Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

Offshore Artificial Reefs (Newcastle, Sydney & Wollongong) Summary Report

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

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Cover Image: Artificial reef in Japan. Photo courtesy of I&I NSW.

Summary Report

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.

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.

This Summary Report outlines the main details of the project, describes background information and identifies potential issues which were identified in the EA/draft PER. The full EA/draft PER and supporting documents are currently on exhibition for public comment and can be viewed and downloaded at the NSW Department of Planning website www.planning.nsw.gov.au.

The EA/draft PER and Summary Report were prepared by Cardno Ecology Lab Pty Ltd on behalf of I&I NSW.

Glossary and Acronyms

Artificial reef	A man-made structure placed underwater that provides a habitat for a variety of marine animals and plants.
Artisanal fishing	Small-scale commercial or subsistence fishing operations based on simple, traditional collecting techniques.
Assemblage	A group of species living together in a particular place at the same time.
Backscatter	Deflection of acoustic sounds from the seabed to a receiver.
Baseline investigations	Studies designed to define the existing state of an assemblage.
Bathymetry	Measurement of the depths of a water body.
Benthic	Associated with the seabed or substratum.
Biodiversity	The variety of life forms found in a particular place. The term includes the species that are present, the genetic material they contain and the ecosystems they form.
BRUVS	Baited Remote, Underwater, Video Station consisting of a frame enclosing a camera housing with a canister containing bait located at the end of a pole in front of the camera lens.
Cartilaginous fish	Fish such as sharks and rays which have a skeleton made of cartilage (a, soft gristle-like material) rather than bone.
Coastal processes	Collective term for the physical processes that result in erosion and deposition of sediment along the coastline.
Commonwealth marine area	Marine waters situated between three nautical miles and 200 nautical miles of Australia's coastline and over the continental shelf that does not fall within state or territorial water boundaries.
Constraints mapping	Identifies areas that are unsuitable for an activity by superimposing map layers using a geographical information system (GIS).
Crustaceans	A group of organisms, including crabs, prawns, lobsters and barnacles that have a hard exoskeleton, segmented body and jointed appendages.
Decommissioning	The planned shut-down from operation or removal of an object (e.g. artificial reef) from use.
Direct study area	The area occupied by each 'reef set', including an area of approximately 4 km^2.
EMP	Environmental Management Plan.
Environmental Management Plan	A document that describes the procedures that an organization will use to minimise harm to the environment during the construction, operation and decommissioning of a development project.
Environmental stewardship	An ethic that encourages individuals, communities, private organizations and government agencies to take responsibility for the quality and management of their shared environment and its resources.
FAD	Fish Aggregating Device – A man-made moored or free-floating structure that is deployed in the ocean to attract pelagic fish.

Habitat	The place in which an organism or group of organisms lives. Habitats are characterised by physical structures such as substratum and topography, and by biological structures such as the dominant plants.
Impact	A disturbance that causes a change in a measured variable such as abundance of an organism or composition of an assemblage.
Invasive marine pest	Marine organisms relocated by human activities into an area outside their normal geographic distribution range and that have subsequently spread into other areas by their own means, where they now pose a threat to human health, economic values and/or the marine environment.
Invertebrates	Animals lacking a backbone.
Marine debris	Persistent solid waste material that is manufactured or processed and subsequently disposed of either accidentally or intentionally into the marine environment.
Migratory species	Species of marine birds (e.g. albatrosses, petrels and waders), reptiles (e.g. turtles) and mammals (e.g. whales, dolphins and dugongs) that migrate to Australia and its external territories, or pass though or over Australian waters during their annual migrations.
Molluscs	A group of animals, including snails, slugs, squid, octopus, scallops and oysters, that have an unsegmented soft body, an internal or external shell, a fold in the body wall that lines the shell, a muscular foot and/or tentacles.
Monitoring	Sampling undertaken at one or more locations that is repeated over time.
OAR	Offshore Artificial Reef.
Particle size distribution	The relative amounts of sediment particles within particular size ranges present within a sample.
Pelagic	Organisms that inhabit open water.
Phyla	Major taxonomic divisions of the animal kingdom.
Plankton	Small free-floating animals and plants that live in the sea and have no or only limited ability to move of their own accord.
Polychaetes	A group of segmented worms that have fleshy protrusions bearing bristles (chaetae) on each segment.
Ponar grab	A scientific tool that is used to collect a quantitative sample of sediment and associated organisms from the surface of the seabed.
Production	Total amount of living matter manufactured in an ecosystem during a certain period of time.
Protected species	Rare species that are protected from fishing or collection to prevent their populations declining.
Reef group	Two or more reef sets.
Reef set	Two or more individual reef units (i.e. a multi component artificial reef).
Reef unit	A single artificial reef unit.
Control location	An area situated far enough away to be unaffected by any form of disturbance associated with the deployment or operation of a

	structure (e.g. offshore artificial reef).
Rehabilitation	Re-establishment of the ecological attributes of a modified ecological community.
Restoration	The return of an ecological community to its pre-disturbance or natural state in terms of physical and chemical conditions, community structure and species composition.
Risk analysis	Procedure that is used to identify and assess factors that may jeopardize the success of a project or prevent it from achieving its goal(s).
Sessile	Permanently attached to the substratum.
Side-scan sonar	A scientific instrument that transmits pulses of acoustic energy sideways and uses a record of the sound that is reflected back from the seabed to create an image of the texture (e.g. mud, sand or rock) and morphology of the seabed (e.g. depressions, trawl marks or reefs).
Study regions	The three metropolitan regions selected for OAR installation (i.e. Newcastle, Sydney and Wollongong).
Substratum	A surface on which organisms grow or to which they are attached (e.g. reef or seafloor).
Swath mapping	A technique that is used to map the topography of the seabed and distribution of different types of habitats by collecting depth and backscatter data.
Threatened species	A species that is in danger of becoming extinct in the near future.
Topography	The shape and features present on the surface of an area (e.g. seabed).
Turbidity	A measure of the cloudiness of water caused by suspended particles or solids.
Wider study area	The area outside of the direct study area within the study region.

