NSW GOVERNMENT | Department of Primary Industries

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Shoalhaven Offshore Artificial Reef

Long term management plan

Published by the NSW Department of Primary Industries

Shoalhaven Offshore artificial reef – Long term management plan

First published August 2015

More information

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Cover Image: Yellowtail kingfish schooling around the Sydney offshore artificial reef in April 2014 (image: DPI)

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LONG TERM MANAGEMENT PLAN

DPI is responsible for the reef operation, including management, monitoring and maintenance operations of the Shoalhaven offshore artificial reef. This long term management plan has been developed to provide clear direction on the implementation of environmental management best practices during the construction/installation, and operation of the reef.

This plan has been developed as part of the environmental assessment (EA) process and the DPI is committed to carrying out the mitigation measures outlined in Section 9 of the EA. As such, detailed assessment of ecological, biological and socio-economic impacts have been considered and addressed by the EA and are summarised in this plan. *For a more detailed description, reference should be made to the EA.*

1 Introduction

NSW Department of Primary Industries (DPI) aims to improve recreational fishing opportunities in NSW through the development of offshore artificial reefs in offshore locations.

The assessment of impacts (Section 9 – environmental assessment [EA]) identified components of the marine environment and potential impacts/issues related to those components that require further investigation and potential monitoring. The potential risks identified in the EA would be minimised or removed to an acceptable level of risk through implementation of the Long Term Management Plan. This plan aims to consolidate the mitigation and management measures that the DPI is committed to implementing.

Figure 1. Artist impression of the Shoalhaven offshore artificial reef

1.1 Project Planning

The DPI has been responsible for the preparation of all documentation, stakeholder consultation, risk analysis and specialist flora and fauna investigations. The DPI has also coordinated a team of highly qualified environmental consultants who have extensive experience in ecology, environmental management, oceanography and coastal processes of the NSW coast (Figure 2) to provide further expertise when required.

The DPI reviewed relevant planning and legislative requirements, provided detail for requirements of artificial reef design and planning and provided an overview of the construction and deployment process. In addition, DPI developed research and monitoring plans and procedures to assess potential impacts relating to threatened species, pest species, angler catch, fishing related marine debris and monitoring of the effects of scouring and deposition in the vicinity of the reef post deployment and its impact on the structural integrity of the reefs.

DPI engaged the services of;

- Cardno Pty Ltd to provide technical expertise and participate in the risk assessments for the process and to also compile the Shoalhaven offshore artificial reef offshore artificial reefs 'Location and constraints mapping' report (Technical Report A).
- Umwelt Pty Ltd was contracted to investigate the cultural significance of the site and potential impacts on Indigenous heritage (Technical Report B).
- BMT WBM Pty Ltd was contracted to provide expertise in coastal processes including wave behaviour and sediment movement and circulation (Technical Report C).
- The Office of Environmental and Heritage – Habitat Mapping Branch was contracted to complete acoustic SWATH mapping to provided maps of habitats in the vicinity of the proposed reef locations (Technical Report D).
- Bio-Analysis Pty Ltd was contracted to provide a report on in-fauna and epi-fauna communities found in the vicinity of the reef and potential impacts post deployment (Technical Report E).

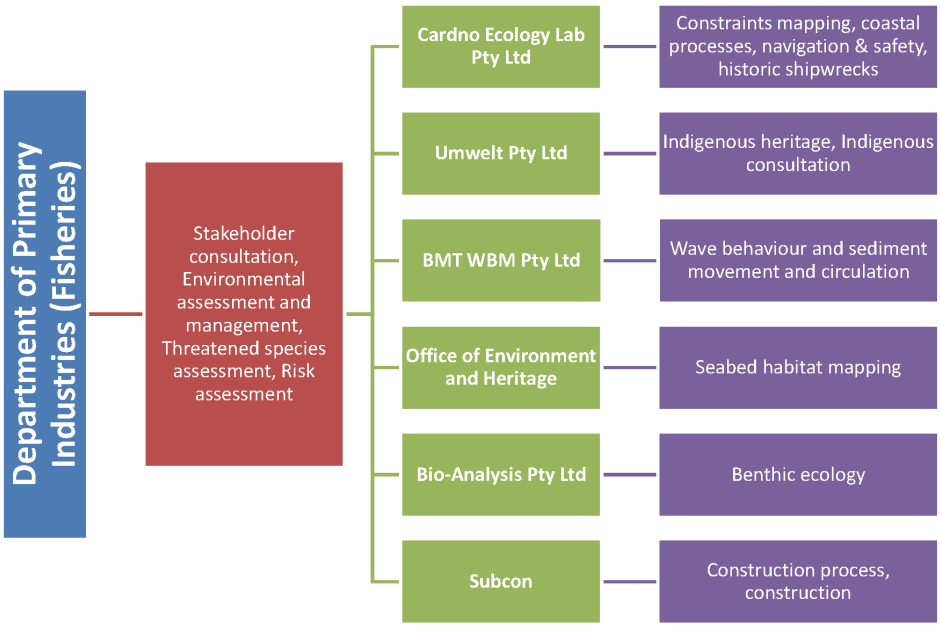

Figure 2. Shoalhaven offshore artificial reef EA team

1.2 Consultation with relevant Commonwealth, State and Local Government agencies and interested non-government organisations

Consultation was carried out by letter (a total of 354 letters were distributed), email, phone calls and through stakeholder consultation meetings. Fisheries enhancement and the proposed offshore artificial reef were also included as agenda items as part of regular stakeholder meetings (e.g. The Ministers Advisory Council on Recreational Fishing [ACoRF], the Recreational Fishing Saltwater Expenditure Committee [RFSTEC] and the Marine and Estuarine Recreational Charter Management Advisory Committee [MERCMC]). In addition, consultation relating to the Indigenous Cultural Heritage Assessment was carried out by Umwelt Pty Ltd and outcomes of this consultation were summarised in the corresponding report (Technical Report B).

Additionally, a website specifically relating to the proposed Shoalhaven offshore artificial reef was launched at the beginning of the consultation period. The website was used to provide updates on the progress of the proposal and information regarding the environmental assessment, and a dedicated email address was provided (fisheries.enhancement@dpi.nsw.gov.au) as an additional avenue for community feedback.

Responses from the statutory and non-statutory groups consulted were received via mail, telephone, email and from the stakeholder consultation meetings. Not all groups contacted during the consultation responded. However, the proposal was generally well-received in terms of the location and design of the reef and the processes used in selecting these.

Table 1. Summary of community-raised issues

Stakeholder Group/Forum(s)	Issue	Assessment/Response
Email correspondence	Potential better placement of reef, specifically requesting placement out of Kiama Harbour.	Responded to via email. Placement was reviewed.
Email correspondence	Requested offshore reefs are made into recreational fishing havens.	Responded to via email. Detailed there has been no conflict between sectors to date and, as such, no need to create the havens. Reef will be monitored for conflict issues.
Email correspondence	Requested electronic version of the areas mapped in the proposal.	Responded to via email.
Email correspondence	Interested in whether fish are aggregated or created via the reef placement; concerned about other nearby fishing locations.	Responded to via email. Gave explanation regarding current science on the aggregation vs. production debate.
Community consultation meeting	Concerned that the placement was too close to existing natural reef, and placement north of the river mouth would create a better location.	Location was reviewed and shifted north of the river mouth.

The results of cultural heritage investigations and consultations with relevant stakeholders by Umwelt Pty Ltd in accordance with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (due diligence code, DECCW 2010), which considered any potential impact the proposal may have on Aboriginal cultural values and activities (such as fishing) in the area (Technical Report B), The seafloor within the project area is currently approximately 30 m underwater, and is understood to be functionally flat, sandy, with no significant vegetation or other ecological considerations. Given the depth and distance from shore, it is considered that:

- there is negligible potential for the presence of in situ Aboriginal objects within the project area; and

- there is a low possibility of Aboriginal objects being transported to the project area by natural or assisted means. Due to the submerged nature and relatively small footprint of each of the reef units, it is not likely that spiritual significance or Dreamtime stories will be affected during the implementation or operation of the reefs.

For further information on the consultation conducted as part of the EA and the results of this consult Chapter 6 of the EA.

