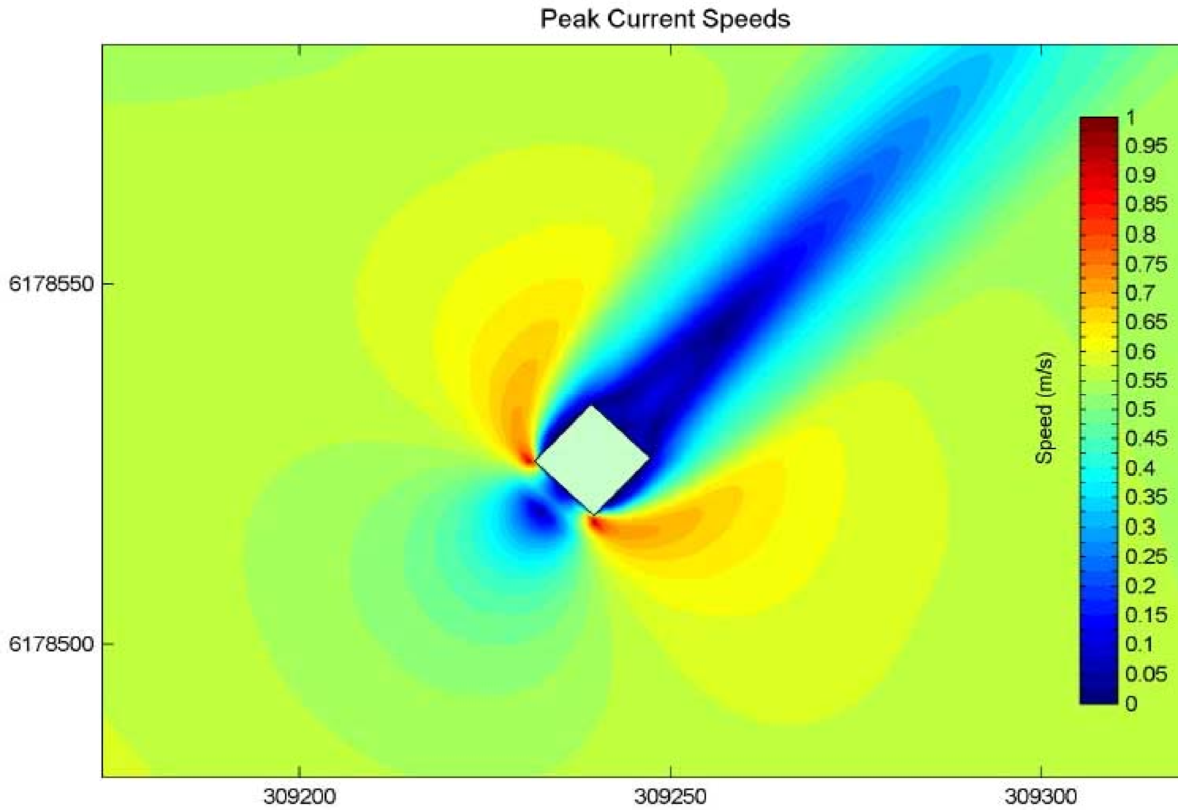
Emplacement of the reef units has potential to influence local sediment conditions at the seabed and indirectly affect the stability of the units, by scouring sediments and thus undermining the OAR. Each structure will cause a perturbation of the near seabed currents with some local increase in the speed as the flow is partially diverted around the structural elements. Where current speeds exceed about 0.3 m/s, there is likely to be an initiation of sediment transport. In the natural state, these currents would cause seabed ripples, but where the artificial reefs touch the seabed there will be a perturbation and possibly localised scour. In order to investigate these effects, the Delft3D numerical modelling system was applied (Technical Report C).

Tidal currents are small and will have negligible influence on the seabed sediments. However, under extreme wind and current conditions shear bed stresses are likely to exceed thresholds for initiation of sediment transport. Morphological change under extreme current conditions was investigated to estimate the amount of possible scour or sedimentation that may be caused by the presence of the artificial reef structures. The 100 year Average Recurrence Interval (ARI) current time series specific to each site was applied to provide a typical scenario of potential morphological change around the structures.

Bed change as a result of the extreme current speed during a 100 year ARI event is presented in Figures 29, 30 and 31. The patterns of morphological change mimic the current formation around the reef structure, with areas of scour present at the south-west facing corners of the reef where current speeds are expected to increase. This scour is up to approximately 10 cm as a result of the 100-years ARI event in these particular locations. However, during more ‘normal’ conditions of lower current speeds, there is likely to be minor (i.e. less than 1 cm) deposition of suspended sediments. As the reefs are an open frame, there will likely be some sand infilling of the interior of the structure during high current events.

Areas of greater sedimentation occur in the immediate lee of the reef corners and are in the order of 6 cm. The infrequency of these events, however, suggests that the stability of the structure over a reasonable design life of 30 years will not be undermined by morphological processes at the seabed. Areas of scour will likely be filled during less severe current flows by suspended sediments near the bed. These sediments will also be deposited at the bed, albeit slowly over time. Also the extent of the scoured areas should not cause any vertical movement of the reef structures and hence the position of the structure should remain constant over time.

The above results demonstrate that the influence of the individual reef structures on the surrounding hydrodynamics and morphology would be limited in extent and magnitude. As such, there would be no cumulative effects from placing a set of individual structures as proposed. It is important to note that these investigations were based on the original structure 11 m x 11 m x 13.6 m, not the dimensions of the OAR concept design later prepared by Worley Parsons. Based on the new concept design, impacts on seabed morphology around the submerged reef structure would be similar to those of the previous investigation. The depth of scour is related to the underwater profile of the reef structure and its alignment to the prevailing current conditions. The width of the revised reef structure in the direction of the predominant flow will be only marginally increased (i.e. 12 m as opposed to 11 m). The reef base dimension along the direction of the predominant flow will be increased to 15 m. This may result in an increase in scour by up to 35 % (from empirical relationships described in Sumer and Fredsøe 2002), should currents flow normal to this face. Given that even in extreme current events the scour would be up to 10 cm for the previous design, this would mean scour of less than 15 cm for the revised design. Under normal conditions this is unlikely to exceed 2 cm. The reduced vertical profile of the reef structure (with the main bulk reduced to 4 m height) along the length will also reduce this potential. Scouring to this degree is considered to be minor and it can therefore be assumed that any changes in the morphological response around the revised reef structure would not undermine its stability, as indicated in the previous investigations. It is therefore concluded that impacts on seabed sediment transport at the base of the structures would be minor and unlikely to undermine their stability. This issue has therefore not been considered further and no mitigation or management measures are recommended.



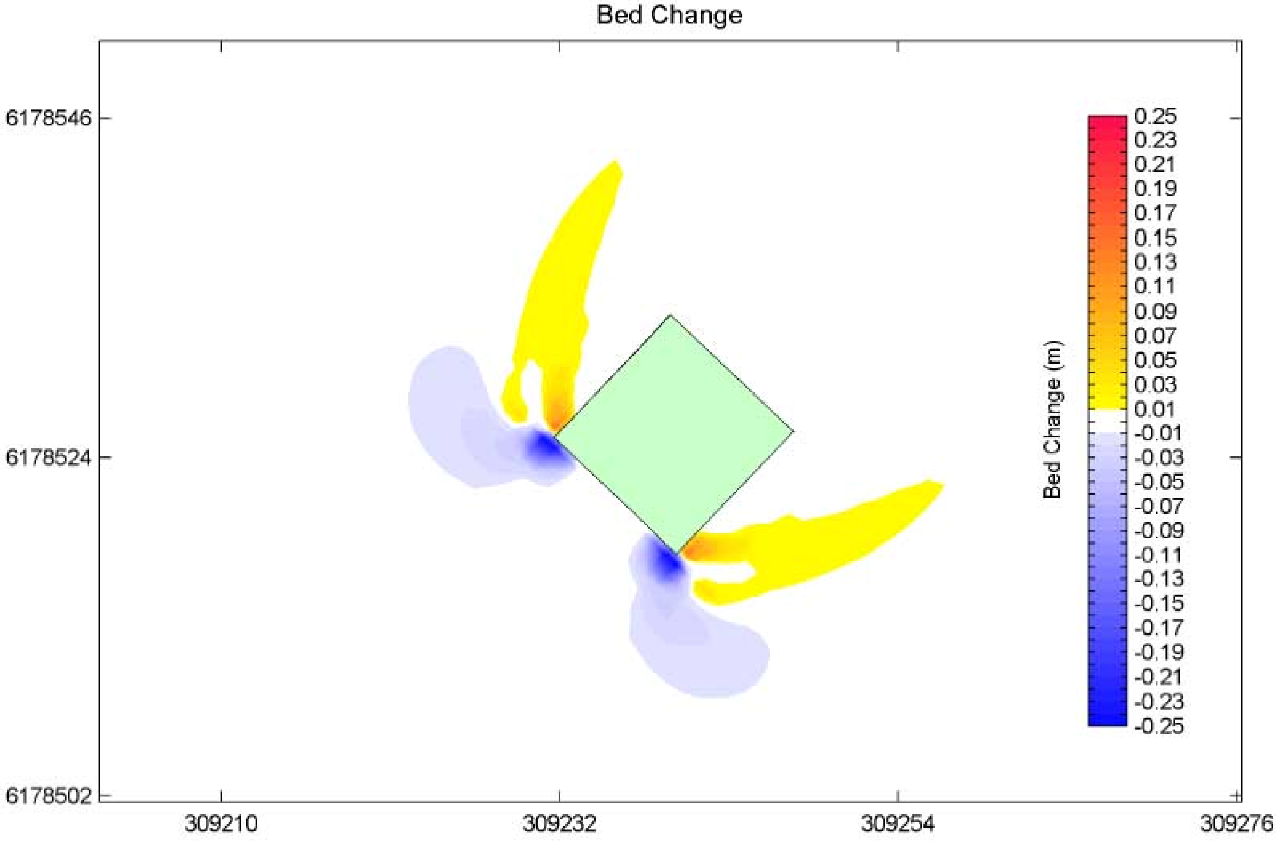


Figure 29: Morphological modelling – 100 year ARI event (Newcastle study region). Source: Cardno Lawson Treloar.

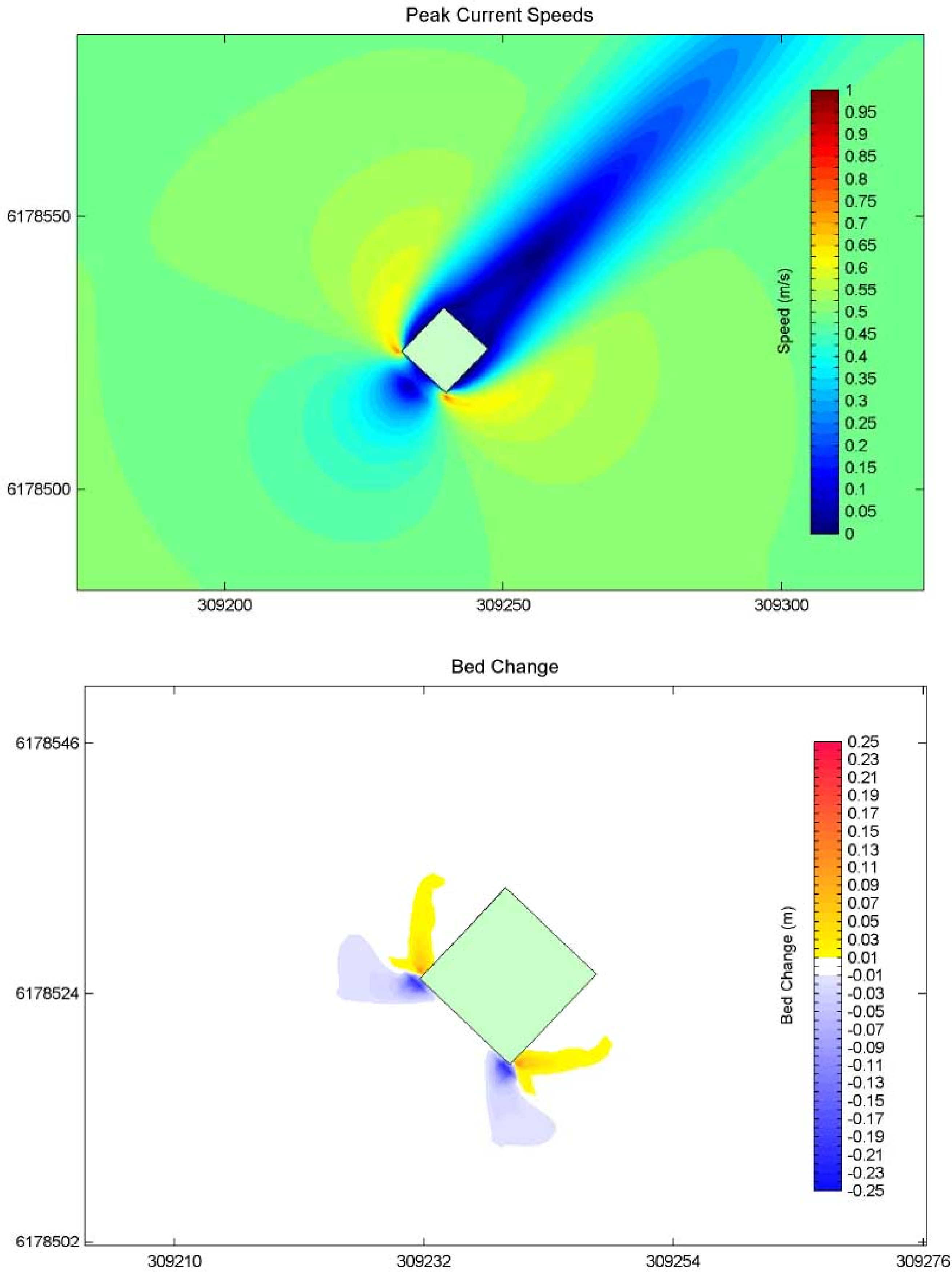


Figure 30: Morphological modelling – 100 year ARI event (Sydney study region). Source: Cardno Lawson Treloar.

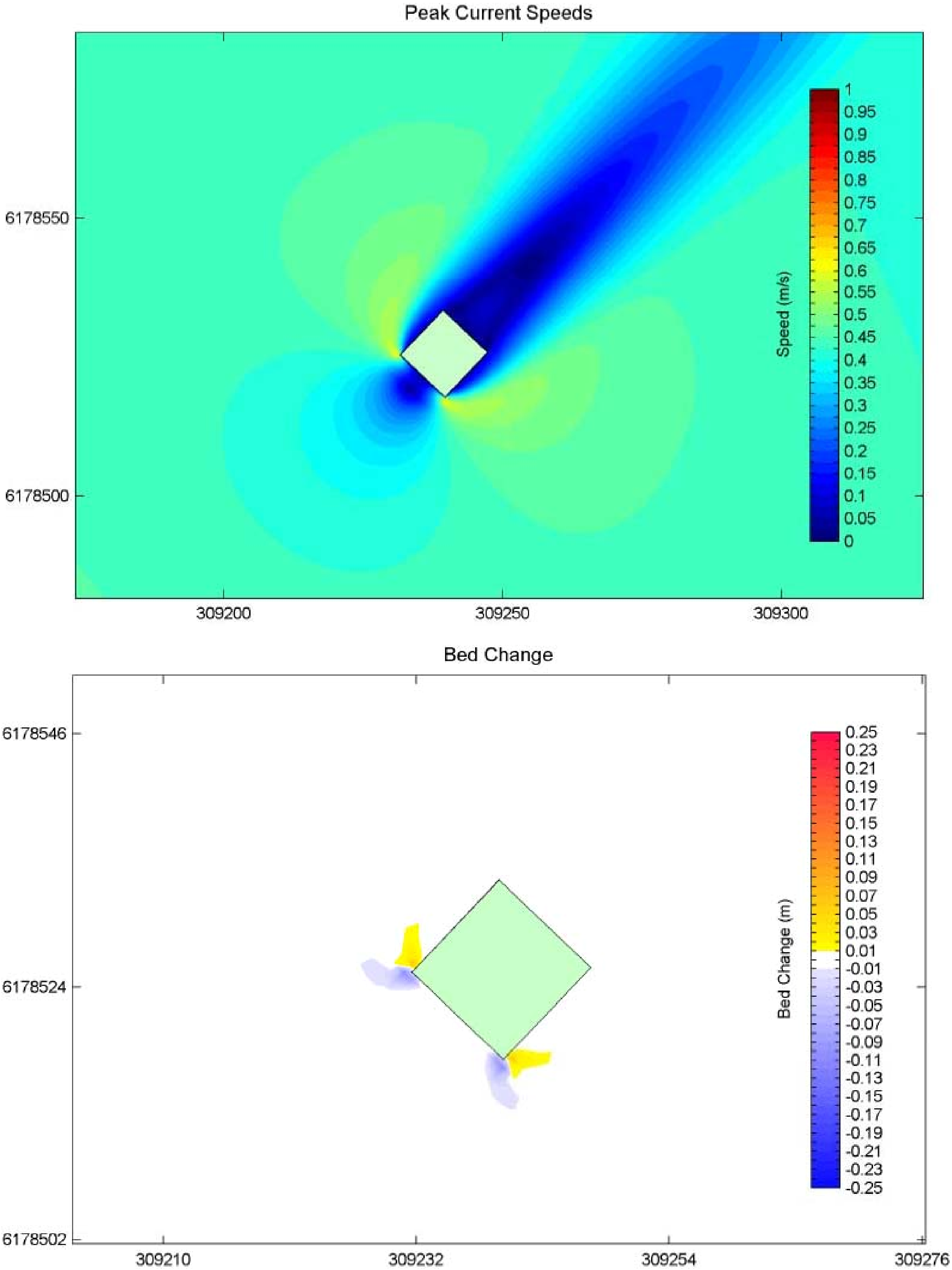


Figure 31: Morphological modelling – 100 year ARI event (Wollongong study region). Source: Cardno Lawson Treloar.

8.2.2 Structural Integrity and Stability

8.2.2.1 Assessment of Impacts

The OAR concept design (prepared by Worley Parsons as part of the assessment process) has been designed to cope with extreme storm conditions (i.e. a 1 in 100 year storm event) and allows for the rate of corrosion for similar marine structures under Australian standards over the 30 year design life. The design also allows for extra weight and stresses incurred from marine growth over the 30 year design life. Potential risks to structural integrity or stability (i.e. risk of overturning and/or sliding) are therefore considered to be low. There is however, a small risk that marine growth could occur at a disproportional or greater than expected rate or that excessive corrosion occurs compromising the structural integrity or design life. This risk would be managed by monitoring of marine growth and corrosion rates as outlined in the following section.

8.2.2.2 Recommendations and Mitigation

In order to ensure the long-term stability of the OAR units it is recommended that:

- the OAR concept design developed by Worley Parsons is used as a basis for the final structural design and that this is certified by a structural design engineer;
- the final design is certified to Australian standards;
- the structural integrity and stability of the OAR units is monitored over the duration of the 30 year design life and that clear sets of criteria are established for both the success or otherwise of the deployment and of the potential decommissioning of the OAR. Recommended procedures to monitor the structural integrity of the units are given in Section 11 and in the EMP (Appendix 9).

8.2.3 Flora and Fauna

8.2.3.1 Soft Sediment Environment

8.2.3.1.1 Assessment of Impacts

A description of the existing soft sediment environment in the wider study areas is given in Section 6.1.2.1. Results of field investigations also provide a detailed description of soft sediments in the direct study areas (Sections 6.3.3 and 6.3.4). Potential long-term impacts on soft sediments are listed and discussed below.

Direct loss of habitat.

Based on the proposed concept design (Appendix 8), the area of seabed directly occupied by each unit would be 180 m^2 (a total of 720 m^2 for each reef set). Some loss of infaunal communities will occur directly below where the supporting legs and hollow tubular sections are laid, although much of the sandy area between supporting sections would be unaffected due to void space. The area of sandy habitat occupied by the OARs, is however, negligible when considered in context with the extensive areas of similar habitat in the direct and wider study areas. Area occupied as a result of the proposal is not considered unique in the wider study area and adjacent sandy habitat is likely to support very similar assemblages to those sampled in the current survey. Furthermore, the habitat will continue to support a wide variety of marine organisms found living on or over soft sandy substrata. Direct loss of habitat is therefore not considered to have a significant impact within the wider study area.

Change to sediment characteristics

As indicated in Section 8.2.1 soft bottom habitats adjacent to artificial reefs would partially be affected by current patterns and some minor scouring and deposition which may consequently affect grain size. Once established, detritus from dead organisms and waste materials produced by the reefs inhabitants will sink to the seafloor and may also alter the physical properties of the substratum. Changes to sediment characteristics would be investigated as part of the Monitoring Plan (Section 11) as this is likely to influence soft sediment assemblages (see below). It is considered that change to sediment characteristics alone would not have a significant impact on the direct or wider study areas.

Change in soft sediment benthic community structure

As macroinvertebrate assemblages are closely correlated with sediment properties, particularly grain size (Connell and Gilanders 2007), it is likely that there will be a change in assemblages over time within the immediate vicinity of the OAR. This in turn, could have impacts at higher trophic levels for example, demersal fish that feed upon invertebrates. To validate the extent of those changes in macroinvertebrate assemblages, they would require investigation as part of the Monitoring Plan (Section 11).

Increased predation by fishes and decapods on soft bottom species (infauna and epifauna)

It is possible that species numbers and/or diversity in sandy habitat adjacent to the OARs may decrease as a result of increased predation by benthic and demersal fish or decapods attracted to and/or growing on the reef, feeding in the adjacent sandy habitat. This effect is known as a 'feeding halo'. Halo effects of reefs may be confined to areas very close to a reef (within a few metres) or extend over a much larger area and may depend on the size of the reef and/or the trophic structure of fish occupying it. Halo effects would be addressed as part of the Monitoring Plan (Section 11).

Commercial fishing

Given that commercial fishing would be permitted within the direct OAR study areas then trawling could occur in the vicinity of the units where there is good fishing potential. If this is the case, there would be disturbance of soft sediments and associated infauna in the sandy habitat adjacent to the reefs. Alternatively, the OARs may deter trawling in the vicinity of the OARs due to the risks of gear hook up and obstruction. Monitoring of soft sediment assemblages and trawling activities would help determine the extent of this impact and whether mitigative action would be required (Section 11).

8.2.3.1.2 Recommendations and Mitigation

Monitoring of soft sediment assemblages at the proposed OAR locations and at control locations is recommended to detect changes in soft sediment particle size and assemblages of associated fish and invertebrates. It is also recommended that monitoring would aim to detect halo effects. Procedures to monitor soft sediment assemblages and mitigative steps to be taken, should significant changes occur, are outlined in the Monitoring Plan (Section 11).

8.2.3.2 Proximal Natural Reef

8.2.3.2.1 Assessment of Impacts

A general description of the rocky reef environment in the study regions is given in Section 6.1.2.2. Results of seabed habitat mapping carried out as part of the EA/draft PER also provides a detailed description of habitats in the direct study areas (Section 6.3.3).

Potential long-term impacts on proximal natural reefs are listed and discussed below:

Change in benthic natural reef assemblages

Ecological impacts of artificial reefs on surrounding ecology are not well understood (Pears and Williams 2005) and it is possible that artificial reefs may affect the structure of nearby natural reef assemblages. The effect on adjacent natural reef is likely to be dependent on factors such as distance from the artificial reef and the type of fish found on the artificial reef that are also likely to forage on adjacent natural reef. Hence, overlap of predators, competitors or grazers from the artificial reef could lead to over-grazed or altered natural reef habitat or feeding halos (Bortone *et al*. 1998).

The structure of assemblages on natural reef habitat is largely dependent on larval settlement and recruitment that in turn depends on current and dispersal patterns. It is possible that the artificial reef structures could alter or interrupt dispersal patterns by:

- providing alternative settlement substratum for recruits that could otherwise occur on natural rocky reef;
- increasing predation of planktivorous fishes on artificial reefs;
- providing a link between otherwise separate populations, or facilitating recruitment of invasive pest species (Pears and Williams 2005); and
- altering local hydrology (Spieler *et al*. 2001).

The extent of impact on neighbouring natural reef may also depend on the size of the natural reef with impacts likely to be greater for a smaller neighbouring reef than a larger one. Any change in rocky reef assemblages as a result of the proposal would occur over a relatively long time period and would therefore require a suitably long period of monitoring to detect and even then it may be very difficult, to attribute those changes to the development of the OAR.

Change in natural reef fish assemblages

It is likely that demersal species resident to adjacent natural reefs will be attracted to the proposed OARs if not sufficiently separated from natural reef (this is referred to as 'draw-down' effects). By being drawn away from the protection of their natural habitat fish may become more susceptible to capture if attracted to the OAR. This, in turn could impact upon the dynamics of the adjacent natural reef assemblage. Investigations of fish assemblages inhabiting artificial reefs have shown that the local area of influence of an artificial reef may range from 5 m to 50 m, depending on the local environmental conditions and the reef size (Fabi and Sala 2002, Continental Shelf Associates 1982, Gerlotto *et al*. Fabi *et al*. 1999). A minimum of 500 m is therefore considered sufficient distance to allow for variation and minimise the risk of interaction between resident natural and artificial reef populations. Potential impacts on nearby natural reef are not likely to be an issue at the proposed Newcastle OAR site due to the significant distance between the proposed OAR location and known natural reef (Figure 21). There is a relatively small outcrop of rocky reef (Dunbar Head) approximately 400 m south of the proposed Sydney OAR which extends out 500 m from the shore (Figure 22). More extensive natural reef is present in the Wollongong study area, directly to the east and to the south of the proposed OAR units (Figure 23). OARs should be located as far from natural reef as feasible to minimise any potential impacts on nearby natural reef.

It is unlikely that larval supply to natural reefs would be limited by larvae or juveniles recruiting to an OAR before or preferentially settling on natural reef. Movements of fish assemblages between proximal rocky reefs and OARs would be investigated as part of the Monitoring Plan (Section 11).

8.2.3.2.2 Recommendations and Mitigation

Recommendations to mitigate, minimise or manage potential long-term impacts on proximal natural reef are listed below:

- Maximum separation of OAR units from existing natural reef should be achieved in order to minimise potential draw-down effects. It is therefore recommended that the Wollongong OAR units are relocated to the west/north-west of the present location, but still within the direct study area. It is recommended that the Sydney location is moved a minimum of 500 m from existing natural reef at Dunbar Head.
- Monitoring assemblages of reef fish and invertebrates at the proposed OAR locations and at control locations is recommended to assess the influence of the OARs. Procedures to monitor reef assemblages and mitigative steps to be taken, should significant changes occur, are outlined in the Monitoring Plan (Section 11).

8.2.3.3 Pelagic Environment

8.2.3.3.1 Assessment of Impacts

The pelagic environment of the study regions is described in Section 6.1.2.3. Long-term impacts on the pelagic environment are listed and discussed below:

Loss of habitat

Direct loss of sandy habitat (and associated infauna) where the artificial reef units are emplaced will result in a small loss of foraging habitat for some demersal fish. These groups may relocate to similar alternative habitat within the study areas. Given the negligible area of sandy habitat occupied by the OARs within any direct study area (approximately 0.01 %) and the relative area of similar habitat within any direct study area, this is not likely to have a significant impact in terms of habitat loss for these groups. Loss of sandy habitat is therefore not considered to have a significant impact on fish and is not considered further.

Attraction and aggregation

Previous studies have indicated that after a relatively short period post-deployment, transient pelagic species will be found on the reefs. Initially, this would be due to the behaviour of certain types of fish which are attracted towards hard objects in an otherwise barren environment. Once the reefs are established, it is likely that fish will also be attracted to the biota inhabiting the reef and that this will also provide a food source. According to Polovina (1990) attraction and aggregation of existing fish populations can have two effects:

- redistribution of already exploited resources; and/or
- availability of previously unexploited species or components of populations.

If the latter occurs, it is possible that the OAR could result in an overall decrease in fish numbers within a given area. Some species may be aggregated and attracted to the OARs whereas others are likely to contribute to local productivity. In reef-limited environments it has been inferred that both attraction and production are likely to interact in driving artificial reef assemblages. This is likely to be the case within the wider study areas.

Increased production

The OAR is designed to increase fish abundance and diversity within a given area. The most favourable outcome, however, is that the increase in numbers of fish results from significant increases in biomass. The proposed OAR could contribute to increased production in the following ways:

- Provision of additional habitat. Fish production results from fish growth (Jennings *et al*. 2001) and to grow, a fish must feed effectively to convert food into tissues. Given that once established, an OAR provides additional habitat and food for certain species of fish, then there is potential for increased production within a given area.
- Habitat and substratum for recruitment. The OARs can provide refuge and food for recruitment of juvenile fish and a substratum for the settlement of planktonic larvae.
- Reduction of harvesting pressure on natural reefs.

OARs are likely to be most effective if habitat is a limiting factor for population growth. It is considered likely that initial increases in fish numbers would be a result of attraction and aggregation, but that over time (once the reef has become established) the OARs would contribute to overall production.

Increased fishing effort.

Fishing ‘effort’ is a function of the number of participating fishers, number of fishing events (e.g. fishing trips) and time (days/hours) spent fishing. The convenience and likely popularity of the OARs could attract more recreational fishers, increase participation and length of time fishing and thus increase fishing effort rather than simply redistributing it. Commercial fishing in areas nearby to the reefs that were not previously fished may also occur. An increase in fishing effort would also have positive socio-economic effects which are discussed in Section 8.2.10.

Increased fishing mortality

The OARs have been specifically designed to attract species such as kingfish and snapper to enhance recreational fishing. Increased fishing mortality could occur if there was a net increase in fishing effort (see above) or if species became more susceptible to fishing as a consequence of OARs. An expected increase in fishing mortality would therefore occur, but this would be balanced by an increased production of fish. Hence additional mortality related to fishing would be unlikely to reduce populations below existing levels. Notwithstanding this, regulation and management may be required to ensure acceptable levels of fishing mortality are not exceeded.

Not all species are equally vulnerable to fishing mortality and different types of species are likely to be affected differently. Productivity Susceptibility Analysis (PSA) highlighted which recreationally and commercially important species are likely to be most vulnerable to fishing mortality (Section 7.4) and which species should therefore be a priority for monitoring and management.

Concentration of plankton

The design of the OAR structures is such that it allows concentration of plankton in small eddies around the structures in the lee of ocean currents. Such concentrations would be localised and affect only a minute fraction of regional populations but would serve as a source of food (and hence productivity) for planktivorous fishes and their predators. This would be beneficial for sustaining populations of some target species on the OARs.

8.2.3.3.2 Recommendations and Mitigation

Recommendations to mitigate, minimise or manage potential long-term impacts on the pelagic environment are as follows:

- Potential contributions of attraction/aggregation, fishing effort and fishing mortality measured against potential productivity should be considered as part of the environmental monitoring and management of the project (Section 11).
- Affects of attraction and aggregation would be addressed through monitoring of abundance, diversity and movements of fish within the wider study areas. Procedures to monitor and mitigative steps to be taken, should significant changes occur, are outlined in the Monitoring Plan (Section 11).

8.2.3.4 Threatened and Protected Species

8.2.3.4.1 Assessment of Impacts

Threatened species potentially affected by the proposal (including those which are of matters of NES) are identified in Section 6.1.2.4. Assessments of significance for species protected under State legislation and profiles of species protected under the Commonwealth EPBC Act are given in Appendix 6 and 7 respectively.

The majority of impacts are relevant to threatened or protected species only if they were to move and/or recruit into the direct study areas. Potential impacts on these species are addressed below.

Key Threatening Processes:

Information on key threatening processes relevant to this study is given in Section 6.1.2.6. The following KTPs are considered relevant to the proposal:

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

No areas considered important to the survival of a threatened fish species occur within any of the direct study areas. It is therefore considered unlikely that the proposal would exacerbate the impacts of hook and line fishing in areas important to the survival of a threatened fish species. The proposed OARs could, however, have a positive impact on threatened species by relieving fishing effort on areas where threatened species are susceptible to hook and line fishing.

The proposal is likely to result in the concentration of and increase in recreational fishing activity in the direct study areas. This potentially increases the risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed OARs. Threatened marine species, particularly marine turtles, pinnipeds, small cetaceans and seabirds, can ingest or become entangled in marine debris such as plastics. This can lead to lethal or detrimental impacts such as strangulation, increased drag, poisoning, blockage and/or perforation of an individual's digestive system, wounds, consequent infection and gastric impaction (Web Reference 13). Sub-lethal effects of entanglement or ingestion of marine debris may reduce an individual's fitness and ability to successfully reproduce, catch prey and avoid predation, potentially resulting in early mortality.

Many threatened species that are vulnerable to this KTP could occur within the wider study areas, although most would only be transient within the direct study areas. Furthermore recreational fishing is not considered to significantly contribute to the release of harmful marine debris (Henry and Lyle 2003). Risk of harm to threatened species from this KTP (as a direct result of the proposal) is considered relatively low, providing that activities in the OARs are properly managed and monitored. For example, the units would require inspections to remove any fouled fishing gear, debris or litter.

Concentration/increase in recreational boating activity

In addition to impacts of KTPs, concentration of recreational boating within the direct study areas could also increase the risk of:

- poor water quality;
- boat strike (marine mammals and turtles); and
- acoustic disturbance (marine mammals).

As the artificial reefs are located in exposed offshore areas, leakage of fuel or oil would be quickly dispersed and would constitute a very small risk to flora or fauna within the direct or wider study areas.

Cetaceans and sirenians (dugongs) are considered most vulnerable to boat strike as they are slow moving and swim just below the water line. Risk to dugongs however, is considered minimal as the animals rarely occur within the study regions. Large cetaceans such as humpback whales and southern right whales would be most vulnerable during their annual migrations along the NSW coastline (May to November). During these periods it is possible the species would pass through or rest in any of the direct study areas. There are restrictions on the distance of approach to baleen whales and it is considered that risk to these species from boating activity to and from the proposed OAR would be minimal.

Incidental capture

Incidental capture from recreational fishing gear could potentially affect fish, marine turtles and seabirds that could forage in the surface waters. Incidental capture could lead to post-capture stress and in some cases, mortality. Species such as the critically endangered grey nurse shark and vulnerable black cod are considered potentially at risk. Even when returned to the water, hooks caught in fishes mouths can result in damage that can impact on feeding behaviour and success. Over a longer period of time, hooks retained in the mouth, throat and stomach of fishes and sharks can lead to early mortality (FSC 2003).

Grey nurse sharks often inhabit rocky reefs and islands, or near sandy-bottomed gutters and rocky caves (Otway and Parker 2000). Grey nurse sharks may be at risk to incidental capture if they reside on the OAR during their migratory movements and potentially if they ranged over large distances away from natural reefs. However, the sharks exhibit a high degree of site fidelity once a site (gutter or cave) has been occupied (Otway *et al*. 2003) and many of the sites where grey nurse sharks aggregate have been declared critical habitat. Given that the proposed OAR sites are located on bare sand, a significant distance from GNS critical habitat or known aggregation sites (see Section 6.1.2.7, Figures 15, 16 and 17), the frequency of GNS occurring on the OAR and the likelihood of incidental capture is likely to be low. As a precaution, regular monitoring would be carried out by different methods to detect the presence of GNS in the vicinity of the OARs (Section 11.2).

Black cod defend territories on natural reef and some artificial reef such as breakwaters. Post-settlement black cod are unlikely to move outside of their territories. Black cod settling on the OAR would be susceptible once they grew large enough to be caught. As noted above, it is unlikely that larval supply would be limiting to the extent that black cod would be ‘deprived’ of natural reef by settling on an OAR before or preferentially settling on natural reef.

Interruption of movement corridors

Cetaceans and species of fish, such as the grey nurse shark, that undertake migrations along the NSW coastline, could alter their migratory behaviour in response to the presence of the OARs. Most cetaceans are likely to avoid the structures. Sharks however, may occasionally forage on the OARs while moving between aggregation areas and in doing so, become susceptible to incidental capture or harm from marine debris. Providing that threatened species in the vicinity of the OARs are properly monitored and managed and given the relatively small-scale of the OARs within the movement range, impacts on movement corridors would be minimal.

Loss of habitat

No areas of habitat considered important to the survival of any threatened or protected species is unique to the direct study areas. The area of sandy habitat lost through the proposal, would be negligible compared with the extensive areas of similar habitat in the direct and wider OAR study areas. Therefore, it is considered highly unlikely that OARs would significantly affect threatened species dependent on such habitat and no mitigation or management is recommended.

Increased potential for disease and pest species harmful to threatened or protected species

The risk of increased potential for disease associated with biota at the OAR is considered to be extremely small. Similarly, the risk to threatened species from invasive marine pests associated with the OAR is considered very small.

8.2.3.4.2 Recommendations and Mitigation

Impacts on threatened and protected species (including those of National Environmental Significance) should be minimised by:

- Education on the potential impacts of harmful marine debris on marine life and the responsible disposal of litter and discarded fishing gear.
- Inspection and removal of fouled fishing gear and debris to minimise the risk of KTPs e.g. entanglement or ingestion of harmful marine debris. This would be incorporated into the Monitoring Plan (Section 11).
- Ensuring there are mechanisms to report sightings or incidental capture of threatened and protected species. Note that threatened species sighting forms can be completed online at the I&I NSW website (Web Reference 29).
- Providing education on threatened and protected species identification, best practice for returning incidentally captured fish, minimising risks to seabirds and boating restrictions in the vicinity of large cetaceans.

- Providing education on best practice to minimise the spread of invasive marine pests (e.g. *Caulerpa taxifolia*).
- Educational information would be published in a set of OAR 'User Guidelines' which are outlined in the EMP (Appendix 9).
- Threatened species and species of recreational and commercial importance found to occur on the OARs should be prioritised for monitoring and management. Procedures to monitor threatened and protected species and mitigative steps to be taken, should a threatened species be impacted, are given in the Monitoring Plan (Section 11).

8.2.3.5 Invasive Marine Pests

8.2.3.5.1 Assessment of Impacts

The proposed OAR structures could provide a substratum or habitat suitable for invasive marine pests (also referred to as' introduced', 'alien' or 'non-indigenous'species). Invasive marine pests are defined as organisms (usually transported by humans) which successfully establish themselves and then overcome or displace otherwise intact, pre-existing native ecosystems (Connell and Gillanders 2007). Of those species known to occur in NSW, the European fan worm (*Sabella spallanzani*, family: Sabellidae) could potentially occur on the units. The species is known to inhabit depths to 30 m and colonize artificial structures such as marinas, submerged wrecks and pontoons. The species can compete with native species for food and space, thus inhibiting their settlement. Ship's ballast water is a major vector for introduced species. Fouling of ships hulls, aquaculture and the aquarium and bait industries are also considered vectors. Major ports and estuaries are therefore hotspots for invasive species. Whilst the proposed OAR sites are potentially at risk from colonisation by invasive marine pests, the scale of the potential impact is small and would be unlikely to have any significant impact on the marine environment.

8.2.3.5.2 Recommendations and Mitigation

As best practise and to minimise the potential spread of invasive marine pests, it is recommended that the colonisation of the structures is documented and procedures to monitor and remove pest species be incorporated into the Monitoring Plan (Section 11). Significant incursions of invasive marine pests would be managed according to appropriate NIMPIS (National Introduced Marine Pest Information System) methods.

8.2.3.6 The Commonwealth Marine Area

8.2.3.6.1 Assessment of Impacts

The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is *not* State or Northern Territory waters. The Commonwealth marine area stretches from 3 to 200 nautical miles from the coast (Web Reference 26). The proposed Newcastle, Sydney and Wollongong OARs are located within State waters approximately 1.2 km (0.7 nm), 2.36 km (2.4 nm) and 2.5 km (1.4 nm) west of the 3 nm limit, respectively. Although the OARs are located outside the Commonwealth marine area, it is a requirement under the EPBC Act that any actions that could impact on the Commonwealth marine area are considered in the EA/draft PER. This includes and is not restricted to:

- The potential direct, indirect and consequential impacts on regional habitat and the Commonwealth marine environment.
- Impacts on other users of the area (e.g. divers, spearfishers); and
- Potential impacts on important amenities, navigation, culturally and historically significant sites, threatened or migratory species or sensitive habitats in the Commonwealth marine area.

Given the significant distances of the proposed OAR locations from the boundary of Commonwealth waters, the proposal is not considered to have any direct or indirect effects on regional habitat, within the Commonwealth marine area. Any direct impacts on habitat would be limited to the seabed within the direct OAR study areas. Similarly, navigation, or areas of cultural or historic significance would not be directly or indirectly affected within the Commonwealth marine area.

The only user group that could be indirectly affected by the proposed OARs are commercial fishers that operate within the Commonwealth marine area. They have potential to be affected if the proposal indirectly impacted upon commercial fish stocks (e.g. by affecting regional fishing effort and productivity). However, given the relatively small-scale of the OARs within the region it is considered highly unlikely that OARs either individually or cumulatively across the three study regions would contribute to a reduction in commercially fished populations or productivity in the Commonwealth marine area. Furthermore, OARs could potentially contribute to productivity as described in Section 8.2.3.3.1. The proposal would therefore be considered environmentally acceptable as no significant impacts on commercial fisheries operating in the Commonwealth marine area would be expected.

There are a number of threatened or migratory species, including sharks, whales and dolphins, turtles, pinnipeds, sirenians and marine birds that occur in the jurisdiction of both State waters and the Commonwealth marine area. Species which could potentially be affected by the proposal are identified and listed in Section 6.1.2.5. Profiles for these species which are matters of NES are given in Appendix 7. Appendix 7 identifies important habitat values and resources and potential impacts of the proposal on the relevant species or species group. These impacts are summarised and discussed in Section 8.2.3.4.1. and include:

- impacts of KTPs;
- concentration/increase in recreational boating activity;
- incidental capture;
- interruption of movement corridors,
- loss of habitat; and
- increased potential for disease and pest species harmful to threatened or protected species.

Areas of habitat or resources that are important to threatened species would not be directly affected by the operation of the OARs. Indirect impacts from increased recreational fishing and boating activity are likely to be minimal given that the frequency of threatened species occurring on the OARs would be low and the scale of the potential impacts small. Furthermore, recreational and boating activity at the OAR locations would be similar to background levels in the relatively busy port and urban areas. Provided the OARs are monitored and managed as outlined in the EMP (Appendix 9), the overall impact on relevant matters of NES is therefore considered to be environmentally acceptable.

8.2.3.6.2 Recommendations and Mitigation

Measures to mitigate or minimise potential impacts on threatened and migratory species that potentially occur in the Commonwealth marine area are outlined in Appendix 7 (for each species) and summarised in Section 8.2.3.4.2.

8.2.3.7 Areas of Conservation Significance

8.2.3.7.1 Assessment of Impacts

Areas of conservation significance relevant to the wider study regions are described in Section 6.1.2.7.
The proposal would not have any direct impacts on areas of conservation significance, although species associated with conservation areas and which forage in the vicinity of the proposed OARs, may be indirectly affected.
The Moon Island Nature Reserve, part of the Lake Macquarie State Conservation Area and the Five Islands Nature Reserve near Port Kembla, are of particular concern as they are breeding and roosting habitats for several species of protected seabirds. Diving seabirds and little penguins could be attracted to OAR sites as a foraging area, if suitable prey items were to aggregate there or be attracted to discarded bait. This could increase the risk of interactions with fishing gear and/or harmful marine debris. Australian fur-seals and more rarely leopard seals, occur in and around the Five Islands Nature Reserve and although the species do not breed there, may be vulnerable to interactions with fishing gear and/or harmful marine debris.
Critical habitat for the Little Manly population of little penguins is located approximately 3 km north of the proposed Sydney OAR. Little penguins are known to forage significant distances on a daily basis and may also be vulnerable to interaction with fishing gear for reasons identified above. Grey nurse shark critical habitats in the wider Sydney and Wollongong study regions are located approximately 12.5 km and 8 km respectively from the proposed OAR sites (Figures 16 and 17). At these distances there would be no direct impacts on grey nurse shark critical habitat. Individuals moving or foraging outside aggregation areas, however, may be indirectly affected. The proposal is not considered to have any direct impacts on areas of conservation significance, including aquatic reserves, marine parks and nature reserves located within the wider study areas.

8.2.3.7.2 Recommendations and Mitigation

Indirect impacts on species associated with areas of conservation significance including threatened and protected birds, marine mammals and the grey nurse shark would be addressed through monitoring and adaptive management. Procedures to monitor threatened and protected species and mitigative steps to be taken, should a threatened species be impacted, are outlined in the Monitoring Plan (Section 11).

8.2.4 Recreational and Commercial Fishing

8.2.4.1 Assessment of Impacts

A description of recreational and commercial fishing activity across the three study regions is detailed in Section 6.1.3. Long term impacts on commercial and recreational fishing are listed and discussed below:

Loss of commercial fishing ground/obstruction to trawling

Fisheries likely to be affected by the proposal include the Ocean Trawl and the Ocean Trap and Line fisheries. The proposed Newcastle OAR location (Figure 6 – indicated in red) is likely to conflict with the Ocean Trawl fisheries, which operates offshore from Nine Mile Beach (between Swansea and Red Head). OAR units at the initially proposed location and configuration would result in the maximum loss of approximately 0.39 km^2 of fishing ground, but would also prevent trawling a further 100 m outside the area to prevent the risk of gear becoming hooked up on the units. Given the area of similar habitat in the area, this loss is considered to be minimal, however, alternative options to further minimise the loss of fishing ground are discussed in Section 8.2.4.2.

Based on consultation with local commercial fishers, loss of fishing area within the proposed Sydney and Wollongong study regions is not considered to be a significant issue. Issues have been raised for the proposed Newcastle OAR by one group that operate out of Sydney. Commercial fishermen that were consulted in the Hunter region were not opposed to the proposed Newcastle OAR location.

Conflict between user groups

Recreational fishing involves a variety of user groups including sportfishers, gamefishers, spearfishers and charter boat fishing. The proposed OARs are aimed at all recreational fishers, but it is likely that commercial fishing would also take place. Some overlap between user groups is therefore likely and the potential for conflict would be addressed through a suitable monitoring and management plan including a code of practice for all users which is provided in the EMP (Appendix 9).

Safety issues

Potential safety issues which could occur as a result of recreational or commercial fishing in the direct study area include:

- gear hook up;
- collision;
- increased risk of encounters with dangerous marine animals (spearfishing);
- drowning (spearfishing).

The risk of gear hook up is considered relatively likely, particularly for recreational fishing gear and could result in detrimental impacts to species vulnerable to entanglement or injury from fishing line and hooks (Section 6.1.2.6). Management and mitigation strategies that aim to minimise potential risks to the safety of commercial and recreational fishing groups are discussed in the following section. It is anticipated that free divers and spear fishers would utilise the reefs. The majority of spear fishers would benefit from accessing pelagic species aggregating above the units in the top 15 m – 20 m. There is however, a risk that spear fishers/free divers would attempt to dive to depths beyond their limits.

Impacts on commercial fish stocks

It is considered highly unlikely that the proposed OARs either individually or cumulatively across the three study regions would contribute to a reduction in commercially fished populations in the wider study area. It is possible that species most vulnerable to fishing mortality could be affected within the direct study area, but this is unlikely to have impacts at a population level.

Risk that the OAR project will not meet its objectives

The overall effectiveness and success of the reefs can be assessed only by monitoring of user satisfaction, structural integrity and impacts of the OARs on the surrounding environment. If the proposal were shown not to meet its objectives and/or to have significant adverse impacts on significant components of the marine environment, then appropriate mitigative action would be taken and deployment of future reefs would need to be considered differently.