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1 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 draft EA/draft PER. The assessment process is outlined in Figure 1.

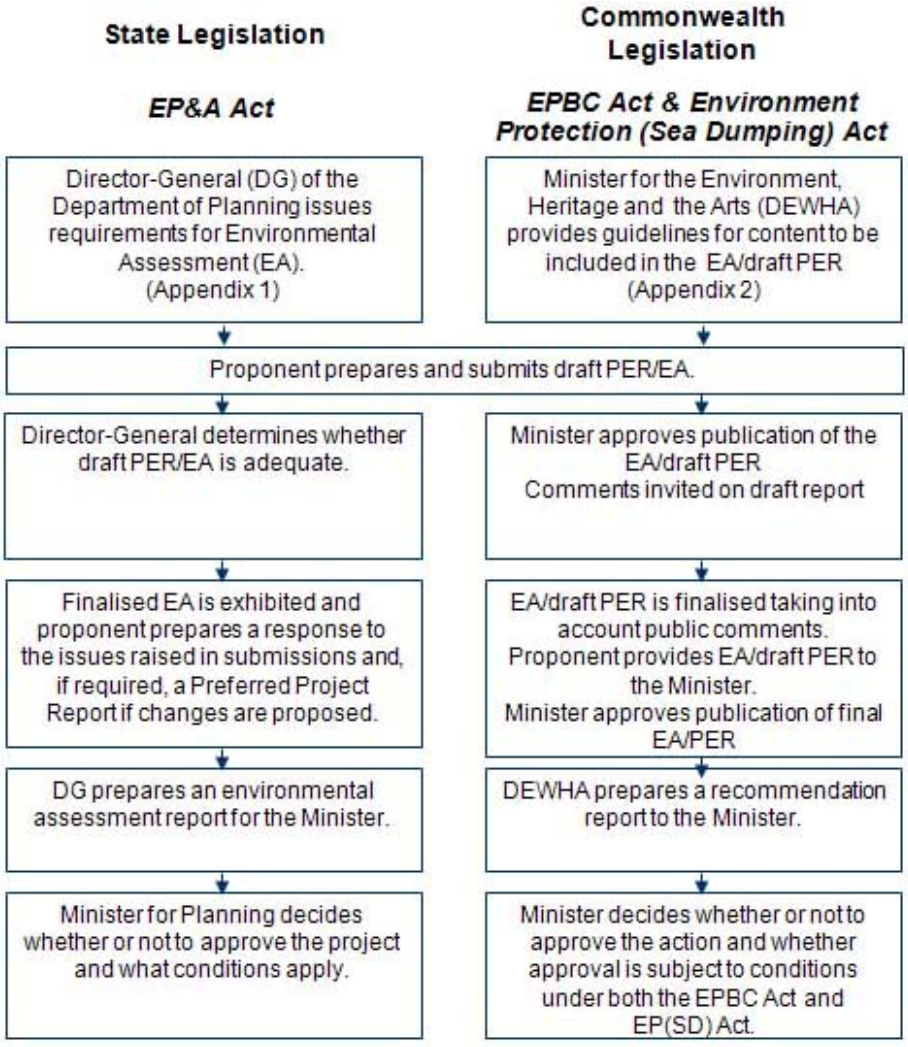

Figure 1: Steps in the assessment and approvals process.

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 2). 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.