2 Project goals and objectives`

2.1 Vision for the Activity

The long-term vision for the deployment of offshore reefs is:

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

2.2 Goals for the Activity

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

1. To manage the activity in a manner that minimises impacts on ecological sustainability and aquatic biodiversity and improves the knowledge of the activity and ecosystems in which it operates.
2. To enhance fishing opportunities through cost-effective reef deployment which complements other existing DPI programs to ensure sustainable fisheries resources and that maximise social benefits, consistent with achieving outcomes aligned with the priorities of the NSW State Plan.
3. To ensure the consistent production, deployment and monitoring of appropriate quality reefs.

3 Risk Assessment

3.1 Introduction

As part of the Environmental Assessment, a risk analysis workshop was held on 28 May 2013 and attended by representatives of Cardno Pty Ltd and the DPI. The aim of the workshop was to identify potential issues/hazards associated with the proposed offshore Shoalhaven offshore artificial reef, to assess the likelihood of occurrence of such 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, fisheries (commercial and recreational) and interference with existing coastal infrastructure, obstructions and exclusion zones. The constraints mapping process (Technical Report A of the EA) 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 risk assessment focusses on issues identified through the risk assessment workshop, during consultation and identified for consideration through both State and Commonwealth legislation.

3.2 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 ([1]). The following risk assessment was based on the principles of Australian Standards for Risk Management 4360:2004 and Fletcher ([1]).

Typically, assessment of risk entails the identification of a potential hazard, i.e. some aspect of the activity that could affect the environment, a judgement of the likelihood that the hazard has of occurring and a judgement of the consequence 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 receptors.

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 (Technical Report A) 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.
- Risk is often scale-dependent; therefore the risks were assessed using scales where they were thought to have the greatest potential impact. To reduce the subjectivity of this analysis, the scale on which each of the risks was assessed is listed in the risk assessment table.
- 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.
- The risk analysis (and environmental assessment) is based on the proposed reef design as given in Section 8 of the EA.

Table 2 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 being of very low, low, medium or high significance. The result of the risk assessment does not mean that the project should not proceed, i.e. if the level of risk is high, 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.

Table 2. Risk analysis matrix

Likelihood			
A	Almost certain	Is expected to occur as a result of the project under most circumstances	>1/month
B	Likely	Will probably occur as a result of the project in most circumstances	>1/year
C	Possible	Could occur and has occurred in similar circumstances	1–10 years
D	Unlikely	Could occur as a result of the project but is not expected	10—100 years
E	Rare	Could occur only in exceptional circumstances	<1/100 years
Consequence (Environmental)			
1	Catastrophic	Widespread extreme impact beyond the deployment area; limited prospect of full recovery	
2	Major	Substantial impact/serious harm within the immediate deployment area; limited prospect of full recovery	
3	Moderate	Serious/significant impact; recovery longer than 3 years	
4	Minor	Localised harm; recovery measurable within 1-3 years.	
5	Minimal	No impact on the baseline environment; minimal or no mitigative actions required	
Consequence (Health and Safety)			
1	Catastrophic	Single or multiple fatalities	
2	Major	Catastrophic illness or injury	
3	Moderate	Extensive/major injury	
4	Minor	Minor injury e.g. medical treatment required	
5	Minimal	No medical treatment required	

			Likelihood				
			A	B	C	D	E
			Almost certain	Likely	Possible	Unlikely	Rare
Consequence	1	Catastrophic/Extreme	A1	B1	C1	D1	E1
	2	Major	A2	B2	C2	D2	E2
	3	Serious/Moderate	A3	B3	C3	D3	E3
	4	Moderate/Minor	A4	B4	C4	D4	E4
	5	Minimal/Insignificant	A5	B5	C5	D5	E5

H	High Risk	Risk is significant and requires significant cost-effective measures for risk reduction and/or management.
M	Moderate Risk	Routine and cost effective measures required to reduce and/or manage risk. Risk may be acceptable.
L	Low Risk	Risk can be managed by routine procedures and/or no further measures to manage the risk are required.
VL	Very Low Risk	Risk is accepted, no further measures to manage the risk are required.

4 Shoalhaven Offshore artificial reef Management Area

The location of the proposed reef deployment site is situated within Shoalhaven Bight, east-north-east of the Shoalhaven River entrance at an approximate depth of 30 m LAT. The size of the management area is 150 m x 250 m and the centre point of the reef area is 34°50.955 S, 150°47.731 E (WGS84). A licence to occupy the site for the purpose of the artificial reef has been granted by NSW Crown Lands (Lic. No. RI534468). For individual reef patch centre points coordinates refer Table 5.

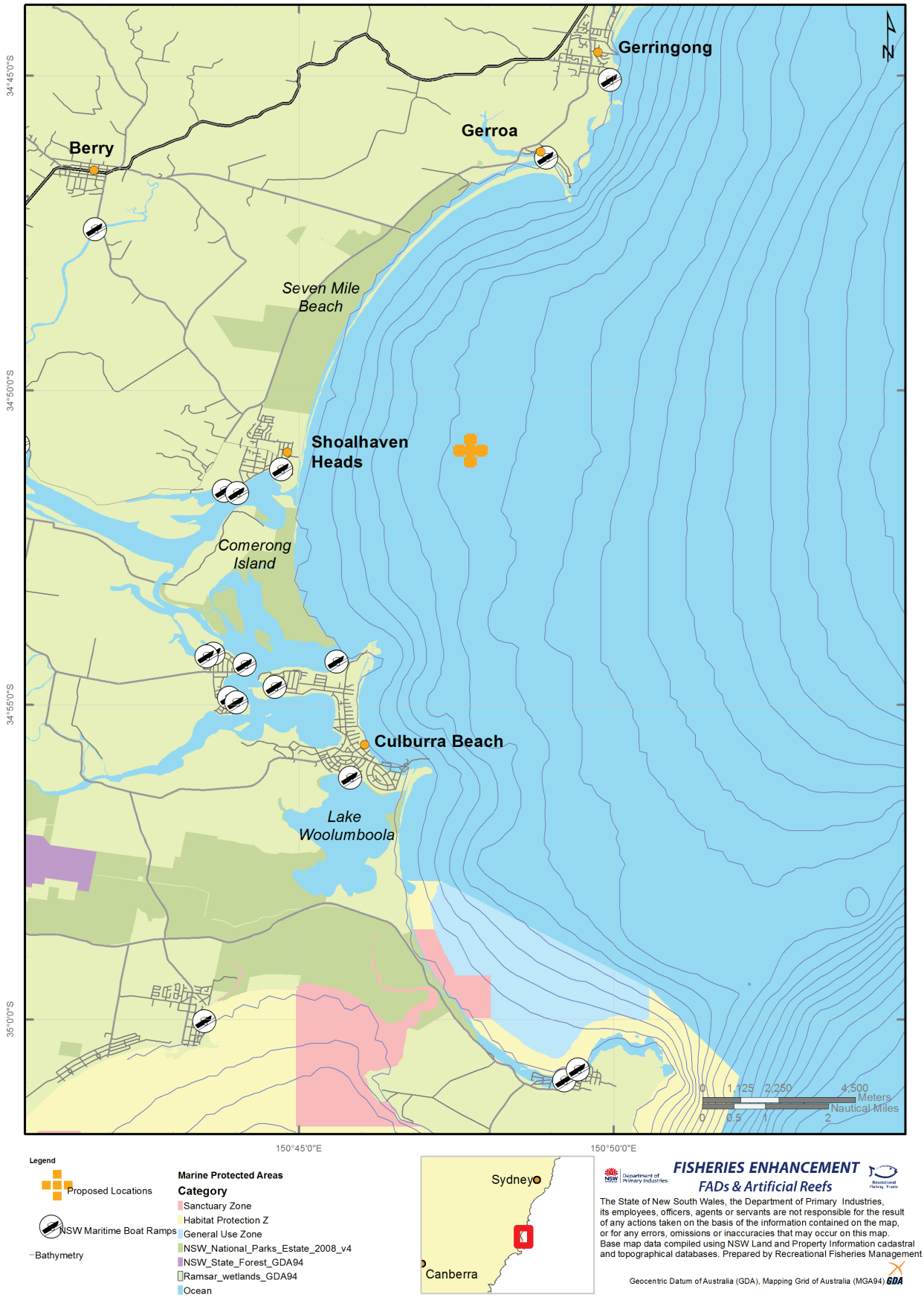

Figure 3. General location for proposed deployment of the reef.