8.2.4.2 Recommendations and Mitigation

Recommendations to mitigate, minimise or manage potential long-term impacts on recreational and commercial fishing are listed below:

- To minimise loss of commercial trawling area, It is recommended that the units are spaced 200 m apart and configured in a line running parallel with depth contours (approximately north to south) as opposed to the initially proposed diamond configuration. This is not considered to impact on the effectiveness of the OARs, but would significantly reduce the area lost to trawling from 0.393 km^2 (original configuration) to 0.010 km^2 (a 97.5 % reduction in area) and would improve navigation around the OARs.
- In order to minimise obstruction to trawling, consideration should be given to repositioning OAR units in the Newcastle study region approximately 1.75 km southwest of the currently proposed location. It is recommended that commercial fishing groups are involved in further consultation and kept informed about developments of the proposed Newcastle OAR and notified of the final locations.
- In order to minimise potential conflict between user groups a code of conduct and an ‘OAR management area’ should be defined. Recommendations for the OAR management area and a code of conduct are given in the EMP (Appendix 9). Formal consultation between sectors would be undertaken to resolve any issues of conflict (or similar).
- Scuba diving in the vicinity of the OARs should be strongly recommended against in the User Guidelines and code of conduct because of the potential safety risks and conflict with recreational and commercial fishing activities.
- Safety issues, e.g. risk of gear fouling and risks to spearfishers cannot be mitigated but can be managed through education. A set of User Guidelines would aim to provide the best possible information to inform different user groups on best practice and safety within the OAR management area. An example of these guidelines is included in the EMP (Appendix 9).
- As best-practise, monitoring of species catch composition, size-frequency distribution and habitat utilisation within the wider study area is recommended to help determine whether project objectives are being met and provide an indication of impacts on commercial fish stocks (Section 11).

8.2.5 Sediments and Water

8.2.5.1 Assessment of Impacts

Artificial reefs in the marine environment tend to corrode over time, potentially affecting adjacent sediments and water quality. Many organisms take up contaminants from surrounding waters, sediment or their food, which accumulate and persist within their tissues for long periods of time or are transferred to consumers higher up the food chain i.e. bioaccumulation. Where these organisms also function as habitat, there is potential for accumulated contaminants to negatively affect associated epifauna.

Worley Parsons estimate the steel OAR structure would corrode at a rate of 0.01 mm per year over the 30 year design life. It is therefore likely this will result in the leaching of iron oxide over time and potentially elevated iron levels within sediments adjacent to the reef. Iron is not however, considered a significant contaminant in the sea (Clark 1997) and even at elevated levels, would be unlikely to have adverse effects on infaunal assemblages. Any leachate is likely to be quickly dispersed and diluted and any potential impacts would be of relatively small-scale and localised.

8.2.5.2 Recommendations and Mitigation

OAR units should be constructed in accordance with Australian standards for minimum corrosion rates. It is also recommended that water quality and adjacent sediments are monitored for contaminants over the long-term to determine any significant changes from baseline conditions. Procedures to monitor sediments and water quality are outlined in the Monitoring Plan (Section 11).

8.2.6 Navigation and Safety

8.2.6.1 Assessment of Impacts

The proposed OAR locations are adjacent to the three major population centres of NSW and therefore may impinge on the recreational and commercial vessel operations. The potential impacts of the proposed OARs on navigation and vessel are listed below:

Clearance

There is a potential risk that vessels transiting over the OARs may be damaged or damage the OAR structures if their hull or propeller comes into contact with the structures. This would however, be easily mitigated by ensuring sufficient clearance at all tides and in high wave conditions.

Anchor fouling/gear hook - up

Vessels may foul their anchors on the OARs. This may cause loss of the anchor and anchor line, and possible damage to the OAR. In some circumstances, the loss of an anchor may cause consequential impacts on safety such as a disabled vessel drifting towards the coast.

The recommended anchorage area for bulk carriers in the Newcastle study region is south of 32°58' latitude (Little Redhead Point) and not closer than 3 nautical miles (5.5 km) to the coastline (at a depth of approximately 40 m relative to Chart Datum). The most eastern unit location (furthest seaward) is located approximately 1.2 km west of the 3nm limit. It would be highly unlikely that vessels could drag anchor from the recommended anchorage area into the OAR site. Providing that the structures are marked on the relevant maritime charts however, this potential risk is considered negligible.

In an extreme situation where a vessel has lost propulsion (e.g. because of extreme weather or mechanical failure), a ship would drop anchor if getting too close to shore. Off Newcastle and Port Kembla, the shipping lanes are well out to sea - therefore a vessel would have anchored well away from them. Off Sydney, a mechanical failure could require a prompt anchoring, which could result in the vessel being close to the OAR. In such a situation, it would be safe to assume that emergency procedures had already been put in place by the Australian Maritime Safety Authority (AMSA) combined with the local marine authorities (e.g. Port Authority and NSW Maritime). This may include sending out a tug to tow the vessel to safety. If the anchor is fouled on the OAR, then the anchor and chain can be jettisoned.

Commercial trawling would not be excluded in the vicinity of OARs. Therefore, there is a potential risk of gear hook up on the OAR units, which could result in damage to the OAR, fishing vessel and safety implications for the vessel. Provided that commercial fishing businesses that operate in the region are made aware of the OAR locations, follow a code of conduct and the structures are marked on the relevant Aus Chart this potential risk is considered to be low.

Vessel Traffic

It is possible that there would be an increase or aggregation of small fishing vessels in the vicinity of the proposed OAR locations which could increase the risk of collision or boating accidents. .

8.2.6.2 Recommendations and Mitigation

Recommendations to minimise, mitigate or manage potential navigational and safety hazards are given below:

- OARs would be located to ensure there is sufficient clearance between the top of the structure and transiting vessels at all tides and in extreme wave conditions;
- Anchoring in the vicinity of the OARs would be strongly advised *against*. Target user groups would be informed about general boating rules in the vicinity of the OARs and recommended against anchoring in the area; and
- A code of conduct and guidelines would be published to promote awareness of boating safety within a defined management area and minimise navigational hazards such as anchor fouling and collisions (Appendix 9).

Consultation held with the three port corporations and also with NSW Maritime (Section 5.3) resulted in the following recommendations:

- The Australian Hydrographic Office should be notified of the final OAR locations, so that a 'Notice to Mariners' can be issued, and the official hydrographic charts can be amended. A note to warn of the prohibition of anchoring in the close vicinity of the structures should be included.

- NSW Maritime should be notified of the final OAR locations such that relevant publications and maps are amended to show the location of the OARs.
- A minimum of 20 m clearance from the uppermost part of the OAR at LAT (Lowest Astronomical Tide) is ensured for the proposed Sydney OAR. This requires that the initially proposed Sydney OAR location is moved into deeper water east/south-east (Section 9).
- Recreational fishing vessels should give way to movement of commercial vessels in the shipping channel at the entrance to Port Jackson (Port of Sydney).

The location of the OARs should *not* be marked with a buoy and light, because such markers can become a navigation hazard to small boats.

The potential impact of a vessel striking the OAR has been prevented by ensuring suitable clearance from the upper part of the structures. It is not possible to completely remove the risk of anchor fouling/loss on the structures as the actions of recreational boat operators are hard to control. However, providing the above recommendations are adhered to, potential impacts of anchor fouling/loss on an OAR are considered minimal and the navigational and safety impacts low. OAR units should be inspected and fouled fishing gear removed to minimise impacts on threatened or protected species. This would be incorporated into the Monitoring Plan (Section 11).

8.2.7 Infrastructure

8.2.7.1 Assessment of Impacts

Infrastructure requirements such as good quality boat ramps and associated facilities e.g. parking, toilets, nearby shops and amenities are required within an accessible distance to the proposed OAR locations. Inadequate facilities at the most accessible boat ramps could result in congestion and parking problems and even discourage target groups from utilising the OARs. A detailed assessment of existing infrastructure is given in Section 6.1.5.

In summary, the existing facilities and boat ramps in the Newcastle study region are considered adequate and no further upgrades would be considered necessary. Provision of lighting and disabled access could however, be an improvement to the closest boat ramps that do not already have these facilities. Otherwise most facilities and supplies for recreational fishing could be obtained from the nearby town of Swansea. Infrastructure at the Wollongong study region is also considered adequate.

The condition of existing boat ramps and provision of facilities within the Sydney study region is considered adequate. It is possible however, that very high demand could result in congestion of nearby boat ramps during peak times. Little Manly (one of the nearest to the proposed OAR location) can become congested at weekends due to the limited parking space. This already causes parking problems for local residents. If this was the case, upgrades to the Milson's Point and MacMahon's Point boat ramps and facilities should be prioritised as there is not room for expansion of parking or facilities at Little Manly.

8.2.7.2 Recommendations and Mitigation

The accessibility and quality of existing infrastructure is considered adequate for the target groups that would utilise the OARs and is likely to manage a potential increase in numbers. It is however, possible that boat ramps, particularly in the Sydney area, could become congested at peak times (e.g. weekends and school holidays) if the reefs become increasingly popular. Questionnaires and interviews with target user groups would be undertaken as part of the monitoring program and should specifically address infrastructure requirements.

8.2.8 Heritage

8.2.8.1 Historic Shipwrecks

Based on the desktop review (Technical Report D), results of the sidescan sonar swath mapping and towed video surveys carried out by DECCW in December and March 2009 (Technical Report E), the proposal is not considered to have any impact on historic shipwrecks or submerged items of cultural significance. Furthermore, no anomalies on the seabed that may be of cultural or heritage significance were detected during the surveys. No mitigative or management action is therefore recommended.

8.2.8.2 Cultural Heritage

8.2.8.2.1 Assessment of Impacts

Potential Aboriginal deposits

Following field investigations (Section 6.3.3), background database searches and stakeholder consultation (Technical Report B), it is considered unlikely that items of Aboriginal heritage would be significantly impacted as a result of the passive operation of the artificial reefs at any of the three study regions. No mitigative or management action is therefore recommended.

Spiritual significance and dreaming

There are two dreamtime stories that have cultural significance within the Wollongong study region, these include:

- 'Gang-man-gang' – the story of Windang Island and;
- 'Oola-Boola-Woo' – Five Islands Group.

Both of these stories describe creation and have local cultural significance. No similar stories have been identified for the Newcastle or Sydney study regions, however, whale dreaming and migration stories are of regional significance to numerous Aboriginal tribes along the east coast of NSW.

Due to the submerged nature and relatively small footprint of each of the artificial reefs, it is not likely that spiritual significance or Dreamtime stories will be affected during the implementation or operation of the reefs.

Aesthetic amenity

Aboriginal culture is directly linked to the landscape with strong spiritual associations to the land and the water dictating tribal boundaries and beliefs. The aesthetic amenity of the landscape should be maintained in order to preserve such cultural associations.

Evaluation of possible impacts on visual amenity at each of the three sites has been made. These calculations account for the 'view angle' as a factor of distance from shore and height of the object (i.e. recreational fishing vessel). A view angle of <0.5° is considered insignificant whilst an angle of ≥2.5° is noticeable. For the purpose of this assessment, the height of fishing vessels likely to visit the reef sites has been estimated at 3 m above the water level. Calculations for each of the three sites are as shown in Table 14.

Based on the values reported in Table 14, it is considered unlikely that there would be any impact on visual amenity at the proposed artificial reef sites. The view angle calculated for the Sydney site shows the greatest potential impact created by recreational fishing vessels. However, it is considered that the movement of such vessels would be consistent with movement of water traffic from Sydney Harbour.

Table 14: View angles for recreational fishing vessels above the artificial reefs

Study Region	View Angle	Assumptions
Newcastle	0.038°	Recreational fishing vessels are being observed from water level at Blacksmiths beach.
Sydney	1.5°	Recreational fishing vessels are being observed from the top of the cliffs at Watsons Bay 30m above sea level.
Wollongong	0.049°	Recreational fishing vessels are being observed from water level at Primbee beach.

8.2.8.2.2 Recommendations and Mitigation

It is considered highly unlikely that the proposal would significantly impact the local or regional cultural heritage at the three proposed sites and therefore no mitigative action is considered necessary. In accordance with DEC (2005), it is however recommended, that Aboriginal stakeholder groups be informed about the progression of works and the final locations of the proposed OARs.

8.2.9 Occupational Health and Safety

8.2.9.1 Assessment of Impacts

Structural inspections and environmental monitoring would be carried out by divers. There are a number of potential risks associated with this activity (including diving related injuries, fatigue and encounters with dangerous marine animals).

8.2.9.2 Recommendations and Mitigation

Risks associated with monitoring and maintenance diving would be addressed through the development and implementation of a safe work method statement (specifically for diving). This would be the responsibility of either I&I NSW or the subcontractor appointed to carry out the work. Details of what should be included in the Work Method Statement are outlined in the EMP (Appendix 9).

8.2.10 Socio – Economic Considerations

8.2.10.1 Assessment of Impacts

Statistical studies have shown that recreational fishing is an important past-time and sport in NSW, which contributes to significant economic expenditure and social well-being (Web Reference 28). Relaxation is shown to be the main motivation for recreational fishing, although experiencing the outdoors, spending time with family and friends and sport were also important factors. During 2000/2001, recreational fishers in NSW spent more than $550 million on fishing related items, this equates to an average expenditure of about $550 per angler per year (Web Reference 28). It is extremely likely that if OARs increase fishing effort, then there will be an increase in expenditure on fishing related items (as opposed to just a redistribution of spending). This is likely to include travel/vehicle related costs, food, drink, accommodation, charter vessel hire, ice and bait as well as just fishing gear. The proposal could also encourage tourism from other states and from international visitors. This could also indirectly contribute to employment in related sectors. Provided that the OARs meet their objectives, then these benefits are likely to be long-term.

In the short-term, the design verification, construction, transport and deployment stages of the project are estimated to provide employment for approximately 30 people. This would include structural marine engineers, truck drivers, construction workers, supervisors, welders, crane operators, barge crew, commercial divers and support staff.

8.2.10.2 Recommendations and Mitigation

It is important that user satisfaction, popularity and expenditure on fishing related services and items is surveyed as part of the Monitoring Plan to help determine the success of the OARs. This would also allow issues such as overcrowding/conflict at the OAR site and suitability of existing infrastructure to be assessed and resolved accordingly. Monitoring of expenditure directly related to the OAR would assist in assessing cost-benefits.

8.3 Summary

Key issues, proposed mitigation and/or management measures and the predicted outcomes after these measures are implemented are summarised in Table 15. I&I NSW would be committed to and responsible for ensuring that all mitigative measures are carried out as described in Table 15.

Table 15: Summary of key issues, proposed mitigation/management measures I&I NSW are committed to and the predicted outcomes after these measures are implemented.

A. Construction, Transport and Deployment

1. Noise		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Noise pollution from construction activities.	The maximum noise level for industrial and commercial premises (i.e. 75 dB) would not be exceeded for sensitive surrounding receptors. Specific hours of operation during the construction stage would be complied with.	No significant impacts expected.

2. Sediments and Water		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Contamination from stormwater run-off at the construction site.	The contractor would prepare a WQMP (Water Quality Management Plan) as part of the CEMP. As a minimum, this would include provisions for the capture, storage, testing, treatment and release of stormwater runoff from the construction site as outlined in the EMP.	No significant impacts expected.
Contamination of the marine environment during deployment.	The contractor would ensure that: • prior to deployment, the structures are cleaned of all slag, rust, water, oil, paint and other substances; • only adequately treated salt or freshwater liquid waste would be permitted for discharge into marine waters; and • other non-liquid waste materials that may be harmful or hazardous to aquatic life or that result in an unsightly appearance, are not disposed of into the waters.	No significant impacts expected.

Continued

Table 15: Continued

3. Air Quality		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Reduction in local air quality (from dust and exhaust emissions).	An Air Quality Management Plan (AQMP) would be prepared by the contractor as a component of the CEMP. The contractor would ensure that: • material transported by truck is covered; • works cease in extreme wind conditions (i.e. > 40 km/h); • plant and equipment is maintained to minimise exhaust emissions; and • that the correct specification, storage, and preparations of raw materials to minimise requirements for shot blasting or further cleaning is used. Air quality would be maintained in accordance with the National Ambient Air Quality Standards and as outlined in the EMP.	No significant impacts expected.

4. Waste		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Generation and disposal of construction related waste or harmful materials.	The contractor would prepare a Waste Management Plan (WMP) as a component of the CEMP in accordance with the Waste Avoidance and Recovery Strategy and the relevant local government Development Control Plan. The contractor would ensure that: • appropriate planning and ordering of materials takes place to minimise waste; • waste material is recycled where possible; • waste material is treated and disposed of according to EPA guidelines on the Assessment, Classification and Management of Liquid and Non-Liquid Waste;	No significant impacts expected.

Continued

Table 15: Continued

4. Waste continued...		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
	• every precaution is taken to prevent structural metal debris from falling into the ocean; • scrap material, including sea-fastenings are disposed of onshore and that dumping of scrap at sea is not permitted.	

5. Traffic		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Increase in local traffic volume/parking congestion.	The contractor would prepare a detailed Traffic Management Plan (TMP) as part of the CEMP. The contractor would ensure that: • provisions are made for truck parking and manoeuvring; • truck and construction traffic routes are established; • parking zones for construction traffic are designated; • signage is erected to warn motorists of traffic entering and leaving the works site if required; • stabilised access points are established to minimise damage to the surrounding environment; • the movement of construction vehicles is limited to general construction work hours in order to comply with noise regulations.	No significant impacts expected.

Continued

Table 15: Continued

6. Soil		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Potential for soil contamination/erosion within the construction site.	The contractor would prepare an Erosion and Sediment Control Plan as part of the CEMP in accordance with the Managing Urban Stormwater – Soils and Construction guidelines. Bunding and catchment drains would be used where appropriate and clean water directed around the site.	No significant impacts expected.

7. Structural integrity and stability.		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Damage to structures during deployment.	I&I NSW would ensure that a suitably qualified contractor is appointed. Lift analyses would be carried out to ensure barges and vessels are stable during the loading transportation and deployment process. Specific procedures would be required for each of the loading, transportation and deployment stages which are outlined in the EMP.	No significant impacts expected.
Incorrect positioning/ orientation.	Use of GPS equipment and diver inspection would ensure the correct location and orientation.	No significant impacts expected.

Continued

Table 15: Continued

8. Navigation and Safety		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Conflict with shipping and/or other waterway users during transportation and deployment.	Communication and clearance from relevant Port Authorities would be obtained to ensure it is safe to undertake the transport and deployment process. The contractor would ensure the correct navigational lighting is displayed on the barge. Appropriate temporary navigational aids would be provided on the structure and vessel during deployment and anchor buoys positioned at anchor locations.	No significant impacts expected.
Damage to cargo barge.	Detailed lift and mooring analyses would be carried out by the appointed contractor as outlined in the EMP. Loading, transportation and deployment procedures would be carried out as outilned in the EMP.	No significant impacts expected.

9. Flora and Fauna		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Disruption to marine mammals during transportation and deployment.	Transport and deployment stages would not go ahead if there are reports of marine mammals (particularly whales), in the vicinity of the transport route or deployment site. Operations would be temporarily stopped should migratory marine mammals be observed within 300 m of the deployment site.	No significant impacts expected.

Continued

Table 15: Continued

10. OH&S		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Health and safety of contracting staff during the construction, transportation and deployment stages.	I&I NSW would ensure that a suitably qualified contractor is appointed. The appointed contractor would be responsible for the preparation of a OH&S Plan and ensuring the temporary construction site and barge are adequate in terms of OH&S.	No significant impacts expected.

B. Long-Term Operation

1. Structural Integrity and Stability		
Potential Impacts	Mitigation/ Management Measure	Predicted Outcome (with mitigation)
Risk of sliding or overturning.	The final OAR concept design has been developed to resist overturning or sliding in a 100 year storm event. The final design would be verified by a structural marine engineer and developed in accordance with Australian standards for similar marine structures. Local scouring/ deposition around the base of the units would be monitored over the operational life of the units.	No significant impacts expected.
Loss of structural integrity from corrosion or excessive marine growth.	The final design would be verified to meet Australian standards for corrosion allowance and structural capability for the 30 year design life. Monitoring would be carried out over the duration of the design life to ensure the structural integrity of the unit. Units would be inspected for unforseen stresses, movement from the deployment location, orientation, corrosion and thickness of marine growth. Findings of inspections would be compared to design documentation and previous studies to determine if changes have occurred.	No significant impacts expected.

Continued

Table 15: Continued

2. Flora and Fauna		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
a) Benthos		
Change to soft sediment assemblages.	Monitoring of soft sediment assemblages.	No significant impacts expected.
b) Proximal Natural Reef		
Change to epibenthic and fish assemblages of proximal natural reef.	There would be a minimum distance of 500 m between the OAR and adjacent natural reefs. Monitoring of fish assemblages and habitat utilisation and epibenthic assemblages in the wider study area.	No significant impacts expected.
c) Pelagic Environment		
Potential for OARs to contribute to over-exploitation of target species. (e.g. through increased fishing effort).	Monitoring of fish assemblages (i.e. species catch composition, size-frequency distribution, catch rates) Ensure that user groups are informed of minimum catch sizes and bag limits. Promote catch and release	No significant impacts expected.
d) Threatened and Protected Species (including Matters of NES)		
Incidental catch	Monitoring of threatened species occurrence on OARs.	No significant impacts expected.
Potential to increase the risk of entanglement or injury from harmful marine debris (e.g. discarded fishing gear).	Inspection for and removal of fouled fishing gear or debris hooked on the OARs to prevent injury or entanglement of threatened/protected species.	
Boat strike Acoustic disturbance from boating activity	Mechanisms for reporting of sightings or interactions with threatened species in the vicinity of the OARs. Provision of relevant educational information relating to threatened species (including boating regulations in the vicinity of large cetaceans) would be included in a set of OAR 'User Guidelines' made available to target user groups.	

Continued

Table 15: Continued

2. Flora and Fauna continued...		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
e) Invasive Marine Pests		
Colonisation of OAR structures by marine pests. Potential for spread of marine pests (e.g. *Caulerpa taxifolia*) via recreational boating.	Monitoring to determine the type and extent of invasive marine pests. Assessment and potential removal of marine pests would be carried out according to the National Introduced Marine Pest Information System (NIMPIS) guidelines. Relevant educational information on how to minimise the spread of marine pests would be included in a set of OAR 'User Guidelines' made available to target user groups.	Minor incursions possible but overall, no significant impact expected.

3. Commercial and Recreational Fishing		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Loss/obstruction to trawling (Newcastle study region only)	An alternative (final) OAR location has been selected that would aim to minimise loss/obstruction to approximately 0.01km^2 of potential trawling areas. An alternative (line) configuration would be used to minimise loss of trawling area and potential for obstruction/gear hook up.	This impact is considered to be of moderate significance.
Risk of injury or drowning (spearfishing)	A set of User Guidelines would inform different user groups on best practice, personal responsibility and safety within the OAR management area.	This risk is considered to be of high significance but manageable through appropriate education.
Conflict between user groups	Monitoring. A code of conduct for user groups would be outlined in the OAR User Guidelines. Commercial fishing groups would be informed of the final OAR locations. Formal consultation between sectors would be undertaken to resolve any issues of conflict (or similar).	No significant impacts expected

Continued

Table 15: Continued

4. Sediments and Water		
Potential Impacts	Mitigation/Management Measures	Predicted Outcome (with mitigation)
Leaching of heavy metal contaminants into adjacent sediments (e.g. iron oxide).	It would be ensured that the structures are manufactured from materials that conform to Australian Standards for minimum corrosion rates. Monitoring of adjacent sediments (according to ANZECC/ARMCANZ guidelines) to ensure acceptable levels of contaminant are not exceeded.	No significant impacts expected.

5. Navigation and Safety		
Potential Impacts	Mitigation/Management Measures	Predicted Outcome (with mitigation)
Insufficient clearance	Sufficient clearance between the upper part of OARs and transiting vessels would be ensured, accounting for coincidence of severe weather conditions and Lowest Astronomical Tide (LAT). A minimum clearance of 20 m would be ensured at the proposed Sydney location as specified by Sydney Port Authority.	No significant impacts expected.
Anchor fouling/gear hookup	The Australian Hydrographic Office would be informed of the finalised OAR locations. Locations would be charted on maritime maps and a notice to mariners issued to warn of the OAR location. Appropriate locations have been selected in consultation with Ports Authorities and NSW Maritime to ensure units are placed away from designated anchorage areas. The User Guidelines would state that anchoring is not recommended within the OAR management area. OAR units would be regularly inspected in accordance with the EMP so that fouled gear may be removed and would not become a hazard to marine life.	Anchor fouling by large commercial vessels is considered unlikely. It would be likely that fishing gear would become snagged or lost on the structures. A minor , but acceptable level of impact is therefore expected.

Continued

Table 15: Continued

5. Navigation and Safety continued…		
Potential Impacts	Mitigation/Management Measures	Predicted Outcome (with mitigation)
Vessel traffic	Recreational vessels utlising OARs would be instructed to give way to commercial vessels. User groups would be informed of a code of conduct and recreational boating guideilnes in the OAR management area.	Unlikely but possible that impacts related to vessel traffic could occur. Acceptable level of risk expected.

6. Infrastructure		
Potential Impacts	Mitigation/Management Measures	Predicted Outcome (with mitigation)
Congestion at boat ramps and insufficient facilities.	OAR locations have been selected in major urban centres where the provision of boat ramps and facilities is considered to be sufficient for the expected demand. Monitoring questionaires are recommended to determine the need for improvements or upgrades.	No significant impacts are expected.

7. Heritage		
Potential Impacts	Mitigation/Management Measures	Predicted Outcome (with mitigation)
Impacts on historic shipwrecks and submerged items of cultural significance.	OAR will be deployed in areas where there are no historic shipwrecks or items of cultural significance.	No significant impacts expected.
Impacts on spiritual significance or visual amenity (Wollongong study region).	Aboriginal stakeholder groups in the Wollongong study region would be informed of the final locations to ensure the visual amenity and spiritual significance of the region was not compromised.	No significant impacts expected.

8. OH&S		
Potential Impacts	Mitigation/Management Measure	Predicted Outcome (with mitigation)
Health and safety of divers during maintenance and monitoring inspections.	A Safe Work Method Plan would be implemented for diving in the appropriate conditions by the group carrying out the work, and as a minimum would include a temporary fishing closure at those times. This is outlined in the EMP.	No significant impacts expected.

9 Final Locations and Configuration

Based on the outcomes of the impact assessment and further discussions with I&I NSW, the initially proposed OAR locations and configuration at each of the three proposed study areas have been altered to minimise potential impacts on proximal natural reefs (draw-down effects), commercial trawling and aspects of navigation and safety. The final configuration is for a line arrangement running approximately north to south with units spaced approximately 200 m apart. This configuration is considered to have practical advantages by potentially allowing utilisation by more vessels at any one time and to allow drift fishing with the prevailing current (generally running north to south at all locations). Commercial operators approached during the consultation meetings have indicated that a line configuration would also be preferable to navigate past. GPS positions for the final locations are given in (Section 4.3, Table 2).

The final locations are indicated by blue dots in Figures 32, 33 and 34 and described below:

- Newcastle region (Swansea). Approximately 2 km SW of the original location, configured in a line, at a depth of approximately 28 m. The depth of water over the structures would be approximately 16 m. (Figure 32).
- Sydney region (South Sydney). Immediately east of the original location, configured in a line, at a depth between 36 m – 38 m. The depth of water over the structures would be a minimum of approximately 24 m (Figure 33).
- Wollongong region (Port Kembla). Approximately 300 m NW of the original location, configured in a line, at a depth of approximately 34 m. The depth of water over the structures would be approximately 22 m (Figure 34).

Also see Figures 6, 7 and 8 for broad scale maps indicating final locations.

Implications for Further Assessment

Given the similar conditions in terms of seabed habitat morphology, coastal processes and depth at the final Sydney and Wollongong locations to the originally proposed locations, it is not considered necessary to undertake any further studies to assess potential impacts. The final locations are not considered to have any additional impacts (including on relevant matters of NES) other than those described in the current EA/draft PER. The final Newcastle location, however, is outside the direct study area and although the scale for which many impacts were assessed in the current study (for the long-term operation) would still be relevant for planning considerations, additional site-specific surveys are recommended and will be discussed below.

The inshore wave climate investigations showed that placement of reef structures would have no discernible influence on the adjacent shorelines and this advice is considered applicable to the final reef locations, including Newcastle. In terms of design wave criteria, the final reef locations are in comparable depths with similar exposure to offshore wave conditions and hence the outcomes of the existing investigations are considered appropriate.

As shown in Figure 35 the peak current speed distribution at the seabed for the 100 years ARI design storm shows that the new reef locations are subject to equivalent current speeds at depth and therefore the outcomes of the existing investigations would remain valid in terms of current speed criteria and seabed morphology processes.

Spacing between the structures in the final configuration is reduced to approximately 200 m. However, this is still considered adequate to prevent any cumulative effects from the placement of the set of individual reef structures – for both currents and waves. In terms of waves the spacing of 200 m is in the order of the longest wave lengths and so the waves would not ‘see’ the structures. The zone that is influenced by the presence of the individual reef structures, in terms of currents, is limited to about 10 times the structure width. Hence 200 m is too great a distance for there to be any interaction between individual structures.

As previously mentioned, additional site-specific surveys are recommended for the revised Newcastle site. As a minimum, this would require swath habitat mapping. Site-specific baseline information on benthos, fish and sediments are also recommended, although this would be addressed as part of the Monitoring Plan for all study regions (Section 11). It is not considered that any further studies relating to coastal processes would be necessary for the final locations.

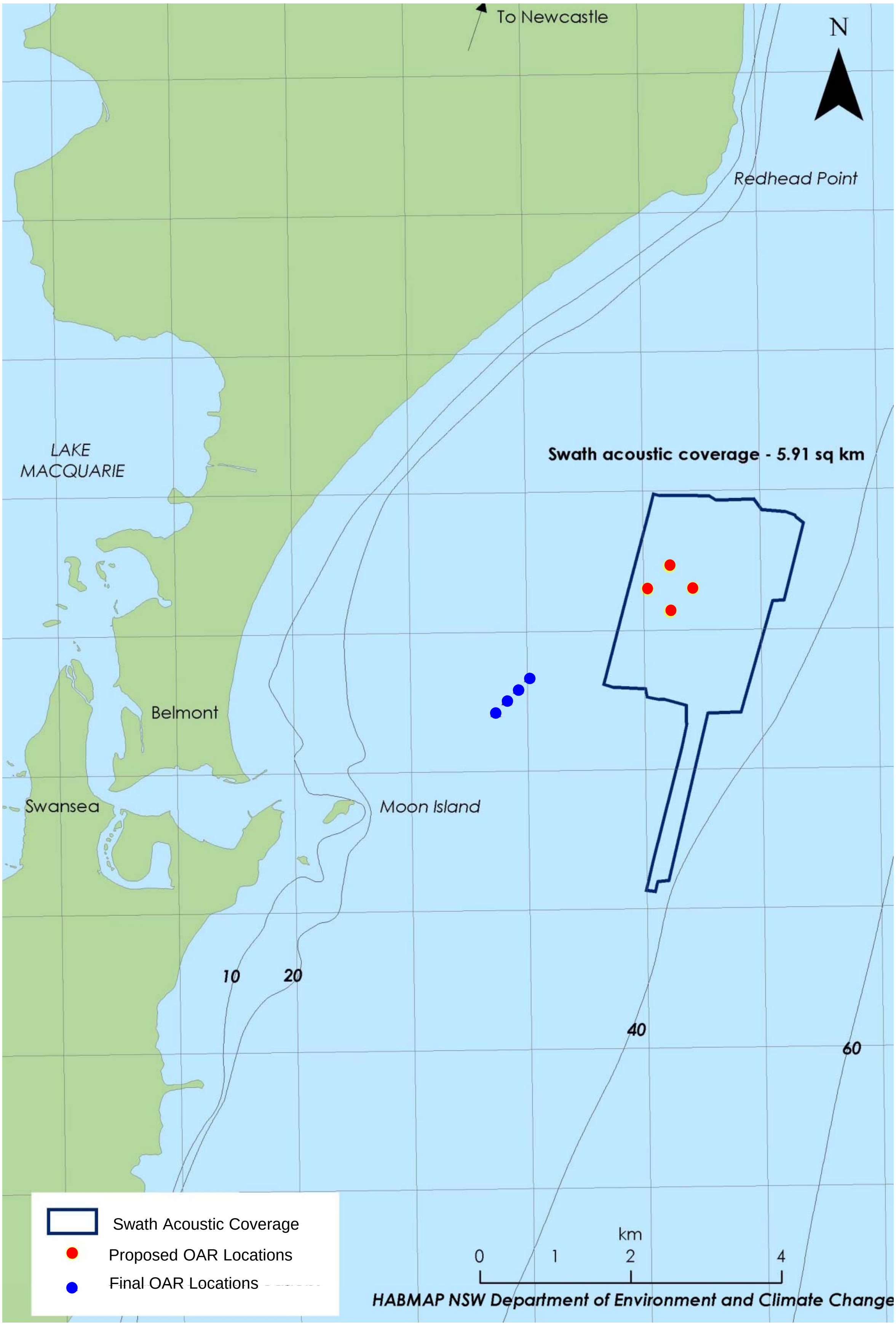


Figure 32: Broad scale map showing the final Newcastle site. Depths shown along contour lines are in metres AHD.

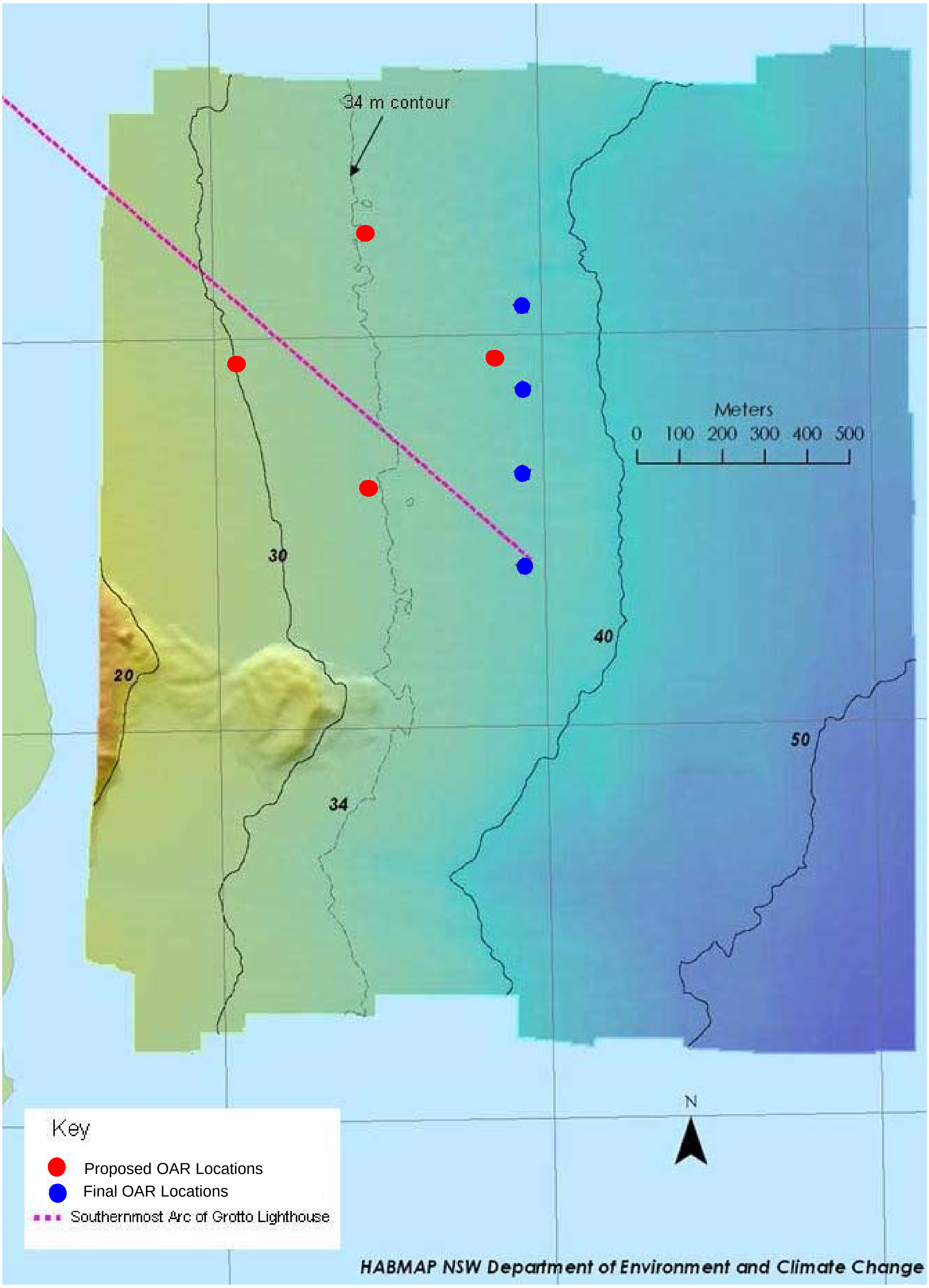


Figure 33: Bathymetry with hillshaded relief at the final Sydney Site. Depths shown along contour lines are in metres AHD.

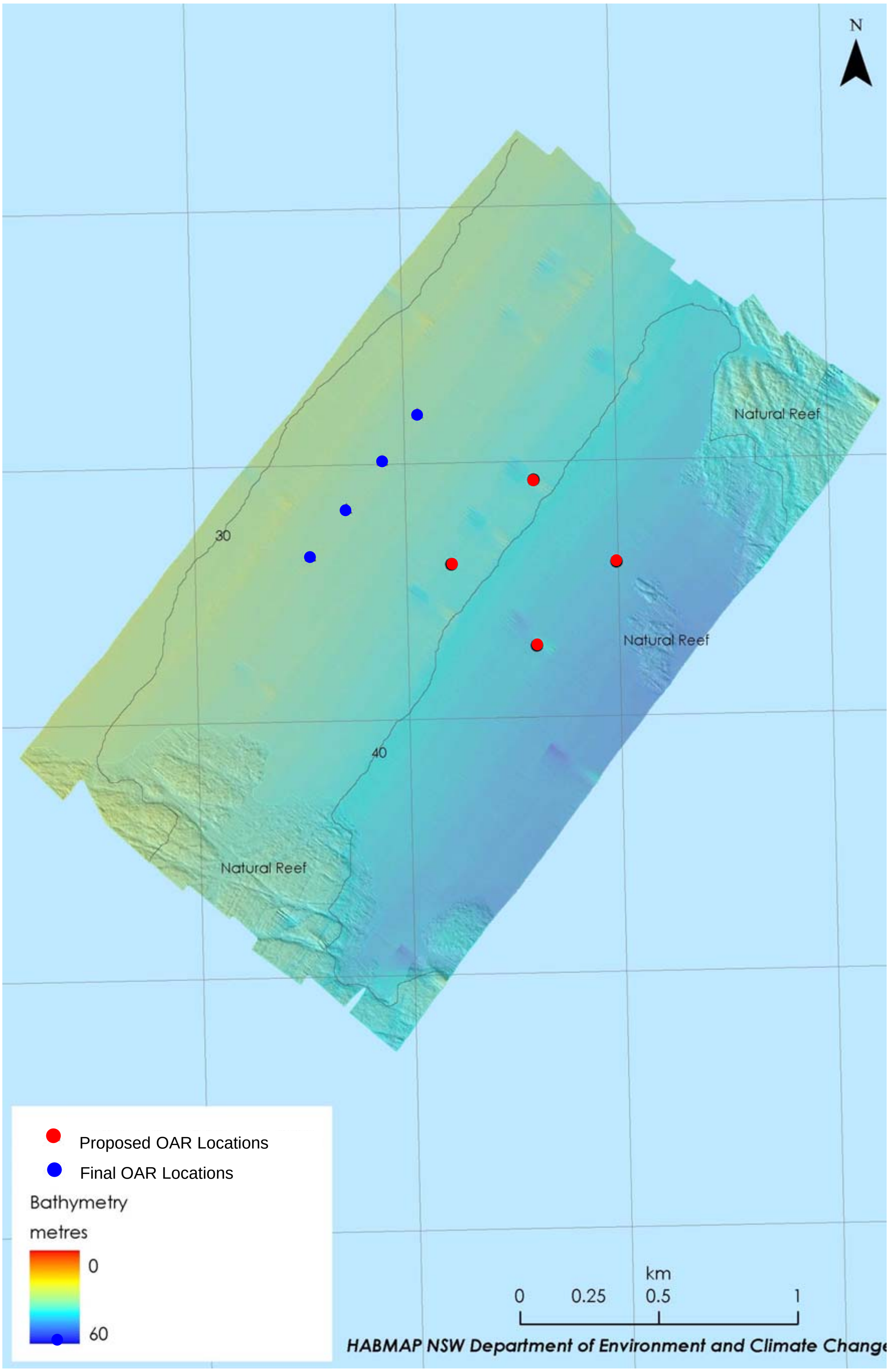


Figure 34: Bathymetry with hillshaded relief at the final Wollongong Site. Depths shown along contour lines are in metres AHD.

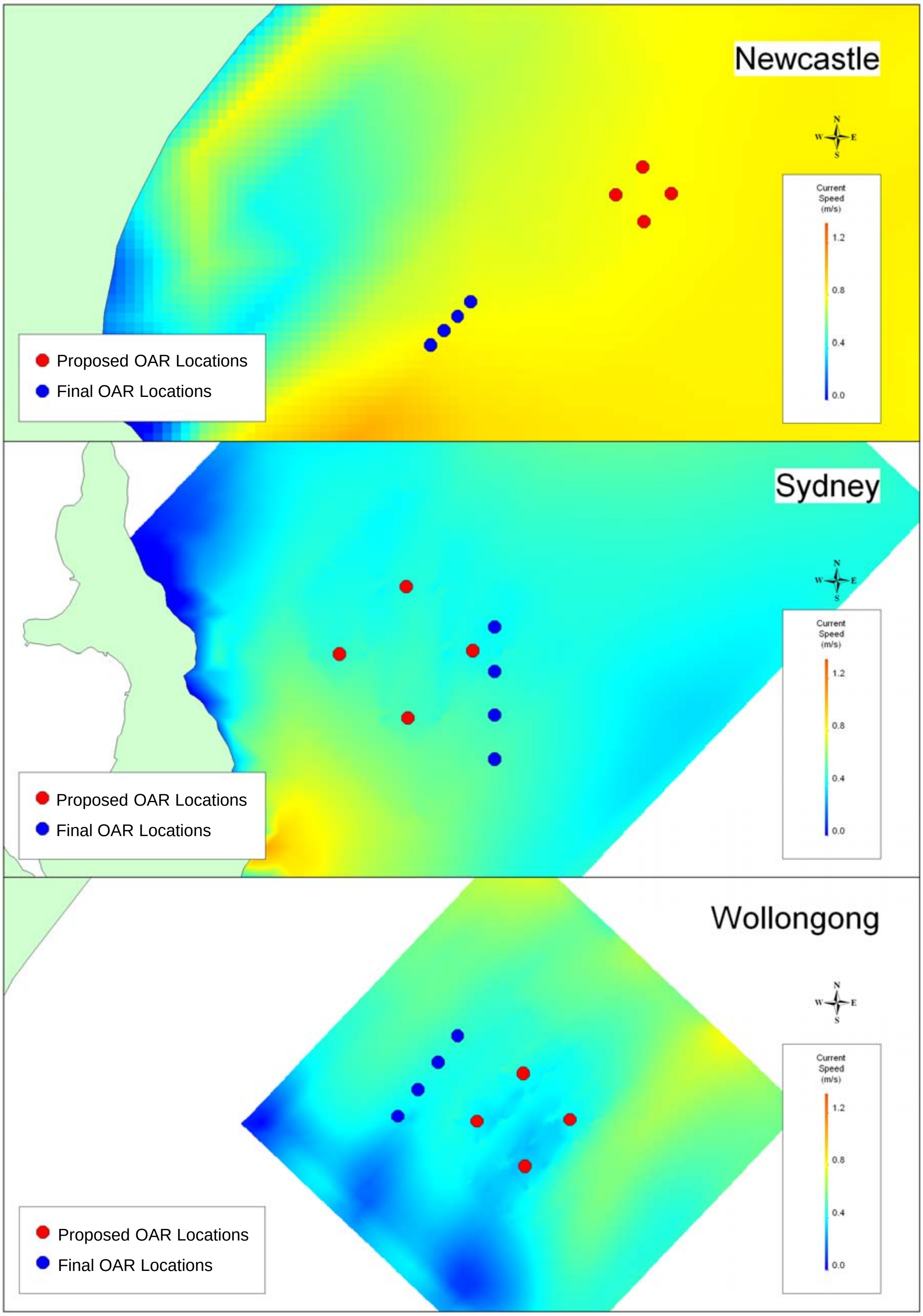


Figure 35: Peak bed current distributions for proposed and final OAR locations and configurations – 100 years ARI design event. Source: Cardno Lawson Treloar.

10 Suitability Analysis

Only one location will initially be selected for OAR deployment (i.e. one reef set) and any further deployments would depend on the outcomes and success of the initial monitoring program. The final locations were therefore compared in terms of suitability (e.g. accessibility, demand and infrastructure for construction, transport and deployment) and residual impacts with mitigation (Table 16). Based on these criteria, Sydney was ranked as the most suitable location followed equally by Newcastle and Wollongong. Although the Sydney location is indicated as the preferred option for the first project, both Newcastle and Wollongong are still considered to be highly suitable locations for the installation of an OAR.

Table 16: Suitability asessment for the three proposed study areas. Each location was ranked as follows (1)=Most Suitable, (2)=Suitable (3)=Least Suitable. The lowest total score is considered to be the most suitable.

Assessment Criteria	Study Region					
	Newcastle		Sydney		Wollongong	
1. Accessibility		Rank		Rank		Rank
Boat ramps within 10 km of the proposed OAR location	4 (average - excellent condition)	2	5 (2 of poor quality, 2 of excellent quality and 1 of average quality).	1	4 (good - excellent condition)	2
Boat ramps within 20 km of the proposed OAR locations	7 boat ramps within 20 km of the OAR site.	2	6 boat ramps within 20 km of the OAR site.	3	9 boat ramps within 20 km of the OAR site.	1
2. Popularity (Fishing participation rate)*	25.2% (Hunter)	1	13.1% (Sydney)	3	20.9% (Illawarra)	2
3. Demand (number of anglers)*	131,000 (Hunter)	2	483,000 (Sydney)	1	74,000 (Illawarra)	3
4. Transit distance (km) from potential construction site to recommended OAR site	23 km	3	12 km	1	10 km	1
5. Extent of habitat limitation	No existing natural reef in the direct study area.	1	Limited natural reef in the direct study area.	2	Natural reef exists within the direct study area.	3
6. Conflict with commercial fishing	Representatives of fishing businesses operating out of Sydney are opposed to a Newcastle OAR.	3	Not considered an issue.	1	Not considered an issue.	1
7. Heritage	Not considered an issue.	1	Not considered an issue.	1	Minor concerns over impacts on aesthetic amenity and the spiritual significance of the FINR	2
Total Score		**15**		**13**		**15**

* Figures based on FRDC national Recreational Fishing Survey 2000/2001(Web Reference 30). Note that these figures include both saltwater and freshwater fishing and are therefore limited to providing an indicative comparison only.

11 Environmental Management

The potential impacts identified, recommended mitigation/management and predicted outcomes after mitigation are summarised in Table 15. All of the potential issues identified in the impact assessment would be removed or minimised to an acceptable level of risk through implementation of the Environmental Management Plan (EMP) and the Monitoring Plan as described below.