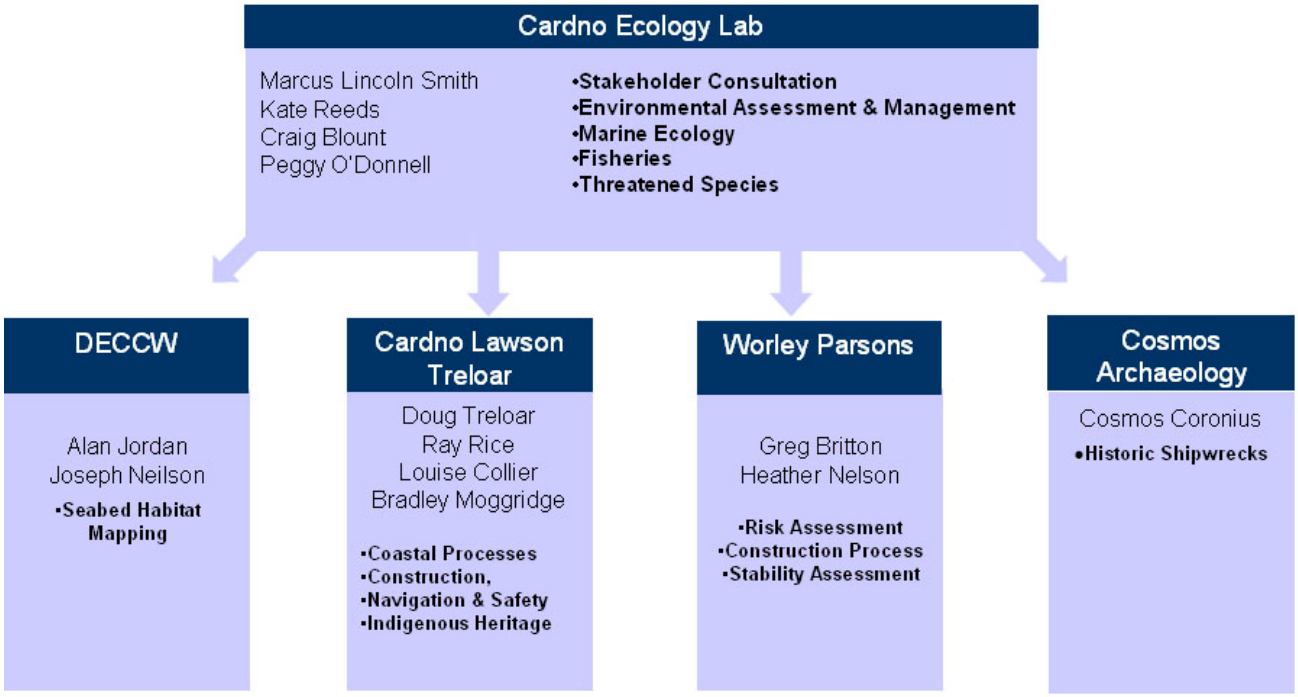

Figure 2: Offshore Artificial Reefs EA/PER study team.

2 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 1a). 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 1d). 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 1e, 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.

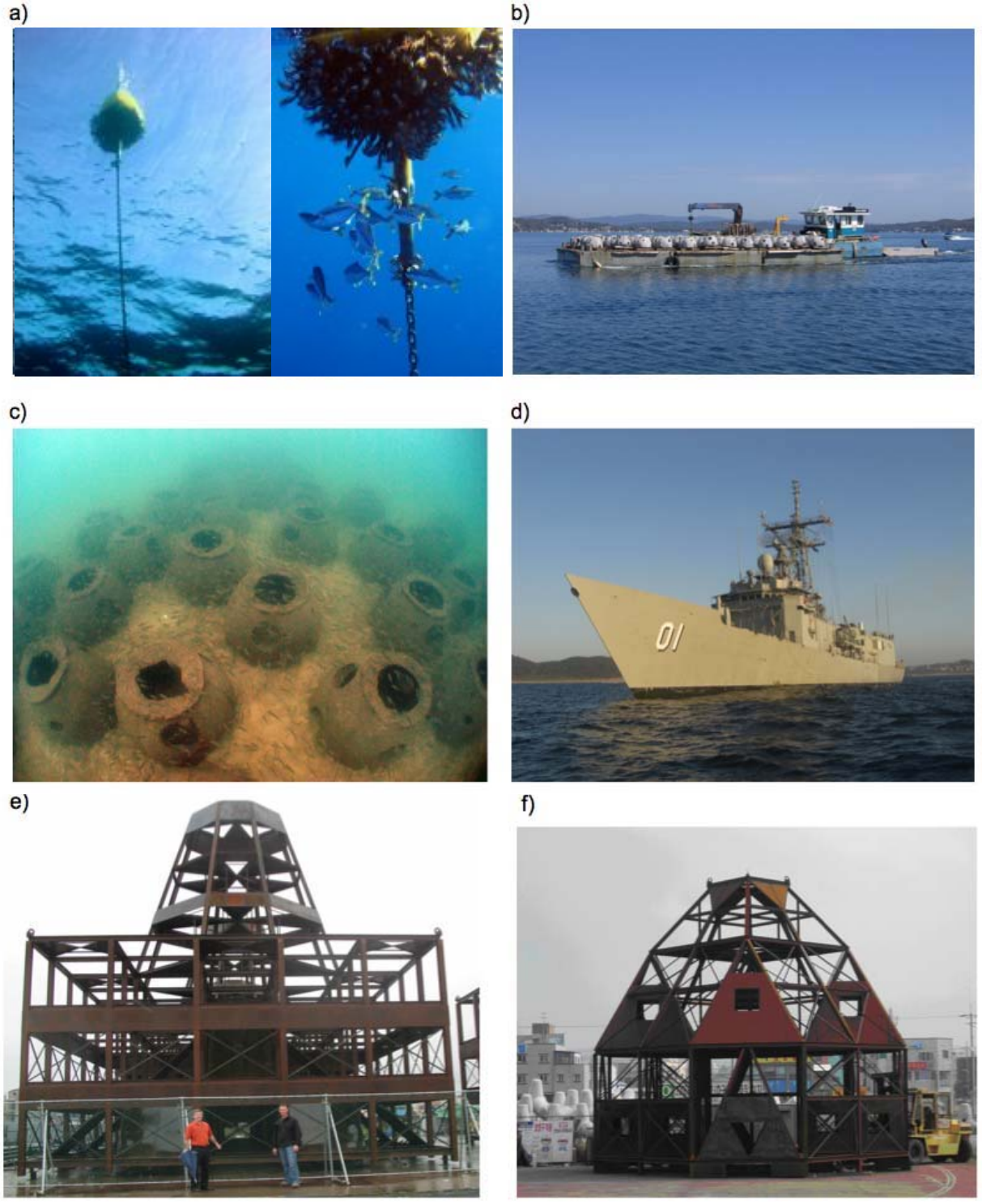

Plate 1: a) Fish Aggregation Devices (FADs) b) Reef balls being deployed in Lake Macquarie 2005. c) Concrete moulded Reef Balls at Lake Macquarie 2005. d) The ex-HMAS *Adelaide* in transit to Garden Island, Sydney to be prepared for scuttling. e) Korean designed two-storey octagonal steel reef unit. f) Three-storey Korean steel reef unit. Photos courtesy of I&I NSW.