4.1 Socioeconomic considerations

There have been a limited number of studies conducted which focus on the economics of recreational fishing. To demonstrate the regional significance of the Shoalhaven area as a tourism destination, in the Year ending June 30 2013 NSW tourism identified that the South Coast of NSW received over 3 million domestic overnight visitors. Sydney (43.0%) was the largest source of visitors to the region, followed by regional NSW (28.5%) and the ACT (15.4%).

When Recreational Fishing Licence holders were asked their main reasons for coming to Bermagui- Narooma area, fishing was the highest primary reason for visiting, followed by general holiday. Fishers prioritized ocean fishing, with estuary and fishing from the rocks, or beach, also being important.

Preliminary analysis of the visitation rates to the Sydney offshore artificial reef found that recreational fishers were utilising the reef at consistently higher proportions than were observed at the reference location (Figure 4). As expected visitation rates were strongly influenced by prevailing weather conditions and day type (weekend or weekday). An assessment of levels of effort directed by anglers around the structure indicate moderate levels of fishing activity with a decrease over the winter period followed by a strong increase in angler usage over the following summer and autumn.

The Shoalhaven Offshore artificial reef is expected to deliver direct social and broader economic benefits by providing recreational fishing opportunities in the region. The following have been identified as beneficiaries of the reef:

- recreational fishers who have an interest in healthy fish stocks and a quality marine environment;
- Coastal resorts and tourism facilities who base their developments around the demand generated by quality recreational fishing experiences;
- tourism and charter operators who base their businesses around the quality of the fishing experience and the abundance of fish, and;
- the tackle and boating industry that depend on having sustainable fish resources in the Shoalhaven Bight area.

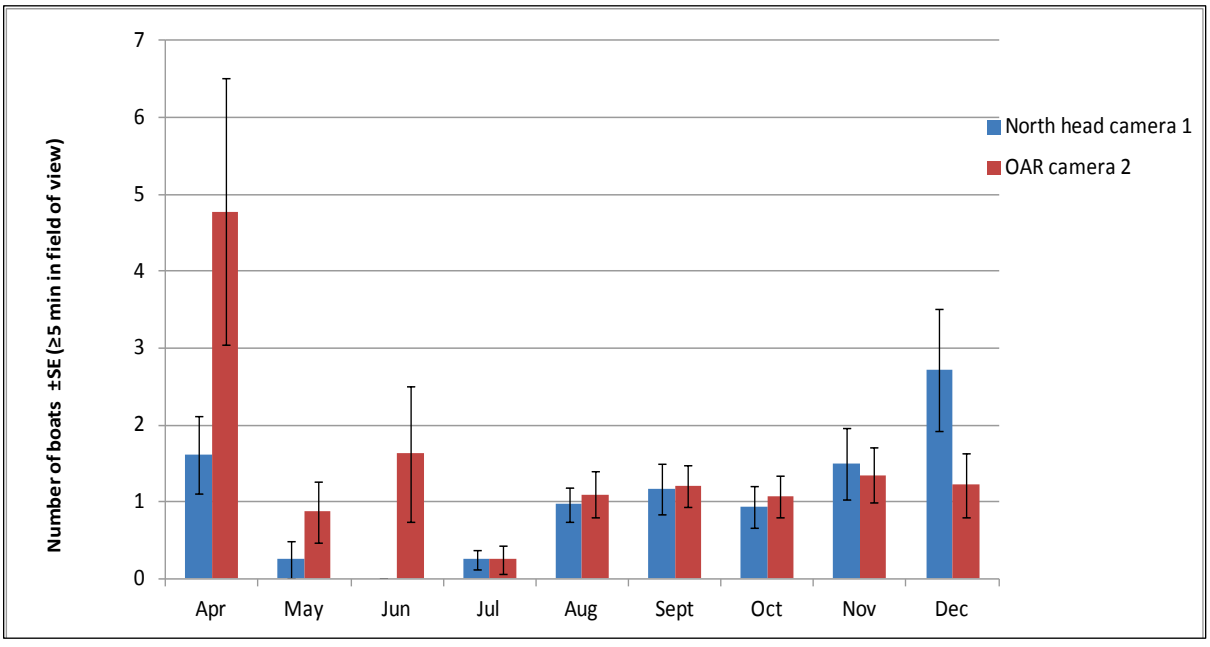

Figure 4. Daily mean number of boats recorded between 6am and 6pm April to December 2012 on the Sydney OAR and reference locations

4.2 Environmental considerations

Reef layout should incorporate a variety of biological, economic, and physical sciences and engineering factors ([2]). Size, relief, complexity, location and biological factors can all influence assemblages of fishes on artificial reefs ([3]). Biological principles that should be considered include habitat limitation ([4]), habitat complexity ([5], [6]) and refuge from predators ([7]). Physical principles deal with the size of the reef structure ([8]) and the strength and stability of the reef materials. 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 ([9]). Conversely, greater densities of fish on smaller artificial reefs have also been reported ([3]). The vertical relief, relative to water depth of an artificial reef, can also influence abundance and diversity. In temperate waters, diversity has been shown to be greater on low-relief artificial structures than on natural structures ([10]). Conversely, a study of high-relief reefs found greater diversity on natural reefs than on artificial reefs ([11]). Psychological, social and economic aspects of human behaviour also are important when considering reef design, taking into account the requirements of possible end user groups ([12], [13], [14]).

The extent and structure of seabed habitats on the continental shelf of NSW have been mapped to varying degrees, with particular focus on habitats within NSW State coastal waters. Technical report D was commissioned to look in detail at the seafloor within the vicinity of the proposed reef deployment site and involved the collation and analyses of existing broadscale bathymetric and marine sediment datasets, and seabed habitat data defined from previous single-beam and SWATH acoustic surveys and aerial photography. The information was combined with new SWATH acoustic data collected using the OEH interferometric sidescan sonar system, allowing the development of high-resolution maps of the seabed bathymetry and habitats.

From SWATH mapping results, depths across the proposed artificial reef deployment site ranged from 25.8 m to 33.9 m. A visual interpretation of backscatter, bathymetry and their spatial derivatives (slope and aspect) indicated that the seafloor in the survey area was relatively homogeneous. No areas of reef were identified within the targeted survey area and sections of intermediate unconsolidated sediments (likely to be coarse sand-gravel-pebble habitat) cover the majority of the seafloor within a 500 m radius of the proposed site. Areas of mobile unconsolidated sediments, likely to be sands, generally occupy the seafloor in shallower water to the south-west, while features indicating migration and erosion of the bottom substrate were evident in the north, west and south-east.

All habitats have been mapped from aerial photographs and SWATH mapping of the seafloor has been conducted as part of this assessment (Section 8.2.1 of the EA). Offshore artificial reefs are considered to be most effective when placed in bare sandy ‘habitat limited’ environments. Selection of the reef site has therefore focussed on areas known or likely to consist of sandy substratum away from areas of naturally occurring reef.