11.1 Environmental Management Plan (EMP)

The EMP (Appendix 9) aims to provide a framework for implementing the mitigation measures outlined in Section 8. It may also be used as a reference for the contractor appointed to undertake the construction, transportation and deployment stages of the project. Construction methodology, performance criteria, timeframes and contingencies for unplanned events are detailed in the EMP where relevant. An indication of the predicted effectiveness of the proposed management strategy/mitigation measures is also provided. The Monitoring Plan (Table 17) which is detailed in the following Section is incorporated into the EMP. I&I NSW will be committed to and responsible for ensuring that all mitigative measures are carried out as described in the EMP.

11.2 Monitoring

11.2.1 Introduction

In order to better understand how the installation of OARs will impact upon significant components of the marine environment and evaluate their overall effectiveness in relation to the project objectives, a monitoring strategy is required. Spellerberg (2005) defines ecological monitoring as 'the systematic collection of data in a standardized manner at regular intervals over time' and assumes a specific reason for the collection of data such as meeting standards or objectives. Often, studies investigating impacts of artificial reefs have undertaken extensive multi-disciplinary research post-deployment and failed to gather sufficient pre-deployment data thereby reducing the value of subsequent research (Underwood 1996). A lack of replication of the reef systems has also resulted in less powerful statistical designs. Underwood (1997) quotes a series of papers on 'beyond BACI' (Before, After, Control, Impact) sampling designs which make use of multiple controls in space and time. This allows changes of the potential impact location to be evaluated against background variation measured at multiple control locations and is considered 'best practice' in environmental impact monitoring. This design requires that sampling is done in at least two external control locations in addition to the potential impact location. Sampling should also be carried out at least twice before deployment and at least twice post-deployment. This is particularly important as assessments of impacts are more reliable if data on prevailing conditions over a period of time before development are available for comparison. For this reason pre-deployment monitoring should begin as far ahead of deployment as possible. The additional studies described in Section 6.3 have provided information on existing baseline conditions at the proposed impact (OAR) and control sites. Although multiple control and impact locations have been sampled pre-deployment as part of the baseline study, further pre-deployment investigations are recommended. This is due to the broad spatial scale of the baseline study and the significant amount of small-scale variation observed between sites within any given location. The results also suggest that further controls within each study region are required and that each study region should be investigated individually.

Replication in time is also crucial to the current proposal as biological variables such as abundance, biomass and diversity) in fish and macroinvertebrate assemblages are likely to be influenced by seasonal patterns (Kingsford and Battershill 1998). Many studies involving the census of fish in relation to artificial structures have been limited to periods of only a few years, often due to lack of resources and funding (Relini *et al*. 2002). To evaluate positive effects on fish assemblages, long-term seasonal variations and trends in relation to the age of the artificial reef are of crucial importance (Relini *et al* .1994). Stabilisation of fish assemblages is also likely to be a slow and long-term process, with changes likely to be observed even after 20-30 years. For this reason, the monitoring program should ideally continue throughout the operational lifespan of the artificial reef. As funding and resources for a monitoring period of this timescale cannot be guaranteed, an absolute minimum monitoring period of three years is recommended for the current proposal. Initial colonisation of the OARs by fish and epifauna is likely to occur rapidly post-deployment. Biological sampling events should therefore be more frequent in the initial post-deployment phase to record early stages of succession which can influence the long-term structure of the species assemblage.

Studies of fish assemblages in relation to artificial reefs, benefit from simple sampling designs that allow for sufficient replicates to evaluate one or two variables rather than overly complex studies that are subject to large variance (Bortone *et al*. 2000). There has also been a focus of sampling effort on dependent variable parameters for a single species or a life-history stage of a species rather than attempting to address too many reef fish assemblage questions in one study. Non-parametric, multivariate, statistical packages (such as PRIMER-E), are also considered an important and useful tool in recent artificial reef research (Bortone 2006). In regard to the project objectives, the Monitoring Plan outlines procedures to monitor:

1. *Usage of reefs by anglers, other members of the public and conflicts between users;*
2. *Effectiveness of reefs including catch rates, species catch composition and fish stocks;*
3. *Any impacts on significant components of the marine ecosystem;*
4. *Any impacts and aggregation of threatened/protected species and communities*;
5. *The integrity of the reef structures.*

The assessment of impacts (Section 8) identified components of the marine environment and potential impacts/issues related to those components that require further investigation and monitoring. A Monitoring Plan (Table 17) has subsequently been developed to address each of the impacts/issues which require monitoring and identifies the objectives, recommended monitoring periods, locations and sampling methods. Note that in many instances, provision has been made for monitoring to begin *before* construction and deployment. Funding and undertaking of monitoring studies would be the responsibility of I&I NSW. Funds have been approved from the NSW Fishing Trust until the end of 2012/2013 for detailed monitoring of the OARs. Further funds for 2013/2014 and beyond will be sought if required.

11.2.2 Locations

It is recommended that a separate Monitoring Plan be implemented per study region (Newcastle, Sydney, Wollongong). The Monitoring Plan proposed in Table 17 is, however, generic and could be applied to any of the three study regions. Sampling locations should include:

- direct OAR placement sites;
- impact sites (including adjacent soft sediment and proximal natural reef); and
- control sites (including soft sediments and distant natural reef).

The sampling design would vary according to the variables being monitored but would incorporate a combination of the above locations (Table 17). The locations of reference sites for the monitoring of soft sediment macroinvertebrate assemblages would be the same as those used in the current field investigations. Location of impact sites would depend on the final location of the OAR units. Additional sites would be required to assess effects on proximal natural reefs which have not been previously sampled. These would include areas of proximal natural reef as further 'impact' locations and natural reef sites outside the direct study area (but within the wider study region) as further control sites. It is important that control reef sites be at a similar depth and habitat type to the proximal (impact) reefs.

11.2.3 Timing

Six different monitoring periods (A – F) are recommended according to different components of the Monitoring Plan (outlined in Table 17). It should be noted that in order to investigate temporal seasonal patterns (e.g. between winter and summer) in biological components of the study, a minimum of two sampling events within each season investigated are recommended (Underwood 1994). As discussed in Section 11.2.1, the monitoring program should run for a minimum of 3 years, but a considerably longer term plan (covering the operational life of the OARs) is recommended, if funding and resources allow. Pre-deployment monitoring should begin as soon as possible to provide sufficient 'before' data for comparison.

11.2.4 Methods

The recommended Monitoring Plan (Table 17) consists of three main components (biological, physical and socio-economic). It should be noted that standardisation and consistency in monitoring methods is essential to enable meaningful conclusions to be drawn from the data and to support appropriate management actions. Monitoring methods for each of these areas are discussed below.

1. Biological

The aims and methods to monitor impacts on biological components of the environment (including the success of the proposed OARs) are summarised in Table 17. The biological monitoring section focuses on three components (macrobenthos, fish and threatened species):

Macrobenthos

Methodology for the macrobenthic monitoring of soft sediments (including field, laboratory and analyses) should be consistent with that used for the field investigations described in the marine ecology report (Technical Report F). Monitoring for the occurrence and extent of feeding haloes would also be addressed.

It is recommended that monitoring of natural rocky reef sites be carried out by photo video quadrats deployed by boat. This method would be preferable to diver surveys for sampling at depths of 30 m or greater. The technique would involve the deployment of a rig (similar to that used in BRUVS) incorporating a square quadrat (0.5 m x 0.5 m) and high definition video cameras fitted in underwater housings. It is important that auto-focussing cameras capable of recording high resolution footage at very low light levels are used. Information about species present, percent cover of each species and signs of disease or mortality would be recorded from each quadrat.

As it is possible the structures would be colonized by introduced species, a process for identifying pests and potentially removing them is required. This would be carried out by visual inspections of all reef units. Management of pest species would be carried out in accordance to NIMPIS (National Introduced Marine Pest Information System) rapid response control options (Web Reference 27). This database specifies the most appropriate management methods according to species and scale of the incursion. As it may be impractical to remove all species, consideration should be given to removing the most prolific or those considered to be a significant threat to species of commercial or recreational importance and to threatened or protected species.

Fish

Methods for monitoring fish, including species of recreational and commercial importance and threatened species could include surveys of recreational and commercial fishers and/or charter boat log book data, deployment of BRUVS, stereo-videography, biotelemetry and visual diver census. Employing a combination of such techniques would provide a complete assessment of species occurring in the study areas. A single technique would be biased towards certain habitat groups or could fail to sample certain species/groups. Surveys of fishers and/or charter boat log book data would provide an indication of:

- catch composition (including size and weight of fish to calculate biomass);
- fishing effort in terms of number of anglers;
- threatened and protected species (by providing information on incidental catch).

BRUVS can provide qualitative information on species abundance and diversity. Detailed methodology for BRUVS is outlined in the marine ecology report (Technical Report F). The limitation of the BRUVS technique is that the video stations can only be deployed directly adjacent to the structures and may therefore under-represent or miss species occurring within the void space of the structures. For this reason, visual diver census could be carried out to account for such species. Stereo-videography is another technique which can be used to provide quantitative, size-frequency distribution data and habitat usage information for fish associated with the OAR and proximal reef. Stereo-videography has been used successfully as a monitoring technique in the I&I estuarine artificial reef programs.

Biotelemetry involves the deployment of acoustic listening stations and fish tagging which can be used to investigate movements and resident times of fish inhabiting the reef. Key recreational species would be prioritised for tagging, although this would also depend on the type and numbers of species found on the OARs. Monitoring would also work in conjunction with the Australian Acoustic Tagging and Monitoring System (AATAMS) enabling the movement of tagged fish to be tracked between the OARs and AATAMS arrays.

After the first year of post-deployment monitoring, these techniques would be reviewed and the most cost-effective and accurate techniques retained for long-term application.

Threatened Species

Investigations on threatened species would be incorporated into the fish surveys (above) using BRUVS, diver surveys, stereo-videography and survey information where feasible. In relation to the critically endangered grey nurse shark, ultrasonic telemetry studies as part of the monitoring program would be recommended. This would involve fitting remote, underwater receivers or 'listening stations' to the OAR units that could continuously detect sharks (and other species) tagged with internal ultrasonic transmitters. As tagging programs are run by different governmental departments and organisations (including CSIRO and I&I NSW) collaboration and coordination between relevant groups would be required to compile a register of tagged individuals.

2. Physical

Aims and methods to monitor impacts on the physical components of the environment (including the OAR units) are summarised in Table 17.

Sediments

Samples of surface sediments for analyses of particle size distribution would be collected by benthic grab from a boat using methodology consistent with that used for the current field study (Technical Report F). Sub-samples for analyses of heavy metals would be taken from the particle size samples using methodology consistent with that used for the current field investigation (Technical Report F).

OAR Structure

Underwater structures in the marine environment are difficult to maintain and underwater repairs can be difficult to carry out and costly. As a result, the OAR structures have been designed to have sufficient corrosion allowance and maintain their structural integrity for a minimum 30 year design life. It is recommended that visual inspections be carried out at two yearly intervals for the duration of the operational life. Ad-hoc inspections may also be carried out after extreme storm events.

The following items would be monitored and recorded during the inspections:

- unit location;
- unit orientation;
- all main structural members (i.e. ensure that structural members are intact and not loose);
- any severe corrosion; and
- thickness of marine growth on random steel sections at the top and base of each unit.

Following the monitoring inspections, the findings would be compared with the design documentation and previous studies to determine if there has been a significant change in the structure. If any significant changes occur, a structural engineer would be engaged to determine the best remediation options.

More regular inspections of the structures and removal of any entangled debris or fishing gear (potentially harmful to marine animals) would be carried out during biological aspects of the monitoring program.

3. Social/Economic

The objectives that would be used to monitor social and economic impacts of the proposal are summarised in Table 17. Effectiveness of the OARs should be monitored in terms of socio-economic consequences in addition to biological indicators. Sutton and Bushnell (2007) suggest that monitoring of use levels, users' perception of crowding, levels of conflict, users' attitudes, opinions, satisfaction and artificial reef-related expenditures are particularly important. Monitoring of public and stakeholder attitudes towards OARs is also important to evaluate the extent of negative social and economic impacts. It is recommended this would be carried out by questionnaires aimed at both user groups and stakeholders after the first year of operation. If undertaken, feedback from fisher surveys could also be incorporated into the initial survey. Questionnaires could be filled out and submitted online via the I&I website/fax, post or interviews could be conducted by telephone.

11.2.5 Management Response

Table 17 identifies management options based on the dissemination and review of results over the given monitoring period i.e. an adaptive management approach. Results of the monitoring program should be disseminated and reviewed at appropriate stages (indicated in Table 17). Where no impact is detected, then monitoring would continue or be scaled-down as appropriate. Should negative impacts be detected, then a series of relevant management options would be considered depending on the severity of the impact. Development of specific criteria to assess the severity of a potential impact may also be of benefit once the Monitoring Plan has been implemented. It should be noted that the Monitoring Plan outlined in this study would be considered a pilot. Experience from the initial Monitoring Plan is likely to result in the development of best practice methods for any subsequent reef deployments.

11.2.6 Monitoring Priorities

As best practise, all objectives outlined in the Monitoring Plan (Table 17) would be met and appropriate monitoring carried out. It is, however, recognised that funding and resources may not be immediately available to cover all of the objectives outlined. To assist in the most appropriate allocation of available funds and resources, objectives in the Monitoring Plan have been prioritised as follows:

Priority 1 (Monitoring objectives I&I NSW are committed to undertaking):

Biological

A.2.1. Investigate movements of high priority species within the direct study area.

A.2.2. Assess effectiveness in terms of catch rates, species composition and fish stocks.

A.3. Investigate occurrence of threatened/protected species on the OARs.

Physical

B.3.1. Assess structural integrity.

B.3.2. Remove fouled gear and debris.

Socio-Economic

C.1.1. Assess effectiveness in terms of popularity with recreational fishing groups and OAR related expenditure.

Priority 2 (Monitoring objectives to be addressed given availability of additional funds/resources):

Biological

A.1.1. Assess influence of OARs on benthic assemblages (soft sediments) including potential halo effects.

A.1.2. Assess influence of OARs on benthic assemblages of proximal natural reefs (benthos).

A.1.3. Document colonisation of the reef structures by macroinvertebrates including pest species.

Physical

B.1.1. Assess influence of OARs on sediment characteristics.

B.1.2. Assess concentrations of heavy metals in adjacent sediments to OARs.

B.2. Assess water quality.

Socio-Economic

C.1.2. Identify issues of conflict between user groups.

Table 17: Recommended OAR Monitoring Plan. (*) Details of each monitoring program (A - F) is given at the end of the Table.

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
A. Biological							
A.1 Macrobenthos	**A.1.1** Assess influence of OARs on benthic assemblages (soft sediments) including potential halo effects.	A or C*	Impact sites (soft sediment habitat adjacent to OARs) and control sites	Benthic grab deployed by boat	Annual	■Continue monitoring	■Determine acceptable level of impact in context with other cumulative impacts
	A.1.2 Assess influence of OARs on benthic assemblages of proximal natural reefs (benthos)	A*	OAR sites, proximal natural reef sites (impact sites), and reference natural reef sites (controls)	Photo video quadrats	Annual	■Continue monitoring	■Determine acceptable level of impact**:** ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	A.1.3 Document colonisation of the reef structures by macroinvertebrates including pest species	D*	OAR Structures only	Photo video quadrats and visual diver inspections	As for monitoring period	■Continue monitoring	■Verify species identification ■Determine threat of pest species if observed: ■Continue monitoring ■Removal of pest species according to appropriate NIMPIS method

Continued

Table 17: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						Impact not detected	Negative impact detected and/ or failure to meet objectives
A. Biological							
A.2 Fish	**A.2.1** Investigate movements of high priority species within the wider study area	A or C*	OAR sites, proximal natural reef sites (impact sites), and reference natural reef sites (controls)	BRUVS, biotelemetry and visual diver census	Annual	■Continue monitoring	■Determine acceptable level of impact: ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	A.2.2 Assess effectiveness in terms of catch rates, species composition and fish stocks	A or C*	OAR wider study area	Stereo-videography, BRUVS and/or visual diver surveys, on-site surveys and/or charter boat log book data	Annual	■Continue monitoring	■Determine acceptable level of impact: ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
A.3 Threatened/ protected Species	Investigate occurrence of threatened and/or protected species on the OAR	C and F*	OAR sites	BRUVS or stereo-videography, visual diver census and/or listening stations if feasible	As for the monitoring period and on an 'ad hoc' basis	■Continue monitoring	■Determine acceptable level of impact: ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures

Continued

Table 17: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
B. Physical							
B.1 Sediments	**B.1.1** Assess the influence of OARs on sediment characteristics (sediment particle size composition)	A or C*	Impact sites (soft sediment habitat adjacent to OARs) and control sites (Note that control sites should be of similar particle size composition and depth to impact sites	Benthic grab deployed by boat	Annual	■Continue monitoring	■Determine acceptable level of impact in context with other cumulative impacts
	B.1.2 Assess concentrations of heavy metals in adjacent sediments	B*	Impact sites (soft sediment habitat adjacent to OARs) and reference sites (Note that Reference sites should be of similar particle size composition and depth to impact sites	Benthic grab deployed by boat	Annual	■Continue monitoring and compare against ANZECC guidelines.	■Determine acceptable level of impact in context with other cumulative impacts
B.2 Water Quality	Assess water quality	A*	Impact and control sites	Water quality probe	Annual	■Continue monitoring and compare against ANZECC guidelines	■Determine acceptable level of impact in context with other cumulative impacts

Continued

Table 17: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
B.3 OAR Structure	**B.3.1** Assess structural integrity	E*	OAR units only	Diver survey	Every two years	■Continue monitoring	■Consider need for maintenance
	B.3.2 Remove fouled gear and debris	E*	OAR Structures only	Diver survey	Every two years	■Continue monitoring	■Continue monitoring and/or; ■Removal of entangled fishing gear and debris
C. Social and Economic							
C.1 Recreational and Commercial fishermen	**C.1.1** Assess effectiveness in terms of popularity with recreational fishing groups and calculate relative expenditure related to OAR usage and whether this leads to a net increase at the regional level	E*	N/a	Stakeholder questionaires	Annual	■Continue monitoring until project objectives are met	■Analyse feedback from user groups against project ■Implement necessary changes ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	C.1.2. Identify issues of conflict between user groups (e.g. from crowding)	F*	N/a	Mechanism for incident reporting	Annually and on an 'ad hoc' basis	■Continue monitoring	■Analyse feedback from user groups against project ■Continue monitoring or; ■Resolve issues within a forum between user groups

Continued

Table 17: Continued

Monitoring Program					
A*	B*	C*	D*	E*	F*
Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment
winter x1 summer x1	x1	winter x2 summer x2	N/A	N/A	N/A
Post-deployment	Post-deployment	Post-deployment	Post-deployment	Post-deployment	Post-deployment
3 months 6 months 12 months Every year thereafter (winter x1 and summer x1) for a minimum of 3 years	12 months Every year thereafter (x1) for a minimum 3 years	3 months 6 months 12 months Every year thereafter (winter x2 and summer x2) for a minimum of 3 years. Note this option allows temporal seasonal comparisons.	3 months 6 months 12 months Every year thereafter (winter x1 and summer x1) for a minimum of 3 years	12 months Every 1-2 years thereafter	Continuous mechanism for feedback e.g. reporting incidents or remote data transfer

12 Statement of Commitments

I&I NSW is committed to ensuring that environmental stewardship is effectively applied throughout the construction, transport, deployment and long-term operation of the proposed OAR. Having successfully implemented artificial reefs in estuarine locations and fish aggregation devices in offshore locations, I&I NSW has an understanding of the management and monitoring requirements and the resources and expertise necessary to ensure that significant environmental impacts are avoided, appropriately mitigated or managed.

A considerable amount of planning and consultation work has also been undertaken prior to the environmental assessment stage to identify and minimise potential constraints and select locations likely to have the least environmental impact, with optimal results.

The EA/draft PER has identified measures to mitigate and manage potential environmental impacts specific to the proposed OAR project that I&I NSW are committed to. These measures have been consolidated into an EMP and a Monitoring Plan.

In summary, actions committed for the project are as follows:

- Construction, transport and deployment activities will be carried out in accordance with procedures outlined in the EMP. The appointed contractor will be fully certified and qualified to carry out the works as outlined in the EMP safely and efficiently and will develop an additional CEMP and OH & S plan to address site-specific environmental and safety issues.
- A management area will be established around the OAR, in consultation with the Land and Property Management Authority by creation of a Crown Reserve under the *Crown Lands Act 1989*.
- Information on activities permitted within the proposed management area and user guidelines including a code of conduct will be provided via the I&I NSW website and through relevant publications to ensure best practice and safety during the operational life of the OAR.
- Long-term management of the proposed OARs will be the responsibility of I&I NSW and carried out in accordance with the EMP. This includes implementing measures to manage and mitigate impacts on flora and fauna (including threatened species and matters of national environmental significance), water and sediments, navigation and safety, infrastructure, commercial and recreational fishing.
- Monitoring of the OARs will be carried out by I&I NSW for a minimum period of three years.
- Monitoring and review will be carried out to ensure the structural integrity and stability of the units as described in the EMP and Monitoring Plan.
- Monitoring and review will be carried out to mitigate any potential impacts on threatened and protected species (including matters of NES) as described in the EMP and Monitoring Plan.
- I&I NSW will be responsible for the removal of fouled gear and debris collected on the OARs, that could be harmful to threatened or protected species as described in the EMP and Monitoring Plan.
- Monitoring and review of catch rates, species catch composition, size-frequency distribution and habitat utilisation of fish will be carried out within the study areas to identify the need to mitigate potentially adverse impacts as described in the EMP and Monitoring Plan.
- Monitoring and review will be carried out to ensure that the proposal is effective in meeting the project objectives and that target user groups are satisfied with the operation of the OARs.
- I&I NSW will ensure that appropriate sand penetration tests are carried out in the final OAR locations.
- At the time of preparation of the EA/draft PER, no minerals licence applications were found to occur within the vicinity of the proposed OARs. I&I NSW will, however, consult the relevant databases for offshore minerals exploration licences and applications which have potential to conflict with the final proposed OAR locations in advance of any approved deployment.

I&I NSW are also committed to ensuring that local community groups, LALCs, commercial fishing groups and the general public are informed of the project staging and EMP for the proposed OARs as it develops in the future.

13 Conclusion and Justification

Recreational fishing is an important leisure activity for approximately 17 % of the NSW population (approximately 1 million people) and is considered by the government to provide significant social and economic benefits. In NSW, approximately 30 % of the total fishing effort takes place between the shoreline and 5 km offshore (Henry and Lyle 2003). It is likely that the proposed offshore artificial reefs would contribute to long-term socio-economic benefits on local communities by improving fishing opportunity and expenditure on fishing related items and services. There may also be increased opportunity for employment in fishing related industries. In the short-term, the construction, transport and deployment stage of the project would provide employment for a number of engineers, construction workers and support staff.

The deployment of OARs would complement existing recreational fishing enhancement projects managed by I&I NSW, such as the deployment of fish aggregation devices (FADs) and the estuarine artificial reef (EAR) projects which have proven successful as fisheries enhancement tools over the past seven years.

Provided that the project is managed as described in the EMP and Monitoring Plan, the proposal is not considered to have a significant environmental impact. All issues that have been identified in the EA/draft PER are considered to be appropriately mitigated for or pose an acceptable and manageable level of impact.

The proposal is considered to be acceptable in terms of its potential environmental impact on relevant matters of NES as there would be no direct impacts on habitat or resources important for threatened/migratory species or regional values of the Commonwealth marine area. Indirect impacts from the placement of the OARs, or associated fishing activity, on individual animals or populations that are matters of NES would be negligible and unlikely, provided OARs are managed and monitored as outlined in the EMP. As a precaution, regular monitoring would be carried out by different methods to detect the presence of threatened species in the vicinity of the OARs. In the unlikely event that a threatened species was considered to be vulnerable, appropriate mitigative action to remove the risk (as specified in the EMP) would be taken.

It is extremely likely that the proposal will provide high quality fishing opportunity, contribute to productivity within the management area (in the long-term), provide additional fishing locations and potentially relieve pressure on natural reef habitats. Monitoring studies would contribute valuable fisheries information and could also provide opportunities for research and education. The project is considered to be consistent with the objects of the EP&A Act which are to:

- encourage the proper management, development and conservation of natural and artificial resources and natural areas (i.e. the marine environment);
- promote the social and economic welfare of the surrounding local communities by improvement of recreational fishing opportunity;
- promote and co-ordinate the orderly and economic use and development of land (i.e. submerged Crown Land);
- provide land (sub-merged Crown Land) for public purposes;
- promote the protection of the environment, including the protection and conservation of native animals, including threatened species, populations and their habitats;
- promote the sharing of the responsibility for environmental planning between the different levels of government in the State; and
- provide increased opportunity for public involvement and participation in environmental planning and assessment stage.

The deployment of OARs is also consistent with the objectives of the FM Act which are 'to conserve, develop and share the fishery resources of the State for the benefit of present and future generations', to promote Ecologically Sustainable Development (ESD), including the conservation of biological diversity and specifically to promote 'quality recreational fishing opportunities'.

14 Declaration

I Kate Reeds, of Cardno Ecology Lab Pty Ltd declare that every effort has been made to ensure that information contained within this document is neither false nor misleading. Where supporting information has been supplied every effort has been made to ensure reliable and accurate sources were obtained.

Kate Reeds

Environmental Scientist

Cardno Ecology Lab

Marine and Freshwater Studies

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17 Appendices

Appendix 1: Legislative requirements under State legislation (Director Generals Requirements).

Appendix 2: Legislative requirements under Commonwealth Legislation (EPBC Act).

Appendix 3: Stakeholder contact details.

Appendix 4: Stakeholder consultation workshops – issues summary.

Appendix 5: Stakeholder letters.

Appendix 6: Threatened species – State assessment of significance.

Appendix 7: Threatened species – EPBC species profiles.

Appendix 8: OAR concept design.

Appendix 9: Environmental Management Plan.

Appendix 1

Director Generals Requirements (DGRs)

Director-General's Requirements
Section 75F of the *Environmental Planning and Assessment Act 1979*

Project	Establishment of three offshore artificial reefs at Newcastle, Sydney and Wollongong. The artificial reefs structures would be approximately 10m in height and constructed of steel.
Site	~2-3km off the east coast of Newcastle, Sydney and Wollongong
Proponent	Department of Primary Industries
Date of Issue	July 2008
General Requirements	The Environmental Assessment must include: • an executive summary; • a detailed description of the project, including the: – need for the project; – alternatives considered; – likely staging of the project; and – plans that sufficiently outline the spatial arrangement of deployed structures; • a risk assessment of the potential environmental impacts of the project, identifying the key issues for further assessment; • a detailed assessment of the key issues specified below, and any other significant issues identified in the risk assessment (see above), which includes: – a description of the existing environment, using sufficient baseline data; – an assessment of the potential impacts of all stages of the project, including any cumulative impacts, taking into consideration any relevant statutory provisions, technical or policy guidelines (see below); – a description of the measures that would be implemented to avoid, minimise, mitigate, rehabilitate/remediate, monitor and/or offset the potential impacts of the project, including detailed contingency plans for managing any potentially significant risks to the environment; • a statement of commitments, outlining all the proposed environmental management and monitoring measures; • a conclusion justifying the project on economic, social and environmental grounds, taking into consideration whether the project is consistent with the objects of the *Environmental Planning & Assessment Act 1979*; • a signed statement from the author of the Environmental Assessment, certifying that the information contained within the document is neither false nor misleading.
Key Issues	• **Coastal Processes** – including: – coastal hazards, coastal inundation, wave run up/ reflection, and adequacy of the structures stability and height in light of the projected sea level rises; – sediment circulation, sedimentation budgets, erosion and sand bypassing; and – changes in wave behaviour, including wave dispersion and creation via amendments to orbital/oscillatory motions; • **Flora and Fauna** – including: – an assessment of any impacts on critical habitats, threatened species, protected species, populations or ecological communities and their habitats in the region, and in particular potential impacts from angling activities and measures to mitigate these impacts; – potential significant impacts from draw down effects from faunal populations in adjacent natural reef areas and aggregation of any

	threatened/protected species and communities; and – an assessment if any potential impacts on the Five Islands Nature Reserve; • **Project Monitoring** – including procedures to monitor: – the integrity of the reef structures; – any impacts on significant components of the marine ecosystem; – any impacts and aggregation of threatened/protected species and communities; – the effectiveness of the reefs including catch rates, species composition of catch, and fish stocks; – the usage of the reefs by anglers and other members of the public; and – any conflicts between users of the reef; • **Sediments and Water** – including sediment disturbance during the sinking process and leaching of contaminants from the reef structures; • **Navigation and safety** – including an assessment of the impacts on water based traffic; • **Infrastructure** – requirements for land base infrastructure including any upgrades required for existing infrastructure; • **Heritage**; and • **Construction** – including the measures to minimise potential noise, air quality, traffic, soil and water and waste impacts.
References	While not exhaustive, the following attachment contains a list of the guidelines, policies, and plans that may be relevant to the project.
Consultation	During the preparation of the Environmental Assessment, you should consult with the relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners. In particular, you must consult with: • Department of Environment and Climate Change; • Sydney Ports Corporation; • Newcastle Ports Corporation; • Port Kembla Ports • NSW Maritime; • Department of Lands; • Department of Primary Industries (Aquatic Habitat Protection) • Commonwealth Department of Water, Environment, Heritage and the Arts; and • relevant Councils, coastal patrol groups, commercial and recreational fishing groups etc. The consultation process and the issues raised must be described in the Environmental Assessment.
Deemed refusal period	60 days

Technical and Policy Guidelines

Aspect	Policy /Methodology
Risk Assessment	
	AS/NZS 4360:2004 Risk Management (Standards Australia)
	HB 203: 203:2006 Environmental Risk Management – Principles & Process (Standards Australia)
Soil and Waters	
Soil	Acid Sulfate Soil Manual (ASSMAC)
	Managing Urban Stormwater: Soils & Construction (Landcom)
Water	NSW Coastal Policy (NSW Government)
	Coastline Management Manual (NSW Government)
	State Environmental Planning Policy No 71 – Coastal Protection
	National Water Quality Management Strategy: Water quality management - an outline of the policies (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Policies and principles - a reference document (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Implementation guidelines (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)
	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC)
Flora and Fauna	
	Policy & Guidelines - Aquatic Habitat Management and Fish Conservation (NSW Fisheries)
	Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities. Working Draft (DEC)
	Draft Guidelines for Threatened Species Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* (DEC)
	Threatened Species Assessment Guidelines: The Assessment of Significance (DECC)
Heritage	
Aboriginal	Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC)
	Aboriginal Cultural Heritage Standards and Guidelines Kit (NSW EPA)
	Interim Community Consultation Requirements for Applicants
Non-Indigenous	NSW Heritage Manual (NSW Heritage Office & DUAP)
	The Burra Charter (The Australia ICOMOS charter for places of cultural significance)
Noise	
	NSW Industrial Noise Policy (DECC)
	Environmental Criteria for Road Traffic Noise (NSW EPA)
	Environmental Noise Control Manual (DECC)
Air Quality	
	Protection of the Environment Operations (Clean Air) Regulation 2002
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC)

Appendix 2.

Commonwealth Legislation Requirements (EPBC Act)

GUIDELINES FOR THE CONTENT OF A DRAFT PUBLIC ENVIRONMENT REPORT (PER)

Pilot Offshore Artificial Reefs off Newcastle, Wollongong and Sydney, NSW

Environment Protection and Biodiversity Conservation Act 1999

(Reference: 2008/4176)

TABLE OF CONTENTS

GUIDELINES FOR A DRAFT PUBLIC ENVIRONMENT REPORT

Pilot Offshore Artificial Reefs off Newcastle, Wollongong and Sydney, NSW

NSW Department of Primary Industries

PREAMBLE

The proponent, the NSW Department of Primary Industries, proposes to create 3 groupings (4 artificial reef units at each site) of steel structures for the purpose of creating offshore artificial reefs (OARs) off the coast of Newcastle, Wollongong, and Sydney. The installation dates and time frames for deployment of the artificial reef units have not been determined, however it is likely to occur around August 2009.

On 23 April 2008, the proposal was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) to the Minister for the Environment, Heritage and the Arts. On 23 May 2008, the delegate of the Minister determined that the proposed action requires approval under the EPBC Act, and that it will be assessed by a Public Environment Report (PER). The proposed action has the potential to have a significant impact on the following matters of national environmental significance (NES) that are protected under Part 3 of the EPBC Act.

- Listed threatened species (sections 18 and 18A)
- Listed migratory species (sections 20 and 20A)
- Commonwealth marine environment (sections 23 and 24A)

Information about the action and its relevant impacts, as outlined below, is to be provided in the PER. This information should be sufficient to allow the Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.

GENERAL ADVICE ON GUIDELINES

1 GENERAL CONTENT

The PER should be a stand-alone document that addresses the NES matters listed above. It should contain sufficient information to avoid the need to search out previous or supplementary reports.

The PER should enable interested stakeholders and the Minister for the Environment, Heritage and the Arts to understand the environmental consequences of the proposed development. Information provided in the PER should be objective, clear, and succinct and, where appropriate, be supported by maps, plans, diagrams or other descriptive detail.

The body of the PER is to be written in a clear and concise style that is easily understood by the general reader. Technical jargon should be avoided wherever possible. Cross-referencing should be used to avoid unnecessary duplication of text.

Detailed technical information, studies or investigations necessary to support the main text should be included as appendices to the PER. It is recommended that any additional supporting documentation, studies, reports or literature not normally available to the public, from which information has been extracted, be made available in an appropriate form during the period of public display of the PER. The proponent should also make the PER and supporting information available on the Internet.

If it is necessary to make use of material that is considered to be of a confidential nature, the proponent should consult with Department of the Environment, Water, Heritage and the Arts (DEWHA) on the preferred presentation of that material, before submitting the draft PER to the Minister for approval for publication.

The level of analysis and detail in the PER should reflect the level of significance of the expected impacts on the environment. Any and all unknown variables or assumptions made in the assessment must be clearly stated and discussed. The extent to which the limitations, if any, of available information may influence the conclusions of the environmental assessment should be discussed.

The proponent should ensure that the PER addresses the matters stated in Schedule 4 of the EPBC Regulations *Matters to be addressed by draft Public Environment Report* at **Attachment 1**.

2 FORMAT AND STYLE

The PER should comprise three elements:

- the executive summary;
- the main text of the document, and
- appendices containing detailed technical information and other information that can be made publicly available.

The guidelines have been set out in a manner that may be adopted as the format for the PER. This format need not be followed where the required information can be more effectively presented in an alternative way. However, each of the elements must be addressed to meet the requirements of the EPBC Act and Regulations.

The PER should be written so that any conclusions reached can be independently assessed. To this end all sources must be appropriately referenced using the Harvard standard. The reference list should include the address of any Internet "web" pages used as data sources.

The main text of the PER should include a list of abbreviations, a glossary of terms and appendices containing:

- a copy of these guidelines;
- a list of persons and agencies consulted during the PER;
- contact details for the proponent;
- the names of, and work done by the persons involved in preparing the PER; and
- the qualifications and expertise of the people involved in work contributing to the PER.

Maps, diagrams and other illustrative material should be included in the PER where appropriate. The PER should be produced on A4 size paper capable of being photocopied, with maps and diagrams on A4 or A3 size and in colour where possible.

The proponent should consider the format and style of the document appropriate for publication on the Internet. The capacity of the website to store data and display the material may have some bearing on how the document is constructed.

Information about species listed under the EPBC Act should be provided in electronic format to DEWHA. The provision of this information will help facilitate decision making under the EPBC Act and assist in the protection and recovery of species and communities.

SPECIFIC CONTENT

1 GENERAL INFORMATION

This should provide the background and context of the action including:

(a) the title of the action;
(b) the full name and postal address of the designated proponent;
(c) a clear outline of the objective of the action;
(d) legislative background for the proposal, including the NES matters protected under Part 3 of the EPBC Act and any other requirements and approvals needed under the EPBC Act;
(d) the specific location of the action including coordinates and maps;
(e) the background to the development of the action;
(f) how the action relates to any other actions (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action;
(g) the current status of the action; and
(h) the consequences of not proceeding with the action.

2 DESCRIPTION OF THE ACTION

All components of the action should be described in detail and a summary of reasons for the selection of each site provided. This should include:

(a) the precise location and alignment of all artificial reef groupings, distances from nearest land, depth of water at proposed sites, and estimated depth of water over the structures at lowest astronomical tide (LAT);
(b) a description of installation procedures, including stages of deployment and time period over which installation will take place, methods of transport and installation for artificial reef units;
(c) a description of design parameters of the structures or elements of the proposed action that will manage and mitigate potential impacts, for example, design specifications to ensure structural stability of the units in situ (given expected variable oceanographic conditions). Photographs/sketches of the reef units and information on the materials used and the source of materials must be provided.

3 FEASIBLE ALTERNATIVES

Any feasible alternatives to the proposed action need to be addressed, including:

(a) if relevant, the alternative of taking no action;
(b) a comparative description of the impacts of each alternative on the NES matter protected by Part 3 of the EPBC Act; and
(c) sufficient detail to clarify why any alternative is preferred to another.

Short, medium and long-term advantages and disadvantages of the options should be discussed.

4 DESCRIPTION OF THE ENVIRONMENT

Baseline data on the physical and biological characteristics of the environment of the proposed sites and the surrounding areas that may be affected by the action must be provided, including but not restricted to:

(a) Information about listed threatened and migratory species (in particular marine species) and associated habitats that are likely to be present in the vicinity of the proposed areas should be identified and the following information provided:
   - a description of the values and extent of the regional ecosystem impacted;

- contextual information about each species such as regional status, population and distribution, including mapping of regional distributions;
- a description of the species' core breeding and foraging habitats, including information about the regional distribution of suitable habitat; and

(b) Information on oceanographic and coastal processes including types of substrata; and

(c) A description of the surrounding Commonwealth marine environment that is likely to be impacted by the proposal, including but not restricted to:
- significant regional habitat for listed threatened and migratory marine species.

5 RELEVANT IMPACTS

The PER must include a description of all the potential relevant impacts of the proposed action, including consequential impacts as defined by Section 527E of the EPBC Act, on relevant matters of NES protected under Part 3 of the EPBC Act. The PER must include, but is not restricted to information in relation to:

(a) the potential direct, indirect and consequential impacts on listed threatened and migratory species;

(b) the Commonwealth marine environment such as:
  i. the potential direct, indirect and consequential impacts on regional habitat and the Commonwealth marine environment;
  ii. impacts on other users of the area (e.g. divers, spear fishers);
  iii. the potential impacts on important amenities, navigation, culturally and historically significant sites, threatened or migratory species or sensitive habitats;

(c) whether any relevant impacts are likely to be unknown, unpredictable or irreversible;

(d) analysis of the significance of the relevant impacts;

(e) any technical data and other information used or needed to make a detailed assessment of the relevant impacts; and

(f) the social and economic consequences of the action.

6 PROPOSED SAFEGUARDS AND MITIGATION MEASURES

The PER must provide information on mitigation measures, with a particular focus on matters protected under Part 3 of the EPBC Act. Specific measures must be provided and substantiated, based on best available practices and must include the following elements:

(a) A consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including:
- a description of proposed safeguards and mitigation measures to deal with relevant impacts of the action including mitigation measures proposed to be taken by State governments, local governments or the proponent;
- assessment of the expected or predicted effectiveness of the mitigation measures;
- any statutory or policy basis for the mitigation measures; and
- the cost of the mitigation measures.

(b) A detailed Environmental Management Plan (EMP) that sets out the framework for management, mitigation and monitoring of relevant impacts of the action, including any provisions for independent environmental auditing. The EMP must:
- state the environmental objectives, performance criteria, monitoring, reporting, corrective action, responsibility and timing for each environmental issue;
- describe contingencies for unplanned events;
- address monitoring for colonisation of reef structures, structural integrity and stability of the units and rectification of problems;

- name of the agency/s responsible for endorsing or approving each mitigation measure or monitoring program.

7 OTHER APPROVALS AND CONDITIONS

Information given on any other requirements for approval or conditions that apply, or that the proponent reasonably believes are likely to apply, to the proposed action must include:

(a) details of any local or State Government planning scheme, or plan or policy under any local or State Government planning system that deals with the proposed action, including:
- what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy; and
- how the scheme provides for the prevention, minimisation and management of any relevant impacts;

(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the EPBC Act), including any conditions that apply to the action;

(c) a statement identifying any additional approval that is required; and

(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.

8 CONSULTATION

Any consultation about the action, including:

(a) any consultation that has already taken place;

(b) proposed consultation about relevant impacts of the action;

(c) if there has been consultation about the proposed action, any documented response to, or result of, the consultation; and

(d) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.

9 INFORMATION SOURCES PROVIDED IN THE PER

For information given in a draft PER, the draft must state:

(a) the source of the information;

(b) how recent the information is;

(c) how the reliability of the information was tested; and

(d) what uncertainties (if any) there are regarding the information.

10 ENVIRONMENTAL RECORD OF PERSON(S) PROPOSING TO TAKE THE ACTION

Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against:

(a) the person proposing to take the action; and

(b) for an action for which a person has applied for a permit, the person making the application.

If the person proposing to take the action is a corporation, also include details of the corporation's environmental policy and planning framework.

11 CONCLUSION

An overall conclusion as to the environmental acceptability of the proposal should be provided.

ATTACHMENT 1

MATTERS THAT MUST BE ADDRESSED IN A PER
(SCHEDULE 4 OF THE EPBC ACT REGULATIONS 2000)

1 General information

1.01 The background of the action including:

(a) the title of the action;

(b) the full name and postal address of the designated proponent;

(c) a clear outline of the objective of the action;

(d) the location of the action;

(e) the background to the development of the action;

(f) how the action relates to any other actions (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action;

(g) the current status of the action; and

(h) the consequences of not proceeding with the action.

2 Description

2.01 A description of the action, including:

(a) all the components of the action;

(b) the precise location of any works to be undertaken, structures to be built or elements of the action that may have relevant impacts;

(c) how the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts;

(d) relevant impacts of the action;

(e) proposed safeguards and mitigation measures to deal with relevant impacts of the action;

(f) any other requirements for approval or conditions that apply, or that the proponent reasonably believes are likely to apply, to the proposed action;

(g) to the extent reasonably practicable, any feasible alternatives to the action, including:

- (i) if relevant, the alternative of taking no action;
- (ii) a comparative description of the impacts of each alternative on the matters protected by the controlling provisions for the action; and
- (iii) sufficient detail to make clear why any alternative is preferred to another;

(h) any consultation about the action, including:

- (i) any consultation that has already taken place;
- (ii) proposed consultation about relevant impacts of the action; and

(iii) if there has been consultation about the proposed action — any documented response to, or result of, the consultation; and

(i) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.

3 Relevant impacts

3.01 Information given under paragraph 2.01(d) must include

(a) a description of the relevant impacts of the action;

(b) a detailed assessment of the nature and extent of the likely short term and long term relevant impacts;

(c) a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;

(d) analysis of the significance of the relevant impacts; and

(e) any technical data and other information used or needed to make a detailed assessment of the relevant impacts.

4 Proposed safeguards and mitigation measures

4.01 Information given under paragraph 2.01(e) must include:

(a) a description, and an assessment of the expected or predicted effectiveness of, the mitigation measures;

(b) any statutory or policy basis for the mitigation measures;

(c) the cost of the mitigation measures;

(d) an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing;

(e) the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program; and

(f) a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including mitigation measures proposed to be taken by State governments, local governments or the proponent.

5 Other Approvals and Conditions

5.01 Information given under paragraph 2.01(f) must include:

(a) details of any local or State government planning scheme, or plan or policy under any local or State government planning system that deals with the proposed action, including:

(i) what environmental assessment of the proposed action has been, or is being carried out under the scheme, plan or policy; and

(ii) how the scheme provides for the prevention, minimisation and management of any relevant impacts;

(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action;

(c) a statement identifying any additional approval that is required; and

(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.

6 Environmental record of person proposing to take the action

6.01 Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against:

(a) the person proposing to take the action; and

(b) for an action for which a person has applied for a permit, the person making the application.

6.02 If the person proposing to take the action is a corporation — details of the corporation's environmental policy and planning framework.

7 Information sources

7.01 For information given the PER must state:

(a) the source of the information; and

(b) how recent the information is; and

(c) how the reliability of the information was tested; and

(d) what uncertainties (if any) are in the information.