3 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 will be dependent on monitoring results and the success of the first Sydney OAR.

Structure Design

An existing Korean design (Plate 1, 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 3).

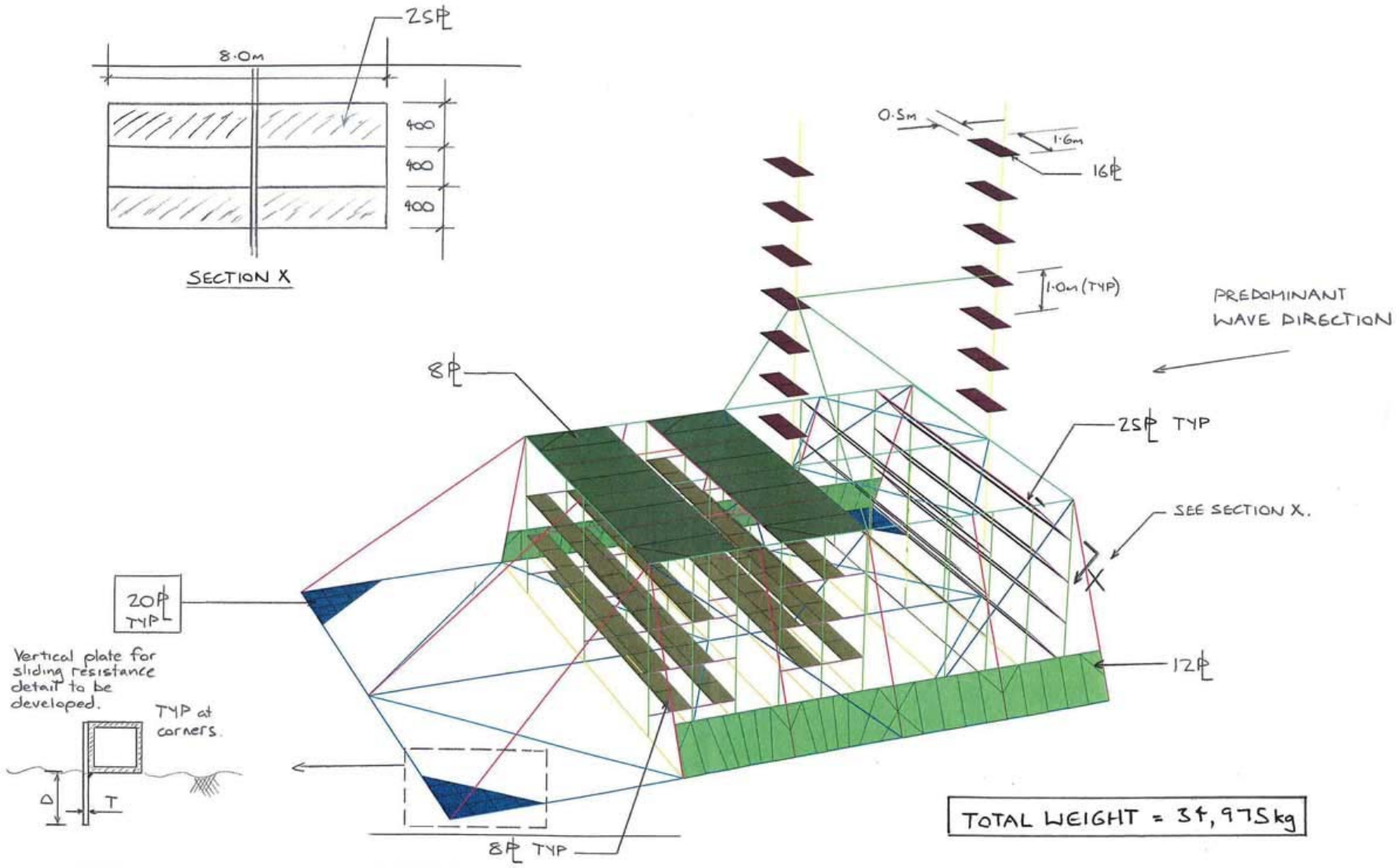

Figure 3. Drawing of the OAR concept design developed by Worley Parsons.

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 4.

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 5, 6 and 7 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 5).
- 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 6).
- 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 7).