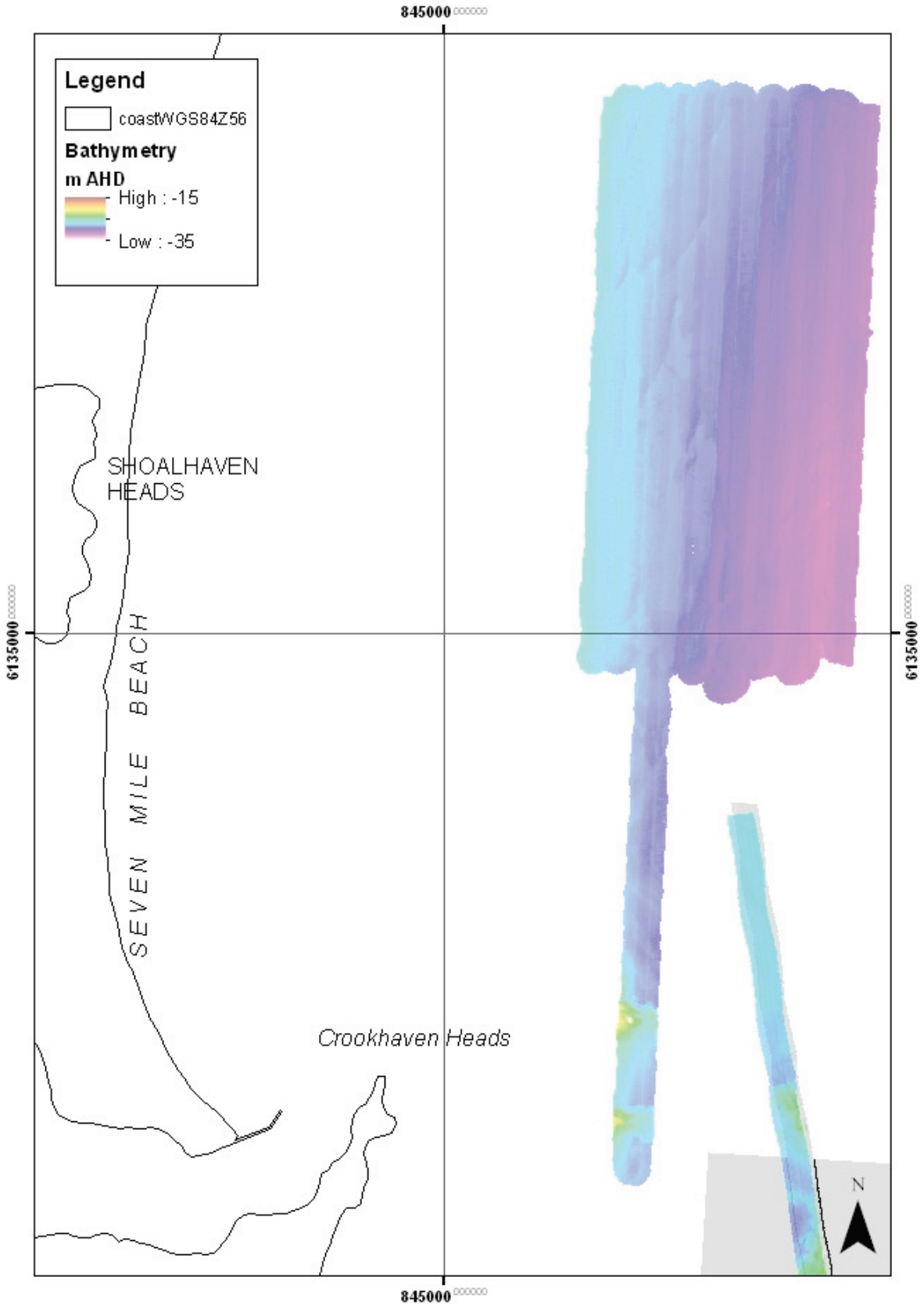

Figure 5. False colour plan view of 2 m (horizontal) binned bathymetric data

Table 3. Risk assessment of the environmental considerations considered in the reef assessment

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Coastal Processes & Oceanography						
Nearshore Coastal	Large	Inshore wave climate	D4	Placement to reflect preferred wave/current conditions. Assessment of impacts of structures on coastal processes.	Reduce Likelihood	E4
Nearshore Coastal	Large	Change to beach erosion/deposition	D4	Placement to reflect preferred wave/current conditions. Assessment of impacts of structures on coastal processes.	Reduce Likelihood	E4
Local Seabed	Sub-Local	Local scouring/deposition around units	A5	Configuration of modules/site selection to minimise scouring. Assessment of impacts of structures on coastal processes. Sediment Particle Size testing.	Reduce Likelihood	C5
Structural Integrity and Stability	Sub-Local	Loss of structural integrity e.g. from corrosion or excessive marine growth	E5	Module design and life appropriate to environmental conditions.	None	E5
	Sub-Local	Risk of sliding or overturning	D5	Module design appropriate to environmental conditions.	None	D5
Flora and Fauna						
Benthos	Sub-Local	Direct loss of habitat	A5	Accept risk, monitor in relation to offshore artificial reef and manage as appropriate.	None	A5
Benthos	Local	Change to sedimentary characteristics	A5	Accept risk, monitor in relation to offshore artificial reef and manage as appropriate.	None	A5
Sediments and Water	Local	Leaching of contaminants	D4	Provided the structures are built to Australian Standards for corrosion rates, there are no relevant impact mitigation measures that can be implemented to further reduce potential impacts during operation.	Reduce Likelihood	E5

4.3 Biological considerations

A study on the benthic assemblages conducted as part of the EA (Technical Report E) found diversity and abundance of benthic organisms collected from the soft sediments did not differ significantly between the proposed artificial reef and reference locations. Temporal variability in macrobenthos has been widely reported but if the lack of spatial differences between the location proposed for deployment of the artificial reef and the reference locations is a general pattern through time, then it seems reasonable to conclude that the assemblages found at the artificial reef is well represented within the general area.

Censuses of fish assemblages associated with rocky reef habitats at depths of < 5 m and 10–15 m off Penguin Head have previously been conducted. For the shallow water (< 5 m) survey, a total of 58 species were recorded, with 25 species being recorded from the deeper water (10–15 m) using UVC reef transects. The Sir John Young Banks reef system located to the south of the proposed reef deployment site is noted for its fish life including grey nurse shark (*Cacharhinus taurus*), bronze whalers *(Carcharhinus brachyurus*), tiger sharks (*Galeocerdo cuvier*), yellowtail kingfish (*Seriola lalandii*), mackerel (*Scombridae*), longfin pike (*Dinolestes leweni*), Australian salmon (*Arripis trutta*) and silver trevally (*Pseudocaranx dentex*).

Results from the post placement monitoring of a similar purpose-built offshore artificial reefs in the Sydney region have identified a total of 22 species residing on the reef itself. Initially following deployment, the number of species identified per month followed a moderate increase in diversity from 4 species pre-deployment to a peak of 16 species 8 months post deployment.

Previous studies have shown that the assemblages of fish known to occur within the study area are diverse and vary in relation to habitat type and depth, but may also be structured by very site specific factors. The site specific surveys of the Shoalhaven deployment site conducted by DPI were consistent with the findings of similar studies conducted in the region and it is expected that the reef will support a wide variety of reef associated fish species. The community is likely to be made up of a larger number of species with greater diversity as the structure will provide suitable space for both sand and reef associated species. Fish surveys were conducted by the DPI on the proposed Shoalhaven artificial reef deployment site and control sites representative of the bottom area prior to reef deployment and also for natural reef using baited remote underwater video (BRUV) units. Results from these surveys indicated that natural rocky reef supported a fish community that was significantly different to the community identified on the proposed artificial reef deployment site. As expected, the community identified on the sand and artificial reef sites was not found to be significantly different in its species composition. Species richness was found to be significantly greater on the natural reef (32 species) as opposed to the proposed artificial reef deployment site and sandy sites (13 and 14 species respectively). Commercially and recreationally important species observed at the artificial reef sites sampled included sand whiting *(Sillago ciliate*), silver trevally (*Pseudocaranx dentex*), yellowtail scad (*Trachurus novaezelandiae*), flatheads (*Platycephalus spp*.) and gummy shark *(Mustelus antarcticus*). On the natural reef sites sampled, blue morwong (*Nemadactylus douglasii*), snapper (*Pagrus auratus*), yellowtail scad (*Trachurus novaezelandiae*) and a variety of leather jackets (*Meuschenia spp*.) were the dominant recreationally and commercially targeted species observed.

Results of the database searches indicated that there are 9 species of fish, 20 species of syngnathids (including seahorses, pipefish and ghost pipefish), 24 species of marine mammal (including whales, dolphins and seals) and six species of marine reptiles (including turtles and seasnakes) currently listed as either threatened or protected in the area. New South Wales and Commonwealth registers of critical habitats were also searched and none were identified within the study area. Only threatened species (from the initial search) that were known or considered likely to occur in the wider study area (based on general species distribution databases) and/or known to utilise habitat in the study area, were considered for further Assessment of Significance. These species were assessed according to OEH and DPI threatened species assessment guidelines (individual species assessments are given in Appendix 6). Overall, 5 species of fish, 3 species of marine turtle, 4 species of cetacean and 2 pinnipeds were assessed according to OEH and the DPI threatened species assessment guidelines.

Following deployment of the reef, it is proposed for any incidents, recorded or reported interactions with threatened or protected species to be reported at 6 monthly intervals to the DPI Threatened Species Unit for further assessment as detailed in this plan. The DPI will also provide 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. This educational information will be published as part the offshore artificial reef 'User Guidelines' (refer to Appendix 9).