Appendix 3

Stakeholder Contact List

Appendix 3: Stakeholders contacted during the Pilot Offshore Artificial Reefs consultation process

Fishery Advisory Councils	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Southern & Eastern Scalefish and Shark Fishery	Beth Gibson	6225 5305	beth.gibson@afma.gov.au	✓	✓	
(Commonwealth Trawl Sector) MAC	Beth Gibson	6226 5305	beth.gibson@afma.gov.au		✓	
Ocean Trap and Line MAC	Jackie Gerard		Jackie.Gerard@dpi.nsw.gov.au	✓	✓	
Ocean Trawl MAC	Neil Ward		"		✓	
Ocean Trawl MAC	Peter Plunkett		PO BOX 96, Montdale 2223		✓	✓
Ocean Hauling MAC			"		✓	
Lobster MAC			"		✓	
Seafood Industry Advisory Council	John Roach	9552 3171			✓	
Advisory Council on Recreational Fishing	Bruce Schumacher	07 3356 1111			✓	

Fishermans Co-operatives	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Newcastle Fishermans Co-operative	Brett Bolinger	49654221		✓		✓
Newcastle Fishermans Co-operative	Bill Pearce	49654221	wpearce@commfish.com.au	✓	✓	
Sydney Fish Markets	Olivia Salimbeli	9004 1100	www.sydneyfishmarket.com.au	✓	✓	
Wollongong Fishermans Co-operative	Antonia	4229 1976				

Commercial Fishermen	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Paul Bagnato	Paul Bagnato	0404232699		✓		✓
Richard Bagnato	Richard Bagnato	0439 343465		✓		✓
Trap and Line Fishery Representatives	Paul Sullivan		sluggois@optusnet.com.au		✓	
Trap and Line Fishery	Jason Moyse	0411 857856		✓		
Trap and Line Fishery	Denis Brown	4296 5376/0428 965376				✓
Rocko Musumeci (Illawarrastar)	Rocko Musumeci	0428 422949	illawarrastar@bigpond.com	✓	✓	
Gratziano Lammachia	Gratziano Lammachia	0410 637089	llinteriors@austar.net	✓	✓	✓

DPI Offices	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Hunter Fisheries Office	Warren Winter	4971 1201	warren.winter@dpi.nsw.gov.au		✓	✓
Sydney North Fisheries Centre	Paul	8437 4900	paul.schuetrumpf@dpi.nsw.gov.au		✓	

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Appendix 3: Continued

Sydney South Fisheries Office	Drew Egan	9529 6021	drew.egan@dpi.nsw.gov.au		✓	
Illawarra Fisheries Office	Daniel Minter	4295 1809	daniel.minter@dpi.nsw.gov.au		✓	✓
Illawarra Fisheries Office	Gavin McDonall	4295 1809/0438 245190	gavin.mcdonall@dpi.nsw.gov.au		✓	
Illawarra Fisheries Office	Emma Corfield	4295 1809	emma.corfield@dpi.nsw.gov.au		✓	✓
Fisheries Volunteer	Allison Maunsell	4422 8886/0438 228182	wombat@shoal.net.au		✓	✓
Fisheries Volunteer	Andrew Connor	4422 8886				✓

Fishing Associations/Clubs	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
MERCMAC/ACoRF	Ann Gerard	0428621875	kiamacharterservice@1earth.net	✓	✓	✓
Ecofishers	Ken Thurlow		suke7@bigpond.com			✓
Central Coast Blue Water Fishing Association	John Paine	4328 4594	jonc@bigpond.com	✓	✓	
Newcastle District Anglers Association	David Hitchcock	6573 1197	dhitchcock@ozemail.com.au		✓	
Newcastle and Port Stephens GFA	Nigel Rushworth	4981 0021	gamefish@nelsonbay.com		✓	
Lake Macquarie GFC	Lyndy Grieves	4971 2179	leatro@bigpond.com		✓	
Fishing Clubs Association, NSW	Margaret Riddell	6584 2728	secretary@nswfca.com.au		✓	
Central Coast Casting and Angling Club	Michael Hirst	4365 6539	mhi10937@bigpond.net.au		✓	
Anglers Action Group	Lionel Jones	4953 6048	jonesbream@hotmail.com		✓	✓
Anglers Action Group	Phil Ingram		aagfish@gmail.com		✓	✓
Australian Fishing Trade Association	Doug Joyner	99446210	tackletrade@optusnet.com.au		✓	
Amateur Fisherman's Association of NSW	Phoebe Forrester	9726 9174	pforrester@bigpond.com	✓	✓	
Amateur Fisherman's Association of NSW	Richard Spatr		26 Currawang Street, Concord West 2138			✓
Anglers Action Group	Warwick Gibson	96406444	aagfish@gmail.com		✓	
Charter Vessels Association	David Cribb	99681184	pearlbeach@bigpond.com		✓	
Australian National Sport Fishing Association	Yanko Serifi	49 720 057	yanko.serifi@atlasmetals.com.au	✓	✓	
Australian National Sport Fishing Association	Stan Constanteras		pastelli@netscape	✓	✓	
Australian National Sport Fishing Association	John Burgess		abtrap@yahoo.com.au	✓	✓	✓
Recreational Fishing Alliance of NSW	Malcolm Poole	043621687 or	president@rfansw.com.au	✓	✓	✓
		403125766	mpoole@optusnet.com.au		✓	
Sydney Game Fishing Club	Ivan Bennett		ivben@hotmail.com		✓	
Sydney Metropolitan Fishing Clubs Association	Paul Cooper	96653714	paul.cooper@nswfca.com.au		✓	
Sydney North Division	Chris Baily	9971 9951	oilsheik@froggy.com.au		✓	
South Sydney Amateur Fishing Association	Joe Garufi	0417 491868	jgred@bigpond.com		✓	
St George & Sutherland Shire Anglers Club	Terry Brown		kirk@netset.net.au		✓	

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Appendix 3: Continued

Sydney GFA	Ruan Simms	0405 255923	webmaster@sgfc.com.au		✓	
MERCMAC	Rolland Persson	0414525968	roland.persson@optusnet.com.au		✓	✓
RecFish	Bruce Schumacher	07 3356 1111	bruces@mefs.mq.edu.au	✓	✓	
South Coast FCA	Ken Cook	4233 1250	southcoastfca@yahoo.com.au	✓	✓	
Wollongong GFC	Bob Kernet	0407 010938	belrebel@bigpond.com	✓	✓	
Warilla Sports Fishing Club	Wayne Balmer	4295 7326	admin@thesporties.com.au	✓	✓	
Port Kembla Macedonian Fishing Club	Mendo Trajeski	4275 2266		✓		

Charter Operators	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Charter operator	Ted Hollis	4256 6173/0427 200739	wgongboatcharter@bigpond.com	✓	✓	
Krista Charters	Gratziano Lammachia	0410 637089	llinteriors@austar.net	✓	✓	✓
Illawarra Boat Charters	Rocko Musumeci	0428 422949	illawarrastar@bigpond.com	✓	✓	
Skuhna Charters		42844618/0414 774086	skuhna2@optusnet.com	✓	✓	
AAA Kiama Harbour Game and Fishing Charters		4232 1725/0429 960969	outfishn@bigpond.net	✓	✓	
Kiama Bluewater Charters		4232 3571/0427323571	kiamablue@bigpond.com		✓	
Signa Charters		0423 251603	info@mvsigna.com.au	✓	✓	
Aqullia Fishing Charters		4271 8440		✓		
Aurora Fishing Charters	Paul Reeves	4261 1710		✓		
Dougo's Fishing Charters	Ron Douglas	4256 6173		✓		
Sealady Fishing Charters		4234 2050		✓		
Tailermade Fishing	David Hayman	0411 096717		✓		✓
Tailermade Fishing	Greg Hayman	0411 006717		✓		✓
All At Sea Charters	Roland Persson		roland.persson@optusnet.com.au		✓	✓

Spearfishing Associations	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Australian Underwater Federation/ACoRF	Adrian Wayne	0418 282696	adrianwayne@optusnet.com.au		✓	
Australian Underwater Federation	Simon Tripp	0439 818409	simontrippe@gmail.com		✓	✓
USFA (Secretary)	Mel Brown	4283 2757	melbrown@tpg.com.au		✓	✓
USFA (President)	Peter Saunders					
USFA	Ian Puckeridge		ian_puckeridge@hotmail.com		✓	

Non-Government Agencies	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Nature Conservation Council of NSW	Ben Birt	9279 2855	bbirt@nccnsw.org.au	✓	✓	

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Appendix 3: Continued

Total Environment Centre	Jeff Angel	9261 3437	tec@tec.org.au	✓	✓	
Australian Conservation Foundation	Chris Smyth	0438 123 536	acf@acfonline.org.au		✓	
World Wildlife Fund	Gilly Llewellyn	9281 5515	gllewellyn@wwf.org.au	✓	✓	
Marine and Coastal Community Network	Craig Bohm?	9021 7091	nc@mccn.org.au	✓	✓	
Oceanwatch	Anissa Lawrence	9660 2262	anissa@oceanwatch.org.au	✓	✓	
Oceanwatch	Lowri Pryce	9661 2262	lowri@oceanwatch.org.au	✓	✓	✓
Oceanwatch	Brad Warren	4126 06959	brad@oceanwatch.org.au	✓		✓
Australian Marine Conservation Society	Kate Davey/Craig Bohm		amcs@amcs.org.au	✓	✓	
Fishcare	Martin Carroll	0414 978504	Martin.Carroll@gen-i.com.au			✓
Fishcare	Rod Macarthy		Rod.McCarthy@foodauthority.nsw.gov.au			✓
Fishcare	Peter Trispolisiosis					✓
National Parks Association	Nicky Hammond	9299 0000	marine@marine.org.au	✓	✓	

Local Councils	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
Newcastle City Council	Fiona Leatham	4974 2000	fleatham@ncc.nsw.gov.au	✓	✓	
Lake Macquarie City Council	Kim Bilham	4921 0333	kbilham@lakemac.nsw.gov.au	✓	✓	✓
Pittwater Council	Joanna Tulau	9970 1111	jtulau@pittwater.nsw.gov.au	✓	✓	
Warringah Council	General	9942 2111	council@warringah.nsw.gov.au	✓	✓	
Manly Council	General	9976 1500	records@manlycouncil.nsw.gov.au	✓	✓	
Woollahra Council	Rebecca Peacock	9391 7000	rebecca.peacock@woollahra.nsw.gov.au	✓	✓	
Waverley Council	General	9369 8000	waver@waverley.nsw.gov.au	✓	✓	
Randwick Council	General	9399 0999	general.manager@randwick.nsw.gov.au	✓	✓	
Sutherland Shire Council	General	9710 0333	ssc@ssc.nsw.gov.au	✓	✓	
Sydney Coastal Councils Group Inc	Geoff Withycombe	9246 7791	geoff@sydneycoastalcouncils.com.au	✓	✓	
Wollongong City Council	Tony Miskiewiz	4227 7111	tmiskiewicz@wollongong.nsw.gov.au	✓	✓	✓
Shellharbour City Council	General	4221 6111	records@shellharbour.nsw.gov.au	✓	✓	

Government Agencies	Contact	Phone No.	Email/Address	Phone	Email/Letter	Meeting
DECCW	Doug Lord	4904 2587	doug.lord@environment.nsw.gov.au		✓	✓
DECCW	Josh Gibson		josh.gibson@environment.nsw.gov.au		✓	✓
DECCW	Peter Davies		peter.davies@environment.nsw.gov.au		✓	✓
DECCW	Veronica Lenevez		veronica.lenevez@environment.nsw.gov.au		✓	✓

Continued

Appendix 3: Continued

Dept. of Lands	Kirsty Chan		kristy.chan@lands.nsw.gov.au		✓	✓
Dept. of Planing	Ann-Maree Caruthers		ann-maree@planning.nsw.gov.au		✓	✓
Dept. of Planning	Chris Richie		chris.richie@planning.gov.nsw.au		✓	✓
NSW Maritime	Sandy Allan		sallan@maritime.nsw.gov.au		✓	✓
NSW Maritime	Brett Moore	02 9563 8660	brett.moore@maritime.nsw.gov.au	✓	✓	
Port Authorities	**Contact**	**Phone No.**	**Email/Address**	**Phone**	**Email/Letter**	**Meeting**
Sydney Ports Corporation	Capt. Robin Heath	1 9296 4650	rlorraine@sydneyports.com.au		✓	✓
Newcastle Port Corporation	Mr Tim Turner	02 4926 4596	tim.t@newportcorp.com.au		✓	✓
Port Kembla Ports Corporation	Don Buckthought				✓	✓
Port Kembla Ports Corporation	Kell Dillon	02 4275 0132	kjd@portkembla.com.au	✓		
Indigenous Heritage Stakeholder Groups	**Contact**	**Phone No.**	**Email/Address**	**Phone**	**Email/Letter**	**Meeting**
Central Coast Hunter Region Aboriginal Co-Management Committee					✓	✓
La Perouse LALC	Ros Fields	9311 4282	lapaland@bigpond.com.au		✓	✓
Illawarra LALC	Sharralyn Robinson	02 4226 3338	srobinson@exemail.com.au		✓	✓
Batabah LALC	Michael Green	02 4791 4800	bahtabah@nexon.com.au		✓	✓
Registrar of Aboriginal Owners						

Appendix 4

Stakeholder Consultation Workshops

Issues Summary

Offshore Artificial Reefs Environmental Assessment - Stakeholder Consultation Meetings

Issues Summary

December 2008

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Cardno
Ecology Lab
Shaping the Future

Offshore Artificial Reefs Environmental Assessment - Stakeholder Consultation Meetings

Issues Summary

Project Representatives

Marcus Lincoln Smith	Cardno Ecology Lab
Kate Reeds	Cardno Ecology Lab
Heath Folpp	NSW DPI
Brian Van der Walt	NSW DPI
Micheal Lowry	NSW DPI

Final List of Participants

Doug Lord	DECC
Peter Davies	DECC
Ken Thurlow	ECOfishers
Peter Plunkett	AB MAC/Ocean Trawl
Dennis Brown	OHMAC/SPFMAC
Lowri Pryce	Oceanwatch
Brad Warren	Oceanwatch
Peter Tripalitsiotis	Fishcare Volunteer
Rod McCarthy	Fishcare Volunteer
Martin Carroll	Fishcare Volunteer
Simon Trippe	Underwater Skindivers and Fisherman's Association
Mel Brown	Underwater Skindivers and Fisherman's Association
Malcolm Poole	NSW Recreational Fishing Association
Richard Spatr	NSW Amateur Fishing Association
Ann Garard	ACoRF/Kiama Charter Service/RFTEC
Phil Ingram	Anglers Action Group
Lionel Jones	Anglers Action Group
John Burgess	Australian National Sports Fishing Association
Paul Bagnato	Commercial Fisherman
Richard (Diego) Bagnato	Commercial Fisherman
Gratziano Lammachia	Commercial Fisherman/Charter Operator
John Diplock	Independent consultant
Roland Persson	All at Sea Charters
Greg Hayman	Tailormade Fishing Charters
David Hayman	Tailormade Fishing Charters
Kym Bilham	Lake Macquarie Council
Tony Miskiewitz	Wollongong City Council
Don	Hunter Fisheries Office
Brett Bollinger	Commercial Trawl Fisherman
Emma Corfield	DPI Lake Illawarra
Dan Minter	DPI Lake Illawarra
Andrew Connor	Fisheries Volunteer
Allison Maunsell	Fisheries Volunteer

Introduction

This document summarises the main issues and concerns raised during three stakeholder consultation meetings held at Newcastle, Sydney and Wollongong in November/December 2008. Note that this document addresses issues raised only during the consultation meetings and does not include other written comments which have been independently submitted to Cardno Ecology Lab Pty Ltd. Additional comments or written contributions will be included in the final Environmental Assessment and Public Environment Reports.

The aims of the stakeholder consultation meetings were:

- to introduce key stakeholders to the aims and objectives of the offshore artificial reef (OAR) project;

- to allow input from stakeholders and user groups to be included into the environmental assessment process for offshore artificial reefs;

- to allow stakeholders and user groups to have input into the fine tuning of *potential* offshore artificial reef locations and;

- to provide a forum for feedback on the proposed offshore artificial reef project.

Results of the consultation have been summarised as follows:

1. Need for Offshore Artificial Reefs

Local commercial fishing representatives raised concerns that the expenditure on offshore artificial reefs (OARs) was unnecessary as there is already a great deal of artificial structure (such as scuttled ships, wrecks etc.) present in NSW waters, with particular reference to the Sydney region. It was also suggested that there is a significant amount of existing natural reef present (Sydney/Wollongong regions). NSW DPI explained that the OARs are specifically designed and positioned to produce a high quality recreational fishing reef aimed at attracting certain types of fish species and that specific designs have been based on long term research from other countries where artificial reefs have proven successful tools for fisheries enhancement.

2. Cost

Enquiries were made about the cost of the project and unit prices of the structures themselves. DPI estimated the cost of individual structures at $160,000 per unit i.e. $640,000 for a reef set (per location). It was enquired as to why the artificial reefs couldn’t be created more cheaply e.g. out of existing scrap materials and car tyres which have been utilised in the past. DPI explained that there is still considerable cost in preparing any scrap material or vessels for scuttling and that car tyres are no longer considered suitable for artificial reefs as their use if often perceived as simply a means of waste disposal. The importance of having a reef designed and positioned for high quality fishing was again stressed and that use of scrap materials are likely to produce sub-optimal results.

The issue of where and how the reefs would be constructed was also raised. DPI thought it likely that a different contractor would be appointed for each of the three regions. DPI is currently preparing a ‘request for quote’ for the appointment of suitable contractors.

3. SCUBA Diving
General concern was expressed about the potential use of offshore artificial reefs by SCUBA divers including potential conflict with other users and safety issues. Those user groups which pay a recreational fishing license fee also felt that as SCUBA divers don't contribute to the recreational fishing license fee and already have a number of sites exclusively for recreational diving they should not be entitled access to the reef.
Safety was also a major concern in regards to SCUBA divers. DPI does not intend that the reefs be utilised by SCUBA divers and are investigating the possibility of legislating against their use under the Crown Lands Act.

4. Spear fishing
Representatives from the Underwater Skin divers and Fisherman's Association (USFA formerly the AUF), were confident that a number of young free divers are now capable of diving to depths in the OAR range (in excess of 25 m) and that the associated safety risks should be considered.
It has also been suggested that one of the four reef units (per location) be placed at a depth accessible to the majority of spear fishers to prevent conflict with other users and for safety. Time management was also suggested as a way of reducing user conflict.
The consensus was that recreational fishers supported the use of the reefs by skin divers, providing that the reefs are managed appropriately. Communication between spear fishing and recreational fishing groups has proven successful in the past, whereby agreement on a code of conduct (a right of way for recreational fishing over spear fishing) was agreed upon. The FAD (Fish Aggregation Device) program (run by DPI) was highlighted by the USFA as a generally successful example of this, with few instances of conflict. DPI would aim to address any reported incidents on a case by case basis unless further action was considered necessary.

5. Commercial fishing
Recreational fishing representatives enquired whether the OARs would be open to commercial fishing. DPI's response was that they did not intend to exclude commercial operators from utilising the reefs although the objective of the proposal is to enhance recreational fishing and not commercial fishing. This was considered an issue of concern for some of the recreational fishing representatives. DPI intend to manage the issue accordingly should problems with conflict arise.
Professional fishermen (Richard and Paul Bagnato) operating in the Sydney and Newcastle study regions, were generally against further obstacles and restrictions on trawling areas and requested further consultation prior to determining the final locations of OARs in the Newcastle and Sydney regions. However, providing that they are consulted on determining the final positions and that the OARs would not be in the way of trawl shots, PB and RB were not opposed to the proposal.
Trap and line fisherman Dennis Brown (DB), was concerned that deployment of an offshore artificial reef at the proposed Wollongong location would prove very popular and encourage individuals to vandalise or steal commercial trap gear deployed in the vicinity. A mechanism to compensate for lost gear was suggested. However, a distance of 1 km from the proposed reef and areas of natural reef where traps are set was considered a reasonable distance to restrict any direct interference.

6. Location and Configuration

A concern in the Newcastle region was the potential for bulk carriers to drag anchor into shallower water. Newcastle Port Authority does not recommend that vessels anchor within the 3 nm limit of State waters, however, commercial fisherman that operate in the region often observed large vessels dragging anchors into shallower water. Commercial operators suggested that reef units should be located on the 35 m contour (rather than 40 m) to avoid this potential hazard.

In the Sydney region, increased shipping movements from the completion of the Port Botany expansion (likely to be completed in 2011) was considered a potential issue if commercial traffic was to significantly increase. Cardno Ecology Lab is addressing these issues in detail as part of the Environmental Assessment and consultation with relevant Port Authorities/NSW maritime in terms of navigation and safety is currently under way.

It was generally considered that distance from land based infrastructure was important for public recreational fishing (at all locations) and therefore the reef set should be located within a safe and accessible distance for small boat users. This was of particular concern for the Sydney and Newcastle regions. Conversely, a deeper location was thought preferable in terms of stability and would discourage SCUBA diving.

It was questioned whether reefs would be physically marked. DPI expected that the reefs would be marked on Auscharts by NSW Maritime but not by marker buoys as they are likely to be lost.

The current configuration of the individual reef units is a square/diamond shape. Discussions with recreational, charter and trawl operators indicated a preference for a line arrangement (orientated north to south) that would help spread out users and would be easier for trawlers to navigate past.

Commercial and charter vessel representatives in the Wollongong region were in agreement that the proposed location for the Wollongong reef was generally suitable in terms of substratum (which is known to be predominantly sand) and accessibility, as there are three major access points. It was, however, considered too far for vessels based in the Kiama region to utilise. It was agreed that some minor adjustment of the final location would be required to ensure the OAR was positioned away from existing natural reef which is known to extend either side of the proposed location. DPI will be undertaking side scan sonar surveys of the area in January 2009 to provide a habitat map in and around the proposed location. Local fishermen have also offered to provide GPS reference points of the existing reef in the area. Seabed habitat mapping at the Newcastle and Sydney regions is currently underway.

7. Ecology

Production versus attraction, i.e. the ability for artificial reefs to increase actual productivity, or to simply draw fish from other areas (such as natural reefs) was an issue raised at all meetings. According to DPI, results of research in this area has shown that catch rates and mean size of individuals are shown to increase, but that testing for an overall increase in productivity has proven difficult. Furthermore, DPI highlighted the need to collect species specific data to properly investigate productivity.

According to John Diplock (JD), most recent studies on large scale artificial reef groups in Korea and Japan (where artificial reefs are used extensively to enhance commercial fish stocks) have demonstrated an increase in productivity (not just catch rates). It was explained that Korean and Japanese reefs attract a range of reef species closely related to local species, such as mulloway, yellowtail kingfish and snapper (for example). RB thought it likely that small nannygai and tarwhine would also be likely to occur at the proposed Sydney location. Influence of seasonal current fluctuation was also discussed in terms of species diversity.

Once deployed, DPI would monitor the success of the reefs over a period of at least two to three years (although this is likely to be longer) and that the overall lifetime of the reef units is expected to be at least 30 years. Questions on data ownership were raised and DPI stated that data collected by DPI during any monitoring studies would be owned by DPI but the Environmental Assessment and Public Environment Reports would be publicly available. Raw data can also be requested through DPI.

It was inquired how long it would take before the reefs began attracting fish. According to DPI, fish are likely to be found on the reef almost immediately with a succession of encrusting invertebrates and mobile macroinvertebrates colonising over a period of months. Previous examples (such as estuarine reef balls) have shown an increase in biodiversity over time before reaching a plateau (or carrying capacity) after a period of approximately 2 years.

Potential to increase pest species (by creating surface for settlement) and because of their proximity to major ports was raised as a potential concern at the Newcastle and Sydney meetings. Given the relative surface area of the reefs however, Cardno Ecology Lab thought it extremely unlikely that the introduction of the reefs would exacerbate pest species in any of the regions, but that the issue would be addressed in detail as part of the environmental assessment. Long term monitoring of the reefs was also suggested as a potential tool for assessing the extent of pest species, particularly in the Sydney and Newcastle areas.

8. Mooring/Anchoring

It was questioned whether anchoring would be permitted in the vicinity of the OARs. In terms of safety DPI expected that anchoring would not be permitted at any of the reefs and that drift fishing would be the most suitable fishing method.

9. Minerals Exploration

Lake Macquarie Council was concerned about minerals exploration licenses and seismic survey work granted in the Newcastle region due to commence in 2009. As the minerals extraction license area falls outside of the 3 nm limit of State water, it was considered unlikely to impact on the OARs but has been noted as a matter for further consideration in the Environmental Assessment.

10. Timing

Enquires were made as to when the OARs would be operational if approved. DPI expected timing for the deployment of the structures (if granted approval) to be in late 2009.

11. Naming

Lake Macquarie Council raised the point that the ‘Newcastle’ offshore artificial reef was misleading and that it should be named according to the specific geographic region. ‘Lake Macquarie’ or the ‘Hunter’ were suggested as alternatives which DPI were in favour of considering.

12. Success of OARs

In response to questions about the future of the artificial reefs and assessing the overall success of the reefs, DPI expected this would be gauged by the popularity and uptake of the recreational fishing community. DPI stated that if supported, the project would be likely to result in further reefs being deployed nationwide.

Tasks to be Actioned

- *Cardno Ecology Lab and NSW DPI will address the issue of exclusion to SCUBA divers and management options for integrating spear fishing, commercial and recreational fishing as part of the EA process.*

- *Cardno Ecology Lab, NSW DPI, RB/PB and commercial fishermen in the Wollongong and Newcastle regions will meet to discuss final locations in the New Year.*

- *Cardno Ecology Lab and NSW DPI will investigate the feasibility of altering the reef unit configuration (i.e. a line instead of a square/diamond) to optimise accessibility.*

- *Concern over navigation and safety issues will be addressed in detail as part of the environmental assessment. The Cardno Ecology Lab study team is currently undertaking consultation with the relevant Port Authorities and NSW Maritime.*

- *The Production versus attraction issue will be addressed in detail by Cardno Ecology Lab as part of the Environmental Assessment, as will issues on threatened species, pest species and migratory species potentially affected by the proposal*

It should be noted that the consultation phase of the project is ongoing and further input from interested stakeholders and user groups is welcomed. There will also be an opportunity to formally comment on the Environmental Assessment and Public Environment Report when they are released in 2009.

Appendix 5

Stakeholder Letters

“*Conservation through sustainable use. _Making people part of the solution*”

“The voice of NSW recreational fishers”

Web site; www.ecofishers.com

PO Box 200
Byron Bay NSW 2481
7 . 12 . 08

Ms Kate Reeds,
Cardno Ecology Lab
4 Green St
Brookvale NSW 2100.

Re: Artificial Reef Fields – Offshore.
Newcastle, Sydney and Wollongong.

Dear Kate,

Consultation with our state wide membership has produced the following recommendations, for our recreational fisher funded, offshore artificial reef fields. They should be:-

1) Commercial SCUBA diver free zones. (Research and maintenance dives to be conducted in consultation with local offshore recreational fishers.)

2) Commercial fishing free zones. (Fisheries Management Act Sec 8 Notification / Closures. Refer to Sec 4 definitions of take / interference, etc)

3) Charter fishing boat free zones. (Charter vessels are larger and therefore able to work the traditional and wider offshore grounds in most weathers and greater safety.)

4) Anchor free zones – trolling and drift fishing only.

5) Artificial Reef fields ought be sited in a basically North – South orientation (with the prevailing current) and slightly staggered in a

roughly zig – zag pattern, say 300m apart. This alignment will provide maximum use, with safety.

6) Artificial Reef fields to be excluded, by regulation, from any zoning in any proposed government marine park.

Kate, should you require any further clarification of these requirements, please don't hesitate to contact us.

Regards and best wishes for the festive season,

Ken Thurlow

Ken Thurlow
CEO ECOfishers NSW.

Phone / Fax 02 / 66 857 166.
Email: suke7@bigpond.com

From: Tony Payne [mailto:tpayne@BURNSIDE.ORG.AU]
Sent: Wednesday, 10 December 2008 10:01 AM
To: suke7@bigpond.com
Subject:

Hi There

As spearfisherman who lives in the Newcastle area I would like make a comment on the artificial reef system being tabled as suggestions by New South Wales Fisheries.

I think these reefs are a great idea especially since the release of the suggested new marine park from Newcastle to Wollongong. I am extremely concerned when percentages are used to describe how much of our natural resource will be closed to all fishing activities IE "sanctuary Zones". In other marine parks for example they state only 10 % will be Sanctuary Zones and the general public say "that doesn't seem like much" however what they forget to say is that 10% constitutes 60 -70 % of the suitable fishing arears or reefs the rest is open sand or other areas where fish generally don't congregate.

The idea of these underwater structures is great, I would make mention however that to place all of them in 35meters of water will exclude many spearfishers who do not have the capacity to dive that deep. I understand the shipping lanes as I see them every day just of the coast of where I live. One possible solution is to make some of these structures 8 – 9 meters high and place them in 20 metres of water. This way the ships should not be in less then 20 metres if we use their rule of thumb for the depth of 35meter. On the Newcastle coast and central coast there are plenty of relatively flat rock sections in the 20 metre mark these would be suitable places and would not interfere with the trawlers as they general trawl over open sand arrears were there nets don't get snagged.

These artificial systems of fishing will become our future if the conservationist have there way, and lets face it they will.

Any new systems need to be available for all fishers, to place all reefs in 35 meters also excludes individuals with small tinnies who cant venture that far to sea.

I think I should just take up Knitting?????

Food for Thought

Antony Payne ☺

From:	Paul Cooper	**Sent:** 19/11/2008 7:13:33 AM
To:	Kate Reeds (Brookvale)	
CC:	Ross Zappala; the forresters; Doug Chalker; dougchalker@optusnet.com.au; George Dapas; Howard Coy; Jannali Inn Fishing Club; Jason Woodward; Max Mondolo; sluggois@optusnet.com.au; Steve Elena; Vicky Martin; Brett Turner; GRANT LUGG; Merv McFie; Mr. Allan Cannon; Mr. Mark Aston; Mr. Robert Smith; Mrs. Margert Riddel; ROSS GARVEN	
Subject:	RE: Offshore Artificial Reefs - Stakeholder Consultation Meeting	

Dear Kate,

I won't be attending and I have no interest from my Division. My view is that these will be a waste of time and money and that any money that is spent on this should be redirected to keeping the Gaden Trout Hatchery which the NSW Government has ear marked for closure. I think it unlikely that the Government will spend this money and if they do it is to be seen as a bribe to cover up the loss of facility in Botany Bay (which the anglers of NSW paid for to become a recreational fishing haven) and the impacts of the desalination plan (see below).

It is my view that the NSW Government should fix the state of NSW rather than fund projects like this. Put this up against kids now having to pay to get the bus to school or the blow out in health and I think you will agree that there are bigger fish to fry. I hope that we remove the state level of government completely.

Further, the time and the venue are ridiculous. How are people supposed to get home from the fish market? Also, how long would the briefing be? If it was done at Fisheries Cronulla at 9 am then the whole day could be used and people could drive there and park. This is the case with presentations so why not this?

I'm sorry if this seems negative but this is my view.

Cheers

Kate Reeds (Brookvale)

From: Nicky Hammond NPA [marine@marine.org.au]

Sent: Tuesday, 2 June 2009 5:20 PM

To: Kate Reeds (Brookvale)

Subject: Re: Nicky Hammond - Pilot Offshore Artificial Reefs Proposal

HI Kate,

Apologises for the delayed response. Things have been extremely busy at this end.

Please see below for NPA's views on the proposed articifical reef locations. Please feel free to contact me on the details below should you have any queries.

Nicky

NPA believes that locations for artificial reefs in the Hawkesbury Shelf Bioregion for fishing purposes should not overlap with those waters currently proposed for marine protected areas.

Currently just 0.4% of the Hawkesbury Shelf Bioregion is fully protected as sanctuary and it is the only full NSW bioregion with no marine park. In order to reach international targets for marine sanctuary protection and to meet Government commitments for a comprehensive and representative marine park system, there needs to be additional marine parks and aquatic reserve sanctuaries immediately created in this bioregion.

NPA's *The Torn Blue Fringe* report identifies the gaps in the current NSW sanctuary network. It has presented to the NSW Government, for the first time, marine protected area proposals showing how we can reach internationally recommended levels of marine sanctuary protection.

The Hawkesbury Shelf Bioregion is identified as the immediate priority for additional protection in NSW. A large marine park is recommended stretching from The Entrance to the southern end of Royal National Park whilst a number of smaller aquatic reserve sanctuaries (including the Five Islands Aquatic Reserve) have also been proposed for these coastal waters.

NPA believes that both artificial reefs and marine protected areas could potentially coexist (given more scientific certainty that they contribute to environmental and fish habitat enhancement). However, current marine protected area planning must take precedence over proposals for improved fishing opportunities.

Since the artificial reefs proposed are not compatible with both aquatic reserve sanctuaries and the sanctuary zones within marine parks, NPA believes there should not be any commitment to create artificial reefs within the waters identified in The Torn Blue Fringe as priority marine protected areas. Any pilot projects for artificial reefs should occur outside of these areas.

Nicky Hammond
Marine Program Manager
National Parks Association of NSW
PO Box 337, Newtown NSW 2042
Tel: 02 9299 0000; Fax: 02 9290 2525
Email: marine@marine.org.au
Website: www.marine.org.au

Join NPA~Marine today www.marine.org.au/supportmember.htm
Call 02 9299 0000 to make a donation today

Winners:

Appendix 6

Threatened Species
(State Assessment of Significance)

Appendix 6. 'Assessment of Significance' for threatened species, populations and communities protected under the *TSC* and *FM Act.*

FISH

East Coast Population of Grey Nurse Sharks

Species Name: Grey Nurse Shark (*Carcharias taurus*) - East Coast Population
Status: Critically endangered
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Grey nurse sharks typically occur on shallow rocky reefs along the NSW coast (Last and Stevens 1994). Young are born live and also occur on shallow rocky reefs, often segregated from the adults. Grey nurse sharks can be observed at day hovering or slowly swimming around high-relief reefs. It is thought that the species becomes more active at night where it hunts over rocky reef and over soft substrata (Smale 2005). There is also evidence to suggest that grey nurse sharks migrate along the NSW coast (northwards in autumn/winter and southwards in summer (Pollard *et al.*1996, Otway and Parker 1999). Hence, they could occasionally occur around any of the artificial reefs once installed and may potentially use the area for foraging. If this was the case, then it would be possible for individuals to be susceptible to incidental catch from recreational or commercial fishing (considered a threat to the species). Under State and Commonwealth law it is illegal to catch or harm grey nurse sharks, so those that are accidentally caught should be returned to the water unharmed. It is however, possible that damage caused by accidental catch could contribute to early mortality. While there is potential for grey nurse sharks to utilise the artificial reef habitat on occasion, and be at risk to incidental hooking or catch, it is considered unlikely that this would have adverse impact such that a viable local population would be placed at risk of extinction. This is based on the assumption that the OARs would be monitored for the occurrence of GNS and that appropriate mitigative action would be taken if the species was found to occur near the OARs.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. Under the *FM Act*, the whole NSW population of grey nurse sharks may be considered to be endangered. Notwithstanding this, the impacts of the proposal to grey nurse sharks would be the same as for a) and considered unlikely to have adverse impacts such that a viable local population would be placed at risk of extinction.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* The major habitat utilised by grey nurse sharks comprises rocky reefs, with small sandy gutters within the reef

matrix being often preferred microhabitat. There is some likelihood that the species ranges away from reefs to feed at night, but the extent of this range is unknown (Smale 2005). The proposal would not modify any core reef habitat of grey nurse sharks. The proposal would not isolate any reef from other habitat used by the species. There would, however, be a small loss of soft bottom habitat which grey nurse sharks may forage over on occasion. The lost soft bottom foraging area would amount to only a relatively small proportion of the total foraging area for the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). Many of the known aggregation sites for grey nurse sharks in the eastern Australian population have been declared critical habitat for the species and are protected by legislation administered by DPI. Areas declared critical habitat for the species include Little Broughton Island and The Pinnacle, north of Newcastle (within Port Stephens Marine Park), Magic Point (Maroubra) and Bass Point in the south. The Magic Point critical habitat occurs approximately 12.5 km from the proposed Sydney OAR site. The Bass Point critical habitat occurs approximately 8 km from the proposed Wollongong OAR site. Therefore no critical habitat would be directly or indirectly affected by the proposal.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. Grey nurse sharks are protected from all forms of fishing. Given their movement patterns, it is unlikely that grey nurse populations are confined to the relatively small spatial scale of their reserves (see section 'e'). It is therefore possible that grey nurse sharks occurring at known aggregation sites within the wider study areas could interact with the proposed OARs and be vulnerable to incidental capture. This could contravene objectives of the State and Commonwealth Recovery Plans for the species (Environment Australia 2002, NSW Fisheries 2002) which aim to reduce the impact of commercial and recreational fishing on the species. Conversely, creation of new recreational fishing areas may assist in the species recovery (consistent with recovery plans) by providing alternative fishing locations away from known aggregation areas.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. 'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a key threatening process. Grey nurse sharks are known to forage in sandy habitats characteristic of the proposed artificial reef sites. These sites are not however, considered to be important to the survival of the species or to constitute a significant percentage of total foraging area. The proposal is therefore not considered to constitute part of this, or any key threatening process.

Conclusion:

The proposal would not have any direct or indirect impacts on the habitat critical to the survival of the grey nurse shark. It is possible that the proposed artificial reefs could occasionally draw in migrating or foraging individuals, making them susceptible to incidental capture and consequent injury by commercial and/or recreational fishing. This is considered a threat to the species and contravenes State and Commonwealth recovery plans. However, the frequency, extent and magnitude of that threat is likely to be low and would not place the population at risk of extinction. In order to be prudent the OARs would be monitored to ensure negative impacts on GNS do not occur.

Great White Shark

Species Name: Great White Shark (*Carcharodon carcharias*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Great white sharks are large, highly predatory animals whose life cycle is poorly understood. They occur from cold temperate to tropical waters worldwide and generally frequent coastal waters, often close to shore. They also swim into bays and estuaries. Great white sharks are live bearers that do not appear to frequent specific

habitats. The exception is when they take up residence adjacent to rocky shores, particularly where seals or sea lions are present. Emerging evidence suggests that both juveniles and adults can range widely, with one tagged individual recorded from Tasmania along the NSW coast into southern Queensland. There is also anecdotal evidence that the species follows large schools of migrating fish (e.g. sea mullet, Australian salmon) and migrating whales, particularly those with calves. The sharks' prey also includes wide array of teleost fishes (Pogonowski 2002), it is therefore possible the predator would be attracted to fish aggregating around the OARs and become susceptible to incidental capture. Incidental hooking or capture could lead to mortality or capture induced sub-lethal stress. It is however, unlikely that the proposal would affect the life cycle of the species such that a viable local population would be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. There are no endangered populations of great white sharks listed under the TSC or FM Acts. Under these definitions, no endangered population of great white sharks would be disrupted by the proposal. Stockton Bight is considered an important area for the occurrence of the great white shark. However, given the significant distance from the proposed Newcastle OAR (over 25 km) it is not considered that there would be any adverse effect such that the local occurrence of the species was placed at risk of extinction.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable.
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* If great white sharks do prefer a particular habitat, it is likely to be rocky shores with seals or sea lions. They may also follow schools of fish along the coast, hence it is possible that OARs may affect the 'temporary' habitat of great white sharks. In that case, the proposed OAR locations are not considered to be significant known habitat, as the sharks are likely to simply follow the schools elsewhere. Since the proposed OAR locations are not known habitat, or likely to be significant habitat for great white sharks, it would not become isolated from other habitat used by the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat would be affected for great white sharks.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is an approved Great White Shark Recovery Plan (Web Reference 27). Prior to the implementation of protective legislation, commercial and recreational fishing were some of the most prominent threats to the great white shark. Although protected from all commercial or recreational fishing, the species is still susceptible to incidental by-catch despite management measures. The recovery plan aims to 'monitor and reduce impacts of commercial fishing' and further 'investigate and evaluate the impacts of recreational fishing' on the species. As such, the proposal would not contravene the aims of the recovery plan.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a key threatening process. Great white sharks are known to occur in the wider study areas of the proposed artificial reef sites on occasion. These sites are not however, considered to be habitat important to the survival of the species. The proposal is therefore not considered to constitute part of this, or any key threatening process.

Conclusion:
The proposal is not considered to have adverse affects on habitat important for the long term survival of the great white shark. It is possible that the proposal could lead to incidental hooking or capture, although it is considered unlikely that the species would be affected to the extent that a viable local population would be placed at risk of extinction. Hence, the proposal is not considered to represent a significant threat to the great white shark and no SIS is recommended. Suitable management measures should be employed to minimise any potential harm from incidental capture

Black Cod

Species Name: Black Cod (*Epinephelus daemelii*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Black cod, also known as black rockcod and saddled rockcod, occur from southern Queensland to Kangaroo Island (South Australia) and are found at Lord Howe Island, Norfolk Island, Kermadec Islands and the North Island of New Zealand (Heemstra and Randall 1993). They are protogynous hermaphrodites (i.e. change sex from female to male) and occur on relatively shallow coastal and estuarine rocky reefs. Juveniles may recruit to rock pools; adults are highly territorial, usually adopting a cave as a core territory. At the time of spawning males establish a harem within their territory. The life cycle of the species revolves around rocky reefs and possibly rock pools with pelagic dispersal of eggs and larvae. Black cod are not known to occur over the sandy habitat of the proposed OAR sites and due to their territorial nature it is unlikely that adults would utilise the new artificial habitat. It is however, possible that juveniles or vagrants could recruit to the new artificial reefs and become susceptible to incidental capture and hooking injuries. The likelihood of this occurring to the extent that a viable population is placed at risk of extinction is considered unlikely.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. No known endangered population of black cod exists within the proposed study area.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* As indicated in (a), black cod are usually found in caves or rocky reefs and no such areas would be directly affected by the proposal.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

No critical habitat for black cod would be affected by the proposal.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for this species
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. 'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a key threatening process. The proposed OAR sites are not considered to be habitat important to the survival of the species and therefore the proposal is not considered to constitute part of this, or any key threatening process.

Conclusion: The proposal is not considered to represent a significant threat to black cod, hence no SIS is recommended. Suitable management measures should be employed to minimise any potential harm from incidental capture.

Southern Bluefin Tuna

Species Name: Southern Bluefin Tuna (*Thunnus maccoyii*)
Status: Endangered
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Southern bluefin tuna are a pelagic species mainly occurring seaward of the continental shelf in waters between 50 m – 2743 m (Web Reference 28). The occurrence of the species within the 3 nm limit of State waters is considered rare although their distribution in Australian waters is known to extend from northern NSW around the south of the continent to northern Western Australia (Pogonowski *et al*. 2002). The species is highly migratory, moving to tropical seas off the west coast of Australia to spawn. Over harvesting is considered the main threat to the species. That considered, it is highly unlikely that the deployment and operation of the proposed OARs would have any adverse effect such that it would place local populations of the species at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. Not Applicable
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not Applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Habitat in the direct and wider study areas consists predominantly of fine to medium bare sandy seabed and is not considered unique or important in relation to the southern bluefin tuna. The installation of the OARs at the

three proposed locations is not considered to fragment or isolate areas of habitat important to the southern bluefin tuna.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for this species exists in the study areas
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for the species although the international Commission for the Conservation of the Southern Bluefin Tuna (CCSBT) aim to attain the 1980 spawning stock level by 2020.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. 'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a key threatening process. However, the proposed study areas are not considered important to the survival of the species and this KTP is therefore not considered relevant.

Conclusion:
Given the rarity of southern bluefin tuna inshore, it is considered unlikely that the proposal would have any adverse affect on the population or have any effect on habitat important to the population.

Green Sawfish

Species Name: Green Sawfish (*Pristis zijsron*)
Status: Presumed extinct
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. In 2000, the green sawfish was listed as an endangered species. In 2007 the listing was reviewed and the conservation status changed to 'presumed extinct' in NSW. The population decline of the green sawfish has mostly been attributed to fishing and incidental capture in commercial prawn and gill nets (Web Reference 29), although deliberate capture for sale and degradation of soft bottom areas important for feeding and breeding are also reasons. The last confirmed sighting of the Green sawfish was in 1972 from the Clarence River in Yamba. Green sawfish habitat includes muddy or sandy mud, soft sediment in inshore areas (Web Reference 29) where they mostly feed on shoaling fish such as mullet, molluscs and small crustaceans. Although it is possible that a small portion of soft bottom habitat would be lost through emplacement of artificial reef structures, this would not be significant due to the abundance of similar habitat and more favourable muddy substratum in the wider study area. Furthermore, the rarity of the species in the wider study areas in all regions suggests that the proposal would be very unlikely to have any adverse impact on the population which is already presumed extinct.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. Not applicable
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of*

the proposed action; and *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Habitat in the direct and wider study areas consists predominantly of fine to medium bare sandy seabed. A total of 400 m^2 (consisting of four, 10 m x 10 m areas) of seabed would be occupied by the artificial reef structures, although only the footprint of the actual steel supports would result in the loss of soft bottom habitat. It is possible that potential green sawfish habitat could be modified as a result of the proposal, although the habitat is not considered important to the long term survival of the species. The proposal is not considered to fragment or isolate areas of potential habitat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for this species exists in the study areas although inshore soft bottom areas are considered important to the species (Pogonowski *et al*. 2002).
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for the green sawfish.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. 'Hook and line fishing in areas important for the survival of threatened fish species' is listed as a key threatening process under the *FM Act*. Green sawfish are listed as one of the species likely to be vulnerable to this KTP. In the highly unlikely event that green sawfish were present in any of the direct study areas, it is possible the species could be subject to this KTP.

Conclusion:
Given the rarity of the green sawfish occurring in any of the three study areas, it is considered unlikely that the proposal would have any adverse affect on the long-term survival of the population or adversely affect habitat important to the population.

MARINE REPTILES

Species Group: Marine Turtles
Status: Vulnerable green turtle (*Chelonia mydas),* vulnerable leatherback turtle (*Dermochelys coriacea*) and endangered loggerhead turtle (*Caretta caretta*).
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Most of the listed marine turtles tend to prefer warmer waters, ranging from tropical to warm temperate seas (Marquez 1990). For a large part of their life cycle, marine turtles are pelagic, particularly leatherbacks, although green turtles tend to stay in coastal waters and may even take up residence in some areas. All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries. The species are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. By-catch of marine turtles in fisheries, marine debris, coastal development, loss of habitat and deterioration of water quality is also a significant threat to the species. The leatherback has a wide distribution and may be observed all around Australia. The green turtle is generally found in more northern latitudes of Australia although resident groups of green turtles have been found in northern New South Wales, in Jervis Bay and in more southerly estuaries. Loggerheads occur in coral reefs, bays and estuaries in tropical and warm temperate waters off the coast of Queensland, Northern Territory, Western Australia and New South Wales.

Although these species may occasionally occur within the entire study region (from Newcastle, south to Wollongong) this is outside the range of known nesting, mating or feeding areas. Moreover, although marine turtles are not uncommon within the study region during summer, there is no known breeding population within or near the proposed OAR sites.

On this basis, it is unlikely that a viable local population of any marine turtles would be placed at risk of extinction by the proposal.

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

No endangered populations of marine turtles are identified in the legislation

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

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

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

Not applicable

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

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

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

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

In theory, the proposed study areas could potentially provide foraging habitat for marine turtles but it is unlikely that the small amount of soft bottom loss would constitute a significant area of known foraging habitat. The lost soft bottom foraging area would amount to only a very small proportion of the total foraging area. In addition, it is most unlikely that any area of marine turtle habitat would become isolated by the proposal.

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

This would not occur for marine turtles in relation to the proposal.

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

There is an approved Recovery Plan for Marine Turtles in Australia (Web Reference 30). The proposal is unlikely to affect any of the recovery actions proposed under the plan.

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

'Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the the NSW *TSC Act.*

'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The leatherback and green turtles are considered particularly vulnerable to this KTP.

It is possible that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP are unlikely to increase the impact of this KTP.

Conclusion:
The proposal is not considered to represent a significant threat to marine turtles, hence no SIS is recommended. Suitable management measures should be employed to monitor and regulate boating activities in the vicinity of the OARs so that the risk of boat strike and release of harmful marine debris is minimised or prevented.

CETACEANS

Southern Right Whale

Species Name: Southern Right Whale (*Eubalaena australis*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Southern right whales migrate between summer feeding grounds in Antarctica and winter breeding grounds around the coasts of southern Australia, New Zealand, South Africa and South America. They are thought to feed in the open ocean in summer and known to move inshore in winter for calving and mating. Calving females and females with young usually remain very close to the coast, often in the 5-10 m watermark (Web Reference 31). Their population has increased rapidly since they became protected from hunting. They are slow moving and there is some evidence that they are susceptible to vessel strike. Females travel to temperate waters to give birth and mother and calf sightings are becoming more common in the Sydney region as the species' population increases. Southern rights are known to be present along the east coast of Australia between May and November. During this period it is possible that the proposed OAR structures could impact upon habitat availability, increase acoustic pollution (from increased boating activity) or increase the risk of boat strike. However, given that few transient individuals are likely to occur in the study areas and the relatively small proportion of habitat affected by the proposal (in terms of available habitat), it is most unlikely that the 'local' population of the species (which would extend from Sydney to the Southern Ocean) would be placed at risk of extinction due to the possible impacts listed above.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. Under the *TSC Act*, no endangered population of southern right whales has been scheduled
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* The major habitats of southern right whales are the feeding areas of the Southern Ocean, the mating and birthing areas of southern Australia (e.g. Great Australian Bight) and some birthing areas along the east and west coasts, principally adjacent to coastal sandy beaches. Southern right whales migrate along the NSW coast and may move into sandy embayments. Whilst southern right whales may, from time to time occur within wider study areas of the proposed OARs, these areas would be most unlikely to provide a significant area of habitat. The proposed OAR study areas do not constitute a habitat

for southern right whales that would become isolated from any other currently interconnecting or proximate areas of habitat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for southern right whales would be affected as a result of the proposal
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is an approved Southern Right Whale Recovery Plan 2005 - 2010 (Web Reference 32). Potential threats identified in the plan such as physical injury from boat strike, entanglement in marine debris and acoustic disturbance are relevant to all study regions as they are located in significant metropolitan areas. It is possible that the proposed OAR installment may exacerbate such threats if not properly managed. However, providing that appropriate management measures are implemented to reduce or prevent potential threats from increased boating activity, the proposal would not be considered to affect any of the recovery actions proposed under the plan.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. 'Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The Southern Right Whale is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this and other potential threats from increased boating activity such as risk of boat strike or acoustic disturbance are unlikely to increase the impact of this KTP.