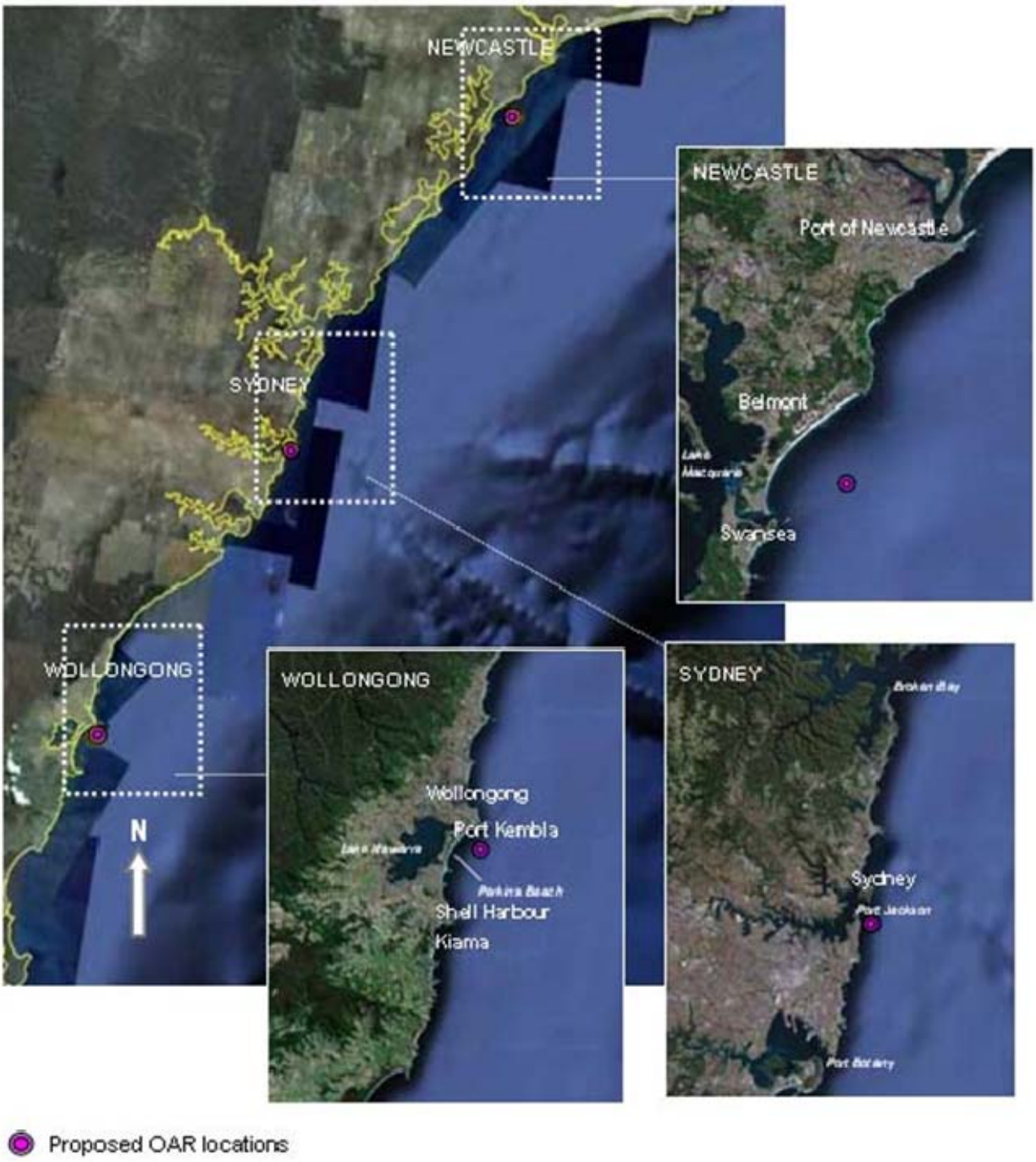

Figure 4: Overview map of the proposed Newcastle, Sydney and Wollongong OAR study regions.