Table 4. Risk assessment of the biological considerations considered in the reef assessment

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Flora and Fauna						
Benthos	Local	Changes to benthic assemblages	A4	Accept risk, monitor in relation to offshore artificial reef and manage as appropriate.	None	A4
Benthos	Local	Increased predation by fishes from the offshore artificial reef on benthos	A4	Accept risk, monitor in relation to offshore artificial reef and manage as appropriate.	None	A4
Benthos	Regional	Commercial trawling in areas not previously trawled	D5	Accept risk	None	D5
Proximal Natural Reef	Intermediate	Changes to benthic assemblages	E5	Accept risk	None	E5
	Intermediate	Reduction in abundance/diversity of assemblages	C3	Ensure sufficient distance from natural reef (e.g. > 1 km) to minimise movement of resident species from natural reefs to artificial reef.	Reduce Likelihood	D3
	Intermediate	Drawdown effects	A4	Monitor. Ensure sufficient distance away from natural reef (e.g. > 1 km) to minimise movement of resident species from natural reefs to artificial reef.	Reduce Consequence	A5
	Intermediate	Increased fishing effort	C4	Accept risk	None	C4
	Intermediate	Increased mortality (from aggregation)	C3	Monitor and manage/regulate as appropriate (seasonal closures/gear types etc.).	None	C3
Threatened and Protected Species						
Fish	Local	Incidental capture	C3	Angler education on best practice release guidelines. Monitor incidences/tagging/listening stations. Monitor occurrence and movement patterns in relation to offshore artificial reef. Monitor and manage/regulate as appropriate (seasonal closures/gear types etc.).	Reduce Consequence	C4

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
	Local	Aggregation of threatened or protected species	C2	Angler education on best practice release guidelines. Monitor incidences/tagging/listening stations. Monitor occurrence and movement patterns in relation to offshore artificial reef. Monitor and manage/regulate as appropriate (seasonal closures/gear types etc.).	Reduce Consequence	C4
	Regional	Alteration of movement corridors (e.g. GNS)	D3	Monitor incidences/tagging/listening stations. Monitor movement patterns in relation to offshore artificial reef and manage as appropriate.	Reduce Consequence	D4
	Local	Increased predation	C4	Monitor in relation to offshore artificial reef and manage as appropriate.	None	C4
	Sub-Local	Loss of habitat	D4	Accept	None	D4
Marine Turtles	Local	Incidental capture	E4	Accept	None	E4
	Local	Boat strike	E3	Accept	None	E3
	Intermediate	Acoustic disturbance	E4	Accept	None	E4
	Large	Interruption of movement corridors	E5	Accept	None	E5
	Intermediate	Loss of habitat	E5	Accept	None	E5
Cetaceans	Local	Boat strike	C3	Education regarding acceptable approach distances to cetaceans.	None	C3
	Intermediate	Acoustic disturbance	D4	Accept	None	D4
	Large	Interruption of movement corridors	D4	Accept	None	D4
Pinnipeds and Sirenians	Local	Incidental capture	C4	Accept	None	C4
	Local	Boat strike (sirenians only)	E5	Accept	None	E5
	Intermediate	Acoustic disturbance	D4	Accept	None	D4
	Large	Interruption of movement corridors	E4	Accept	None	E4
Seabirds	Local	Incidental capture or ingestion of marine debris	D4	Monitor. Education using the reef user guidelines and existing DPI education programs would be provided on the potential impacts of harmful marine debris on marine life and the responsible disposal of litter	None	D4

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
				and discarded fishing gear		
KTPs	Intermediate	Harm from marine debris and pollution (KTPs)	C3	Monitor for fouled gear and remove if necessary.	Reduce Consequence	C4
Invasive Marine Pests	Local	Introduction of invasive (noxious/pest) marine pests	B4	Reef user groups would be informed of boating guidelines to minimise the spread of marine pests, implementation of a monitoring plan. 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.	Reduce Likelihood & consequence	D5

5 Module design, reef configuration and construction

5.1 Material

The module design chosen for the Shoalhaven offshore artificial reef needed to include both vertical relief and ample void spacing to provide a highly effective reef. In response to this and the unique challenges of installation of reefs on Australia's harsh coastal environment, the fabrication and deployment contactor (Subcon Technologies Pty Ltd) have developed the ReefTemple™ module to optimise fabrication and installation as well as its performance as a fish habitat (Figure 6). AS3600 requires a minimum concrete strength of 50MPa for marine applications in harsh environments and as a result the minimum design life of the concrete is 30 years.

Previous structures fabricated by Subcon Technologies Pty Ltd (Subcon) have been made to these standards and are experiencing no discernible degradation. A 28 day curing period during fabrication is used to ensure full structural strength for the 50MPa concrete and stabilised pH prior to deployment. Subcon use environmentally friendly release agents for form work for all its projects.

The Subcon design, construct and install management team contracted by the DPI for this project includes extensive experience in Offshore Construction, Marine Science, Scour Mechanics, Concrete Fabrication and Offshore Installation. Subcon provides:

- The highest safety standards for marine operations based on oil and gas best practices;
- In-house Structural Design, Offshore Installation Engineering and Subsea Stability Design Engineers combined with an in-house Marine Scientist;
- Dedicated QHSE Management;
- ISO9001 and 18001, AS/NZS4801 management system certified by DNV.

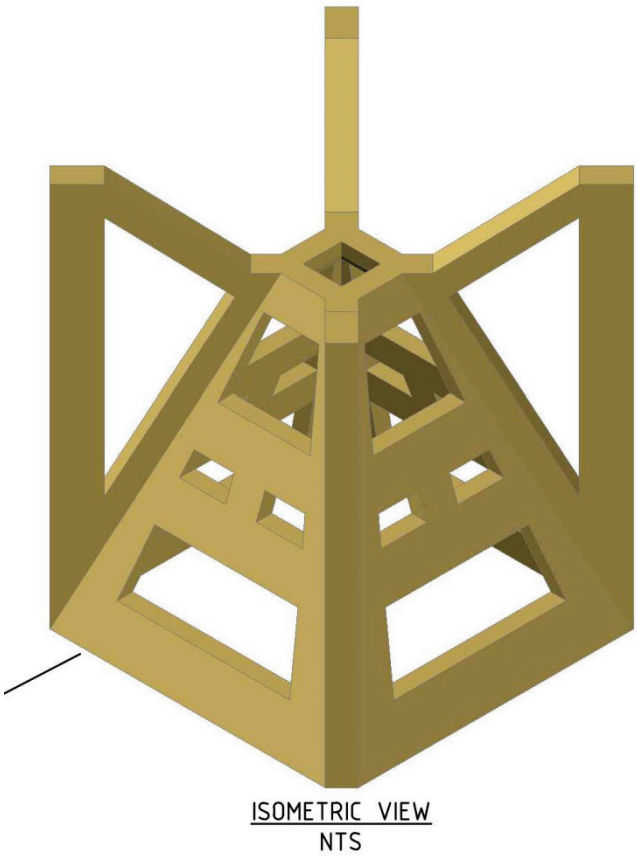

Figure 6. The ReefTemple™ artificial reef module design

5.1.1 Reef design and module dimensions

The proposed reef will consist of 20 x 80m^3 modules with a 1600m^3 total internal volume arranged in 5 clusters of 4 modules each (Figure 6). The individual ReefTemple™ modules are a 4m x 4m x 5m complex cubic structure. *Each unit has a dry-weight of approximately 23 tonne – combined reef weight total is 460 tonne.*

The module is constructed from steel reinforced 50MPa concrete to AS3600 for marine environments designed to withstand a 1 in 100 year storm event. The 5m high pylon structures provide vertical relief whilst the integrated central pyramid provides a highly complex habitat creating the ideal module for permanently recruiting nearshore finfish species including: silver trevally, yellowtail scad, yellowtail kingfish and snapper.

The modules create shade and modify lateral water flow as demonstrated by tank tests at University of Western Australia (UWA) (Figure 7) and are designed to operate effectively in a mobile sand substrate environment. The pyramid promotes up welling and the diagonal “lips” on the pyramid capture the water current by preventing “edge losses”. These “lips” funnel the flow by promoting the vertical component of the current. This in turn helps provide additional downward force on the module to increase stability.

The design is compliant with all relevant Australian standards in accordance with our certified ISO9001 quality management system.