Conclusion:
The proposal is not considered to represent a significant threat to southern right whales, hence no SIS is recommended. Suitable management measures should be employed to minimise any potential harm from increased boating activity in the vicinity of the OARs.

Humpback Whale

Species Name: Humpback Whale (*Megaptera novaeangliae*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. The life cycle of humpback whales in the southern hemisphere involves feeding and advancement to maturity in the Southern Ocean during the summer months, followed by northward migration during winter to mate and give birth in subtropical and tropical waters (Jefferson *et al*. 1993). The east coast population of humpbacks migrates along the Victorian, NSW and Queensland coasts to the Coral Sea from late autumn to winter and back along the coast in spring and early summer. Often on the return trip, adults swim close to the shore and are accompanied by new-born calves. Pairs may rest in large embayments such as Jervis Bay and Twofold Bay. During the annual migration, humpbacks swim past the Newcastle, Sydney and Wollongong study areas. During this period it is possible that the proposed OAR structures could impact upon habitat availability, or increase the risk of acoustic disturbance or boat strike due to increased boating activity in the vicinity of the installations. There is also potential entanglement in discarded fishing gear. However, given that no significant aggregation areas (important for either feeding, breeding, resting or calving) occur in the study areas and that individuals are likely to be transient the risk of these factors having an adverse effect on the life cycle of the species such that it would have an affect on a viable local population is considered highly unlikely.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. There are no listed endangered populations of humpback whales in either the TSC Act or EPBC Act, although both Acts list this species as Vulnerable. Under these definitions, no endangered population of humpback whales could be disrupted by the proposal.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable.
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Major habitats for humpback whales include the feeding/growth and breeding/mating areas in the south and north of their range, respectively, and the migration corridors which extend at least the width of the continental shelf. In addition, some large embayments such as Jervis Bay and Twofold Bay may be used for resting during migration. Given the location, size and present uses of the proposed artificial reefs, it is most unlikely that a significant area of known humpback habitat would be affected by the proposal. It is possible that the OARs could provide a minor obstacle to migrating whales but not to the extent that it could fragment or isolate habitat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No habitat critical for humpback whales would be affected as a result of the proposal
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is an approved Humpback Whale Recovery Plan 2005 - 2010 (Web Reference 33). The proposal would not, however, affect any of the recovery actions proposed under the plan. Potential threats identified in the plan such as physical injury from boat strike, entanglement in marine debris and acoustic disturbance are relevant to all study regions as they are located in significant metropolitan areas. It is possible that the proposed OAR installment may exacerbate such threats if not properly managed. However, providing that appropriate management measures are implemented to reduce or prevent potential threats from increased boating activity, the proposal would not be considered to affect any of the recovery actions proposed under the plan.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The humpback whale is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this and other potential threats from increased boating activity such as risk of boat strike or acoustic disturbance are unlikely to increase the impact of this KTP.

Conclusion:
The proposal is not considered to represent a significant threat to humpback whales, hence no SIS is recommended. Suitable management measures should be employed to minimise any potential harm from increased boating activity in the vicinity of the OARs, particularly during peak migration periods.

Sperm Whale

Species Name: Sperm whale (*Physeter macrocephalus*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Sperm Whales are very large marine mammals with a huge box-like head and underslung lower jaw. Males can grow 18m in length. Distribution is wide, but patchy, from the tropics to the edge of the polar pack-ice in both hemispheres. Concentrations of sperm whales tend to occur where the seabed rises steeply from a greater depth, beyond the continental shelf. It is likely they feed on squid, octopus and fish (Web Reference 34). Main threats to the species are collision with boats and other marine traffic, accidental entanglement in nets, traps, longlines and other fishing gear and rubbish, particularly plastic, which can cause suffocation, abrasion, infection or blockages in the whale's system when swallowed. There have been occasional records of sperm whales occurring inshore in the wider study regions of the proposed OARs. It would be highly unlikely that a viable population of the sperm whale would be placed at risk of extinction as a result of the proposal.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. The proposal is not considered to have an adverse effect such that a local population of the species is put at risk of extinction.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality*. Habitat in the proposed study areas is not considered important to the sperm whale
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No habitat critical to the survival of the sperm whale occurs in any of the wider study areas.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for the species, however, collision with boats and other marine traffic, accidental entanglement in nets, traps, longlines and other fishing gear and harmful marine debris are considered potential threats to the species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The sperm whale is considered particularly vulnerable to this KTP. It is possible, that increased boating and fishing activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP and other threats such as boat strike are unlikely to be increased.

Conclusion:

The proposal is not considered to represent a significant threat to sperm whales, hence no SIS is recommended. Suitable management measures should be employed to minimise any potential harm from increased boating activity in the vicinity of the OARs.

Blue Whale

Species Name: Blue Whale (*Balaenoptera musculus*)
Status: Endangered
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Blue whales are the largest living animals and are found in all oceans of the world. Records indicate that the species may occur right around Australia including the coast of NSW (Web Reference 35). Observations in south-east Australia (and other parts of the world) indicate that aggregations of blue whales are mostly associated with feeding areas. There are however, no known feeding or aggregation areas in the wider study region of any of the proposed OAR locations and no known migration routes in Australasian waters. It is therefore considered unlikely that the proposed action would adversely effect the life cycle of the species such that a viable population is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. Not applicable
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Little is known about the location and characteristics of habitat utilised by blue whales. The best information relates to feeding areas which are known to occur in the south-east of Southern Australia and off Rottnest Island (Western Australia) but is mainly thought to occur in the Antarctic. These areas are considered important as they seasonally support significant aggregations of whales and the ecosystem processes upon which they rely. The

habitat affected by the proposal is not considered important to the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for the blue whale has been declared in NSW.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is a recovery plan for the species (Web Reference 36). The proposal would not affect the recovery plan for this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The blue whale is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this and other potential threats from increased boating activity such as risk of boat strike or acoustic disturbance are unlikely to increase the impact of this KTP.

Conclusion:
The proposal is not likely to have any affect on habitat important to the blue whale or on the life cycle of the species so that viable populations are put at risk of extinction. The action does not contravene the objectives of a species recovery or threat abatement plan. Provided that suitable management measures should be employed to minimise any potential harm from increased boating activity in the vicinity of the OARs, no SIS is recommended.

PINNIPEDS AND SIRENIANS

Australian Fur-Seal

Species Name: Australian Fur-Seal (*Arctocephalus pusillus doriferus*)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Australian fur seals (*Arctocephalus pusillus doriferus*) are coastal mammals that range over the continental slope and shelf waters of Victoria, Tasmania and NSW (Web Reference 37). They may also move into bays occasionally. Australian fur seals eat pelagic and mid-water fish and cephalopods and can dive to approximately 200 m whilst chasing food. They breed on 10 islands in the Bass Strait. Pregnant females return to colonies in late October /early November to give birth to a single pup (Menkhorst and Knight 2001). Pregnant females feed intensively at sea in early spring before returning to give birth. Australian fur seals are reported to have bred in the past in NSW (prior to commercial sealing) at Seal Rocks and Montague Island but they no longer do so. There are other non-breeding colonies between Kangaroo Island in South Australia and Jervis Bay in NSW. These are Green Cape, Montague Isand and Steamers Beach near Jervis Bay. In addition, other various locations along the NSW coast are used irregularly as haul-out sites. Australian fur-seals are known to be found in and around The Five Islands Nature Reserve in the Wollongong study region. Although the species no longer breeds in NSW, habitat and resources within the state remain important to non-breeding individuals. Human activities in the ocean can affect seals by competing with them for prey, by entanglement (i.e. with fishing gear) and through noise (Shaughnessy 1999). The threat to seals from the proposal comes from the expected

increase in boating activity in the study areas whereby there is potential for collision, entanglement in discarded fishing gear and increased noise disturbance. It is also possible that seals would be attracted to aggregating prey or traps which could be set around the reefs. It is likely that Australian fur-seals may use the proposed study area for occasional foraging, although the disturbance to the seals is considered to be relatively minor and unlikely to disrupt the life cycle of this species such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. No endangered population of Australian fur seals is listed in NSW.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable.
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Although a small area of foraging habitat of seals would be potentially affected during emplacement of the structures, this would be temporary and not considered to be significant in terms of the regional distribution of the habitat.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for the Australian fur seal has been declared in NSW.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The Australian fur-seal is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP are unlikely to be increased as a result of the proposal.

Conclusion:
The proposal is not considered to represent a significant threat to the Australian fur-seal as there are no significant seal colonies in any of the wider study areas and provided that suitable management measures should be employed to minimise any potential harm from increased boating and recreational fishing activity in the vicinity of the OARs.

New Zealand Fur-Seal

Species Name: New Zealand Fur-Seal (Arctocephalus forsteri)
Status: Vulnerable
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. New Zealand fur seals (*Arctocephalus forsteri*) are coastal mammals that occur in Australian and New Zealand waters. In Australian waters, New Zealand fur-seals have been recorded in all of the southern states as well as in Queensland (south of Fraser Island). They eat fish and cephalopods and to a lesser extent birds such as penguins, both in shallow waters and around the margins of the continental shelf. In Australia, breeding colonies are known from islands off WA, SA and Tasmania, including Macquarie Island. Although the species does not breed in NSW, habitat and resources within the state remain important to non-breeding individuals. Montague Island is a regular haul-out site in NSW (Shaughnessy 1999), although other infrequently used sites have been recorded along the NSW coast. New Zealand fur seals may range into coastal bays. Human activities in the ocean can affect seals by competing with them for prey, by entanglement (i.e. fishing gear) and through noise (Shaughnessy 1999). The threat to seals from the proposal comes from the expected increase in boating activity in the study areas whereby there is potential for collision, entanglement in discarded fishing gear and increased noise disturbance. It is also possible that seals would be attracted to aggregating prey or traps which could be set around the reefs. It is likely that Australian fur-seals may use the proposed study area for occasional foraging, although the disturbance to the seals is considered to be relatively minor and unlikely to disrupt the life cycle of this species such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. No endangered population of New Zealand fur seals is listed in NSW.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not applicable.
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Although a small area of potential foraging habitat for seals would be affected during emplacement of the OAR this would be temporary and not considered to be significant in terms of the regional distribution of the habitat. The proposal would not cause any area of fur seal habitat to become isolated
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for the New Zealand fur seal has been declared in NSW
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is no approved recovery plan for this species

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The New Zealand fur-seal is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP are unlikely to be increased

Conclusion:
The proposal is not considered to represent a significant threat to the Australian fur-seal as there are no significant seal colonies in any of the wider study areas. Provided that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement) in the vicinity of the OARs it is not considered that a SIS would be required.

Dugong

Species Name: Dugong (*Dugong dugon*)
Status: Endangered
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Dugongs (*Dugong dugon*) mainly occur in northern Australia but there is evidence to suggest that they also occur well beyond the southern limit of their accepted range into NSW (Allen *et al*. 2004). Individuals that have been recorded in NSW are mostly thought to be non-breeding vagrants that are influenced by warm currents and the availability of seagrass further south. The largest remaining dugong population in the world, in 1991 was the northern Australian population, which was estimated at approximately 70,000 with 12,500 in the Torres Straits and 1,700 in the northern Great Barrier Reef (Web Reference 38). Dugongs surface only to breathe, and never come on to land. They like to live in large herds, but due to declining numbers are often now found in smaller "family" groups of between one to three animals. Although they only live where there is seagrass, on which they feed, they may migrate between areas. No seagrass is found within any of the direct study areas as it is too deep. Dugongs that have been observed in NSW including the wider study areas of the proposed Newcastle and Sydney OARs are thought to be non-breeding vagrants. Hence, if they were to occur in the study area they would presumably be passing through. Risks from the proposal would be potential for entanglement in fishing gear and injury from boat strike due to increased boating activity in the OAR study areas. This is, however, considered unlikely and the proposal is not considered to have an adverse effect on the life cycle of the species such that a viable local population of the species is placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. No endangered population of dugongs has been listed in NSW
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local*

occurrence is likely to be placed at risk of extinction. Not applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* Dugongs have been reported feeding in seagrass beds of the North Coast of NSW and vagrants may occur further south. Mating and birthing areas are normally in northern Australian waters between Shark Bay in Western Australia and Moreton Bay in Queensland. The artificial reefs would not be located on seagrass beds and no area of the dugong habitat would be modified or removed through the proposal. The proposal would not lead to any habitat becoming isolated
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). No critical habitat for dugongs has been declared in NSW
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. There is currently no recovery plan for this species in NSW.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The dugong is considered particularly vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, likelihood of this occurring is considered low and providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP and other threats such as boat strike are unlikely to be increased.

Conclusion:
The proposal is not considered to represent a significant threat to the dugong as there is no important habitat (such as seagrass beds) in the direct study area and no known aggregations in the wider study areas. Provided that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement or boat strike) in the vicinity of the OARs it is not considered that a SIS would be required.

MARINE BIRDS

Little Penguin

Species Name: Little Penguin (*Eudyptula minor*)
Status: Endangered Population (Little Manly Point)
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. A critical habitat has been declared for the little penguin population in the Manly Point area that extends from the area on and near the shoreline from Cannae Point generally northward to the point near the intersection of Stuart

Street and Oyama Cove Avenue, including 100 m offshore from that shoreline. The endangered population of little penguins at Manly are the only known breeding population on the mainland in NSW (Web Reference 39). The population utilises a range of nest sites, including under rocks on the foreshore, under seaside houses and structures, such as stairs, in wood piles and under overhanging vegetation. The penguins appear to be opportunistic feeders foraging in relatively shallow waters preying on small schooling fish such as anchovy and pilchards and squid. The daily foraging range for adult penguins is between 10 km and 30 km. Immature birds however, are known to disperse hundreds of kilometres from their colonies. The foraging range and breeding success is considered to be very much dependant on the availability and abundance of food (NSW NPWS 2000). The Manly population of little penguins is located approximately 3.7 km north west from the proposed Sydney OAR site and may therefore utilise the direct and wider study area for foraging. The species commonly dives to depths between 2 m and 10 m but may occasionally forage much deeper than this i.e. > 25 m (Ropert-Couldert et al 2006). The species could therefore potentially forage within the OAR depth range. The major threat to the Manly population is the loss of suitable habitat for breeding nesting and moulting (Web Reference 39), while predation from dogs and foxes is also a significant threat. As the colony is located in an urbanised area, disturbance from noise, light and movement is also a problem. The species may also be put at risk from injury due to harmful marine debris such as discarded fishing gear as a result of increased fishing activity at the proposed Sydney OAR location. However, providing that OARs are suitably managed and carefully monitored for interactions of fishing with the species, then it is considered unlikely the proposal would disrupt the life cycle of this species such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. It is considered unlikely that the proposal would have an adverse effect on the Manly population of little penguins such that the viable local population was put at risk of extinction.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.* Not Applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* The proposal would not affect the habitat important to the survival of the species in any of the ways outlined above.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). The proposal would not have any direct or indirect adverse effect on the manly little penguin critical habitat.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. The proposal does not directly contravene the objectives of the recovery plan, it is however, possible that potential entanglement due to increased recreational fishing activity could be a threat if the species were to regularly forage in the area.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. The little penguin is considered vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and regulated, then impacts of this KTP are unlikely to be increased.

Conclusion:

The proposal is not considered to represent a significant threat to the little penguin but it is recommended that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement or boat strike) in the vicinity of the OARs. The OARs should also be carefully monitored for occurrence and/or interactions of the species with fishing activity it is not considered that a SIS would be required.

Seabirds

Species Group: Seabirds (not including penguins)
Status: (protected, vulnerable and endangered)
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. Commercial long-lining is considered a significant threat to seabirds (particularly albatross and giant petrels) this however, mainly takes place in Commonwealth waters and is not relevant to the current proposal. Other types of line fishing (such as set-lining) do take place within State waters and could potentially affect seabirds if these practices were to increase within the study areas. The recreational practice of trolling a fishing line at or near the surface also has the potential to cause mortality if seabirds are caught on hooks. This risk can be eliminated by setting troll lines at least 2m below the surface of the water. It is possible that discarded bait from recreational fishing boats could also attract seabirds to feed in the area thus, increasing the risk of becoming injured or entangled. Seabirds may also be put at risk from injury due to harmful marine debris such as discarded fishing gear as a result of increased fishing activity within the study areas. Such entanglement can constrict growth and circulation, leading to asphyxiation. Entanglement may also increase the bird's drag coefficient through the water, causing the animal to die due to its reduced ability to catch prey or avoid predators. Species most at risk to these potential threats are those known to roost or breed on land nearby to the direct study areas. This includes the sooty oyster catcher, wedge-tailed shearwater, short-tailed shearwater, silver gull, kelp gull and white bellied sea eagle. These species are known to inhabit the Five Islands Nature Reserve (Wollongong) and/or the Moon Island Nature Reserve (Newcastle) which are located 2.4 km and 4 km from the respective OAR locations. However, providing that OARs are suitably managed and carefully monitored for impacts on such species, then it is considered unlikely the proposal would disrupt the life cycle of this species such that a viable local population of the species is likely to be placed at risk of extinction
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction. It is considered unlikely that the proposal would have an adverse effect on seabirds such that a viable local population was put at risk of extinction.
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: *i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or* *ii) is likely to substantially and adversely modify the composition of the ecological community such that its local*

occurrence is likely to be placed at risk of extinction. Not Applicable
d) In relation to the habitat of a threatened species, population or ecological community: *i) the extent to which habitat is likely to be removed or modified as a result of the action proposed; and* *ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and* *iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.* The proposal would not affect the habitat important to the survival of the species in any of the ways outlined above.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly). The proposal would not have any direct or indirect adverse effect on the critical habitat of a species of seabird.
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan. A recovery plan for albatrosses and giant petrels is available (Web Reference 40). One aim of the recovery plan is to minimise all human induced threats to albatrosses and giant-petrels. The proposal is not considered to directly contravene the objectives of the recovery plan, it is however, possible that indirect impacts from recreational fishing activity (e.g. entanglement in fishing line, increase in harmful marine debris) could be potential threats to seabirds. The proposal would however aim to educate fishers and promote public awareness of the threats to albatrosses and giant-petrels which would be consistent with objectives of the recovery plan. A recovery plan for 10 species of seabirds is also available. This incudes the protected soft-plumaged petrel (*Pterodroma molis*) likely to occur in the Sydney study region. The proposal is considered to be consistent with the objectives of this recovery plan.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process. Entanglement or ingestion of anthropogenic debris in marine and estuarine environments' is listed as a key threatening process under the NSW *TSC Act.* 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (such as discarded fishing gear)' is also listed as a key threatening process under the Australian Government's *EPBC Act*. Seabirds are considered vulnerable to this KTP. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs may exacerbate this KTP by increasing the risk of harmful marine debris being released into the marine environment. However, providing that boating activity in the vicinity of the OARs is properly monitored and managed, then impacts of this KTP are unlikely to be increased.

Conclusion:

The proposal is not considered to represent a significant threat to seabirds but it is recommended that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement or boat strike) in the vicinity of the OARs. The OARs should also be carefully monitored for occurrence and/or interactions of the species with fishing activity it is not considered that a SIS would be required.

Appendix 7

EPBC Act Threatened Species Profiles

1. Fish

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

East Coast Population

Status: Critically Endangered

Distribution:

Grey nurse sharks typically occur on shallow rocky reefs along the NSW coast (Last and Stevens 1994). There is also evidence to suggest that grey nurse sharks migrate along the NSW coast (northwards in autumn/winter and southwards in summer (Pollard *et al.*1996, Otway and Parker 1999).

Critical Habitat Resources:

Many of the known aggregation sites for grey nurse sharks (eastern Australian population) have been declared critical habitat for the species and are protected by legislation administered by DPI. Areas declared critical habitat for the species include Little Broughton Island and The Pinnacle, north of Newcastle (within Port Stephens Marine Park), Magic Point (Maroubra) and Bass Point in the south. The Magic Point critical habitat occurs approximately 12.5 km from the proposed Sydney OAR site. The Bass Point critical habitat occurs approximately 8 km from the proposed Wollongong OAR site.

Site Observations/Habitat Values:

The major habitat utilised by grey nurse sharks comprises rocky reefs, with small sandy gutters within the reef matrix being often preferred microhabitat. Young are born live and also occur on shallow rocky reefs, often segregated from the adults. There is some likelihood that the species ranges away from reefs to feed at night, but the extent of this range is unknown (Smale 2005). The proposal would not modify any core reef habitat of grey nurse sharks.

Recognised Threats and Potential Impact(s) of the Proposal:

Grey nurse sharks are protected from all forms of fishing. Given their movement patterns, it is unlikely that grey nurse populations are confined to the relatively small spatial scale of their reserves. It is therefore possible that grey nurse sharks occurring at known aggregation sites within the wider study areas could forage within the direct study areas of the proposed OARs and be vulnerable to incidental capture. The species could also be indirectly at risk from injury or harm from entanglement or ingestion of harmful marine debris (including discarded fishing gear). Conversely, creation of artificial recreational fishing areas may assist in the species recovery by providing alternative fishing locations away from known aggregation areas.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and best practise for returning incidentally caught species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on grey nurse sharks by surveys of anglers, remote underwater video stations, diver surveys and also listening stations to continuously monitor the presence of tagged individuals in the vicinity of the reefs. If adverse impacts on the grey nurse shark were detected after a review period, then temporary or seasonal closures would be implemented. In the short-term, reported sightings of grey nurse sharks in the vicinity of the OARs would result in a temporary closure to fishing if the sharks were considered to be at risk.

Predicted Outcome/Effectiveness:

It is considered unlikely, but possible that the proposed artificial reefs could occasionally draw in migrating or foraging individuals, making them susceptible to incidental capture. However, provided that the OARs are properly managed and monitored (as above) the proposal is considered unlikely to have any detrimental impact on the grey nurse shark.

References and Additional Information:

Grey Nurse Shark Recovery Plan (2002)
http://www.environment.gov.au/coasts/publications/grey-nurse-plan/pubs/greynurseshark.pdf

NSW DPI Primefact 582 – Grey nurse shark
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0018/150165/Grey-nurse-shark.pdf

Last, P.R. and Stevens, J.D. (1994). Sharks and Rays of Australia. CSIRO Division of Fisheries, Hobart.

Species Name: Great White Shark (*Carcharodon carcharias*)

Status: Vulnerable

Distribution:

Great white sharks occur from cold temperate to tropical waters worldwide and generally frequent coastal waters, often close to shore. They also swim into bays and estuaries. They have been recorded at varying depths down to 1,200 m. Emerging evidence suggests that both juveniles and adults can range widely, with one tagged individual recorded from Tasmania along the NSW coast into southern Queensland. There is also anecdotal evidence that the species follows large schools of migrating fish (e.g. sea mullet, Australian salmon) and migrating whales, particularly those with calves.

Critical Habitat Resources:

There are no Critical habitats declared for this species in NSW.

Site Observations/Habitat Values:

Great white sharks are large, highly predatory animals whose life cycle is poorly understood. If great white sharks do prefer a particular habitat, it is likely to be rocky shores with seals or sea lions. They may also follow schools of fish along the coast, hence it is possible that OARs may affect the 'temporary' habitat of great white sharks. In that case, the proposed OAR locations are not considered to be significant known habitat, as the sharks are likely to simply follow the schools of prey elsewhere. Stockton Bight north of the Port of Newcastle is a recognised site for the occurrence of great whites. Two attacks on surfers in the Sydney study region during January – February 2009 were thought to be by a great white shark. This suggests the species does occasionally occur in the wider Newcastle and Sydney study regions and is likely to occur in the wider Wollongong study region.

Recognised Threats and Potential Impact(s) of the Proposal:

Prior to the implementation of protective legislation, commercial and recreational fishing were some of the most prominent threats to the great white shark. Although protected from all commercial or recreational fishing, the species is still susceptible to incidental capture. It is possible the species would be attracted to fish aggregating around the OARs and become susceptible to incidental capture. The species could also be indirectly at risk from injury or harm from entanglement or ingestion of harmful marine debris (including discarded fishing gear).

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and best practise for returning incidentally caught species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. If the great shark was considered at risk after a review period then temporary or seasonal closures would initially be implemented and longer term closures if necessary.

Predicted Outcome/Effectiveness:

It is possible that the proposal could lead to the incidental capture of the great white shark, however, provided that the OARs are properly managed and monitored (as above) the proposal is considered unlikely to have any detrimental impact on the species. Creation of artificial recreational fishing areas may assist in the species recovery by providing alternative fishing locations away from sites where the sharks have been reported.

References and Additional Information:

Great White Shark Recovery Plan
http://www.environment.gov.au/coasts/publications/gwshark-plan/pubs/greatwhiteshark.pdf

NSW DPI Primefact 6 – Great white shark
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/5105/Primefact_Great_white_shark.pdf

Last, P.R. and Stevens, J.D. (1994). Sharks and Rays of Australia. CSIRO Division of Fisheries, Hobart.

Species Name: Whale Shark (*Rhincodon typus*)

Status: Vulnerable/Migratory

Distribution:

The whale shark inhabits tropical to warm-temperate oceans worldwide. It is thought to be primarily pelagic and highly migratory. Whale Sharks are known to occur in New South Wales, Queensland, Northern Territory, Western Australia, Christmas Island, Indian Ocean and occasionally South Australia and Victoria.

Critical Habitat Resources:

In the territory of Australia, important aggregation areas are off Ningaloo Reef in Western Australia (between March and July), Christmas Island (between December and January) and in the Coral Sea (between November and December). Evidence suggests that seasonal aggregations off Ningaloo Reef are due to migratory behaviour associated with climatic and oceanographic processes, with a possible link between the abundance of aggregating whale sharks and the physical and biological oceanography of the region (DEH 2005). Important habitats for the whale shark within the Australian jurisdiction are the known seasonal aggregation sites.

Seasonal aggregations are also known to occur outside Australian jurisdiction in a number of Range States such as the Philippines, Belize and the Maldives.

Site Observations/Habitat Values:

The whale shark is a slow moving filter feeding shark, which is the largest species of fish, growing up to 20 m (DEH 2005). It is known to occur in coastal waters of NSW. A 5 m whale shark was sighted by a charter vessel operator in the Wollongong region in February 2006 and again a week later (Web Reference 29).

Recognised Threats and Potential Impact(s) of the Proposal:

Commercial harvest is the main threat to the species outside of Australian waters, whereas competition with fisheries, habitat damage, pollution, disease and direct disturbance from tourism are considered potential threats in the Australian jurisdiction. At present, none of these potential threats are thought to have an impact on the number of whale sharks visiting Australian waters (DEH 2005). Potential threats to the species from the proposed OARs include:

- Boat strike;
- Disturbance from fishing vessels/tourism;
- Entanglement/injury from harmful marine debris;
- Noise/acoustic disturbance;
- Interruption of movement corridors.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and boating restrictions in the vicinity of large slow moving species such as the whale shark. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. If the whale shark was considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Given that no important aggregation areas for the whale shark are known to occur in any of the wider study areas, that individuals would rarely occur in the direct study areas and that those that did would only be transient, it is highly unlikely the proposed OARs would negatively impact the whale shark. Furthermore, there are no current threats (in the Australian jurisdiction) thought to have any impact on the population of whale sharks.

References and Additional Information:

Whale Shark Recovery Plan (2005 – 2010)
http://www.environment.gov.au/biodiversity/threatened/publications/recovery/r-typus/

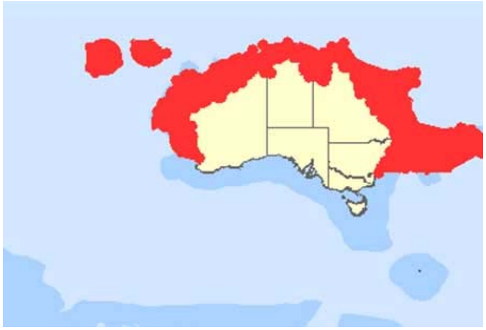
Australian Museum Fishfacts
http://www.austmus.gov.au/fishes/fishfacts/fish/rtypus.htm

Last, P.R. and Stevens, J.D. (1994). Sharks and Rays of Australia. CSIRO Division of Fisheries, Hobart.

2. Marine Turtles

Species Name: Green Turtle (*Chelonia mydas),*

Status: Vulnerable



Distribution:

Green turtles nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms (Marquez 1990), although individuals can stray into temperate waters.

Critical Habitat Resources:

In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) are in Queensland, the Northern Territory and Western Australia. Important foraging grounds and juvenile habitat for green turtles in Queensland include the Capricorn and Bunker region of the Great Barrier Reef, the Wellesley Islands, Moreton Bay, Hervey Bay and Sandy Straits, Shoalwater Bay, Cleveland Bay, Princess Charlotte Bay, the inner shelf coral reefs from Howick Reef to Corbett Reef, and the Torres Strait.

Site Observations/Habitat Values:

Green Turtles spend their first five to ten years drifting on ocean currents. During this pelagic phase, they are often found in association with driftlines and rafts of Sargassum seaweed. Once green turtles reach 30 cm to 40 cm curved carapace length, they settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. The shallow foraging habitat of adults contains seagrass beds or algae mats on which Green Turtles mainly feed. There are a number of records of green turtles occurring in Lake Macquarie (wider Newcastle study area), 5 records in the Sydney study area and 2 records from the wider Wollongong study area (Web Reference 11). No areas of seagrass are however, found to occur in any of the direct study areas.

Recognised Threats and Potential Impact(s) of the Proposal:

All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries. The species are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. By-catch of marine turtles in fisheries, marine debris, coastal development, loss of habitat and deterioration of water quality is also a significant threat to the species. In theory, the proposed study areas could potentially provide foraging habitat, but this would be a negligible proportion of the total foraging area. Other potential direct and indirect impacts from the proposal are:

- Incidental catch;
- Boat strike;
- Entanglement/injury from harmful marine debris;
- Impact on water quality.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear, best practise for returning incidentally caught species and boating guidelines in the vicinity of threatened species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. Water quality would also be monitored. If marine turtles were considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Although the green turtle does occur within the entire study region (from Newcastle, south to Wollongong) this is outside the range of known nesting, mating, feeding or breeding areas. Providing that the OARs are properly managed and monitored it is considered unlikely that the proposal would have a significant impact on the green turtle from any of the identified impacts.

References and Additional Information:

Recovery Plan for Marine Turtles in Australia
http://www.environment.gov.au/coasts/publications/turtle-recovery/pubs/marine-turtles.pdf

DEWHA Species Profile and Threats Database – Green Turtle
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765

Species Name: Leatherback Turtle (*Dermochelys coriacea*)

Status: Vulnerable

Distribution:

This species has the widest distribution of any marine turtle. It is found in tropical to sub-polar oceans, from the North Sea and the Gulf of Alaska, to the southern Pacific and Atlantic Oceans. In Australia, the leatherback turtle has been recorded feeding in coastal waters offshore of all Australian States.

Critical Habitat Resources:

The leatherback turtle is a highly pelagic species, venturing close to shore mainly during the nesting season. Leatherback turtles require sandy beaches to nest, with some evidence that coarser sand is more conducive to successful hatching than finer sand. Sand temperatures between 24–34 °C are needed for successful incubation. Beaches free from light pollution are required to prevent disorientation, disturbance and to allow nesting females to come ashore. The species would co-occupy marine and nesting beach habitat with other marine turtle species. No critical habitats for the species have been declared in NSW.

Site Observations/Habitat Values:

There is no historical evidence of a large nesting population of leatherback turtles in Australia. Small numbers have been reported to nest occasionally along a short stretch of coast in central Queensland, northern New South Wales and the Northern Territory. No nests have been recorded in eastern Australia since 1996 and the majority of leatherback turtles in Australian waters are likely to be foraging migrants, from breeding populations in neighboring countries. There is one record of a leatherback turtle occurring in the wider Sydney study area near Long Reef in 1999 (Web Reference 11).

Recognised Threats and Potential Impact(s) of the Proposal:

All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries. The species are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. By-catch of marine turtles in fisheries, marine debris, coastal development, loss of habitat and deterioration of water quality is also a significant threat to the species. The proposed study areas could potentially provide foraging habitat, but this would be a negligible proportion of the total foraging area. Potential threats relevant to the proposal are:

- Incidental catch;
- Boat strike;
- Entanglement/injury from harmful marine debris;
- Impact on water quality.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear, best practise for returning incidentally caught species and boating guidelines in the vicinity of threatened species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. Water quality would also be monitored. If marine turtles were considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Although these species may occasionally occur within the entire study region (from Newcastle, south to Wollongong) this is outside the range of known nesting, breeding, mating or feeding areas. It is considered highly unlikely the proposal would have any detrimental impact on the leatherback turtle or habitat important to its survival.

References and Additional Information:

Recovery Plan for Marine Turtles in Australia
http://www.environment.gov.au/coasts/publications/turtle-recovery/pubs/marine-turtles.pdf

DEWHA Species Profile and Threats Database – Leatherback Turtle
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768

Approved Conservation Advice for *Dermochelys coriacea.*
http://www.environment.gov.au/biodiversity/threatened/species/pubs/1768-conservation-advice.pdf

Species Name: Flatback Turtle (*Natator depressus*).

Status: Vulnerable/Migratory

Distribution:

The species is generally restricted to the tropical waters of northern Australia and there are no areas of significant habitat such as nesting sites known to occur within NSW.

Critical Habitat Resources:

There are no critical habitat resources for this species in the wider study areas.

Site Observations/Habitat Values:

Juvenile flatback turtles do not have the wide dispersal phase in the oceanic environment like other sea turtles. Adults inhabit soft bottom habitat over the continental shelf of northern Australia, extending into Papua New Guinea and Irian Jaya although the extent of their range is not fully known. Capture locations from trawlers indicate that flatback turtles feed in turbid, shallow inshore waters north of latitude 25° S in depths from less than 10 m to depths of over 40 m. Nesting habitat includes sandy beaches in the tropics and subtropics with sand temperatures between 25 °C and 33 °C at nest depth. Hatchling to sub-adult flatback turtles lack a pelagic life stage and reside in the Australian continental shelf. Flatback turtles require sandy beaches to nest. Sand temperatures between 25 °C and 33 °C are needed for successful incubation. Beaches free from light pollution are required to prevent disorientation, disturbance, and to allow nesting females to come ashore. There is one record of the flatback turtle occurring in the wider Newcastle study region (Lake Macquarie) in 2003.

Recognised Threats and Potential Impact(s) of the Proposal:

All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries. The species are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. By-catch of marine turtles in fisheries, marine debris, coastal development, loss of habitat and deterioration of water quality is also a significant threat to the species. On the rare occasion that a flatback turtle may venture as far south from its range to the proposed study areas, it could potentially be at risk from:

- Incidental catch;
- Boat strike;
- Entanglement/injury from harmful marine debris;
- Deteriorated water quality.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear, best practise for returning incidentally caught species and boating guidelines in the vicinity of threatened species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. Water quality would also be monitored. If marine turtles were considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Although the species could potentially occur within any of the study regions, this would be considered rare and is outside the range of known nesting, mating or feeding areas. Given the low chance of flatback turtles occurring in any of the study areas, it is considered highly unlikely that the proposal would have any direct or indirect impacts on the species.

References and Additional Information:

DEWHA Species Profile and Threats Database
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257

Recovery Plan for Marine Turtles in Australia
http://www.environment.gov.au/coasts/publications/turtle-recovery/pubs/marine-turtles.pdf

Species Name: Loggerhead Turtle (*Caretta caretta*)

Status: Endangered

Distribution:

Loggerheads occur in coral reefs, bays and estuaries (including seagrass beds and muddy substratum) in tropical and warm temperate waters off the coast of Queensland, Northern Territory, Western Australia and New South Wales.

Critical Habitat Resources:

There are no critical habitat resources for the loggerhead turtle in the wider study area.

Site Observations/Habitat Values:

Hatchling to sub-adult loggerheads occur in the open ocean foraging on planktonic organisms. Loggerheads enter the benthic foraging habitat at a larger size than other hard-shelled sea turtles. Adults and large juveniles, greater than 70 cm curved carapace length occur in waters with both hard and soft substrates. Occurrence of the loggerhead turtle in any of the study areas is rare. There is one record of the species occurring in the wider Newcastle study region in 2003 (Web Reference 11).

Recognised Threats and Potential Impact(s) of the Proposal:

All the marine turtles scheduled under the legislation are vulnerable to hunting through much of their range, particularly in developing countries. The species are probably most vulnerable when they come ashore to nest – at this time adults, eggs and hatchlings are subject to direct harvesting, predation by native fauna, feral animals and pets and various forms of human disturbance. By-catch of marine turtles in fisheries, marine debris, coastal development, loss of habitat and deterioration of water quality is also a significant threat to the species. The proposed study areas could potentially provide foraging habitat for loggerhead turtles but it is unlikely that the small amount of soft bottom loss would constitute a significant area of known foraging habitat. The lost soft bottom foraging area would amount to only a very small proportion of the total foraging area. On the rare occasion that a loggerhead turtle may venture as far south from its range to the proposed study areas, it could potentially be at risk from:

- Incidental catch;
- Boat strike;
- Entanglement/injury from harmful marine debris;
- Deteriorated water quality.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear, best practise for returning incidentally caught species and boating guidelines in the vicinity of threatened species. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers, remote underwater video stations and diver surveys. Water quality would also be monitored. If marine turtles were considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Given the low chance of loggerhead turtles occurring in any of the study areas, it is considered highly unlikely that the proposal would have any direct or indirect impacts on the species.

References and Additional Information:

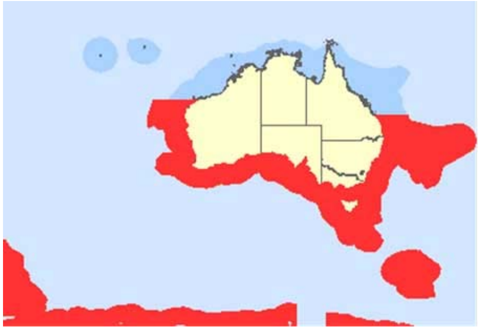
Recovery Plan for Marine Turtles in Australia
http://www.environment.gov.au/coasts/publications/turtle-recovery/pubs/marine-turtles.pdf

DEWHA Species Profile and Threats Database – Loggerhead Turtle
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763

3. Cetaceans

Species Name: Southern Right Whale (*Eubalaena australis*)

Status: Endangered/Migratory.



Distribution:

Southern right whales have been recorded in the coastal waters of all Australian States apart from the Northern Territory. Sightings range from Stradbroke Island and Hervey Bay in Queensland and around the entire southern coastline, including Tasmania, to Exmouth in Western Australia.

Critical Habitat Resources:

Habitat important (and potentially critical) to the survival of the species are those areas known to seasonally support significant aggregations of whales, and those ecosystem processes upon which southern right whales rely. Very little information is available on southern right whale migratory and feeding habitat although important aggregation and calving areas are known. Significant calving areas are located in Western Australia, South Australia and Victoria, generally consisting of shallow (between 5 m and 10 m deep), gradually sloping protected bays. It is thought likely that foraging habitat is related to oceanographic parameters and ecological processes affecting concentration and distribution of prey which consists predominantly of zooplankton. No habitat considered important for southern right whales occurs in the direct OAR study areas.

Site Observations/Habitat Values:

Mother and calf sightings are becoming more common in the Sydney region as the species' population increases. Southern rights are known to be present along the east coast of Australia between May and November. No important habitat for southern right whales is however known to occur in any of the direct study areas.

Recognised Threats and Potential Impact(s) of the Proposal:

It is possible, that increased boating activity in the vicinity of the proposed artificial reefs could exacerbate risks of injury from boat strike, entanglement in marine debris and acoustic disturbance within the direct study areas. The proposal would not result in the loss of habitat important to the species or interrupt movement corridors.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

It is possible that boating activity in the direct study areas could increase the potential for boat strike, entanglement in marine debris and acoustic disturbance. However, provided that the OARs are properly managed as described in the previous section, the proposal is not considered to have a significant impact on the southern right whale.

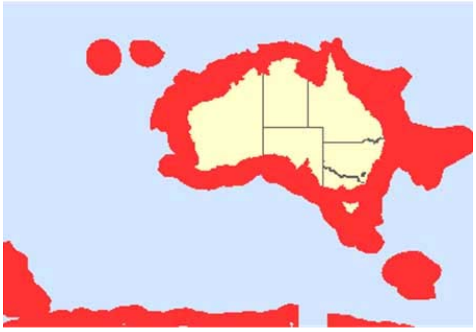
References and Additional Information:

Department of the Environment and Heritage (2005b). *Southern Right Whale Recovery Plan 2005 - 2010*: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/e-australis/index.html

DEWHA Species profile and Threats Database http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=40

Species Name: Humpback Whale

Status: Vulnerable, migratory, cetacean



Distribution:

In Australia, humpback whales are distributed throughout the Australian Antarctic, Commonwealth offshore, State and Territory waters. Humpback whales travel northward to breeding areas between May and July and return southward to their sub-Antarctic feeding grounds between September and November. Calving grounds are found along the mid and northern parts of the east and west coasts and feeding grounds in the Southern Ocean. Northern and southern hemisphere populations are thought to be genetically distinct due to their temporal migration separation.

Critical Habitat Resources

Habitat important and potentially critical to the survival of humpback whales is defined as those areas known to seasonally support significant aggregations of whales and those ecosystem processes upon which they rely. Calving, resting and feeding areas and also certain sections of migratory pathways are considered of particular importance. Feeding usually takes place in productive Antarctic waters where Antarctic krill (a primary food source for hump back whales) is concentrated, although some feeding behaviour has been reported near mainland Australia.

Site Observations/Habitat Values:

During the annual migration, humpbacks would swim past the Newcastle, Sydney and Wollongong study areas. Mother and calf pairs may rest in large embayments such as Jervis Bay and Twofold Bay on their movements south to feeding areas. Given the location, size and present uses of the proposed artificial reefs, it is most unlikely that a significant area of known humpback habitat would be affected by the proposal. It is possible that the OARs could provide a minor obstacle to migrating whales but not to the extent that it would interrupt migration corridors.

Recognised Threats and Potential Impact(s) of the Proposal:

Physical injury from boat strike, entanglement in marine debris and acoustic disturbance are potential risks relevant to all study regions as they are located in significant metropolitan areas along the known migration route for the species. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs could exacerbate these risks. It is unlikely the proposal would result in the loss of habitat important to the species or interrupt movement corridors.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Given that no significant aggregation areas (important for feeding, breeding, resting or calving) occur in the study areas and that individuals are likely to be transient, the significance of potential impacts is considered low.

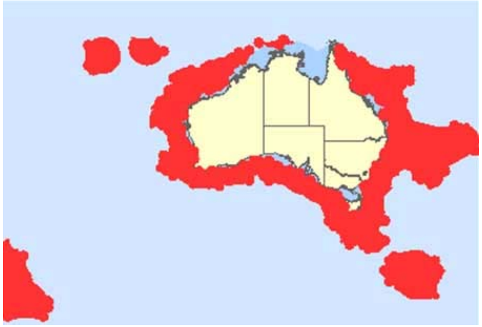
References and Additional Information:

DEWHA Species Profile and Threats Database – Humpback Whale.
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=38

Department of Environment and Heritage (2005c) Humpback Whale Recovery Plan 2005 – 2010.
http://www.environment.gov.au/biodiversity/threatened/publications/recovery/m-novaeangliae/pubs/m-novaeangliae.pdf

Species Name: Sperm Whale (*Physeter macrocephalus*)

Status: Vulnerable



Distribution:

Distribution is wide, but patchy, from the tropics to the edge of the polar pack-ice in both hemispheres. Concentrations of sperm whales tend to occur where the seabed rises steeply from a greater depth, beyond the continental shelf.

Critical Habitat Resources

No habitat critical to the survival of the sperm whale occurs in any of the wider study areas.

Site Observations/Habitat Values:

The habitat of the Sperm Whale is difficult to categorise due to its cosmopolitan nature and its ability to inhabit all oceans. Sperm Whales tend to inhabit offshore areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. There are however, occasional records of sperm whales occurring inshore in the wider study regions of the proposed OARs.

Recognised Threats and Potential Impact(s) of the Proposal:

Current threats to sperm whales primarily include collision with large vessels on shipping lanes beyond the edge of the continental shelf, seismic operations in similar areas causing evasive responses, entrapment in fishing gear (including 'ghost nets'), and illegal whaling or a resumption of legal commercial whaling. Pollution, including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues is an unquantified threat to sperm whales. Physical injury from boat strike, entanglement in marine debris and acoustic disturbance are potential risks relevant to all study regions as they are located in significant metropolitan areas. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs could exacerbate these risks.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Given the rarity of the species in coastal waters it is unlikely the species would be impacted as a result of the proposal and the proposal is therefore not considered to represent a significant threat to sperm whales.

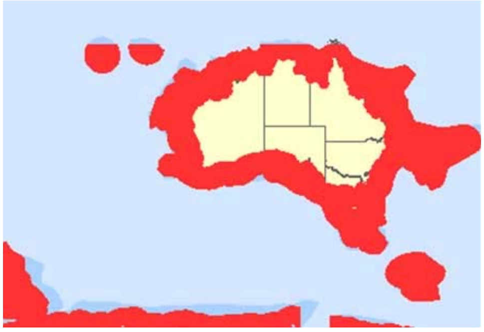
References and Additional Information:

DEWHA Species Profile and Threats Database – Sperm Whale http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59

Ross, G. (2006) Review of the Conservation Status of Australia's Smaller Whales and Dolphins. http://www.environment.gov.au/coasts/publications/pubs/conservation-smaller-whales-dolphins.pdf

Species Name: Blue Whale (*Balaenoptera musculus*)

Status: Endangered



Distribution:

In Australia, blue whales are found in the waters off Australia's Antarctic Territory and along the southern parts of the Australian coast including Western Australia, South Australia, Victoria, Tasmania, NSW through to southern Queensland.

Critical Habitat Resources

Due to the limited knowledge about the distribution and abundance of the species it is not currently possible to define habitat critical to the survival of the species. For blue whales, the best information relates to aggregation and feeding areas. These areas can be considered important to the survival of the species as they seasonally support significant aggregations and those ecosystem processes upon which they rely.

Site Observations/Habitat Values:

Observations in south-east Australia (and other parts of the world) indicate that aggregations of blue whales are mostly associated with feeding areas. There are however, no known feeding or aggregation areas in the wider study region of any of the proposed OAR locations and no known migration routes in Australasian waters.

Recognised Threats and Potential Impact(s) of the Proposal:

Physical injury from boat strike, entanglement in marine debris and acoustic disturbance are potential risks relevant to all study regions. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs could exacerbate these risks in the unlikely event that a blue whale was present in the direct study area.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Provided that the OARs are management and monitored appropriately, impacts of the proposal on the blue whale are considered to be unlikely and of relatively low significance.

References and Additional Information:

DEWHA Species Profile and Threats Database – Blue Whale.
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=36

Blue, Fin and Sei Whale Recovery Plan 2005 – 2010.
http://www.environment.gov.au/biodiversity/threatened/publications/recovery/balaenoptera-sp/pubs/balaenoptera-sp.pdf

Species Name: Brydes Whale (*Balaenoptera edeni*)

Status: Migratory

Distribution:

Brydes whale has a worldwide tropical to warm temperate distribution, preferring waters with a temperature above 20°C. The coastal form of brydes whale appears to be limited to the 200 m depth isobar, moving along the coast in response to availability of suitable prey. The offshore form is found in deeper water (500 m to 1000 m). The offshore form of brydes whale may migrate seasonally, heading towards warmer tropical waters during the winter. Limited data suggest that this migration may be to allow breeding and calving in lower latitudes.

Critical Habitat Resources:

There are no critical habitat resources for brydes whale in the wider study areas.