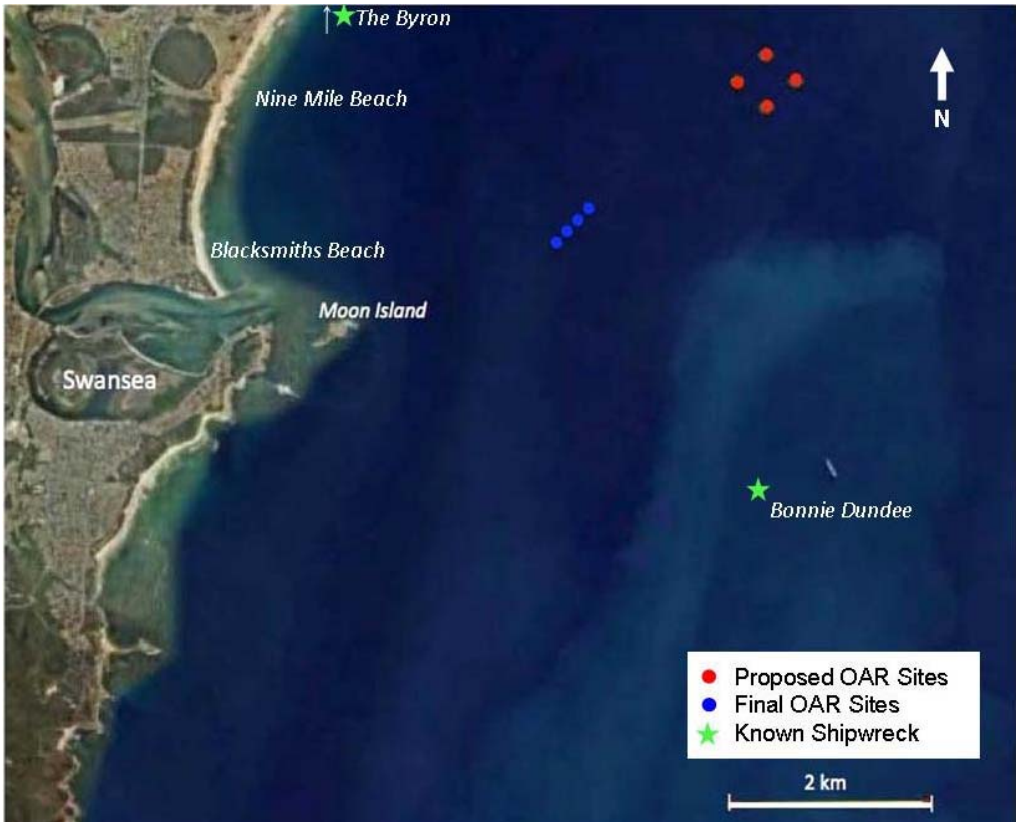

Figure 5: Initial proposed OAR location (red) and final OAR location (blue) for the Newcastle study region.

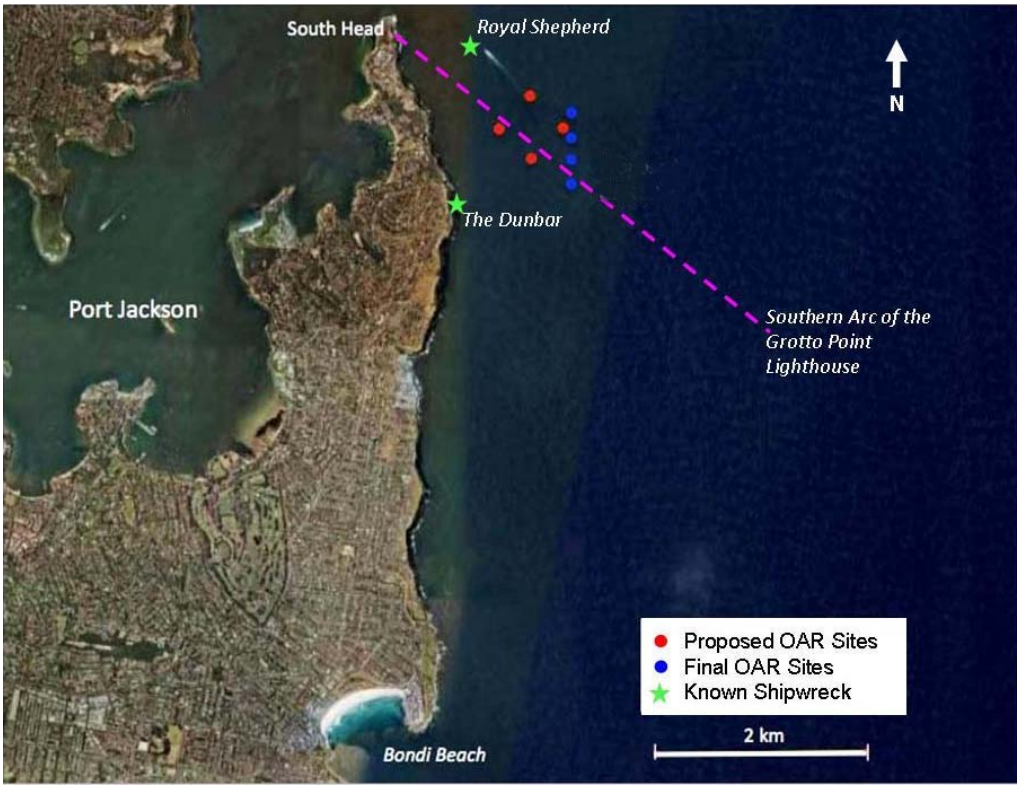

Figure 6: Initial proposed OAR location (red) and final OAR location (blue) for the Sydney study region.