No Annex 1 or Annex II substances (under Schedule 1 of the Sea Dumping Act) that is, heavy metals, oils and grease, radioactive material, or plastics, are used in the fabrication of the modules.

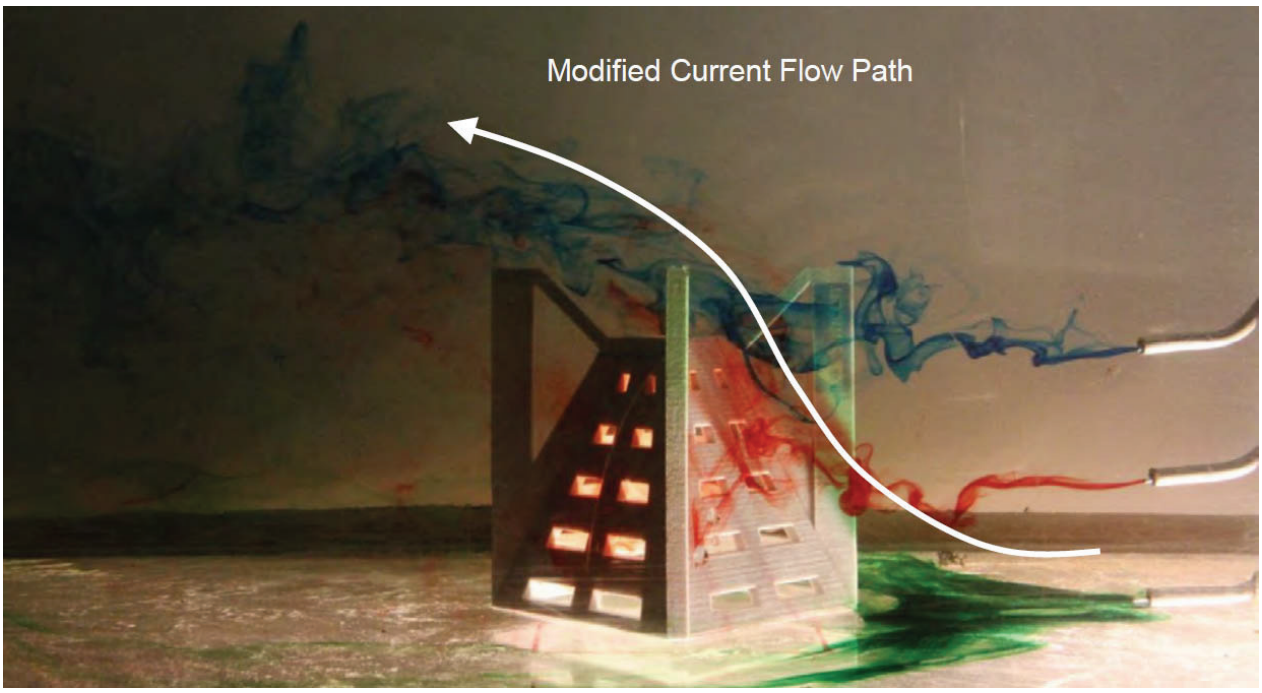

Figure 7. Flow modification testing at the University of WA, Flume Tank

5.1.2 Reef construction methodology

The fabrication of the modules will be performed on location at the Port Kembla Gateway Wharf. The wharf is within the outer harbour and provides a sheltered location for the fabrication, loadout and standby berthing of the cargo barge whilst Subcon waits for a suitable weather window.

The moulds are owned by Subcon and are designed to be road/sea transportable in 20ft containers. The moulds are assembled onsite with the rebar cages built into them as they are lofted and bolted up. Concrete will be delivered by a local supplier in mini mixers to the fabrication site where it is offloaded into concrete pumps and pumped into the completed moulds. Two moulds will be used concurrently to produce one module daily.

Load out of the reef blocks onto the installation barge will be conducted using 40Te fork trucks to drive the modules out onto the quay.

As a general overview, Subcon propose to install the reef using a 4 point, spread moored barge with crawler crane fitted with a custom hydraulic ram release mechanism for module deployment. A single trip with the full complement of reef modules will be loaded onto a 180ft ballastable barge. The barge will be towed from Port Kembla to site by a tug sourced out of Botany Bay (Figure 7 & Figure 8 respectively).

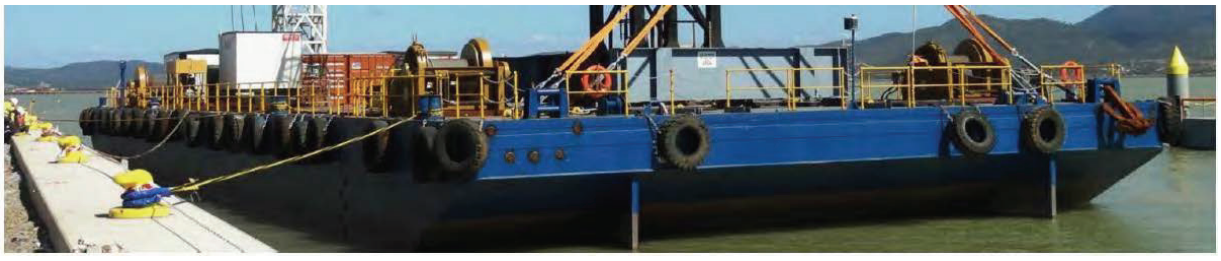

Figure 8. 180ft deployment barge to be tugged to site from Port Kembla

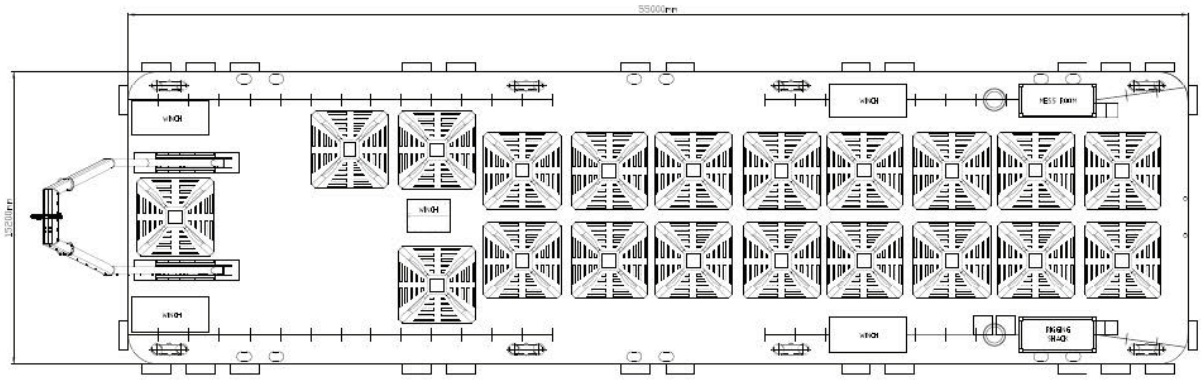

Figure 9. Schematic of 180ft loaded cargo barge (FT407) – 20 ReefTemple™ modules and rear 'A-Frame mounted

5.1.3 Fabrication hardstand and inspection site

The hardstand where modules will be fabricated is located within the Port Kembla port facility, approximately 200m from the loadout quay where the deployment barge will be moored (Figure 10). The access to the wharf from the hardstand is via a private road within the port. There are no overhead powerlines, low height structures, or overwidth limitations meaning the proposed ReefTemple™ construction and load out poses the least interruption and lowest risk to the local community. Access to this site for the purpose of inspection can be arranged upon request.

Figure 10. Fabrication hardstand and Wharf Facility at Port Kembla

5.2 Reef Deployment site – Shoalhaven Bight

The location of the proposed reef deployment site is situated within Shoalhaven Bight, east-north-east of the Shoalhaven River entrance at an approximate depth of 30 m LAT. The size of the deployment and management area is 150 m x 250 m and the centre point of the reef area is 34°50.955 S, 150°47.731 E (WGS84).