Site Observations/Habitat Values:

Generally, brydes whales are considered to move in close association with their prey. As such, it is only likely that inshore form of Bryde's whale would pass through any of the proposed OAR locations. No specific feeding or breeding grounds have been discovered off Australia.

Recognised Threats and Potential Impact(s) of the Proposal:

The coastal form of brydes whale may be particularly threatened by marine debris especially discarded plastic. Other current and future threats to brydes whales include direct disturbance from seismic and/or defence operations, collisions with large vessels and entanglement in fishing gear. In addition, competition with commercial fisheries, particularly species such as anchovy, may also affect the species. Physical injury from boat strike, entanglement in marine debris and acoustic disturbance are potential risks relevant to all study regions. It is possible, that increased boating activity in the vicinity of the proposed artificial reefs could exacerbate these risks.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Provided that the OARs are managed and monitored appropriately, impacts of the proposal on the brydes whale are considered to be unlikely and of relatively low significance.

References and Additional Information:

DEWHA Threatened Species Database (Brydes Whale)
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=35

Species Name: Pygmy Right Whale (*Caperea marginata*)

Status: Migratory

Distribution:

Little is known about the pygmy right whale's exact distribution, but sightings and strandings around Australian and South African coasts in the spring and summer suggest that this small cetacean moves to inshore waters during this time of year. Pygmy right whales seem to be located solely in most waters of the Southern Hemisphere and travel either alone or in pairs. It is virtually impossible to tell this species from the minke whale, unless the head is visible. Hence, there is potential that some of the sightings of minkes in NSW may have actually been pygmy right whales.

Critical Habitat Resources:

There are no critical habitat resources for the pygmy right whale in the wider study areas.

Site Observations/Habitat Values:

As pygmy right whales have been rarely observed at sea, information about their behaviour and habitat is limited. The wider study areas at all three proposed OAR locations are not however, considered important habitat for this species. Areas of coastal upwelling events appear to be an important component regulating Pygmy Right Whale distribution, but further offshore it appears that the Subtropical Convergence may be an important area for sub adult and adult pygmy right whales.

Recognised Threats and Potential Impact(s) of the Proposal:

A potential threat to pygmy right whales is entanglement in drift-nets set outside Australian Territorial Waters and in lost or discarded netting. It is possible, that increased boating and recreational fishing activity in the vicinity of the proposed artificial reefs could exacerbate these risks.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

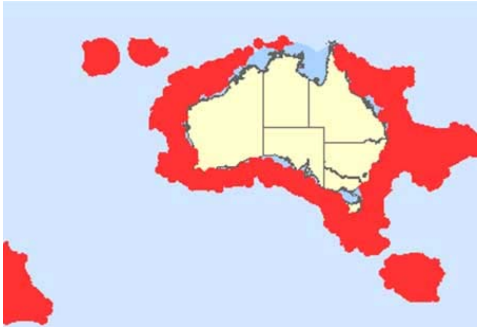
Provided that the OARs are management and monitored appropriately, impacts of the proposal on the pygmy right whale are considered to be unlikely and of relatively low significance.

References and Additional Information:

DEWHA Threatened Species Database (Pygmy Right Whale)
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=39

Species Name: Antarctic Minke Whale (*Balaenoptera bonaerensis*)

Status: Migratory



Distribution:

Antarctic minke whales have been recorded from all States in Australia, apart from the Northern Territory. Little is known about the range of Antarctic minke whales along the Australian coast, although they are known to occur north to 21° S off the east coast. The area of occupancy of Antarctic minke whales is difficult to calculate due to the paucity of confirmed records off Australia and confusion in identification within the minke whale family.

Critical Habitat Resources:

No habitat critical to the survival of the Antartic minke whale occurs in any of the wider study areas.

Site Observations/Habitat Values:

Antarctic minke whales appear to occupy primarily offshore and pelagic habitats within cold temperate to Antarctic waters. On the winter breeding grounds, Antarctic minke whales appear to occupy pelagic waters exceeding 600 m depth. During the summer, they head for higher latitudes to feed. Data on life history, feeding and movement patterns are limited in Australian waters for this species.

Recognised Threats and Potential Impact(s) of the Proposal:

Globally, whaling activities have been the biggest threat to Antarctic minke whales. Pollution, including increasing amounts of plastic debris at sea, oil spills and dumping of industrial wastes into waterways and the sea, leading to bio-accumulation of toxic substances in body tissues, could also be considered an increasing threat to the Antarctic minke whale. Potential risks related to the proposal include boat strike in the direct study area and potentially indirect impacts of entanglement/injury from harmful marine debris.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

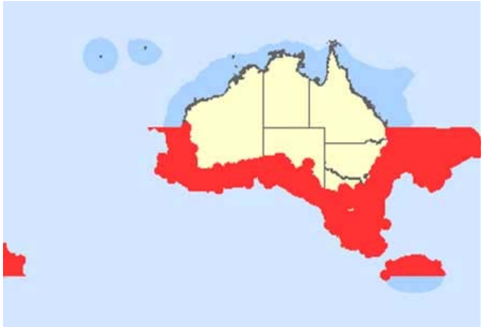
Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Provided that the OARs are managed and monitored appropriately, impacts of the proposal on the pygmy right whale are considered to be unlikely and of relatively low significance.

References and Additional Information:

DEWHA Threatened Species Database (Antarctic Minke Whale).
http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=67812



Species Name: Dusky Dolphin (*Lagenorrhycus obscurus*)

Status: Migratory

Distribution:

Dusky dolphins are southern hemisphere dolphins usually found in temperate waters and often seen in large groups of hundreds. They can be seen inshore in the warmer months and may frequent bays. Low rates of observations or strandings suggest that the dusky dolphin is rare along the south-east Australian coast and are unlikely to be resident.

Critical Habitat Resources:

No habitat critical to the survival of the dusky dolphin occur in any of the wider study areas.

Site Observations/Habitat Values:

The coastal species is usually found over the continental shelf and slope preferring waters with surface temperatures between 10 ºC and 18 ºC.

Recognised Threats and Potential Impact(s) of the Proposal:

Incidental catch in commercial fishing gear and pollution are likely to be the main threats to this species in NSW waters. Potential risks related to the proposal include incidental catch (commercial fisheries), boat strike and entanglement/injury from harmful marine debris.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Given the rare occurrence of the species in NSW, potential impacts of the proposal on the dusky dolphin are considered to be unlikely and of low significance.

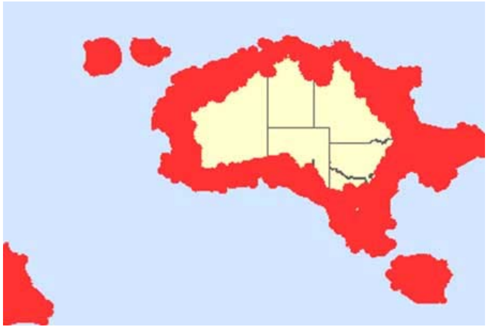
References and Additional Information:

Culik, B. M (2004). Review of Small Cetaceans: Distribution, Behaviour, Migration and Threats. UNEP/CMS Secretariat, Bonn Germany. 343 pp.

Ross, G. (2006) Review of the Conservation Status of Australia's Smaller Whales and Dolphins. http://www.environment.gov.au/coasts/publications/pubs/conservation-smaller-whales-dolphins.pdf

Species Name: Killer Whale (*Orcinus orca*)

Status: Migratory



Distribution:

The killer whale is found in all oceans and seas of the world usually in family groups. It has been recorded from all States of Australia, with concentrations reported around Tasmania.

Critical Habitat Resources:

No habitat critical to the survival of the killer whale occurs in any of the wider study areas.

Site Observations/Habitat Values:

The species occurs in most habitat types from coastal areas to the deep ocean waters, from the tropics to polar regions, although sightings near the coast of NSW are rare. These animals are carnivores and one of the most efficient large predators of the ocean. They often work in packs, and will take a broad range of vertebrates including other whales, seals, penguins, fish, sea otters, and turtles. Killer whales have marked territorial behaviour and home ranges. Their prey is determined by what is available in their home range but they also seek out areas of seasonal abundance such as seal pupping sites.

Recognised Threats and Potential Impact(s) of the Proposal:

Threats to the species includes the reduction of food resources by overfishing of prey species, entanglement in drift nets set outside the Australian Economic Exclusion Zone and in lost or discarded netting. The greatest risk to the species related to the proposal would be the indirect risk of entanglement/injury from harmful marine debris.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If cetaceans were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of cetaceans in the vicinity of the OARs may result in a temporary closure to fishing if an animal was considered to be at risk.

Predicted Outcome/Effectiveness:

Given the rare occurrence of the species in NSW, potential impacts of the proposal on the killer whale are considered to be unlikely and of low significance.

References and Additional Information:

Culik, B. M (2004). Review of Small Cetaceans: Distribution, Behaviour, Migration and Threats. UNEP/CMS Secretariat, Bonn Germany. 343 pp.

Ross, G. (2006) Review of the Conservation Status of Australia's Smaller Whales and Dolphins. http://www.environment.gov.au/coasts/publications/pubs/conservation-smaller-whales-dolphins.pdf

4. Sirenians

Species Name: Dugong (*Dugong dugon*)

Status: Migratory

Distribution:

A significant proportion of the world's dugongs are found in north Australian waters from Shark Bay, Western Australia, in the west to Moreton Bay, Queensland, in the east. Considerable populations occur throughout this region, particularly in the Gulf of Carpentaria (Northern Territory and Queensland), the northern Queensland coast and the northern Western Australian coast. The large populations in Shark Bay, Western Australia and the Great Barrier Reef, northern Queensland were noted as one of the natural features associated with World Heritage listing of these areas. Dugongs are considered occasional visitors to NSW coastal and estuarine waters. It is suggested that warm currents, low rainfall and availability of seagrass in NSW draws some individuals south of their accepted range.

Critical Habitat Resources

No critical habitat for dugongs has been declared in NSW

Site Observations/Habitat Values:

In Australia, dugongs swim in the shallow coastal waters of northern Australia where they find protection from large waves and storms. Dugongs surface only to breathe, and never come on to land. They like to live in large herds, but due to declining numbers are often now found in smaller groups of between one to three dugongs.

Although they only live where there is seagrass, on which they feed, they may migrate between areas. Dugongs have been sighted in NSW in coastal and estuarine waters around Wallis Lake, Port Stephens, Lake Macquarie and Brisbane Water in the summer of 2002/2003. These areas are associated with some of the largest seagrass beds in NSW, some of which contain the *Halophila* species preferred by dugongs. The presence of dugongs in these areas at this time coincided with warm water temperatures (>18°C). No seagrass is found within any of the direct study areas as it is too deep. Dugongs that have been observed in NSW including the wider study areas of the proposed Newcastle and Sydney OARs are thought to be non-breeding vagrants. Mating and birthing areas are normally in northern Australian waters between Shark Bay in Western Australia and Moreton Bay in Queensland.

Recognised Threats and Potential Impact(s) of the Proposal:

The dugong is considered vulnerable to a number of threats including loss/degradation of habitat, boat strike and boating activities, harm from discarded fishing gear, tourism and harassment, acoustic disturbance, chemical pollution, disease and parasites among others. Potential threats to dugongs associated with the proposal include:

- Boat strike;
- Potential for harm from marine debris;
- Acoustic pollution and;
- Harassment.

Proposed Impact Mitigation Measures:

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species sightings or incidental capture, the responsible disposal of discarded fishing gear and boating guidelines in the vicinity of large marine mammals such as the dugong. See Section 10 (Environmental Management Plan).

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. Water quality would also be monitored. If dugongs were considered at risk after a review period then temporary or seasonal closures would initially be implemented. In the short-term, reported sightings of dugongs in the vicinity of the OARs may result in a temporary closure if an animal was considered to be at risk from fishing activity.

Predicted Outcome/Effectiveness:

It is unlikely that the dugong would occur within the direct OAR study areas and the proposal is not considered to represent a significant threat as there is no important habitat (such as seagrass beds) or known aggregation areas in the direct study areas. Provided that suitable management measures are employed to minimise any potential harm from increased boating and recreational fishing activity (i.e. entanglement or boat strike) in the vicinity of the OARs potential impacts would be of low significance.

References and Additional Information:

DEWHA Species Profile and Threats Database – Dugong. http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=28

Allen, S. Marsh, H. Hodgson, A (2004). Occurrence and Conservation of the Dugong (Sirenia: Dugongidae) in New South Wales. Proceedings of the Linnean Society of New South Wales. Vol 125. 211 – 216.

5. Seabirds

Species Group: Seabirds (includes albatrosses, petrels, shearwaters, terns, gulls, gannets, cormorants and boobies).

Status: Protected/vulnerable/Endangered)

Critical Habitat Resources:

There are no critical habitat resources for seabirds within the wider study areas. Moon Island (Newcastle study region), North Head (Sydney study region) and the Five Islands Nature Reserve (Wollongong study region) are however, considered important roosting and breeding habitat for a number of seabirds within the wider study areas.

Site Observations/Habitat Values:

Seabirds occur widely across the world's oceans. Twenty-two of the world's 24 albatross species occur in the Southern Hemisphere. Nineteen of these species occur in Australian waters, and five of these also breed in Australia. Many species, such as the Grey-headed Albatrosses, are extremely dispersive, spending most of their time over surface waters. In contrast, others, like adult Shy Albatrosses, tend to be sedentary, regularly foraging over the coastal waters of southern Australia throughout their adult lives.

Four areas within Australian waters have been listed as critical habitat for albatross. Macquarie Island is listed as critical habitat for the Wandering and Grey-headed Albatrosses. Albatross Island, Pedra Branca and the Mewstone are listed critical habitat for the Shy Albatross. There are no other listed critical habitats for seabirds.

Recognised Threats and Potential Impact(s) of the Proposal:

Commercial long-lining is considered a significant threat to seabirds (particularly albatross and giant petrels) this however, mainly takes place in Commonwealth waters and is not relevant to the current proposal. Other types of line fishing (such as set-lining) do take place within State waters and could potentially affect seabirds if these practices to take place within the study areas. The recreational practice of trolling a fishing line at or near the surface also has the potential to cause mortality if seabirds are caught on hooks. It is possible that discarded bait from recreational fishing boats could attract seabirds to feed in the area thus, increasing the risk of becoming injured or entangled. Seabirds may also be put at risk from injury due to harmful marine debris such as discarded fishing gear as a result of increased fishing activity within the study areas.

Proposed Impact Mitigation Measures:

Risk of hooking seabirds while trolling can be eliminated by setting troll lines at least 2m below the surface of the water.

Management - environmental management would include an education campaign for target user groups outlining mechanisms for reporting threatened species of seabird or incidental capture and the responsible disposal of discarded fishing gear.

Monitoring – OARs would be monitored for impacts on threatened species by surveys of anglers. If seabirds were considered at risk after a review period then temporary or seasonal closures would initially be implemented.

Predicted Outcome/Effectiveness:

Provided that OARs are suitably managed and carefully monitored for impacts on seabirds, then it is considered unlikely the proposal would significantly affect seabirds and the significance of potential impacts would be low.

References and Additional Information:

DEWHA Species Conservation – Marine Seabirds
http://www.environment.gov.au/coasts/species/seabirds/index.html

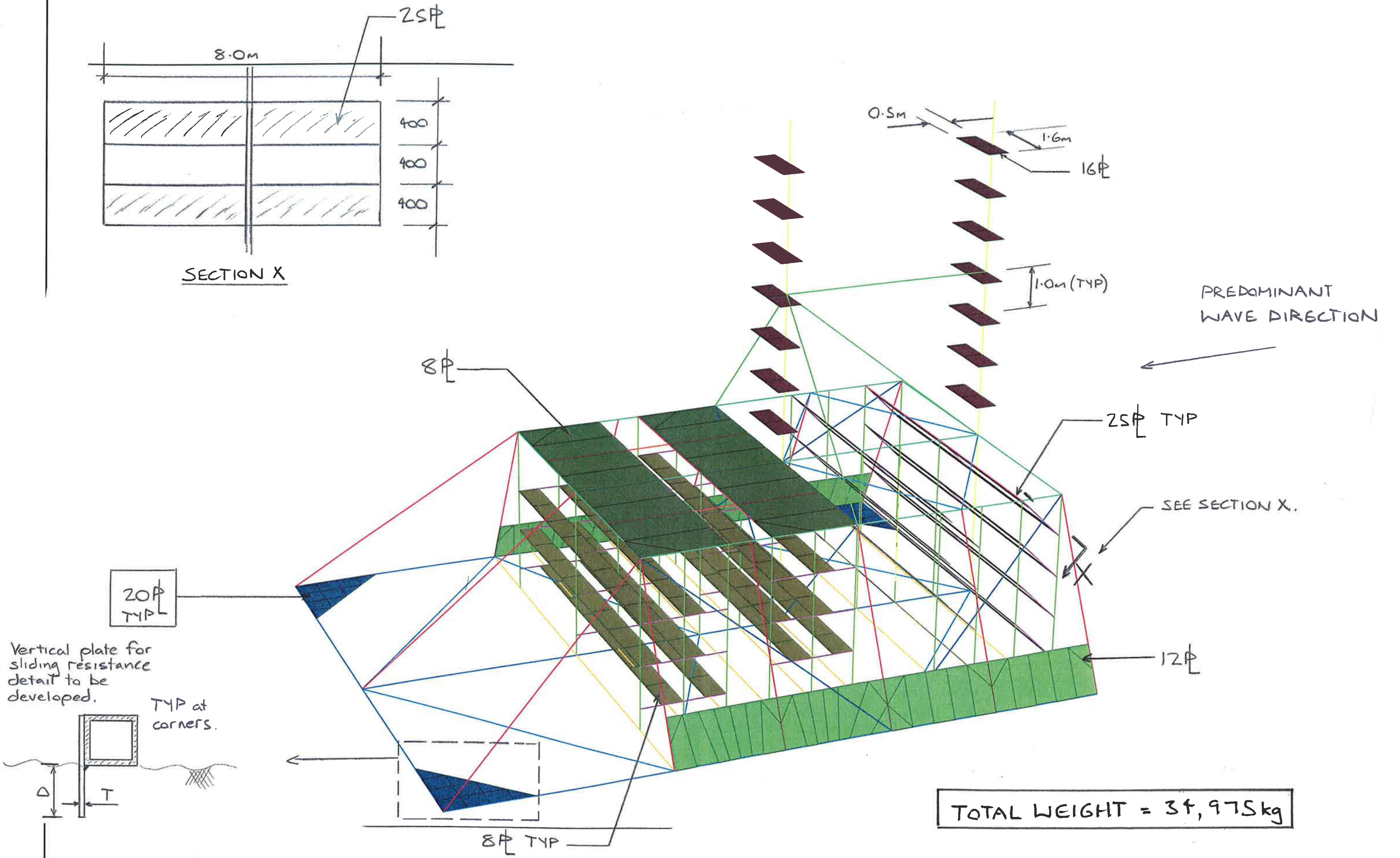
DEWHA National Recovery Plan for Albatrosses and Giant Petrels
http://www.environment.gov.au/biodiversity/threatened/publications/recovery/albatross/index.html

DEH Recovery Plan for 10 Species of Seabirds
http://www.environment.gov.au/biodiversity/threatened/publications/pubs/seabirds.

Appendix 8

OAR Concept Design

(Worley Parsons)



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A1 SHEET SCALE AS SHOWN

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CUSTOMER
CARDINO ECOLOGY LAB

OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
PERSPECTIVE VIEW 1
(PLATE THICKNESSES)

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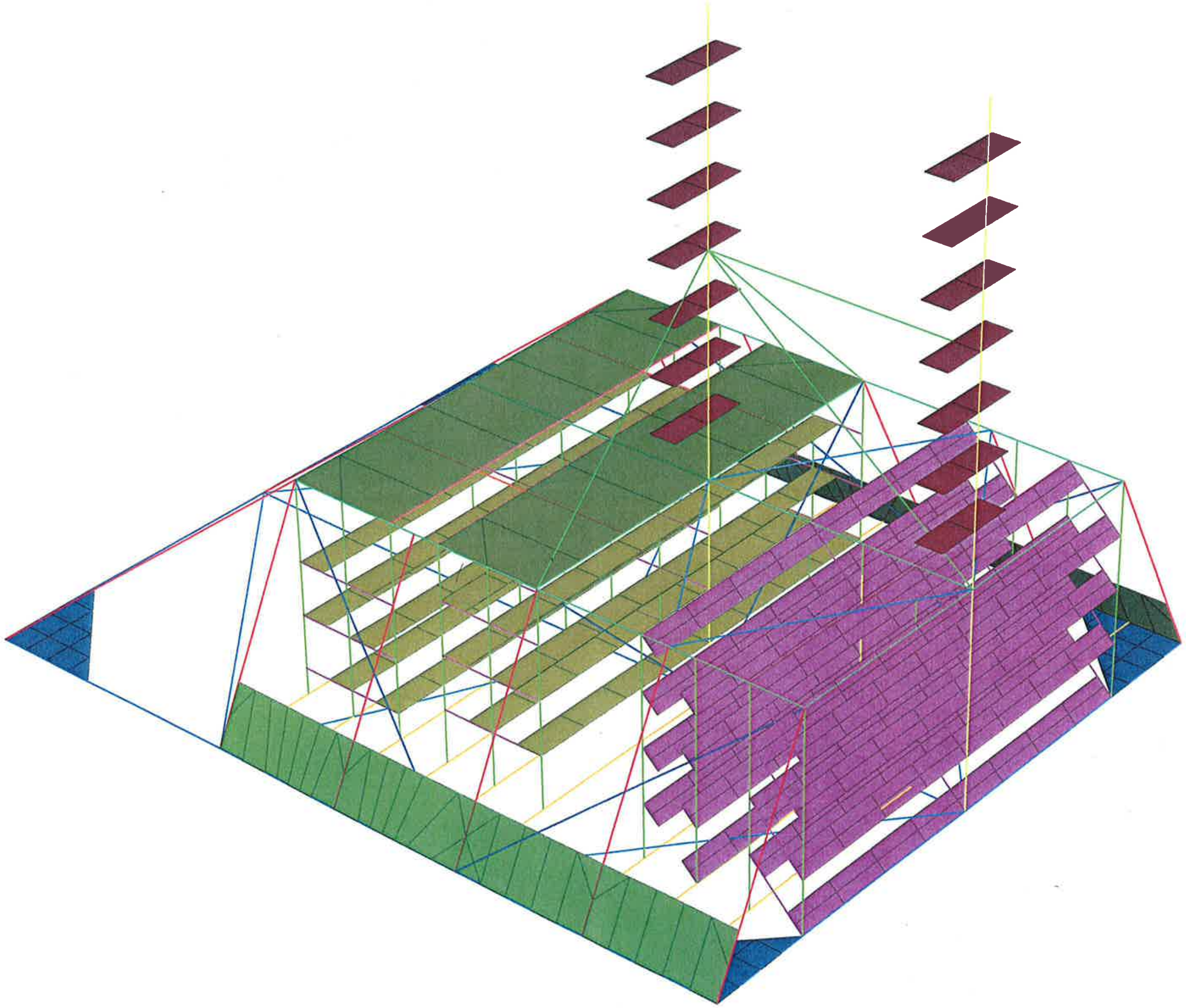

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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CARDINO
ECOLOGY
LAB

OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
PERSPECTIVE VIEW 2

DRG No 00945-CS-DSK-0002 REV A

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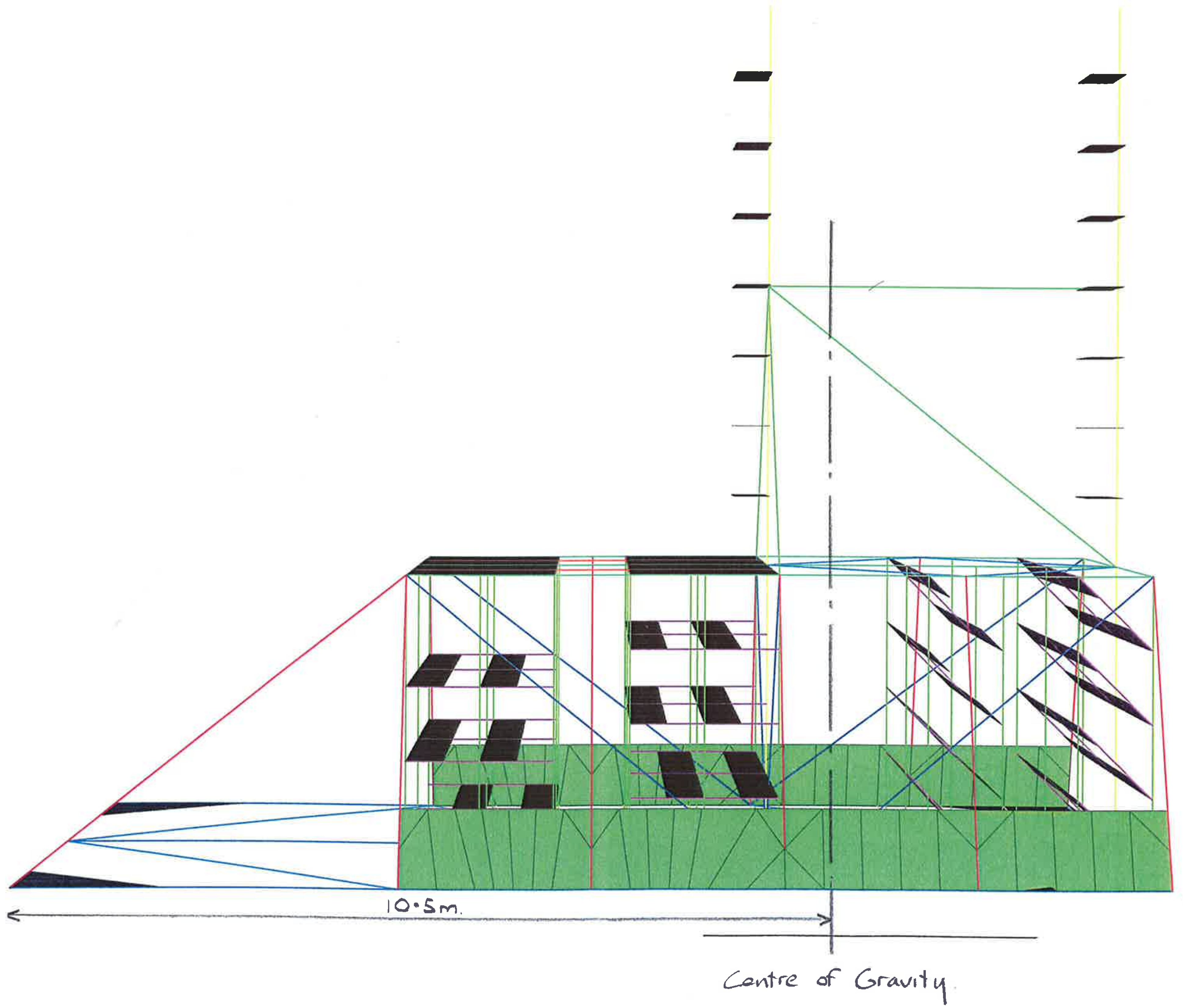

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CUSTOMER
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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
SIDE VIEW

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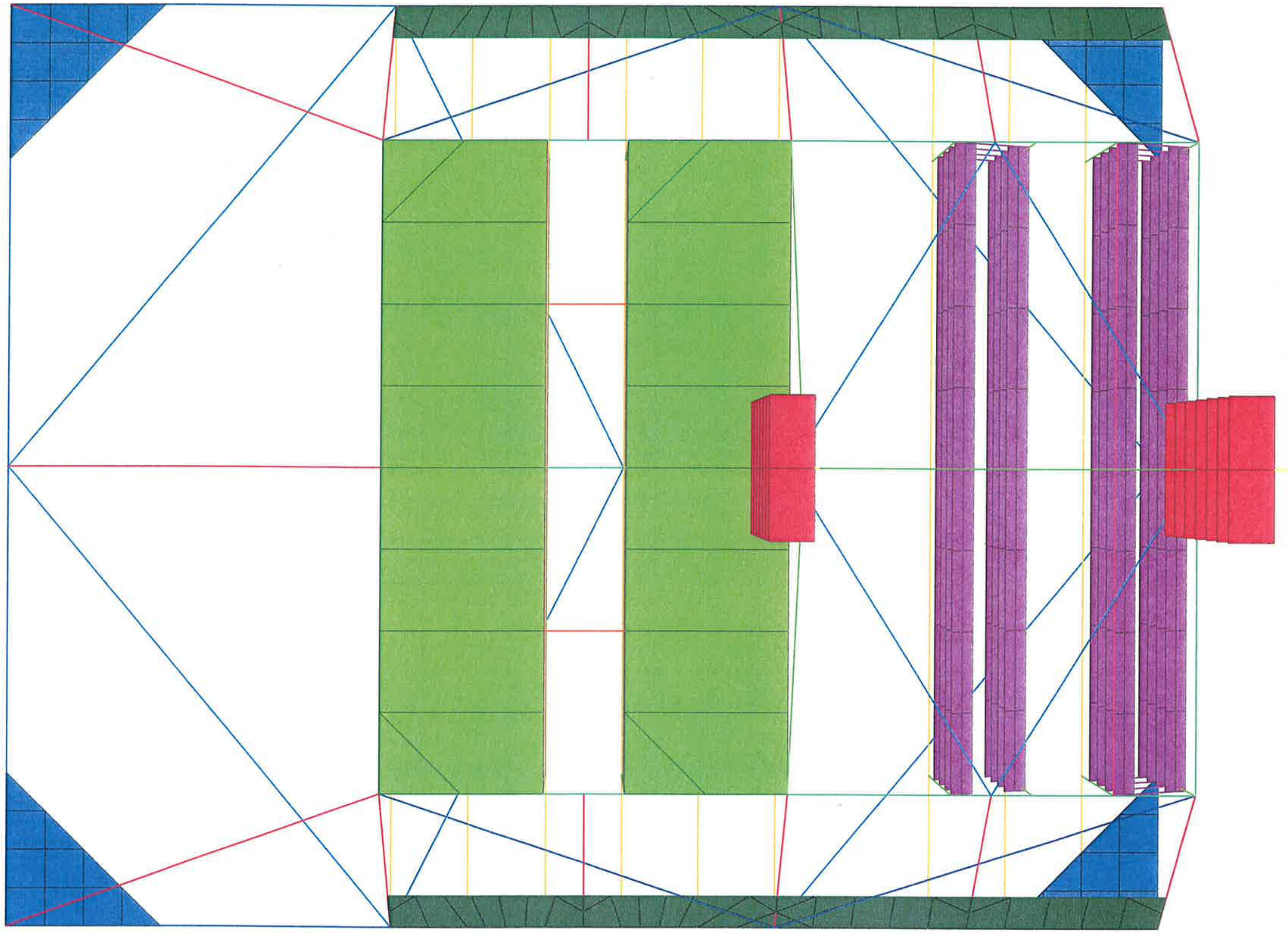

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CUSTOMER
CARDINO ECOLOGY LAB

OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
TOP VIEW

DRG No 00945-CS-DSK-0004
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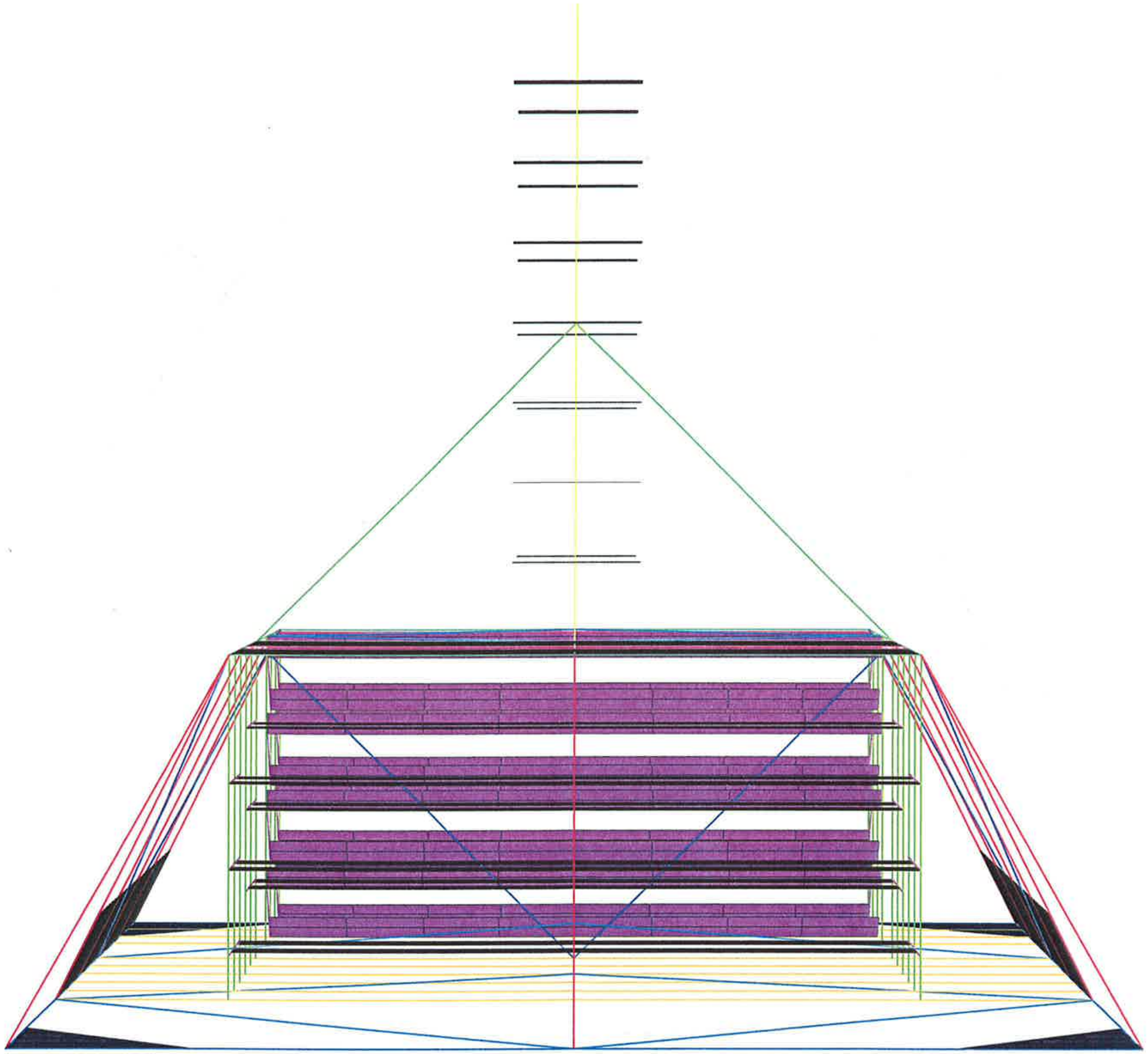

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CUSTOMER
CARDINO ECOLOGY LAB

OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
FRONT VIEW

DRG No 00945-CS-DSK-0005

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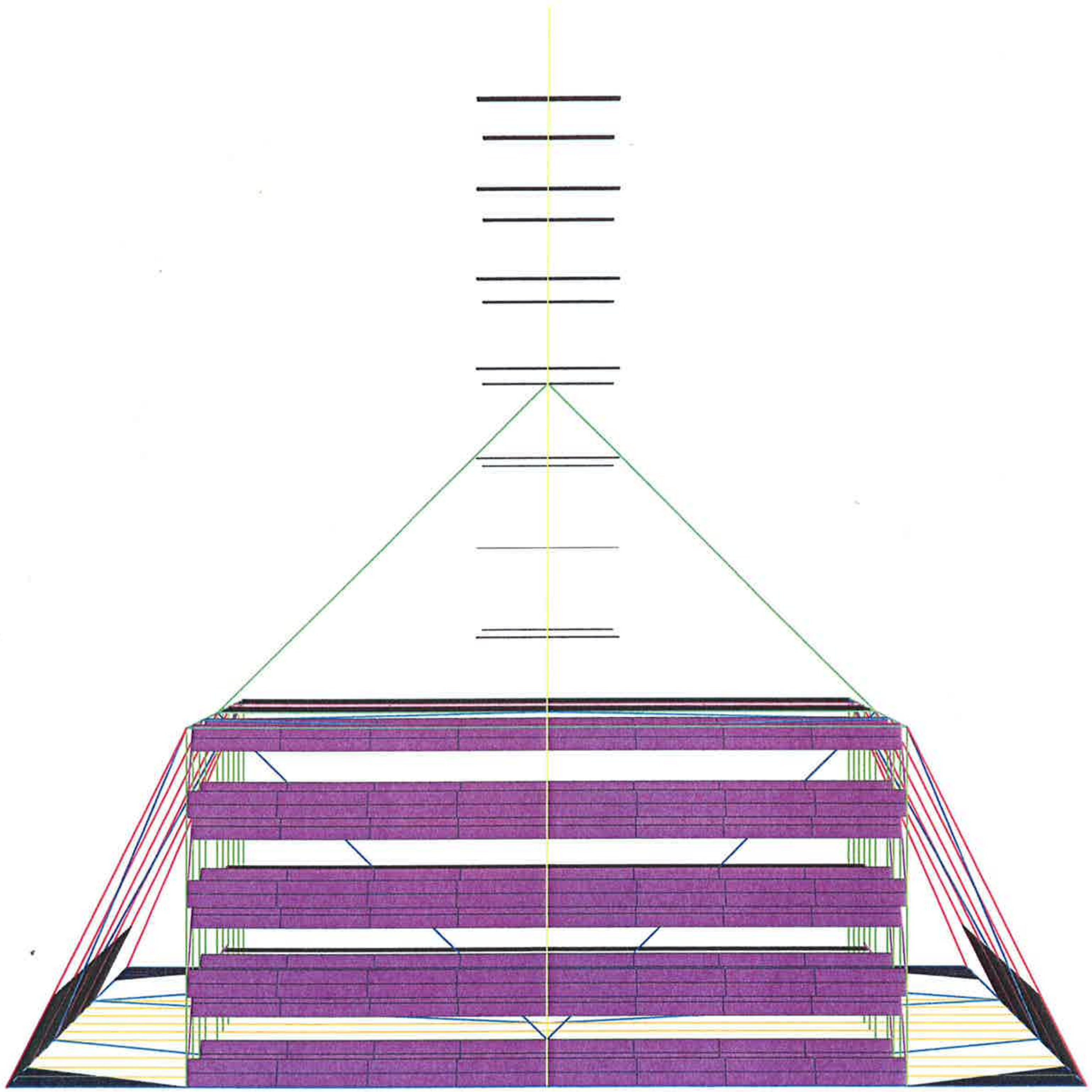

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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CUSTOMER
CARDINO ECOLOGY LAB

OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
REAR VIEW

DRG No 00945-CS-DSK-0006
REV A

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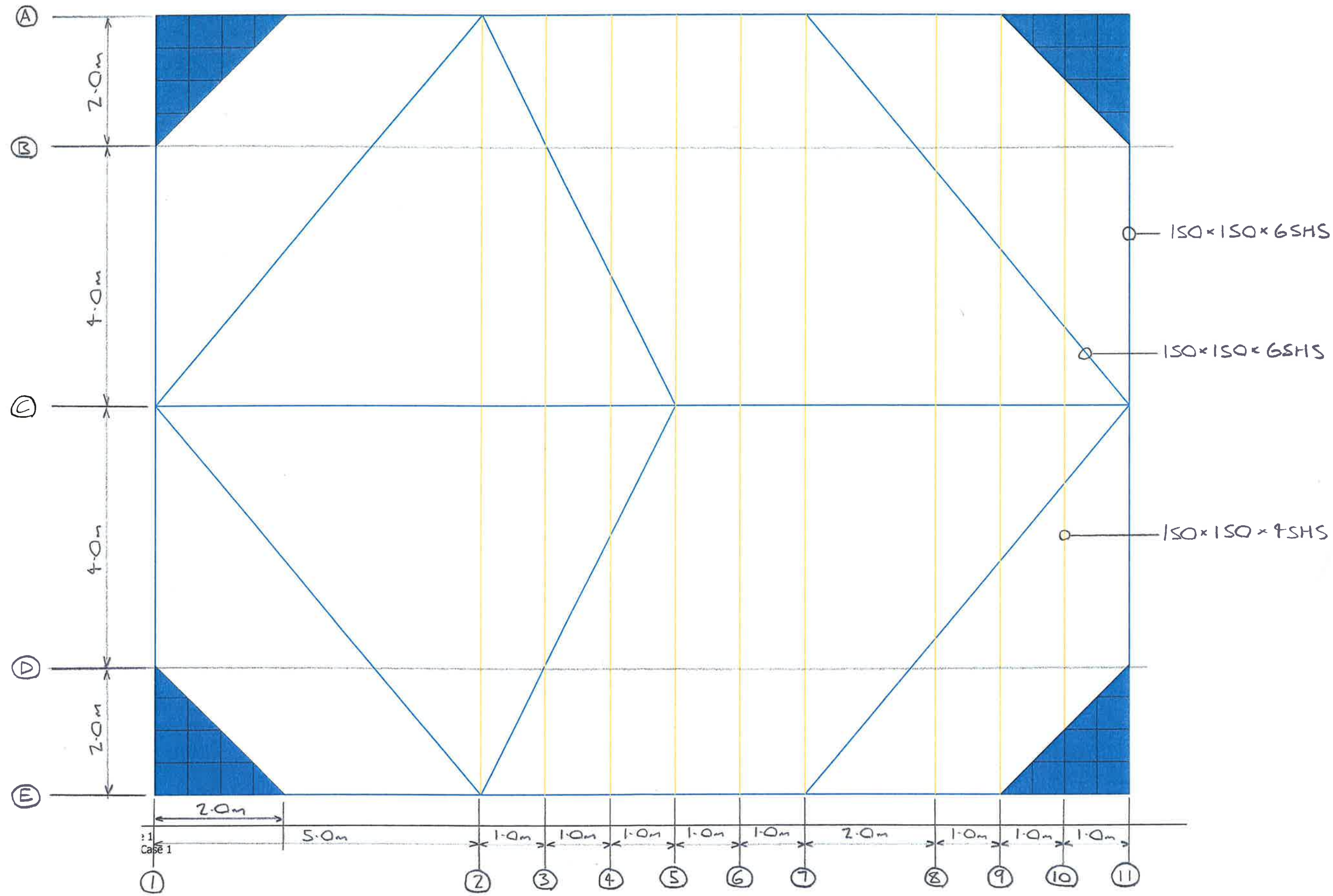

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A	06.08.09	CONCEPT DESIGN ISSUE			GC			

REF DRAWING No	REFERENCE DRAWING TITLE

A1 SHEET SCALE AS SHOWN

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
GROUND LEVEL PLAN (RL : 0m)

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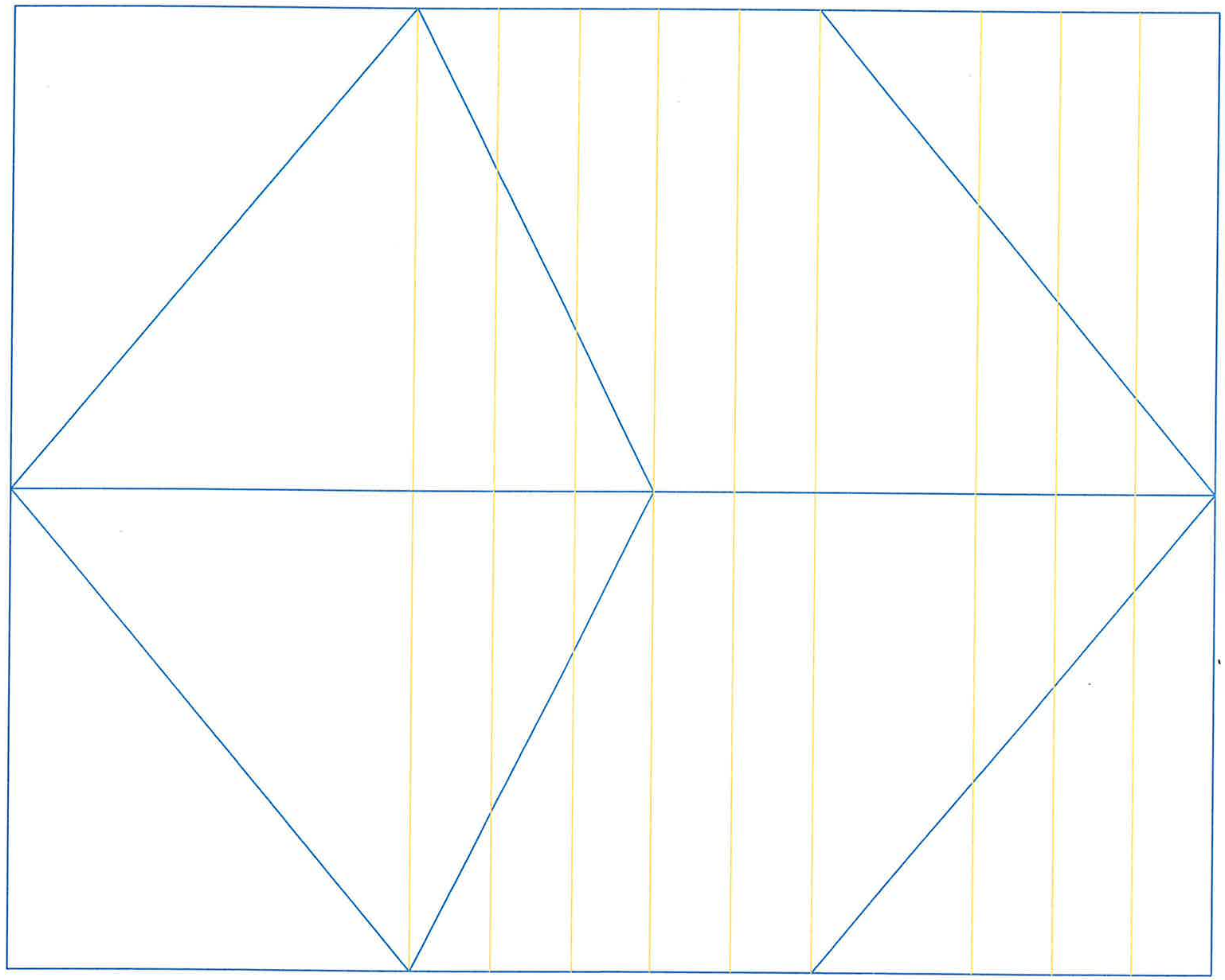