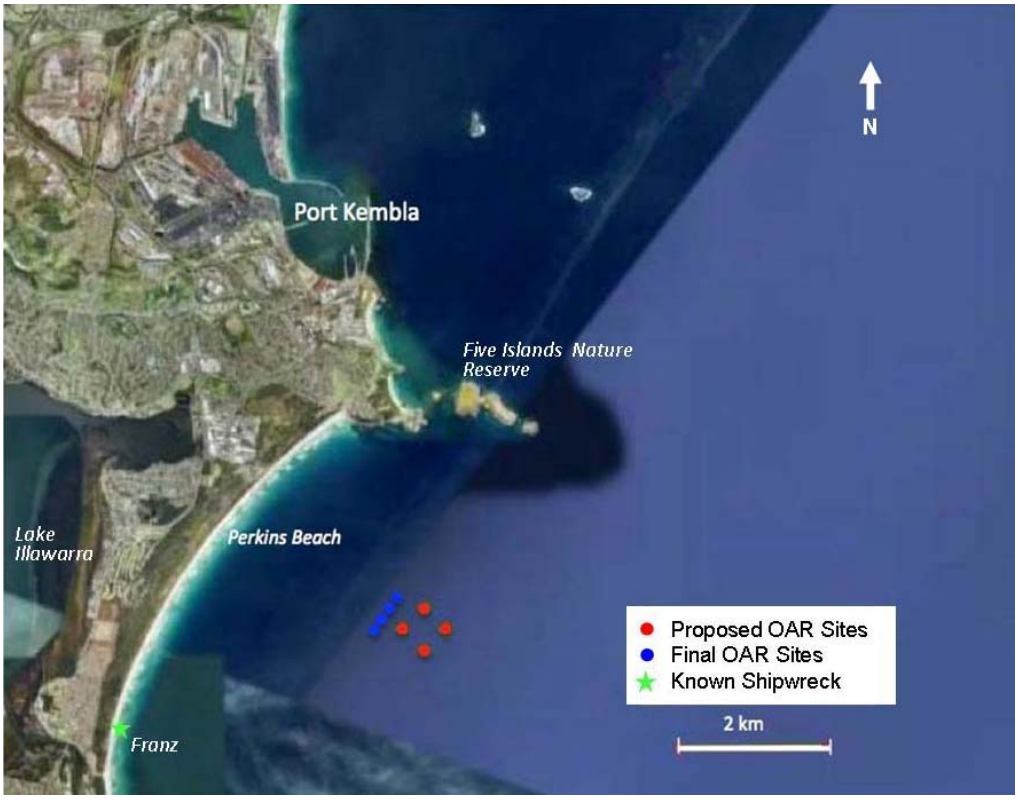

Figure 7: Initial proposed OAR location (red) and final OAR location (blue) for the Wollongong study region.

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 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 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) will also be subject to a separate environmental assessment.

4 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.

5 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 EA/PER 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 1.

Table 1: 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 8). 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 8a). ▪ 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 8b).

Table 1: 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 8c). 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 2a). Benthic assemblages in all study regions were diverse and characterised by large numbers of crustaceans (Plate 2c) and polychaetes (Plate 2d) 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 2b). 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 (Plate 2e, 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.

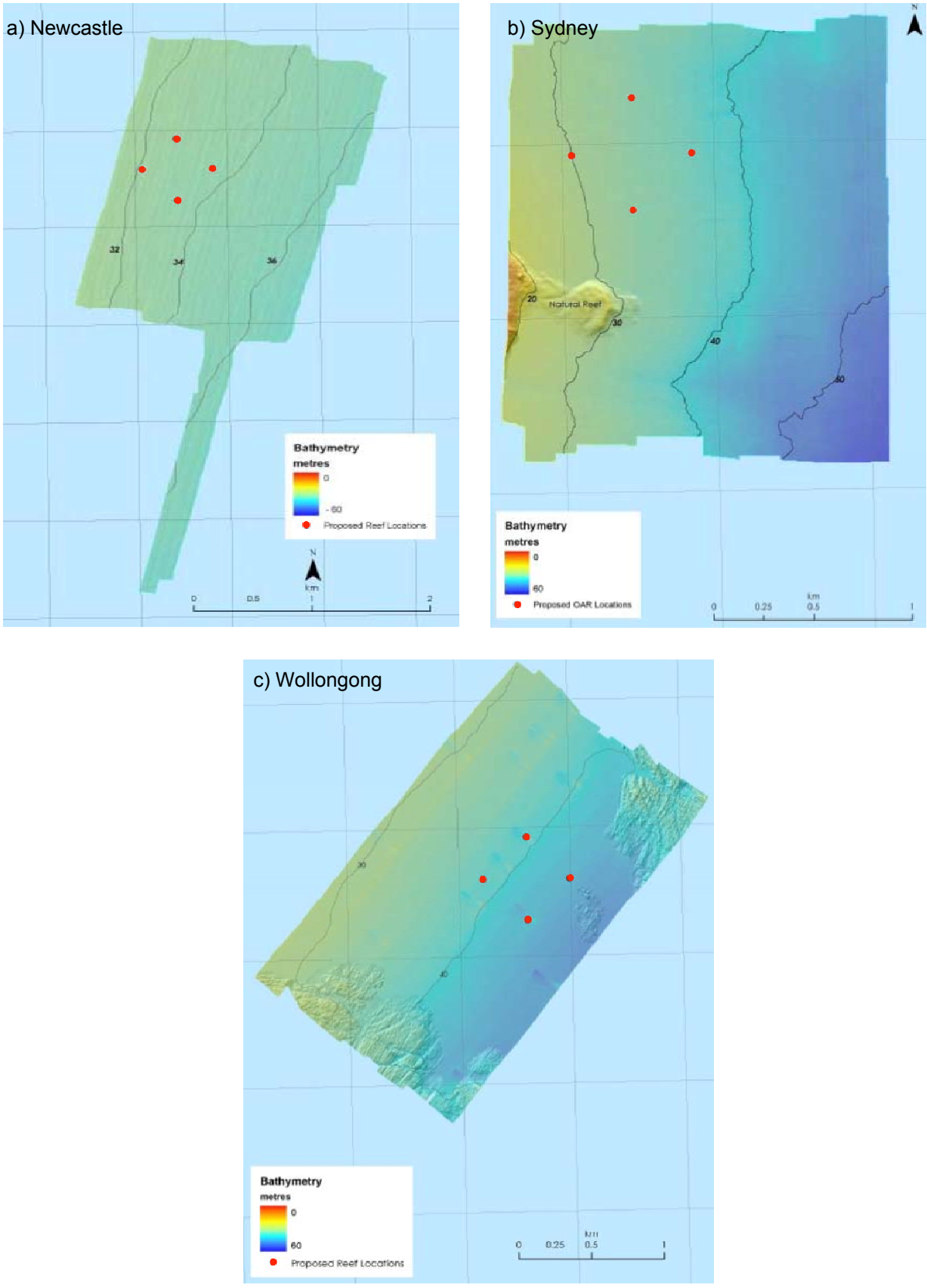

Figure 8: Bathymetry with hillshaded relief at the a) Newcastle, b) Sydney and c) Wollongong study areas. Depths shown along contour lines are in metres AHD. Red dots indicate the initially proposed reef unit locations. Source: DECCW.