5.2.1 Geographical position (latitude and longitude)

Table 5. Geographical position of the proposed reef patches*

Corner	Latitude	Longitude
Centre Patch	34º50.955’ S	150º47.731’E
Northern Patch	34º50.928’ S	150º47.730’E
Eastern Patch	34º50.955’ S	150º47.763’E
Southern Patch	34º50.983’ S	150º47.729’E
Western Patch	34º50.955’ S	150º47.697’E

*Coordinates are in Datum WGS84

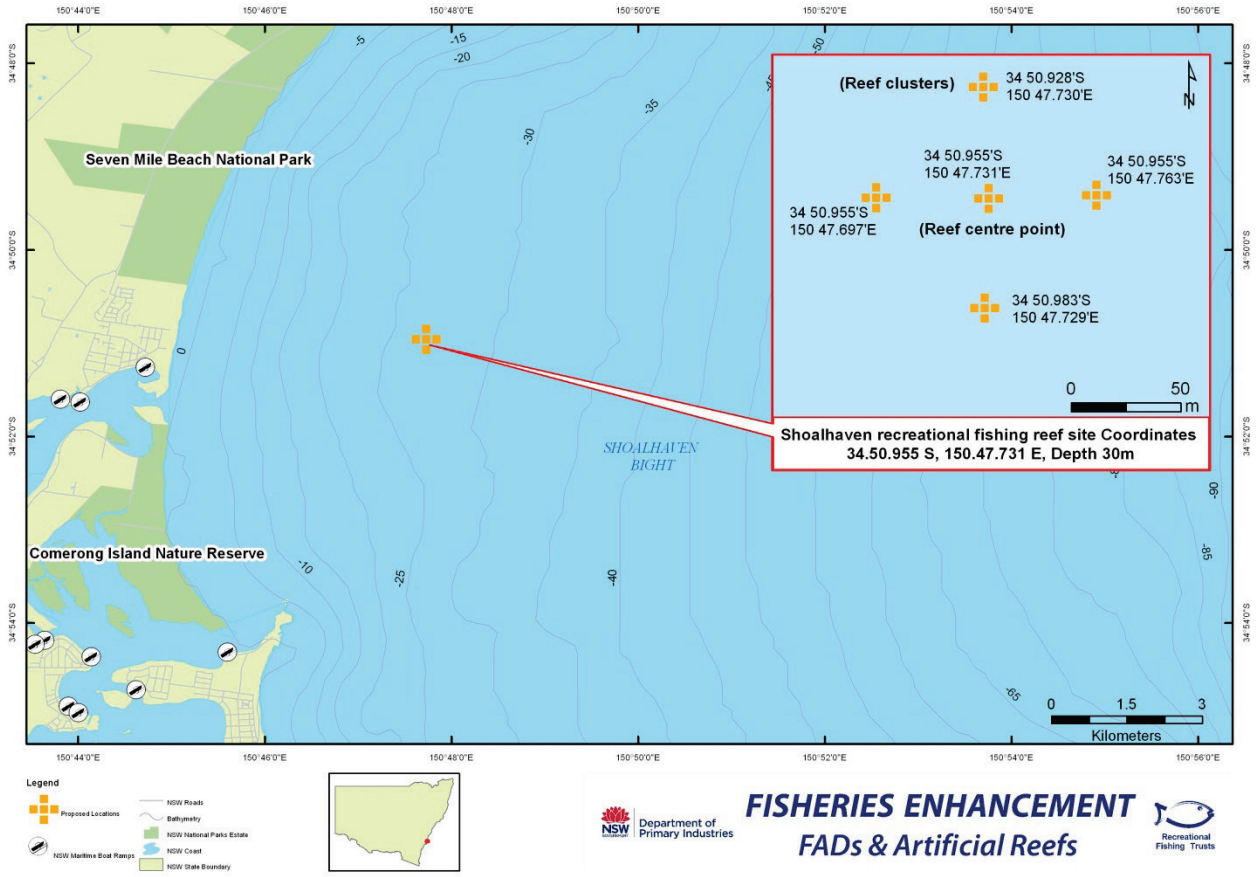

Figure 11. Map of geographical locations for each of the proposed reef modules

5.2.2 ‘As-built’ location confirmation

Differential GPS (DGPS) will be used for surface positioning of the vessel and a frame mounted sonar and cameras for subsea positioning of the modules. The final 'as-built' survey will be conducted by independent survey of the reef site. DGPS will be used to provide a position for each of the 20 individual modules.

5.2.3 Depth of water over the reef

A depth range of between 20–35 m (LAT) on the continental shelf is a requirement in order to avoid creating a navigational hazard. Suitable depth is also important for the stability of the modules (in terms of ability to withstand certain hydrodynamic forces), accessibility to recreational fishers (via boat) and will also influence the type of fish which will aggregate around the structure. Clearance depth over the artificial reef post deployment will be no less than 25m (LAT). This will be confirmed post reef deployment.

Refer to section 4.2.1 in the EA for further information.

5.2.4 Distance from nearest land

The location of the proposed reef deployment site is situated within Shoalhaven Bight, 3.4km east of Shoalhaven heads, 5.77km north east of Culburra heads and 7.94km south west of Black head Gerroa as shown in Figure 12.

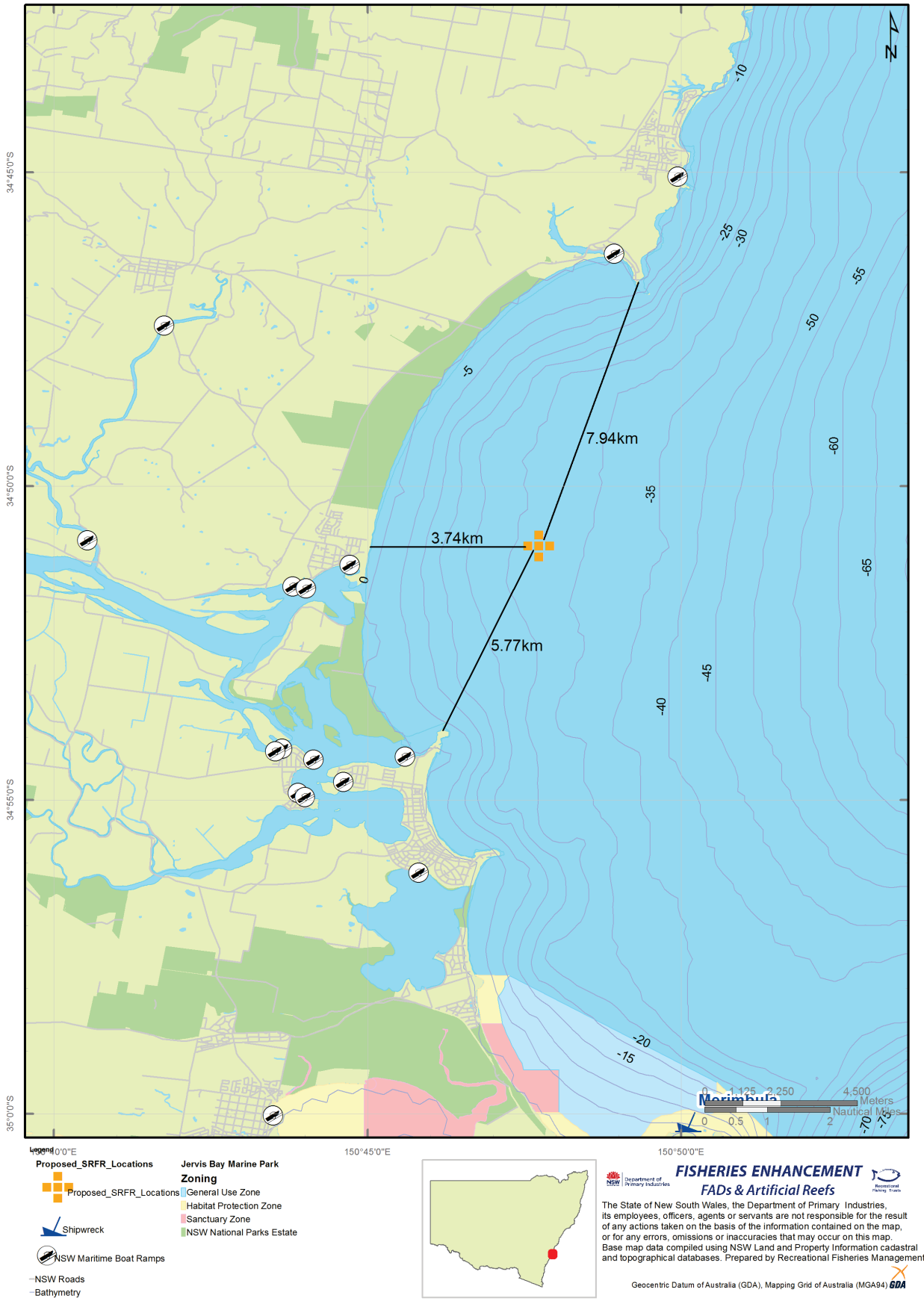

Figure 12. Map showing proposed reef location and distances to nearest land.