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
GROUND LEVEL PLAN (RL: 0m)
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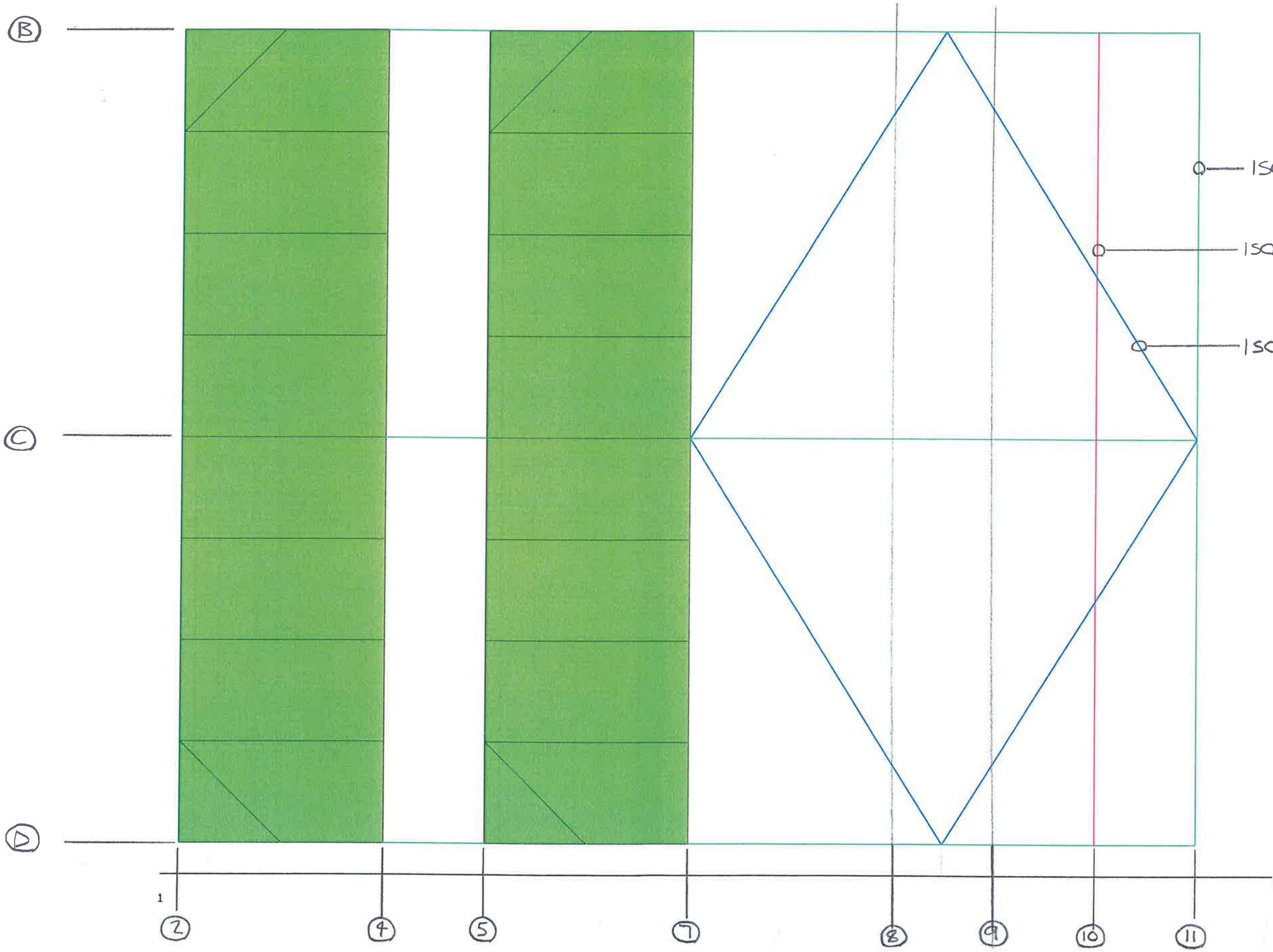

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
FIRST FLOOR PLAN (RL 4.0m)

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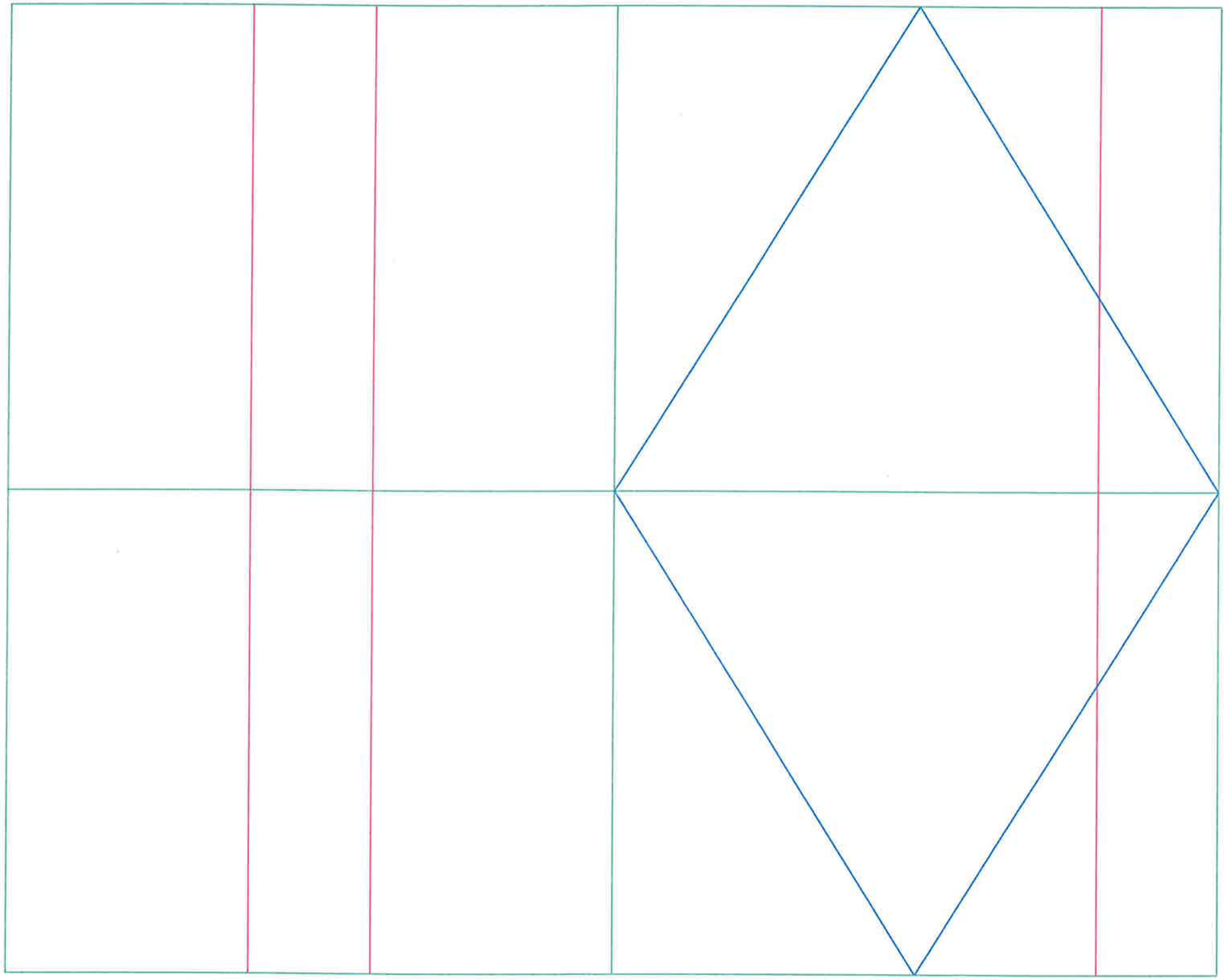

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A1 SHEET | SCALE AS SHOWN

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
FIRST FLOOR PLAN (RL: 4.0m)
(PLATES NOT SHOWN)

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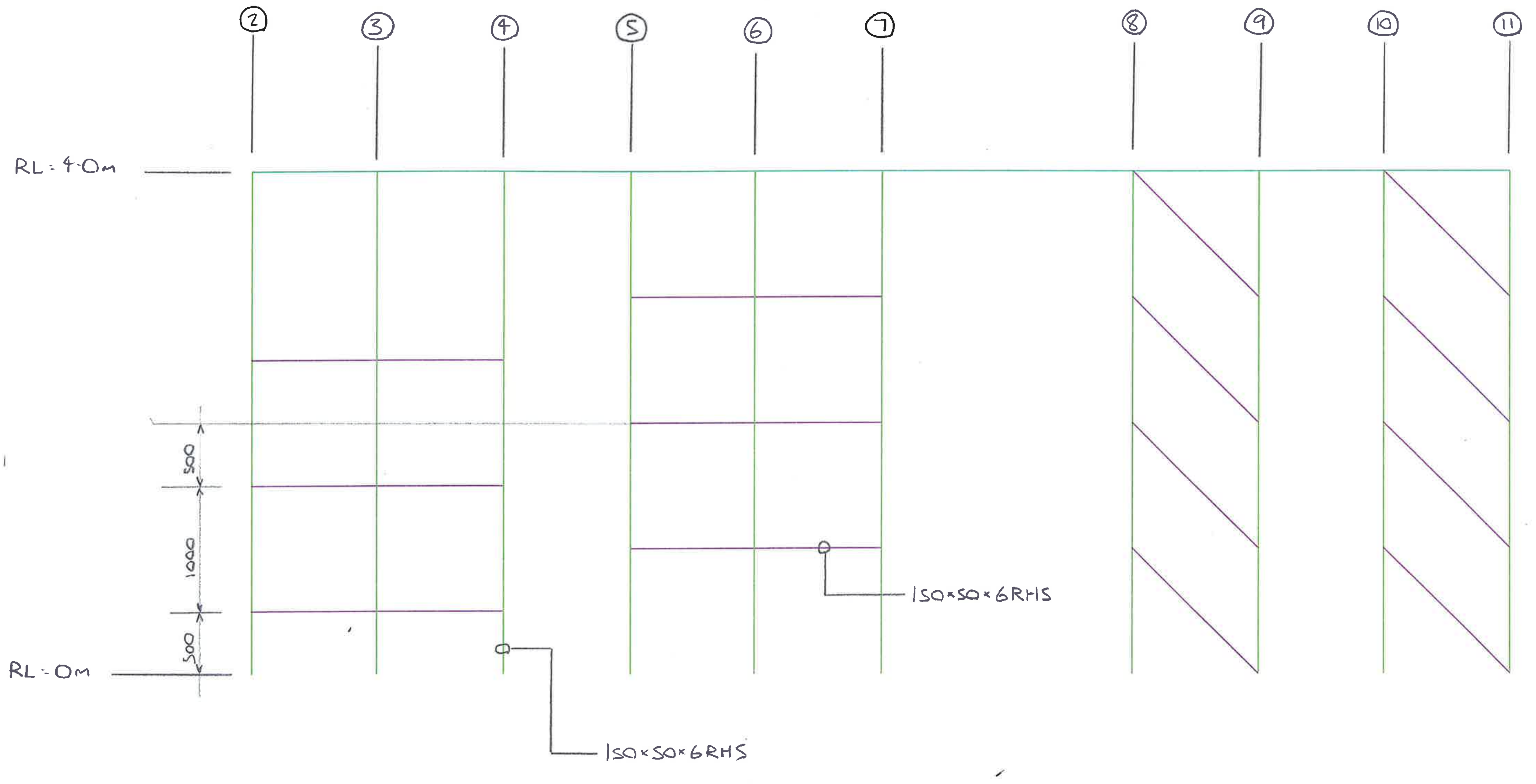

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRID B
(ELEVATION GRID D SIMILAR)

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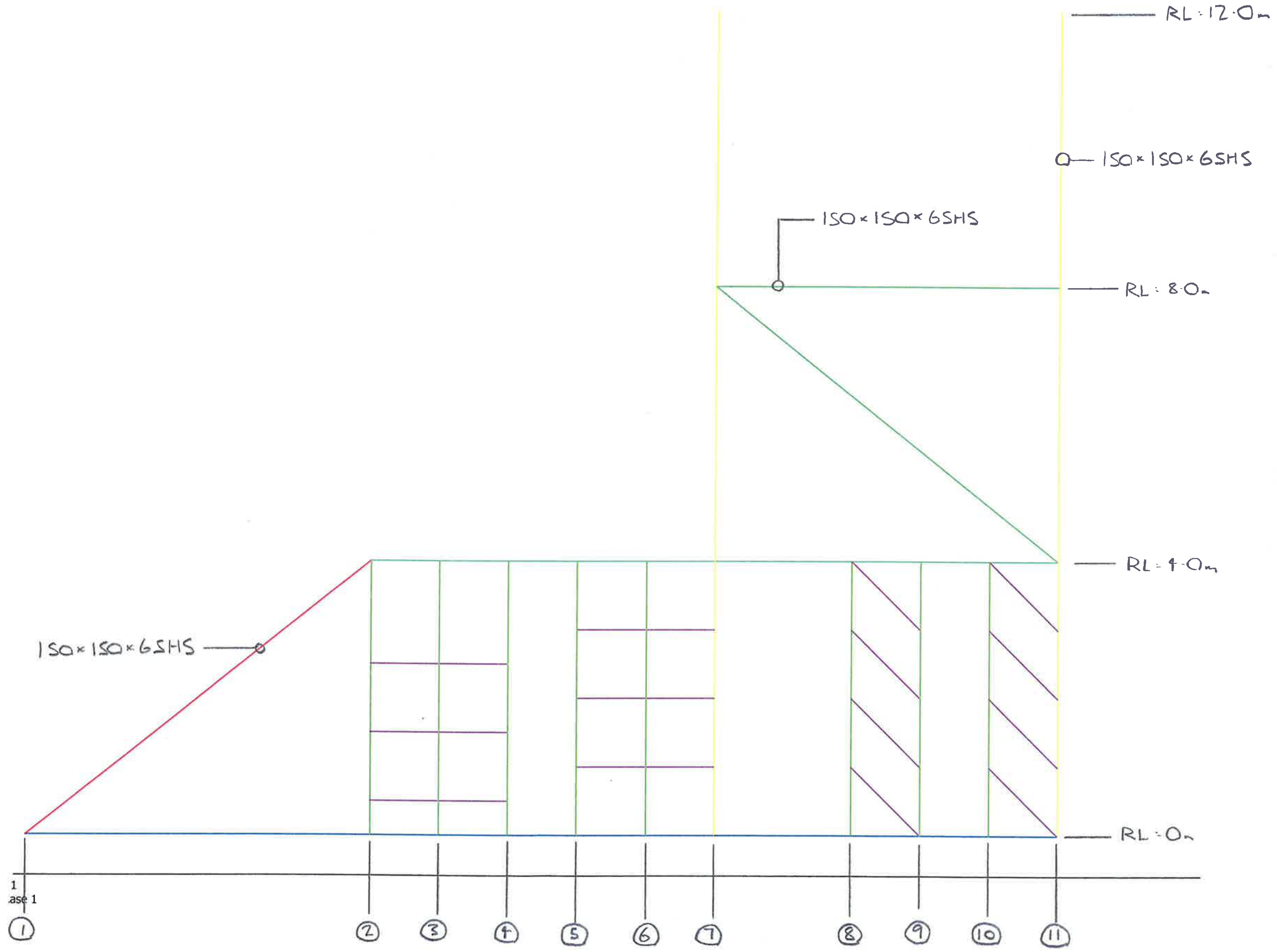

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRID C

DRG No 00945-CS-DSK-0012 REV A

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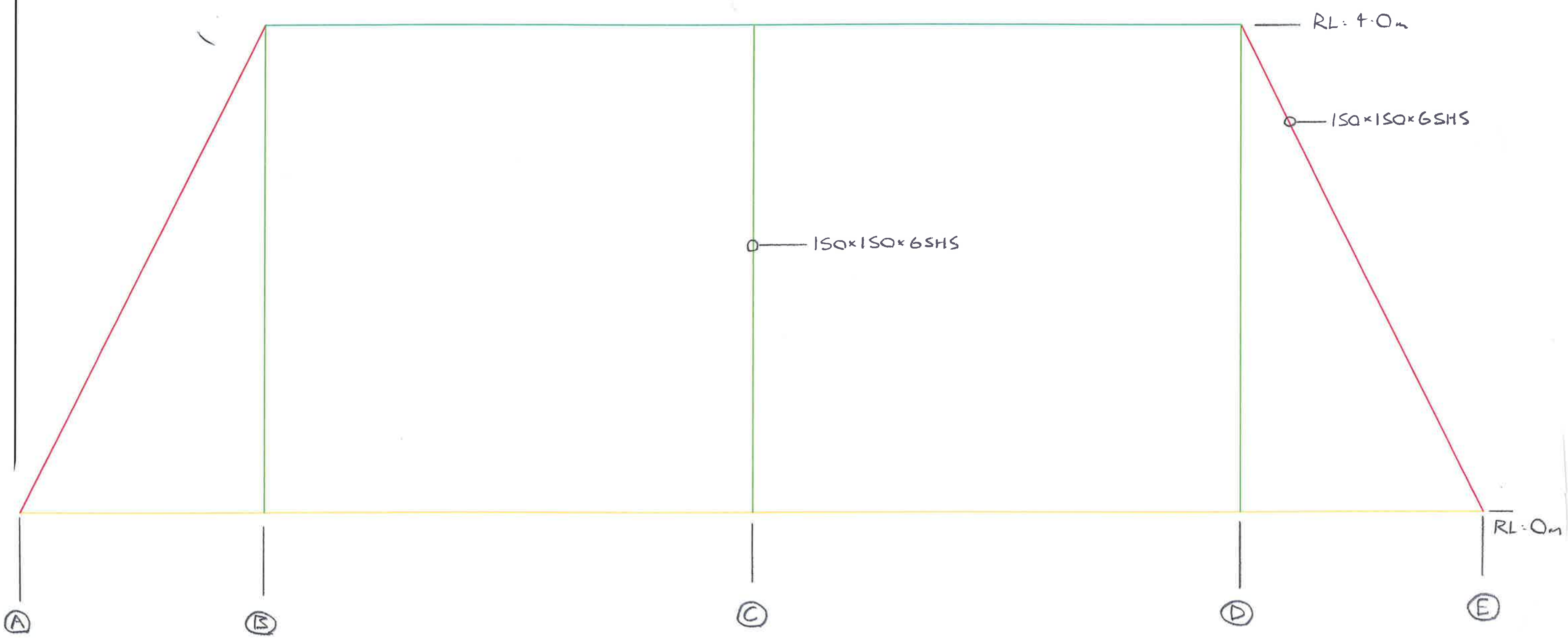

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRID 2

DRG No 00945-CS-DSK-0013 REV A

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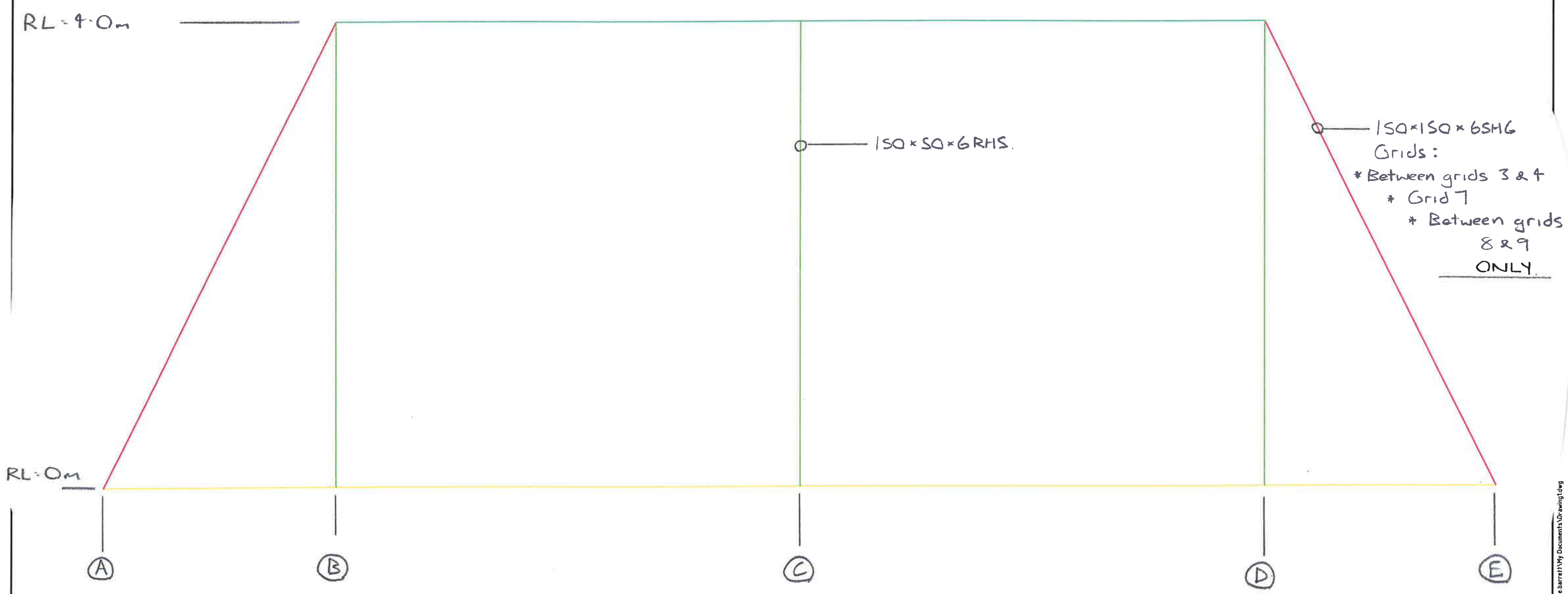

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRIDS :
3-6 AND 8-10

DRG No 00945-CS-DSK-0014 REV A

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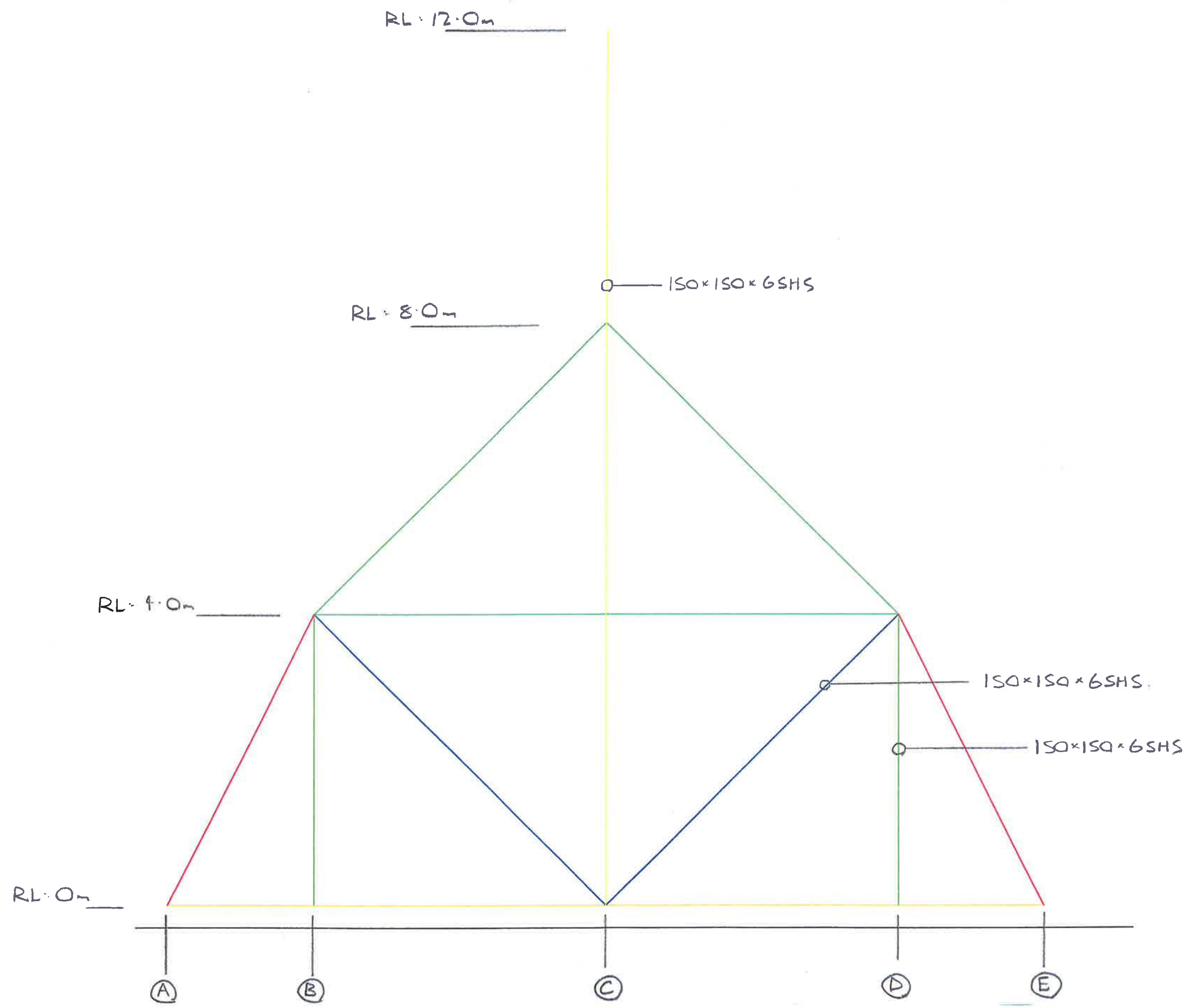

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A	06.08.09	CONCEPT DESIGN ISSUE			GC					

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OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRID 7

DRG No 00945-CS-DSK-0015 REV A

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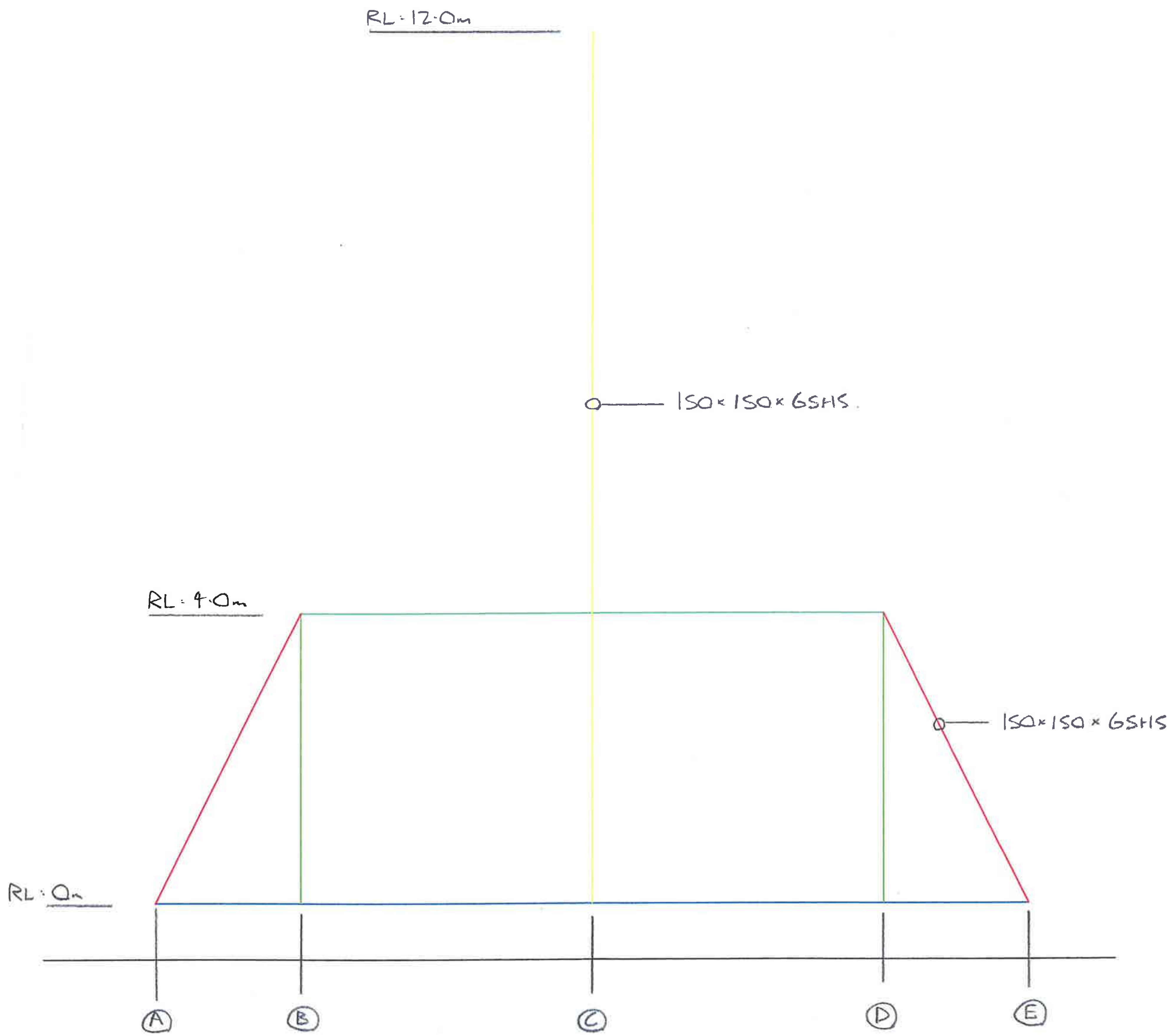

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PH: +61 2 8456 7200 - FAX: +61 2 8923 6877 ABN 61 001 279 812

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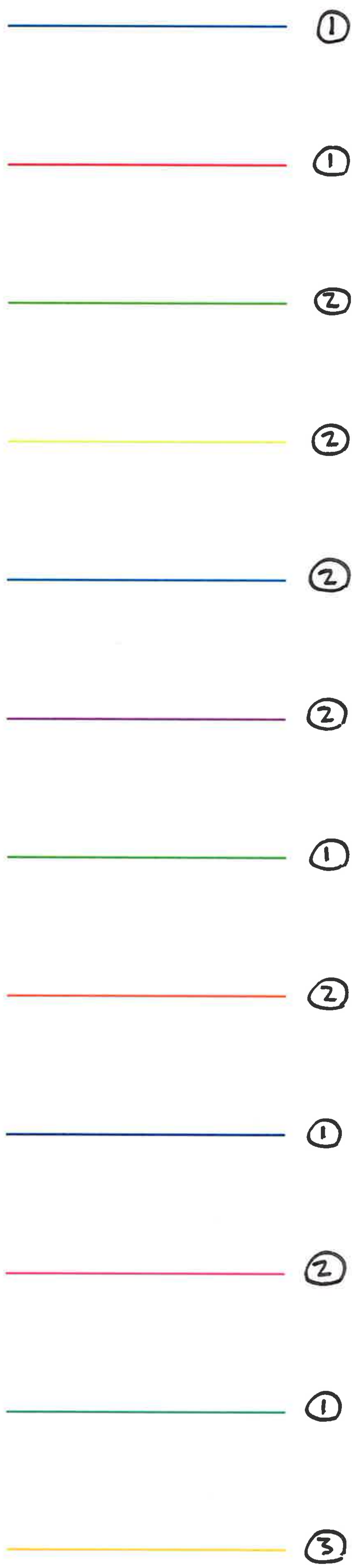
OFFSHORE ARTIFICIAL REEF
CONCEPT DESIGN
ELEVATION GRID 11

DRG No 00945-CS-DSK-0016 REV A

DATE & TIME: 06/08/2009 12:43:33 PM USER NAME: Steve.Barrett LOCATION: C:\Documents and Settings\steve.barrett\My Documents\Drawing1.dwg

Title:	MEMBER / PLATE SCHEDULE
Project:	ARTIFICIAL REEF
Author:	Reference:



1 : 150 × 150 × 6 SHS
2 : 150 × 50 × 6 RHS
3 : 150 × 150 × 4 SHS

STEEL SECTIONS TO BE MINIMUM 350MPa GRADE STEEL (BLACK STEEL). STEEL MEMBER SIZES CONFORM TO AS4100/AS1163. PLATE TO BE MINIMUM 250MPa GRADE STEEL (BLACK STEEL).

PLATE THICKNESSES

20mm PL
16mm PL
8mm PL
8mm PL
25mm PL
12mm PL

Appendix 9

Environmental Management Plan (EMP)

Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Offshore Artificial Reefs (Newcastle, Sydney & Wollongong)

Environmental Management Plan & Construction Methodology

Prepared on behalf of: Industry and Investment NSW
for:
Environmental Assessment (Project 08_0095) and
Draft Public Environment Report (EPBC Referral 2008/4176)

February 2010

Cardno Ecology Lab Pty Ltd

ABN 73 002 379 473
4 Green Street
Brookvale
New South Wales 2100
Australia
Telephone: 02 9907 4440
Facsimile: 02 9907 4446
International: +61 2 9907 4440
ecologylab@cardno.com.au
www.cardno.com.au

Cover Image: Portside construction crane. Source: Bigstock stock photography.

Document Control

Job Number	Status	Date	Author		Reviewer	
EL0809031 A	Final draft	7 December 2009	Kate Reeds	KR	Theresa Dye	TAD
EL0809031 A	Revised	18 January 2010	Kate Reeds	KR	Arthur Dye	AD
EL0809031 A	Revised	22 February 2010	Kate Reeds	KR	Arthur Dye	AD

Table of Contents

1 Introduction

1.1 Background

Industry and Investment NSW (I&I NSW) previously NSW Department of Primary Industries, with funding from the Recreational Fishing Trust, aim to improve recreational fishing opportunities in NSW through the development of offshore artificial reefs (OARs) in the vicinity of Newcastle, Sydney and Wollongong.

This EMP document aims to consolidate the mitigation and management measures that I&I NSW are committed to implementing to minimise potential impacts of the proposal on the environment.

OARs would initially be deployed at one location to enable monitoring and assessment of the success of the reef before proceeding with the other two locations.

In each region, the proposal is for the installation of four individual 'reef units' deployed at water depths between 30 m – 40 m. The combination of the four 'reef units' will collectively create a 'reef set' i.e. the multi-component artificial reef. The units would be configured in a line (running approximately north to south) spaced 200 m apart. At the present stage, only one study region will be selected for the Pilot OAR installation. This Environmental Management Plan (EMP) has therefore been prepared at a generic level for all three potential locations.

Based on the outcomes of the Environmental Assessment/draft Public Environment Report (EA/draft PER) and subject to further consultation with I&I NSW, the locations for each of the study regions are as follows:

- Newcastle region (Swansea). Approximately 3.3 km offshore from The Entrance at Swansea at a depth of approximately 28 m.
- Sydney region (South Sydney). Approximately 2 km SE of South Head, at a depth between 36 m – 38 m.
- Wollongong region (Port Kembla). Approximately 2.4 km offshore from Perkins Beach (south of Port Kembla) at a depth of approximately 34 m.

1.2 Concept Design

The structures would be manufactured from square hollow sections (SHS) and rectangular hollow sections (RHS) sections and plates, would weigh approximately 35 tonnes (dry weight) and would sit directly on the seabed without the need for additional anchorage, other than the weight of the unit itself. As an outcome of the EA/draft PER, a new OAR concept design was developed to ensure structural stability under the local oceanographic conditions, while maintaining the functionality of the artificial reef. The proposed concept design aims to target popular angling species such as snapper and yellowtail kingfish. The OAR concept design is 12 m x 15 m x 12 m (height x length x width) with the bulk of the internal structure in the top 4 m giving it a low centre of gravity (Figure 1). Dimensions of the OAR may vary pending the finalisation of the technical design specifications that will be used for the units manufacture/fabrication, transport and deployment.

The units would be constructed at a suitable waterside location, loaded onto a cargo barge, transported to the deployment site and lowered to the seabed by crane. It is expected that the construction, transport and deployment process would take approximately 7 - 8 months to complete (depending on the weather). The operational lifespan of the OAR units is estimated to be 30 years.

1.3 EMP Outline

The EMP is divided into two sections; construction, transport and deployment and long-term operation. I&I NSW has specified that a single contractor be appointed to undertake the construction, transport and deployment process. The contractor, in consultation with I&I NSW would also be responsible for the final design verification and selection of a suitable construction/fabrication site. Once a final location has been selected for OAR deployment, the appointed contractor would be required to develop and implement a detailed and site specific construction environmental management plan (CEMP) and take responsibility for all occupational health and safety requirements for staff and sub-contractors.

I&I NSW would be responsible for the operational phase, including monitoring, management and maintenance operations.

Performance criteria, timeframes and contingencies for unplanned events are detailed in the Environmental Management sections of this document (Sections 3.2 and 4.2) where relevant.

The predicted effectiveness of the proposed management strategy/mitigation measures has been assessed on the following basis:

- High = the management strategy/impact mitigation measures should effectively reduce the magnitude of the potential impact to an extent where no discernable impact on ambient environmental conditions should be evident.
- Moderate = the impact is still likely to occur but the observed magnitude of the impact should be substantially smaller than if the management strategy or mitigation measure was not implemented.
- Low = the impact is still likely to occur.
- Uncertain = there is insufficient information available to predict with any certainty how effective the management strategy/impact mitigation measure will be in reducing the magnitude of the impact.

Terms referred to throughout the EMP are defined below:

'OAR Management Area' – refers to the area relevant to the mitigation and management measures outlined in Section 4.1.1.

'Monitoring Plan'– refers to the Monitoring Plan outlined in Section 4.1.2 (Table 1). Background information and details of the Monitoring Plan are also given in Section 11.2 of the EA/draft PER document.

'User Guidelines' – refers to the guidelines outlined in Section 4.1.3. These guidelines aim to provide information important for OAR user groups to ensure minimal environmental impact and promote safety within the management area.

The EMP for the long-term operation of the OARs should be reviewed and revised as necessary over time.

2 Statutory Requirements and Policy

2.1 Relevant Commonwealth Legislation

Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is administered by the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) 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;
- provide for the protection and conservation of heritage.

Environment Protection (Sea Dumping) Act 1981 (EP (SD) Act)

Under this Act permits are required to create artificial reefs. Under the Act, 'artificial reef' means a structure or formation placed on the seabed for the purposes of:

- increasing or concentrating populations of marine plants and animals; and/or
- being used in human recreational activities.

Permit conditions usually require research and monitoring to be undertaken, at the applicants expense for dumping or artificial reef placement. Once a permit is issued, the artificial reef is then charted on maritime maps.

DEWHA has advised that the guidelines issued for the Environmental Assessment (EA) have been scoped to meet the information requirements of the EP (SD) Act.

Historic Shipwrecks Act 1976

The *Historic Shipwrecks Act 1976* 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 artificial reef unit would be under the jurisdiction of this Act. Under Section 4 of the 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 Act. Other shipwrecks can be declared historic and granted this protection on an individual basis according to their particular merits, such as the M24 Japanese submarine. Under Section 13 of the 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. The SS *Duckenfield* and the *M24* Japanese Submarine are located within declared protected zones. Under Section 17 of the Act persons discovering a shipwreck are legally obligated to notify the appropriate authorities of the discovery. Although this is a Commonwealth Act (administered by DEWHA), the Heritage Office part of the NSW Department of Planning, is the delegated authority for this State.

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 within their claim area.

2.2 Relevant State Legislation

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

The 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 Act details various planning instruments including State Environmental Planning Policies, Regional Environment Plans and Local Environment Plans and specifies which types of developments require development consent.

The objectives of this 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;
- promoting ecologically sustainable development.

Threatened Species Conservation Act 1995 (TSC Act)

In NSW, the *TSC Act*, administered through the NSW Department of Environment, Climate Change and Water (DECCW) includes provisions to declare and protect threatened species, populations and ecological communities. Species populations and 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 *Threatened Species Conservation Act* provides for the identification of habitat that is that is critical to the survival of an endangered species, population or ecological community.

Fisheries Management Act 1994 (FM Act)

Provisions for the protection of fish and marine plants are administered through Industry and Investment (I&I NSW), previously NSW Department of Primary Industries and listed in schedules of the *FM Act*. Species populations and 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 Act. In addition, Division 3 of the *Fisheries Management Act* provides for the identification of habitat that is critical to the survival of an endangered species, population or ecological community.

National Parks and Wildlife Act 1974 (NPW Act) and the *National Parks and Wildlife Regulation 2002 (NPWR).*

Under the *NPW Act*, the Director-General of the National Parks and Wildlife Service 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, karst conservation reserves and regional parks are also administered under the 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 *National Parks and Wildlife Regulation* which came into effect on 1 September 2002, governs various activities under the *National Parks and Wildlife Act 1974*, including:

- the regulation of the use of national parks and other areas administered by the NPWS (Part 2);
- the preservation of public health in Kosciuszko National Park (Part 3);
- licences and certificates (Part 4);
- the protection of fauna (Part 5) including the protection of certain types of marine mammals (Division 3A);
- the exemption of Aboriginal people from the restrictions imposed by various sections of the Act on the hunting of certain animals and the gathering of certain plants (Part 6);
- boards of management and plans of management in relation to Aboriginal land (Part 7);
- advisory committees constituted under section 24 of the National Parks and Wildlife Act 1974 (Part 8).

The regulation replaces the former *National Parks and Wildlife* (*Land Management*) *Regulation 1995*, the *National Parks and Wildlife* (*Administration*) *Regulation 1995* and the *National Parks and Wildlife* (*Fauna Protection*) *Regulation 2001*.

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 proposed OARs would therefore be located on Crown Land. 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;
- Crown land be occupied, used, sold, leased, licensed or otherwise dealt with in the best interests of the State consistent with the above principles.

Coastal Protection Act 1979

The objectives of this Act 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;
- to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including:

- o benefits to the environment; and
- o benefits to urban communities, fisheries, industry and recreation.

Heritage Act 1977

Under this Act, historic shipwrecks are the remains of any ship (including articles associated with the ship) that has been situated in State waters (within the 3nm 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 Act, a permit is required to move, damage, or destroy any historic shipwreck. The Act does not apply to State waters that are waters to which the Commonwealth's *Historic Shipwrecks Act 1976* applies. There are also provisions within the Act which allow for the declaration of an Interim Heritage Order. The *M24* Japanese submarine wreck, for example, is currently the subject of an Interim Heritage Protection Order.

Maritime Services Act

This Act sets out a range of authorisations for a variety of works in and adjacent to navigable waters.

State Environmental Planning Policy No. 71 – Coastal Protection

The aims of this Policy include to:

- protect and manage the natural, cultural, recreational and economic attributes of the New South Wales coast;
- protect and preserve the marine environment of New South Wales;
- 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 within that zone.

Aboriginal Land Rights Act, 1983

The *Aboriginal Land Rights Act 1983* provides a mechanism for compensating Aboriginal people of NSW for loss of their land. The preamble of the *Land Rights Act*, *1983* 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*).

Protection of Environment Operations Act, 1997 (*PoEO Act*)

The *Protection of Environment Operations Act (1997)* is administered by the Environment Protection Authority (EPA) within DECCW and ultimately aims to protect, enhance and restore the quality of the environment in New South Wales, to reduce risk to human health and promote mechanisms that minimise environmental degradation through a strong set of provisions and offences. This is relevant to the construction of the OARs. A licence is required from DECCW if any of the activities associated with the proposal are determined to be a Scheduled Activity under Schedule 1 of the Act. At this stage, it is not expected that such a licence will be required.

The *Environmentally Hazardous Chemicals Act 1985*

The *Environmentally Hazardous Chemicals Act (1985)* governs the use and disposal of potentially hazardous chemicals and waste material. Any use and/or removal of hazardous chemicals and material defined under this Act require licensing and must be appropriately declared. At this stage it is not expected that any hazardous chemicals will be present at the construction site.

Contaminated Land Management Act 1997

The Contaminated Land Management Act 1997 outlines the assessment criteria and methodology for the management of contaminated land which poses significant risk to human health or the environment. Under the Act, a person or persons (or a public authority) will be held responsible for allowing land contamination to occur. DECCW is responsible for declaring the land as 'contaminated' and will give notice to end the declaration, once satisfied that the land poses no further risk.

Soil Conservation Act 1938

The *Soil Conservation Act 1938* is associated with the preservation of soils and prevention of erosion within a parcel of land. The appointment of a conservation commissioner is primarily to control and protect; proclaimed works, notified catchment areas, rivers, lakes, dams, creeks, lagoons and marshes form the effects of soil erosion, land degradation, siltation and sedimentation. Notice may be issued if the commissioner is of the opinion that the land holder has done or is likely to do something that will ultimately lead to land degradation.

Water Management Act 2000

The management of water state-wide is governed in accordance with the Water Management Act 2000 which repeals and replaces a number of related Acts. The Water Management Act 2000 has replaced the *Rivers and Foreshore Improvement Act (1948)* and now regulates all construction activities in proximity to waterways. As the current proposal is being assessed under Part 3A of the *EP&A Act*, a controlled activity approval under the *Water Management Act* will not be required for undertaking of construction activities on waterfront land. However, principles for water quality management as established within the Act require consideration.

Waste Avoidance and Resource Recovery Act 2001

The *Waste Avoidance and Resource Recovery Act 2001* repeals and replaces the *Waste Minimisation and Management Act 1995*. No permits are required under the Act, though the responsibilities of land occupiers are clearly defined with regards to waste production/ management and natural resource usage. The Act makes reference to 'waste strategies' including minimisation and disposal along with efficient use and disposal of natural resources.

2.3 Other Relevant Approvals and Permits

In addition to approval under the *EP&A* and *EPBC Acts*, a number of other approvals, concurrences, permits and licences are required for the project to proceed, including:

- lease or licence under Section 34 of the *Crown Lands Act 1989* for the area occupied by the OARs;
- permit for artificial reef placement under Section 19 of the *Environment Protection (Sea Dumping) Act 1981 (Commonwealth)*;
- concurrence, under Sections 6 and 7 of the *Coastal Protection Regulation 2004* to carry out work on the open coast below mean high water mark;
- concurrence under Section 199 of the *Fisheries Management Act* if placement of the OARs is considered reclamation work;
- towing permit from NSW Maritime to transport the OAR structures (depending on whether or not a self-propelling barge is used);
- aquatic Licence from NSW Maritime for exclusive use of the waters for the purposes of sinking the structures;
- authorisation under Section 13T of the *Maritime Services Act 1935* for buoys or moorings associated with the offshore artificial reefs;
- Note that under Part 3A some separate approvals, such as those listed below, are not required for an approved project:
    - concurrence to carry out /grant consent for work or to use/occupy the coastal zone under Part 3 of the *Coastal Protection Act 1979*;
    - permit under sections 201, 205 (cut, remove, damage, destroy marine vegetation) or 219 of the *Fisheries Management Act 1994.*

3 Construction, Transport and Deployment

As a contractor has not yet been appointed, the following Section was prepared on the advice of Worley Parsons Pty Ltd and Cardno Lawson Treloar (CLT) who have extensive experience with maritime structures and associated construction activities.

It is generally recommended that a suitably qualified contractor be appointed well in advance, to ensure that a suitable fabrication site can be arranged, that the steel can be procured in accordance with the design specification and that the contractor has suitable equipment available to carry out the work. Costs associated with transporting the steel to the fabrication site should also be considered by the appointed contractor as the maximum load width on NSW roads is 2.5 m. The steel would therefore need to be delivered in pieces.

As the fabrication and deployment stages are weather dependent, allowances for weather downtime (and associated costs) also need to be considered.

3.1 Construction Methodology

3.1.1 Fabrication Site Selection

There are a number of options for the location of the fabrication/construction site depending on the contractor and what facilities are available during pre-construction planning. There is a port facility located near each of the OAR sites at the Port of Sydney (Port Jackson and Port Botany), The Port of Newcastle and Port Kembla. If a waterside location could be found at the port, the units could be constructed and loaded directly on to cargo barges for transportation to the offshore site. The contractor could lease space from the port authority for the duration of the works. Construction at a port based facility is the preferred option however, if a waterside location is not available at the relevant port, it would be necessary to find an alternate private site with waterside facilities. The size of the units precludes transporting the units by road, even for short distances. The units would therefore be fabricated at the relevant port or private waterside facility and then transported along the coast by cargo barge to the deployment site. It is estimated that a site of 100 m x 100 m (10,000 m^2) would be necessary to carry out the works and accommodate the associated facilities such as offices, parking etc.

Based on professional experience and CLT's knowledge of the existing port facilities, the following three sites have been identified to meet the requirements for the construction activities.

- Newcastle Port – Dyke Point;
- Sydney Port – White Bay;
- Port Kembla – Outer Harbour, adjacent to Jetty #6.

It is understood that these ports have the available area required to undertake the construction operations.