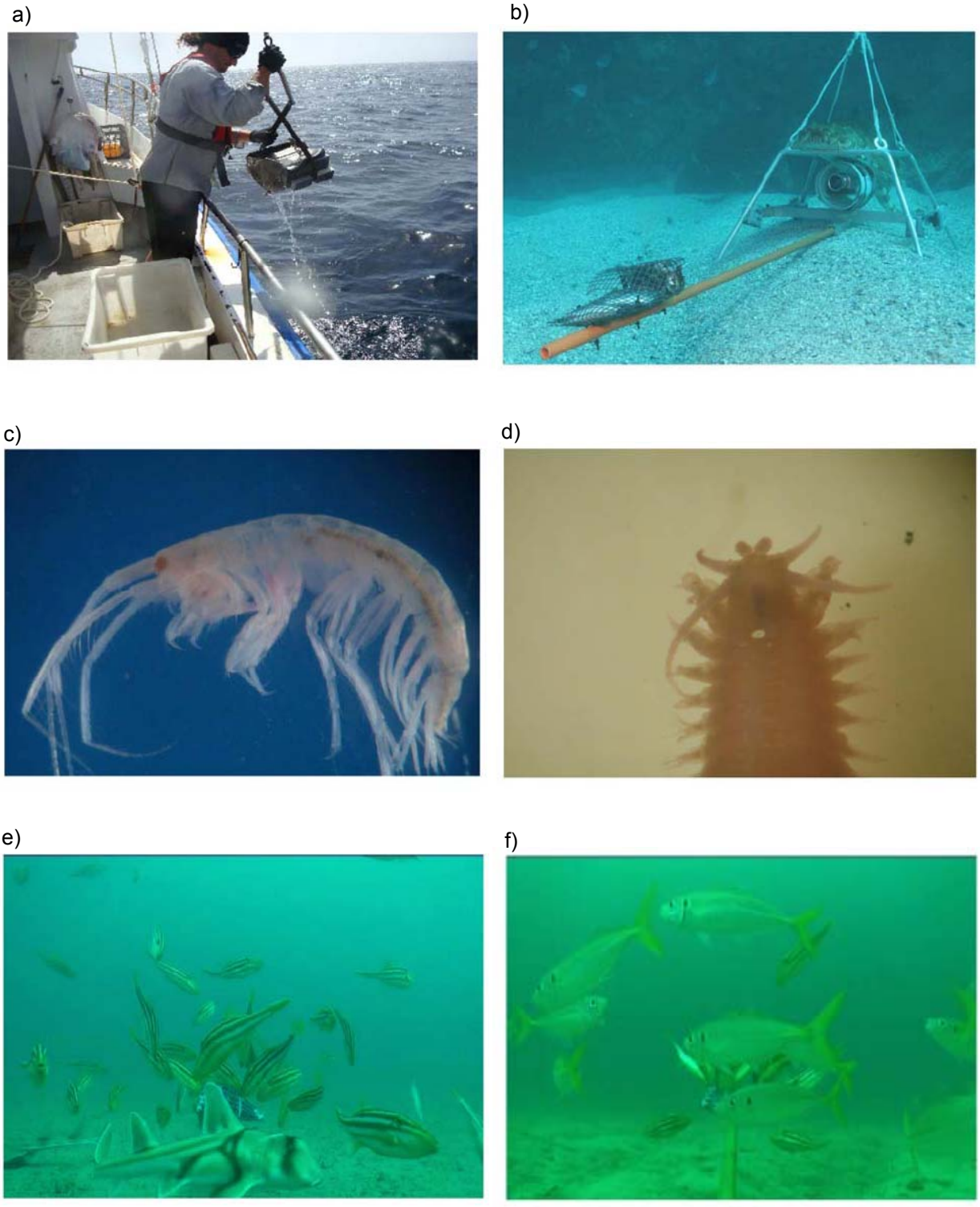

Plate 2: a) Sampling for macroinvertebrates with a Ponar Grab on the vessel 'Krista' in January 2009. b) The BRUVS unit positioned on the seabed. c) An aorid amphipod crustacean collected during the benthic survey. d) Polychaete worm - family: Onuphidae, collected during the benthic survey. e) Chinaman 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 1, 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 3).

6 Consultation

Relevant statutory and non-statutory authorities, port corporations, commercial fishing operators and recreational fishing associations/organisations were consulted as part of the draft 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.

7 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 2 whilst those associated with their long-term operation are summarised in Table 3.

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 2: 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)		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 3: 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)		Large (1-10 km)	
		L	C	L	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 3: Continued.

Receptor/Issue	Hazard/Negative Impact	Scale			
		Small (≤1 km)		Large (1-10 km)	
		L	C	L	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		*		*

8 Assessment of Key Issues/Impacts

Key Issues, potential impacts and recommended mitigation or management measures are summarised in Tables 4 and 5 below. The predicted outcome, given that the recommended mitigation/management measures are applied, are also stated.

Table 4: 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 4: 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 4: 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 5: 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 5: 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 5: 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 5: 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.	As above
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.

9 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 will 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 5,6 and 7, 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 would, 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 will 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.

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 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.

10 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.

11 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).