The selected construction site would require the following:

- Good transportation links to the site, with roads suitable for construction deliveries;
- Site access/security access point to ensure all personnel and materials are accounted for on leaving and entering the site and to ensure the site can be secured from intruders;
- Storage/lay down area for construction materials including steel sections prior to fabrication;
- Site office for controlling documentation and carrying out general office administration for site;
- Contractor facilities for staff, including storage area and seating area;
- Toilet facilities;
- Parking area for contractor staff and visitors;
- Turning area for supply trucks;
- Working area for the assembly of the units, including space for four units, with an additional area where prefabrication is carried out prior to connecting to the main structural units;
- Emergency and fire facilities;
- Utilities including power, potable water and sewerage;
- Generator if no power is available;
- Fuel and refueling area for construction vehicles (if required);
- IT and communications;
- Crane storage area;
- Scaffolding to allow working at a height;
- Welding material and other general construction tools to fabricate steel units;
- Waterside barge access (preferred).

3.1.2 Pre-Construction Inspection and Planning

Prior to commencing works on site, the contractor should undertake pre-construction inspection to document the condition of the site. The contractor would also be responsible for the preparation of an OH & S plan and CEMP which should include, but not be limited to, the following:

- An OH&S induction program for all workers, and ongoing safety training;
- Requirements for the project team, contractor's supervision team and workforce;
- Specific safety awareness training for all project staff;
- Investigation and closeout of all workplace incidents (injuries and near misses);
- Regular inspections of worksite;
- Vehicle and equipment inspections and certification;
- Ablution block inspections and housekeeping guidelines;
- Prescribed regular pre-start meetings and toolbox meetings;
- Safe Work Procedures and/or Job Safety Analysis (JSAs);
- Compilation of safety records and statistics and provision of analysis to the project team and sub-contractors for action and closeout;
- Liaison with statutory authorities on safety matters;
- A health awareness program;
- Minimum PPE requirements on site;
- Drug and alcohol policy on site;
- Minimum training requirements for various classes of work; and
- Competency assessment.

The CEMP should include (but not be limited to):

- Vehicle access routes;
- Spill prevention and clean-up procedures;
- Fuel and oily waste management;
- Temporary field office and domestic waste facilities;
- Vegetation clearing (if required);
- Rehabilitation of disturbed areas if necessary;
- A water quality management plan;
- A waste management plan;
- Noise monitoring and mitigation measures;
- An air quality management plan;
- A traffic management plan;
- Erosion and sediment control plan (where relevant); and
- Licensing requirements.

3.1.3 Fabrication

It is estimated that the fabrication stage would take approximately 5 to 6 months to complete. It is anticipated that steel sections would be readily available from local steel distributors in NSW. The necessary steel would be delivered to the site and using the onsite crane, the contractor would unload the steel and place it in the designated storage area. The steel is likely to be stored in accordance with size and length, allowing the contractor to easily select the correct member during the fabrication process. The units would be built in layers from the bottom up. Steel members would be craned into location and temporary steel supports may be required to ensure stability of the structure during fabrication. As the structure rises from the base, scaffolding would be required to allow construction and inspection access. The steel members would be welded together with butt and fillet weld by suitably experienced and qualified welders in accordance with the drawings and technical specification. The welding methods are likely to include arc manual welding, gas-shielded arc semi- auto welding, self-shield arc semi-auto welding and submerged arc auto-welding. Welding material would include covered electrodes, wire and gas welding materials. All welding material would need to be stored away from moisture. Prior to certification, the steel must be free of slag, water, rust, oil, paint and other material which would affect the weld quality. Grit blasting or other cleaning procedures may be required if any of these items are present. To ensure adequate quality of the welding, a weld quality control plan would need to be prepared to outline the extent of mechanical and non-destructive testing and inspection required before final certification of the works. Once the units are fabricated, a final inspection would be conducted prior to transferring the units to barges for transportation to the offshore site.

The following team would be required on site (some of the services may be provided by subcontractors to the main contractor):

- Construction manager;
- Site surveyor;
- Steel fabricators;
- General labourers;
- Crane operator;
- Quality inspectors;
- Office/ablutions cleaning services.

The total workforce would be approximately 10 - 15 persons.

The following plant and equipment is likely to be required for fabrication activities:

- Shed or warehouse protecting partial fabrication works from weather (rain, wind, dust etc);
- Minimum 100 tonne crane (either a tower or crawler type depending on the site);
- Forklifts;
- Scaffolding;
- Welding material including gas storage and hoses;
- Steel delivery trucks with approximately 40 tonne capacity;
- General power tools.

3.1.4 Loadout

Once fabrication and certification are complete, the units would be loaded onto barges for transportation to the offshore location. This operation is referred to as ‘loadout’. The method of loadout would be at the contractor’s discretion and the contractor would be fully responsible for the structural integrity of the structures during the process. It is estimated that the loadout, transportation and deployment of the units would occur over a two month period depending on weather conditions. If the units are located within 20 km of the site, it is feasible that once loadout is completed, the units could be transported and installed within one or two days.

The contractor would require a cargo barge and tug to transport the units. The barge would need to be seaworthy and of adequate dimensions to accommodate the 12 m x 15 m structure. The barge would be moored at the wharf of the waterside fabrication site or alternatively, positioned with the aid of anchors and tugs at a suitable location. The mooring arrangement should be such that the barge is stable and not moving to allow the units to be transferred with minimal disruption. The contractor would be required to prepare a ‘Loadout Plan’ which would include barge ballasting requirements and a step-by-step schedule of the loadout. The most likely method for moving the units from the wharfside to the barge is by crane lifting. Once the unit is in place on the barge, it would be seafastened to ensure it is secure and ready for transportation. The contractor would be responsible for ensuring the unit is secure for all potential weather and sea conditions which may arise during the transportation to the site.

3.1.5 Transport

A towing tug would be required to transport the units to the deployment site. Deployment of the units would not be permitted unless the current sea state and its direction is less than the maximum safe values determined by the transport stability analysis and unit lift analysis. Before moving from the loadout site, notification would be required from the relevant port authority to ensure that no shipping movements would interfere within the proposed transport route.

3.1.6 Deployment

Once the units have reached the reef site the barge would be anchored in position at the required coordinates using an anchor handling tug. To ensure the barge is at the correct coordinate a GPS system would be used to position the barge. The anchor locations would need to be determined by carrying out a mooring analysis to ensure the barge is adequately restrained from moving while the units are being lifted into position. This would be outlined in a mooring analysis report. Once the barge is secured in position, the units would be lifted by crane and lowered into the sea to the final resting position on the seabed. A dive inspection would then be carried out to ensure the units are in the required position and orientation before releasing the lifting hook allowing the cable to be retracted. Prior to commencing the lifting procedure, the contractor would conduct detailed lifting analysis of the deck, units and equipment, to demonstrate that the methods and equipment chosen would not damage the units or cause instability of the barge during the lifting process. A comprehensive, step-by-step listing of operational procedures would be prepared by the contractor to cover this procedure. During the lifting procedure, appropriate temporary navigational aids would be provided on the structure and attending vessel. Anchor buoys would also be positioned at the anchor locations.

3.1.7 Marine Equipment and Construction

A marine deployment team would be required for the loadout transportation and deployment of the units. As a minimum this would consist of the following:

- Construction manager;
- Barge controller and staff;
- Tug controller and staff;
- Crane Controller and staff;
- Materials Testing;
- Dive Inspectors.

The marine deployment team would consist of a total workforce of 10 - 15 persons. The following marine equipment is considered necessary for the transportation of the units to the offshore site:

- Cargo barge suitable to accommodate the units with minimum 100 tonne crane;
- Towing tugs (min 450 HP);
- Additional positioning tug for anchor handling;
- Adequate mooring lines and anchors (four mooring lines minimum).

3.1.8 Decommissioning of the Construction Site

Following completion of the project the construction site would need to be decommissioned. This would include the following activities:

- Evacuating all areas, cleaning and restoration of the site to its original state;
- Disposal of excess construction materials;
- Evacuating and removing temporary construction facilities;
- Archiving of any site-based hard or soft files.

3.2 Environmental Management

3.2.1 Noise

Issue/s:	Noise pollution from construction activities
Aim:	Ensure sensitive surrounding receptors e.g. residential areas are not significantly impacted by noise pollution and that all viable methods to maintain/reduce duration and intensity of noise output are implemented.
Management Strategy:	▪ Straight-line hemispherical noise calculations, using the highest expected noise generating source (i.e. a truck) at 107 dB would be carried out once a construction site has been finalised. It should be ensured that, $L_{Aeq\ (15\ min)}$ for industrial and commercial premises (i.e. 75 dB) is not exceeded for sensitive surrounding receptors. ▪ Due to the potential of the works to impact local receptors, hours of operation during the construction stage would be limited as follows:

	Monday to Friday 7am to 6pm; Saturday 7am to 1pm; Sunday or Public Holidays No construction work to take place.
Monitoring:	n/a
Performance Indicators:	Exceedance of $L_{Aeq\ (15\ min)}$ for industrial and commercial premises.
Mitigation:	Providing the above management procedures are in operation no further mitigation would be necessary.
Effectiveness:	High

3.2.2 Air Quality

Issue/s:	Reduction in local air quality (due to dust, exhaust emissions from machinery and transport).
Aim:	Ensure protection of human health and wellbeing and minimise impacts on local air quality.
Management Strategy:	▪ An Air Quality Management Plan (AQMP) would be prepared as a component of the CEMP to minimise potential impacts to local air quality ▪ Local air quality would be maintained generally in accordance with The National Ambient Air Quality Standards – under the National Environment Protection Council (NEPC). ▪ Material being transported by trucks would be adequately covered to minimise dust pollution generated. ▪ In instances where extreme wind conditions are experienced (greater than 40 km/h), works would cease immediately. ▪ Regular maintenance of plant and equipment would be conducted to ensure that they are in proper working order, thus minimising the exhaust emissions from such vehicles. ▪ Correct specification, storage, and preparations of raw materials would be ensured to prevent or minimise the requirements for shot blasting or further cleaning.
Monitoring:	The contractor would be responsible for ensuring air quality standards are met.
Performance Indicators:	National Ambient Air Quality Standards
Mitigation:	Providing the above management procedures are in operation no further mitigation would be necessary.
Effectiveness:	High

3.2.3 Traffic

Issue/s:	Increase in local traffic volume/parking congestion
Aim:	Minimise impacts on local traffic/parking
Management Strategy:	▪ A detailed Traffic Management Plan (TMP) would be developed and implemented by the contractor in accordance with the RTA (2002) *Guide to Traffic Generating Developments*. ▪ Construction zones would be designated.

	▪ Crane usage would be provided for. ▪ Truck and construction traffic routes would be established. ▪ General parking zones for other construction traffic would be designated. ▪ If required, signage would be erected to warn motorists of traffic entering and leaving the works site. ▪ The contractor would be responsible for maintaining traffic management procedures to ensure safety within the site and for public road users and pedestrians. ▪ Stabilised access points would be established as required, to minimise damage to the surrounding environment. ▪ All vehicles carrying materials to and from the site would have their loads covered where possible. ▪ The movements of construction vehicles would be limited to general construction work hours in order to comply with noise regulations.
Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Providing the above management procedures are in operation no further monitoring or mitigation is considered necessary.
Effectiveness:	High

3.2.4 Soil

Issue/s:	Potential for erosion or sedimentation within the construction site.
Aim:	Minimise risk of soil erosion during construction.
Management Strategy:	▪ Erosion and sedimentation issues would be addressed in an Erosion and Sediment Control Plan prepared in accordance with the Managing Urban Stormwater – Soils and Construction (Department of Housing, 2004) guidelines. This plan should be prepared as a component of the CEMP and seek to effectively manage and minimise the risk of soil erosion during the proposed construction works by implementing best practice techniques and will therefore seek to: o minimise disturbance; o conserve topsoil; o control water; and o stabilise/rehabilitate all disturbed surfaces. ▪ As the proposed works have the potential to directly influence receiving waters (i.e. Newcastle Harbour, Sydney Harbour and Port Kembla Harbour) it is proposed that ‘clean’ water would be directed around the sites through the use of bunding and catchment drains.
Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Providing the above management procedures are in operation no further mitigation would be

	necessary.
Effectiveness:	High.

3.2.5 Sediments and Water

Issue:	Contamination from construction related contaminants due to stormwater run-off at the construction site and during deployment.
Aim:	Prevent contaminants entering the marine environment.
Management Strategy:	▪ The contractor would prepare a WQMP (Water Quality Management Plan) as part of the CEMP. As a minimum this plan should include provisions for the capture, storage, testing, treatment and release of stormwater runoff from the construction site. ▪ The disposal of liquid waste materials into the waters shall be limited to salt or fresh water and other materials that have been adequately treated for the removal of oil or other constituents that may be harmful to aquatic life or property. Other non-liquid waste materials that may be harmful or hazardous to life or property, or that result in an unsightly appearance, shall not be disposed of into the waters. ▪ Prior to loadout, the structures would be cleaned of all slag, rust, water, oil, paint etc. and inspected before deployment. ▪ The contractor would take every precaution to prevent structural metal debris from falling into the ocean. All scrap material, including sea-fastenings, would be disposed of onshore. The contractor would be responsible for cleaning up the barges after delivery of the cargo. Dumping of scrap at sea would not be permitted. ▪ Clean water would be directed around the site where possible to reduce the total amount of water entering the site. ▪ The site would be regularly swept to remove fine particles. ▪ Bunded refuelling and chemical storage areas would be required to contain spills. ▪ A spill kit would be kept onsite at all times. ▪ A stable access point and site boundaries to minimise the footprint of the works would be established.
Monitoring:	Testing of stormwater run-off.
Performance Indicators:	ANZECC/ARMCANZ Guidelines (2000).
Mitigation:	Providing the above management procedures are in operation no further mitigation would be necessary.
Effectiveness:	High

3.2.6 Waste

Issue/s:	Generation and disposal of construction related waste and/or hazardous waste
Aim:	Minimise total amount of waste generated
Management Strategy:	▪ The contractor would develop and implement a Waste Management Plan (WMP) as a component of the CEMP which outlines the methods to be used to minimise and dispose of waste appropriately. This plan should be undertaken in accordance with the

	framework outlined in the DECCW Waste Avoidance and Recovery Strategy and the relevant local government Development Control Plans for the respective works location. ▪ Prior to construction, the contractor would seek to minimise the total amount of waste required for disposal through appropriate planning and ordering of materials where feasible. ▪ Potential sources of waste during the construction works should be identified. ▪ Measures and strategies to be implemented to minimise the waste generated by the works should be outlined. ▪ Appropriate handling and disposal of certain waste material should be indicated. ▪ Opportunities to reuse and recycle waste material and if necessary, treat and dispose of waste material in accordance with the EPA guidelines on the Assessment, Classification and Management of Liquid and Non-Liquid Waste should be identified.
Monitoring:	Waste production would be monitored throughout the construction process.
Performance Indicators:	n/a
Mitigation:	Providing the above management procedures are in operation no further mitigation would be necessary.
Effectiveness:	High

3.2.7 Structural Integrity and Stability

3.2.7.1 Loadout

Issues:	Structural stress and/or damage to units and cargo barges during the loadout procedure
Aim:	Remove risks of stress and/or damage to units and cargo barges during loadout procedure
Management Strategy:	▪ The contractor would be fully responsible for the structural integrity of the structures during loadout and should prepare a ‘Loadout Plan’. ▪ The mooring arrangement would ensure the barge is stable. Allowances for actual tidal changes and currents would also be made. ▪ A detailed loadout or lift analysis would be carried out for each loadout to ensure that structural member stresses are not exceeded. ▪ All critical mechanical equipment such as winches, cranes, pumps, sheaves, etc., would require a 100 percent redundant back-up system on standby. ▪ The barges may require some strengthening works to be added where large stresses occur. ▪ All padeyes, hooks, shackles, slings, sling platforms or frames would be verified prior to any lifting activity. ▪ OAR units would be seafastened and inspected prior to transportation. The units would be located away from barge fittings such as bollards, tank vents, access hatches and the lights. ▪ Following loadout, the contractor would ballast the cargo barge to its design trim and draft for tow. All towing craft would be equipped with burning and welding gear to carry out repairs to equipment if required.

Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Provided the loadout procedure is managed as described, there are no relevant mitigation measures that can be implemented to further reduce potential risks. In the rare event of an emergency, burning and welding gear suitable for use by crew members would be available to carry out repairs on equipment if required.
Effectiveness:	High

3.2.7.2 Transportation

Issue/s:	Structural stress and/or damage to units and cargo barges during transportation.
Aim:	Remove risk of damage to structures or barges during transportation.
Management Strategy:	▪ Prior to leaving the loading wharf, the contractor shall consult the weather and sea state forecasts to ensure no severe seas or weather would occur before the units are installed. Deployment of the units would not be permitted if the current sea state and its direction exceed the maximum safe values determined by the transport stability analysis and unit lift analysis. ▪ The unit would be secure for all the potential weather and sea conditions which may arise during the transportation to the site. ▪ The barge would be towed from the forward end via a bridle. Alternatively two tugs could be utilised. Motion analysis and stability analysis for the transportation of the units would be required to ensure the barge can safely reach the site in a one year event storm without damaging the units. This would also help the contractor select the correct barge and towing tug for the operations. Consideration should be given to towage resistance, freeboard, motions responses and appropriate draft. ▪ Once the units have reached the offshore location, the units would be inspected to ensure no damage has occurred prior to deployment. If any damage has occurred it may be necessary to return the units to shore to carry out repairs, alternatively minor repairs could be conducted on board the barge.
Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Provided the transportation procedure is managed as described, there are no mitigation measures that can be implemented to further reduce the risk of damage to structures or barges.
Effectiveness:	High.

3.2.7.3 Deployment

Issue/s:	Structural stress and/or damage to units and cargo barges during deployment and risk of incorrect positioning/orientation.
Aim:	Remove potential risks associated with deployment.
Management	▪ To ensure the barge is at the correct location a DGPS system accurate to one metre

Strategy:	should be used to position the barge. ▪ The contractor would prepare a mooring analysis report to ensure the barge is adequately restrained from moving while the units are being lifted into position. ▪ Lifting analysis would be carried out prior to deployment to ensure that the methods and equipment chosen would not damage the units or cause instability of the barge during the lifting process. ▪ A dive inspection would be carried out to ensure the units are in the correct position and orientation before releasing the lifting hook allowing the cable to be retracted.
Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Provided the deployment procedure is managed as described, there are no relevant impact mitigation measures that can be implemented to further reduce potential impacts during OAR deployment.
Effectiveness:	High

3.2.8 Navigation and Safety

Issue/s:	Conflict with shipping and/or other waterway users.
Aim:	Remove risks of interference with commercial shipping and other waterway users during transportation.
Management Strategy:	▪ Before moving from the fabrication site, notification would need to be acquired from the relevant ports authority that it is safe to proceed and that no large shipping movement would interfere within the proposed transport route. ▪ The contractor would liaise with the relevant port authority and ensure the correct navigational lighting is displayed on the barge. ▪ Appropriate temporary navigational aids would be provided on the structure and attending vessel during deployment and anchor buoys positioned at the anchor locations.
Monitoring:	n/a
Performance Indicators:	n/a
Mitigation:	Provided the transportation procedure is managed as described, there are no mitigation measures that can be implemented to further reduce the risk of damage to structures, barges or other vessels and the safety of contractors. In the unlikely event that damage occurs to the units during transportation it may be necessary to return the barges and units to shore to carry out any necessary repairs. Minor repairs could be carried out onboard.
Effectiveness:	High

3.2.9 Flora and Fauna

Issue/s:	Disruption to migratory marine mammals
Aim:	Remove risks of interference with migratory marine mammals during transportation and

	deployment.
Management Strategy:	▪ If feasible, deployment would be undertaken outside the known migration seasons (May to November) for migratory marine mammals (namely humpback and southern right whales). Alternatively, the deployment stage should not be carried out if there are reports of whale sightings in the area. ▪ Deployment activity would be temporarily stopped if a migratory marine mammal is sighted within 300 m of the deployment site.
Monitoring:	Continual observations should be carried out during deployment.
Performance Indicators:	n/a
Mitigation:	Provided the above precautions are taken, there are no mitigation measures that can be implemented to further reduce the risk to migratory marine mammals during deployment.
Effectiveness:	High

4 Long-Term Operation

4.1 Management Strategy

4.1.1 Management Area

An OAR Management Area will be established under the *Crown Lands Act 1989* by creation of a Crown Reserve. This will include the area directly occupied by the OAR units which, if located in the final configuration, will be an area approximately 12 m x 860 m with a further 500 m buffer zone in every direction. The extent of the final Management Area will be determined and gazetted in negotiation with the Land and Property Management Authority (LPMA). Compliance with fisheries regulations will be the responsibility of the Agriculture and Fisheries Compliance Operation Branch (I&I NSW). The frequency of water based patrols will depend on the existing operational plan and resource allocation for the district within which the OAR is located. Districts with high levels of recreational fishing activity may be allocated a larger proportion of time to compliance operations than where fishing is less prominent. Incidences of non-compliance that occur within the OAR Management Area will be logged into a compliance database which is regularly reviewed. Frequent or re-occurring incidences of non-compliance would result in more targeted patrols of the area and notification of the senior district fisheries officer. Where threatened or protected species are affected, sightings or incidence of capture would be reported to the I&I NSW Threatened Species Unit and DEWHA notified.

It is important to note that this is not intended as an ‘exclusion zone’ but an area considered appropriate to manage the potential issues described in this management plan. No groups would be excluded from the management area.

4.1.2 Monitoring

In order to better understand how the installation of OARs will impact upon significant components of the marine environment and evaluate their overall effectiveness in relation to the project objectives, a monitoring strategy has been developed. This also aims to address a number of the potential impacts identified in the EA by implementing an adaptive management approach. The following Section (4.2) refers to the monitoring plan presented in Table 1 of this document.

I&I would be committed to carry out monitoring over a minimum period of 3 years. Funds have been approved from the NSW Recreational Fishing Trust until the end of 2012/2013 for detailed monitoring of the OARs. Further funds for 2013/2014 and beyond will be sought if required. As best practise, all objectives outlined in the Monitoring Plan (Table 1) would be met and appropriate monitoring carried out. It is, however, recognised that funding and resources may not be available to cover all of the objectives outlined. To assist in the most appropriate allocation of available funds and resources, objectives in the Monitoring Plan have been prioritised as follows:

Priority 1 (Monitoring objectives I&I NSW are committed to undertaking):

Biological

A.2.1. Investigate movements of high priority species within the direct study area.

A.2.2. Assess effectiveness in terms of catch rates, species composition and fish stocks.

A.3. Investigate occurrence of threatened/protected species on the OARs.

Physical

B.3.1. Assess structural integrity.

B.3.2. Remove fouled gear and debris.

Socio-Economic

C.1.1. Assess effectiveness in terms of popularity with recreational fishing groups and OAR related expenditure.

Priority 2 (Monitoring objectives to be addressed given availability of additional funds/resources):

Biological

A.1.1. Assess influence of OARs on benthic assemblages (soft sediments) including potential halo effects.

A.1.2. Assess influence of OARs on benthic assemblages of proximal natural reefs (benthos).

A.1.3. Document colonisation of the reef structures by macroinvertebrates including pest species.

Physical

B.1.1. Assess influence of OARs on sediment characteristics.

B.1.2. Assess concentrations of heavy metals in adjacent sediments to OARs.

B.2. Assess water quality.

Socio-Economic

C.1.2. Identify issues of conflict between user groups.

It is important to note that parts of the monitoring work would involve diving. It is therefore essential that a Safe Work Method Statement and diving OH & S plan be prepared prior to any diving activity and that all divers comply with commercial diving standard AS2299.1. The plan should include but not be limited to:

- information on the roles responsibilities and qualifications of diving personnel;
- first aid qualifications of diving personnel;
- procedures and equipment used in diving operations for particular conditions;
- procedures for diving emergencies;
- contact details for hyperbaric units in NSW.

4.1.3 User Guidelines

User guidelines would be produced to form the basis of a targeted education campaign. The guidelines would provide information important for OAR user groups to ensure minimal environmental impact and promote safety within the OAR Management Area (Section 4.1.1). The guidelines would include general information on boating regulations and best practice within the OAR management area such as:

- location information;
- boating safety guidelines in the vicinity of the OARs;
- size and bag limits and method and gear restrictions;
- responsible and ethical fishing practices;
- threatened and protected species identification guide;

- mechanisms for reporting sightings or incidental capture of threatened and protected species;
- information on the potential impacts of harmful marine debris in the marine environment and the responsible disposal of discarded fishing gear and litter;
- guidelines for boating in the vicinity of large marine mammals;
- best practice for returning incidentally caught species;
- best practice for minimising spread of marine pests (e.g. *Caulerpa taxifolia*);
- spearfishing safety recommendations;
- recognition and respect for commercial fishers and their gear and information on associated penalties for interfering with commercial gear;
- a code of conduct for activity within the management area.

In addition, it would be strongly advised recommended that SCUBA divers are advised not to utilise the OARs because of the potential safety implications.
Much of this information is currently available on the I&I NSW website but could be condensed into a dedicated document relating directly to the proposed OARs. These 'User Guidelines; would be made available via the I&I NSW website and in print for distribution to relevant recreational fishing associations and clubs. Notices with links to the relevant web page would also be placed in relevant publications.

4.2 Environmental Management

4.2.1 Structural Integrity and Stability

Issue/s:	Stability and Structural Integrity.
Aim:	Ensure the long-term structural integrity, functionality and stability of the units within the 30 year design life.
Management Strategy:	▪ A design engineer would be required to verify section sizes and plate dimensions and to optimise the design for habitat complexity where feasible. ▪ The certification of the final design would be the responsibility of the appointed contractor. ▪ The units would be inspected for unforseen stresses, movement from deployment location, orientation, corrosion and thickness of marine growth. ▪ Following monitoring inspections, the findings would be compared with the design documentation and previous studies to determine if there has been a significant change in the structure.
Monitoring:	See Monitoring Plan (Table 1 – B.3.1).
Performance Indicators:	Corrosion rate, stresses, extent of movement from deployment location and rate of marine growth.
Mitigation:	Maintenance or remediation works to be investigated by a structural maritime engineer, removal if required.
Effectiveness:	High.

4.2.2 Flora and Fauna

4.2.2.1 Benthic Environment

Issue/s:	Change to soft sediment assemblages
Aim:	Assess influence of OARs on soft sediment assemblages and identify potential halo effects (potentially occurring from increased predation on soft sediments).

Management Strategy:	Monitoring (Table 1 – A.1.1).
Monitoring:	See Monitoring Plan (Table 1 – A.1.1 and B.1.1).
Performance Indicators:	Change in macroinvertebrate abundance and diversity (and sediment grain size) at OAR (impact) relative to control sites. If significant negative impacts are detected i.e. significant reductions in abundance/diversity of macrofauna then appropriate mitigative action would be taken.
Mitigation:	Temporary/seasonal closures.
Effectiveness:	Moderate.

4.2.2.2 Proximal Natural Reef

Issue/s:	Change to proximal natural reef.
Aim:	Minimise and monitor movements of fish from existing natural reefs to OARs (i.e. draw down effects) and associated changes to epibenthos of natural reefs.
Management Strategy:	▪ Final OAR locations would be a minimum of 500 m from existing natural reef. ▪ Where possible, maximum separation from natural reef has been achieved. ▪ Implementation of a Monitoring Plan.
Monitoring:	See Monitoring Plan (Table 1 – A.1.2 and A.2.2)
Performance Indicators:	If negative impacts are detected (e.g. a significant reduction in abundance and diversity of fish species at natural reefs attributed to the OARs) then mitigative action would be taken.
Mitigation:	Temporary or seasonal closure; removal of structures.
Effectiveness:	High.

4.2.2.3 Pelagic Environment

Issue/s:	Overexploitation of target species within the OAR management area as a result of the proposal.
Aim:	Ensure impacts on target species are sustainable within the defined management area.
Management Strategy:	▪ I&I NSW would ensure that relevant user groups are informed of minimum catch sizes and bag limits (see User Guidelines - Section 4.1.3). Compliance with these regulations should be the responsibility of the relevant I&I NSW fisheries officers. ▪ Promote catch and release. ▪ Monitoring of recreationally and commercially important species.
Monitoring:	See Monitoring Plan (Table 1 – A.2.1, A.2.2).
Performance Indicators:	Species catch composition, diversity, biomass, size-frequency and catch rates would be monitored within the study area. If negative impacts are detected or it is considered that a species is being overexploited within the management area (as a result of the proposal) mitigative action would be required.
Mitigation:	Temporary or seasonal closures, removal of structures.
Effectiveness:	High.

4.2.2.4 Threatened and Protected Species

Issue/s:	Potential for negative impacts on threatened and protected species known or likely to occur within the wider study area. This includes direct impacts of the proposal (e.g. incidental capture) and/or indirect impacts related to an increase in recreational boating activity (e.g. gross pollution or boat strike).
Aim:	Minimise potential negative impacts on threatened or protected species related to the proposal.
Management Strategy:	▪ Implementation of a Monitoring Plan. ▪ Information on threatened species identification, best practice for returning incidentally caught species, boating in the vicinity of marine mammals and mechanisms for reporting sightings or incidentally caught species would be included in the OAR User Guidelines (Section 4.1.3).
Monitoring:	Monitoring would be used to assess the occurrence of threatened species on OARs and to remove fouled fishing gear or debris hooked on the OARs to prevent injury or entanglement of threatened/protected species (Table 1 – A.3 and B.3.2). ▪ A multi-method monitoring approach would be used that would include the use of ultrasonic telemetry and stereo-videography. These techniques are proven to be successful from previous studies by I&I NSW (estuarine artificial reefs program) and by fisheries institutes worldwide for investigating fish behaviour and assemblages e.g. Fabi and Sala 2002, Stanley and Wilson 1998). ▪ Stereo video data would be analysed using purpose designed photogrammetry software (CAL), Photomeasure and eventmeasure SeaGIS systems. ▪ Ultrasonic telemetry data would be analysed using conventional univariate and multivariate statistical software packages. ▪ The NSW I&I Wild Fisheries Research Section would be responsible for the analysis of all data. ▪ Data would be used for determining the presence/absence of threatened species and could also be used to record movements of grey nurse sharks if they have already been tagged for research purposes. ▪ Stereo video data would be analysed as it is collected, on a 3, 6 and 12 month basis (as a minimum). Collection of ultrasonic telemetry would be continuous but analysis would be dependent on the availability of the data following downloads from the receivers (likely to be every 3 – 6 months). If a threatened species was considered at risk then mitigative action would be taken and advice sought from I&I NSW Aquatic Ecosystems Unit and relevant authorities e.g. DECCW/DEWHA to determine the most appropriate course of action (see *Mitigation*).
Performance Indicators:	Records of reported sightings/incidental capture and monitoring data would be reviewed.
Mitigation:	Temporary closure (e.g. if a large cetacean was considered at risk from boating disturbance), seasonal closure or removal of structures in extreme circumstances.
Effectiveness:	High.

Limitations: Using the reporting of sightings or incidental capture as a tool to identify negative impacts on threatened/protected species is limited due to under-reporting i.e. through failure to report a sighting or miss-identification of a threatened species. Multi-method monitoring techniques as described in Table 1 (A.3 and B.3.2) would however, provide a reliable method and contingency to ensure any potential impacts on threatened species are detected and mitigated.

4.2.2.5 Invasive Marine Pests

Issue/s:	Colonisation of OAR structures by marine pests. Potential for spread of marine pests via recreational boating.
Aim:	Minimise/prevent colonisation of marine pests on the OAR structures and minimise/prevent the spread of marine pests.
Management Strategy:	▪ OAR user groups would be informed of boating guidelines to minimise the spread of marine pests (see User Guidelines – Section 4.1.3). ▪ Implementation of a Monitoring Plan.
Monitoring:	OAR structures would be monitored for the colonisation of marine pests (Table 1 – A.1.3).
Performance Indicators:	The extent of marine pest incursions would be assessed in terms of area, species type and abundance. Mitigative action would be undertaken according to NIMPIS guidelines.
Mitigation:	Requirements for removal of marine pests (according to NIMPIS) would depend on the extent and nature of the incursion but is likely to involve manual removal by divers in the first instance.
Effectiveness:	Moderate.

4.2.3 Commercial and Recreational Fishing

Issue/s:	Loss/obstruction to trawling (Newcastle study region) and conflict between user groups.
Aim:	Prevent or minimise loss/obstruction to existing trawling ground and conflict arising between user groups.
Management Strategy:	▪ Final OAR locations have been selected that would minimise loss/obstruction to trawling in the Newcastle study region. ▪ Commercial fishing groups would be informed of project developments and notified of the final OAR project location. ▪ A code of conduct for activity within the OAR management area would be defined.
Monitoring:	Stakeholder questionnaires.
Performance Indicators:	User satisfaction, records of reported incidents. If unacceptable levels of conflict arise then mitigative action would be taken.
Mitigation:	Formal consultation between sectors would be undertaken to resolve any issues of conflict (or similar).
Effectiveness:	Moderate.

4.2.4 Sediments and Water

Issue/s:	Potential contamination of sediments adjacent to OARs.
Aim:	Minimise contamination of leachates and ensure levels are within acceptable ANZECC/ARMCANZ guidelines for marine sediments.
Management Strategy:	It would be ensured that structures are built according to Australian Standards for minimum corrosion rates.
Monitoring:	See Monitoring Plan (Table 1 – B.1.2).

Performance Indicators:	Concentrations of heavy metals (particularly iron). If contaminants exceed recommended ANZECC/ARMCANZ guidelines for marine sediments then mitigative action would be considered.
Mitigation:	Provided the structures are built to meet Australian Standards for corrosion rates, there are no relevant impact mitigation measures that can be implemented to further reduce potential impacts during operation. If monitoring identified severe impacts i.e. Levels exceeding ANZECC/ARMCANZ guidelines as a result of the proposal then removal of the structures would be considered.
Effectiveness:	High.

4.2.5 Navigation and Safety

4.2.5.1 Clearance

Issue/s:	Potential for vessels in transit to come into contact with the upper part of the OAR structures.
Aim:	Remove all risks of contact (and potential damage) between vessels and OARs.
Management Strategy:	Sufficient clearance between the upper part of OARs and transiting vessels in severe weather conditions and under Lowest Astronomical Tide (LAT) would be ensured.
Monitoring:	n/a.
Performance Indicators:	n/a.
Mitigation:	Potential impacts have been mitigated by selecting sites at an appropriate depth. The alternative deeper location selected in the Sydney study region upon the advice of Sydney Ports Authority would ensure a minimum clearance of 20 m. There are no other relevant mitigation measures that could be undertaken to further reduce this risk.
Effectiveness:	High.

4.2.5.2 Anchor Fouling/Gear Hook Up

Issue/s:	Anchor fouling from commercial and recreational vessels and gear hook-up (commercial trawling).
Aim:	Minimise the risk of anchor fouling and gear hook-up from commercial trawling.
Management Strategy:	▪ The Australian Hydrographic Office would be informed of final OAR locations. ▪ Locations would be charted on Maritime Maps and a notice to mariners issued. ▪ It would be ensured that final OAR locations are well outside of any designated anchorage area. ▪ It would be recommended in the User Guidelines that anchoring does not take place within the OAR management area.
Monitoring:	n/a.
Performance Indicators:	n/a.
Mitigation:	In the unlikely event that an anchor was lost on a structure, the structures would be inspected by divers for potential damage and if feasible, the fouled anchor removed to minimise further risks of entanglement or injury to marine life.

Effectiveness:	Moderate.

Limitations: It would be recommended that anchoring does *not* take place within the OAR Management Area, but not enforced. If anchoring was to become a problem then legislative action to prevent anchoring in the Management Area would be investigated as a contingency.

4.2.5.3 Vessel Traffic

Issue/s:	Risk of collision from increased vessel traffic in the vicinity of the OARs.
Aim:	Minimise risk of collision.
Management Strategy:	▪ It would be ensured that user groups are informed of NSW recreational boating rules and regulations (see 'User Guidelines' - Section 4.1.3 of this document). ▪ Guidelines and a code of conduct would stipulate that recreational boat users give way to commercial vessels in the area. This is most relevant to the Sydney OAR location which is near to the entrance of Port Jackson. ▪ Mechanisms would be put in place for reporting of incidents.
Monitoring:	Stakeholder questionnaires/reporting of incidents.
Performance Indicators:	User satisfaction and records of incidents reported. If any incidents occur then further mitigative action should be considered.
Mitigation:	Provided that the proposed management strategy is implemented there are no relevant mitigation measures that could further reduce this impact.
Effectiveness:	Moderate.

4.2.6 Infrastructure

Issue/s:	Potential congestion at boat ramps and insufficient facilities.
Aim:	Ensure the long-term adequacy of infrastructure and facilities for OAR users.
Management Strategy:	OARs would be located in the vicinity of major urban centres where the provision of boat ramps and facilities is considered to be sufficient for the expected demand. Monitoring would be undertaken to survey future needs for improvements or upgrades if OARs prove very popular.
Monitoring:	Stakeholder questionnaires (Table 1 - C.1.1.)
Performance Indicators:	User satisfaction.
Mitigation:	As the provision of current infrastructure is considered adequate there are no further impact mitigation measures that can be implemented at this stage. Upgrades to existing facilities would be investigated if OARs proved very popular and user groups were shown to be dissatisfied with existing facilities.
Effectiveness:	High.

5 References

Cardno Lawson Treloar (2009). Artificial Reefs: Construction. Environmental Impact Assessment. Prepared for NSW Department of Primary Industries. Report No.2569.

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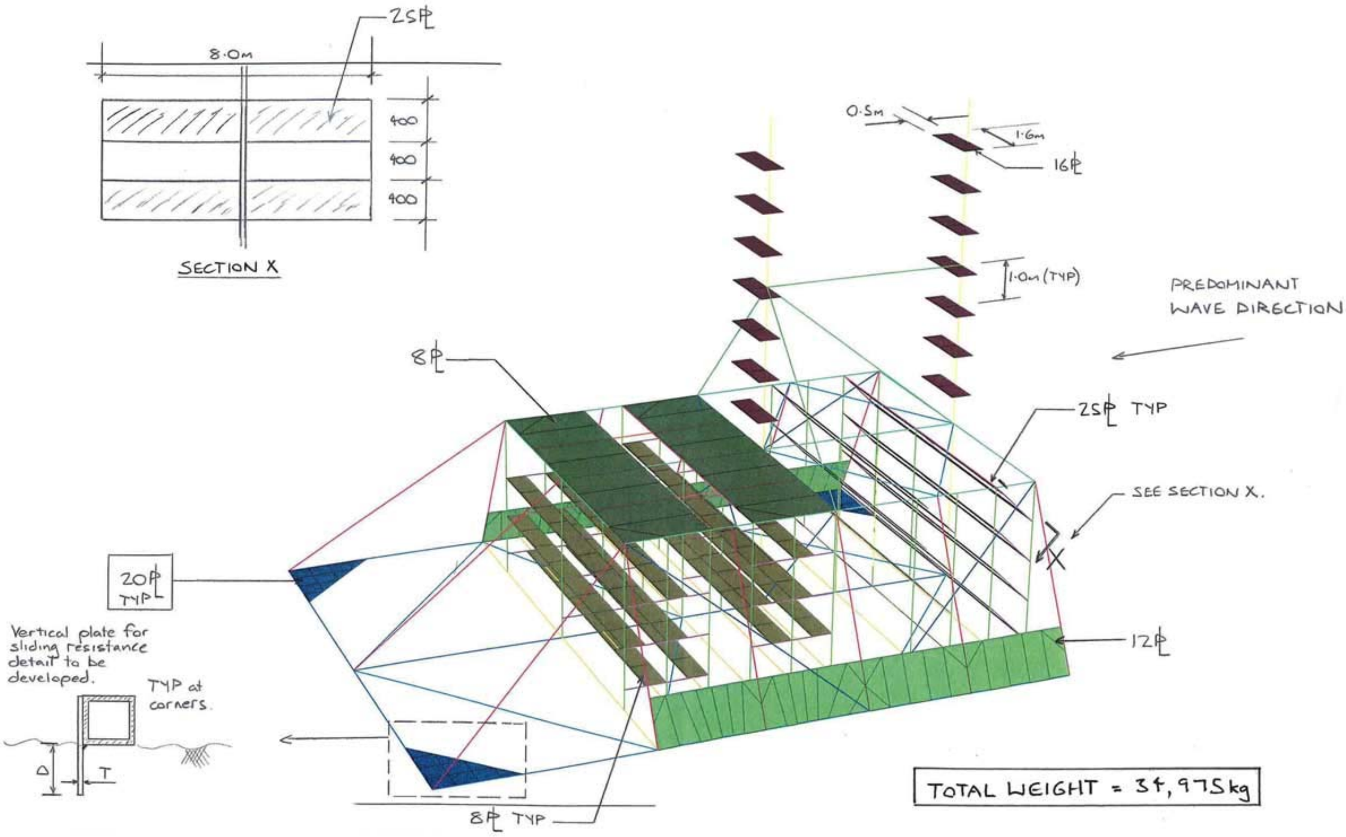
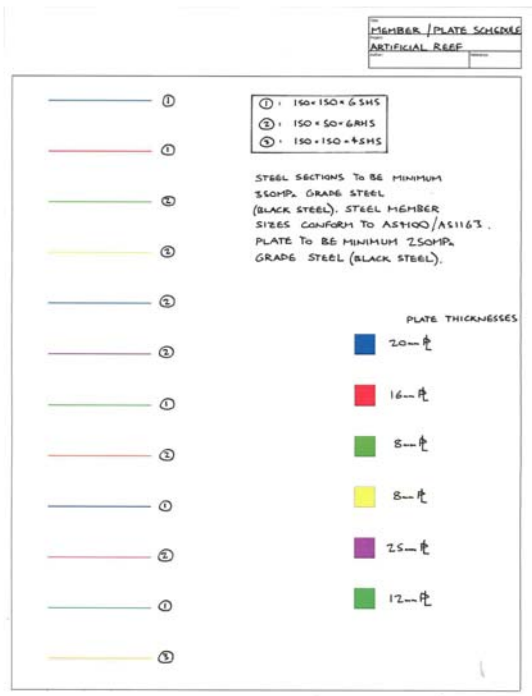
Stanley, D. Wilson, C. (1998). Spatial variation in fish density at three petroleum platforms as measured with dual beam hydroacoustics. Gulf of Mexico Science, 1998(1) 73-82.

Worley Parsons (2009). Offshore Artificial Reefs Draft Construction Methodology. Worley Parsons, North Sydney. NSW.

6 Figures

Figure 1: Proposed OAR concept design prepared by Worley Parsons (August 2009).





7 Tables

Table 1: Offshore Artificial Reefs – Monitoring Program.

Table 1: Recommended OAR Monitoring Plan. (*) Details of each monitoring program (A - F) is given at the end of the Table.

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
A. Biological							
A.1 Macrobenthos	**A.1.1** Assess influence of OARs on benthic assemblages (soft sediments) including potential halo effects.	A or C*	Impact sites (soft sediment habitat adjacent to OARs) and control sites	Benthic grab deployed by boat	Annual	■Continue monitoring	■Determine acceptable level of impact in context with other cumulative impacts
	A.1.2 Assess influence of OARs on benthic assemblages of proximal natural reefs (benthos)	A*	OAR sites, proximal natural reef sites (impact sites), and reference natural reef sites (controls)	Photo video quadrats	Annual	■Continue monitoring	■Determine acceptable level of impact ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	A.1.3 Document colonisation of the reef structures by macroinvertebrates including pest species	D*	OAR Structures only	Photo video quadrats and visual diver inspections	As for monitoring period	■Continue monitoring	■Verify species identification ■Determine threat of pest species if observed: ■Continue monitoring ■Removal of pest species according to appropriate NIMPIS method

Continued

Table 1: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
A. Biological							
A.2 Fish	**A.2.1** Investigate movements of high priority species within the wider study area	A or C*	OAR sites, proximal natural reef sites (impact sites), and reference natural reef sites (controls)	BRUVS, biotelemetry and visual diver census	Annual	■Continue monitoring	■Determine acceptable level of impact ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	A.2.2 Assess effectiveness in terms of catch rates, species composition and fish stocks	A or C*	OAR wider study area	Stereo-videography, BRUVS and/or visual diver surveys, on-site surveys and/or charter boat log book data	Annual	■Continue monitoring	■Determine acceptable level of impact ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
A.3 Threatened/ protected Species	Investigate occurrence of threatened and/or protected species on the OAR	C and F*	OAR sites	BRUVS or stereo-videography, visual diver census and/or listening stations if feasible	As for the monitoring period and on an 'ad hoc' basis	■Continue monitoring	■Determine acceptable level of impact ■Continue monitoring ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures

Continued

Table 1: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
B. Physical							
B.1 Sediments	**B.1.1** Assess the influence of OARs on sediment characteristics (sediment particle size composition)	A or C*	Impact sites (soft sediment habitat adjacent to OARs) and control sites (Note that control sites should be of similar particle size composition and depth to impact sites	Benthic grab deployed by boat	Annual	■Continue monitoring	■Determine acceptable level of impact in context with other cumulative impacts
	B.1.2 Assess concentrations of heavy metals in adjacent sediments	B*	Impact sites (soft sediment habitat adjacent to OARs) and control sites (Note that control sites should be of similar particle size composition and depth to impact sites	Benthic grab deployed by boat	Annual	■Continue monitoring and compare against ANZECC guidelines.	■Determine acceptable level of impact in context with other cumulative impacts
B.2 Water Quality	Assess water quality	A*	Impact and control sites	Water quality probe	Annual	■Continue monitoring and compare against ANZECC guidelines	■Determine acceptable level of impact in context with other cumulative impacts

Continued

Table 1: Continued

Factor to Monitor	Objectives	Monitoring Program	Location	Method	Period	Management Procedures	
						A. Impact not detected	**B.** Negative impact detected and/ or failure to meet objectives
B.3 OAR Structure	**B.3.1** Assess structural integrity	E*	OAR units only	Diver survey	Every two years	■Continue monitoring	■Consider need for maintenance
	B.3.2 Remove fouled gear and debris	E*	OAR Structures only	Diver survey	Every two years	■Continue monitoring	■Continue monitoring and/or; ■Removal of entangled fishing gear and debris
C. Social and Economic							
C.1 Recreational and Commercial fishermen	**C.1.1** Assess effectiveness in terms of popularity with recreational fishing groups and calculate relative expenditure related to OAR usage and whether this leads to a net increase at the regional level	E*	N/a	Stakeholder questionaires	Annual	■Continue monitoring until project objectives are met	■Analyse feedback from user groups against project objectives ■Implement necessary changes ■Consider temporary closure and/or further monitoring ■Limit to seasonal operation ■Removal of structures
	C.1.2. Identify issues of conflict between user groups (e.g. from crowding)	F*	N/a	Mechanism for incident reporting	Annually and on an 'ad hoc' basis	■Continue monitoring	■Analyse feedback from user groups against project objectives ■Continue monitoring or; ■Resolve issues within a forum between user groups

Continued

Table 1: Continued

Monitoring Program					
A*	B*	C*	D*	E*	F*
Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment	Pre-deployment
winter x1 summer x1	x1	winter x2 summer x2	N/A	N/A	N/A
Post-deployment	Post-deployment	Post-deployment	Post-deployment	Post-deployment	Post-deployment
3 months 6 months 12 months Every year thereafter (winter x1 and summer x1) for a minimum of 3 years	12 months Every year thereafter (x1) for a minimum 3 years	3 months 6 months 12 months Every year thereafter (winter x2 and summer x2) for a minimum of 3 years. Note this option allows temporal seasonal comparisons.	3 months 6 months 12 months Every year thereafter (winter x1 and summer x1) for a minimum of 3 years	12 months Every 1-2 years thereafter	Continuous mechanism for feedback e.g. reporting incidents or remote data transfer