5.2.5 Biological characteristics

Reefs designed for the purpose of recreational fishing enhancement should be placed an appropriate distance away from existing reefs in order to create new habitats and create an opportunity to increase local productivity, rather than adding to existing reef habitat (a nominated distance of no less than 0.5km) Natural reef habitats, habitats unique within an area, or locations known to support diverse benthic/epibenthic communities should therefore be avoided. Areas of conservation significance and habitats critical to the survival of a particular species are generally protected under NSW legislation and reefs designed for recreational fishing may not be compatible with the objectives of the protected area. Information on the occurrence and distribution of threatened species is generally sparse and may be limited to predictions based on presence of suitable habitat and/or records of a species occurring at nearby locations. It is especially difficult to predict where highly mobile individuals (such as fish or migratory marine mammals) occur due to their itinerant nature.

Refer to section 4.21‘Constraints mapping and site selection’ of the environmental assessment for further information.

5.2.6 Characteristics of the sea bottom at the site, and impact of material on biota at the placement site or other areas potentially affected by the creation of the artificial reef

Sediment depth of the upper surficial sediment blanket (SSB) is estimated to be approximately 10 metres deep at the proposed reef deployment site. Under this primary layer there is a estuarine back barrier muddy sequence as estimated to be 10 metres thick. This estimation was determined from a seismic survey undertaken as part of the geological survey of NSW, covering the intercontinental shelf of the Shoalhaven/Jervis Bay/Ulladulla region in Southern NSW

Benthic animals living in soft sediments represent a large component of marine biodiversity and ecosystem productivity and are an important source of food for fish and other animals higher up the food chain. A study on the benthic assemblages conducted as part of the EA (Technical Report E) found diversity and abundance of benthic organisms collected from the soft sediments did not differ significantly between the offshore artificial reef and reference locations. Significantly more crustaceans were, however, found at the location situated to the south of the proposed reef deployment site, compared to the west of the proposed reef, mostly due to relatively large numbers of amphipods. The taxa that were consistently most abundant, i.e. crustaceans, bivalve molluscs and polychaete worms, are typical of soft-sediment habitats in marine environments of south-eastern Australia ([15], [16], [17], [18]). These taxa included amphipods and anthuridean isopods (Anthuridae), the bivalve, Nuculanidae and the polychaetes, Lumbrineridae and Orbiniidae. Nuculanidae was relatively abundant in sediments collected at one of the reference locations.

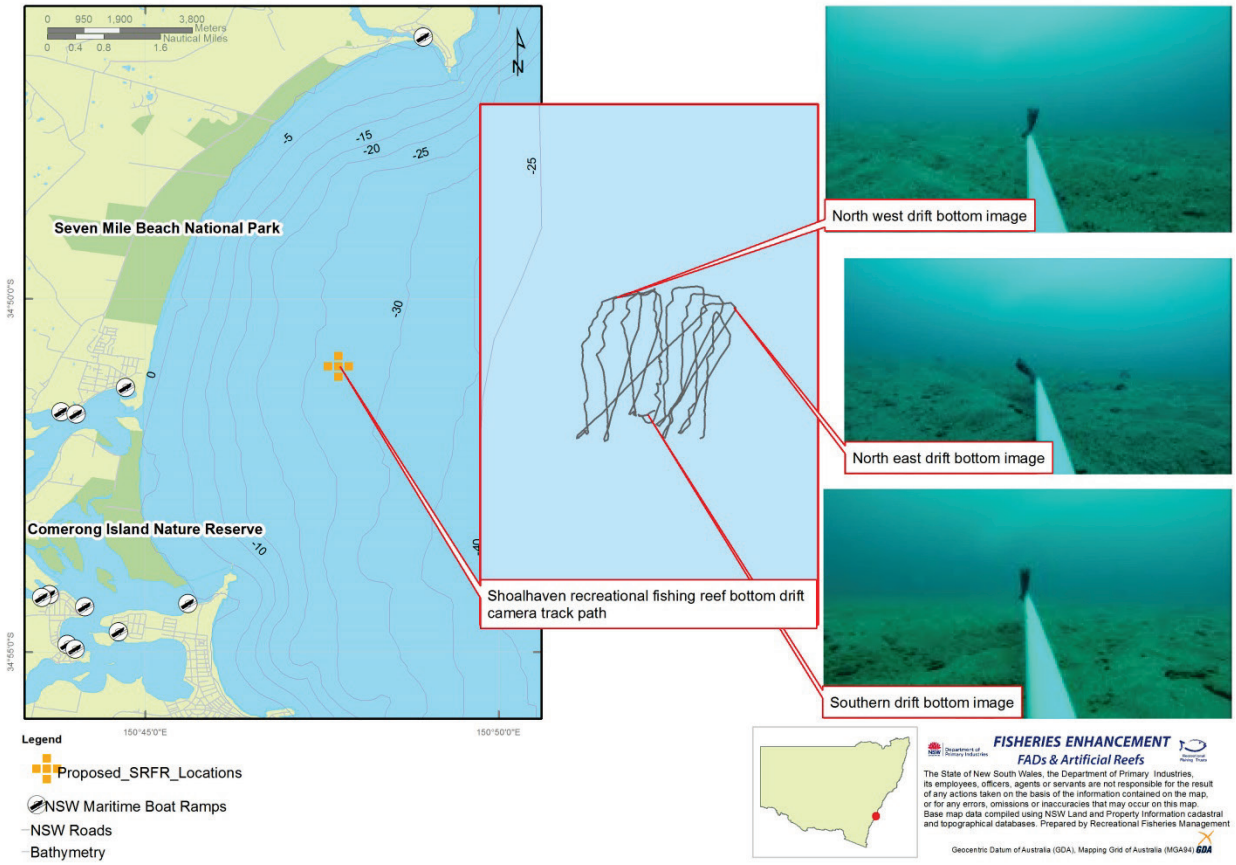

Figure 13. Camera drift paths over proposed site as well as photos of relevant seafloor features

5.2.7 Relation of proposed site to features of importance for amenity, navigation, or exploitation of cultural, historic or scientific interest, fishing, endangered, rare or migratory species or sensitive habitats (such as coral reefs or seagrass beds)

5.2.7.1 Amenity

Boat ramps and amenities in the Shoalhaven area and surrounds are listed in and their locations indicated in Figure 14. There are a total of 15 boat ramps within 20 km of the proposed offshore artificial reef site. This list includes ramps at Kiama Harbour, Gerringong, Gerroa, Shoalhaven River, Crookhaven, Culburra and Jervis Bay.

Table 6. Boat ramps and facilities within 20 km of the proposed reef site

Name	Construction	Lanes	Vessel wash point	Lighting	Pump Out	Fish cleaning table	Fuel	Kiosk	BBQ	Toilets	Distance to reef (km)
Berry-Wharf Rd Ramp, Broughton Creek	CONCRETE	1	Y	N	N	N	Y	N	N	Y	11.1
Gerroa Beach	SAND	0	N	N	N	N	Y	Y	Y	Y	8.6
Boat Harbour-Gerringong	CONCRETE	1	Y	Y	N	Y	Y	N	Y	Y	11.1
Shoalhaven Heads-River Rd Ramp, Shoalhaven River	CONCRETE	1	Y	Y	N	Y	Y	N	Y	Y	4.3
Boughton Creek Ramp-Shoalhaven River	GRAVEL	1	N	N	N	N	N	N	N	N	10.7
Shoalhaven Heads-Hay Ave Ramp, Shoalhaven River	CONCRETE	1	N	N	N	Y	Y	N	N	N	5.8
Shoalhaven Heads-Wharf Rd Ramp, Shoalhaven River	CONCRETE	0	N	Y	N	N	Y	N	N	Y	5.4
Crookhaven-Crookhaven River	CONCRETE	2	Y	Y	N	Y	N	N	N	Y	6.5
Greenwell Point-Wharf, Crookhaven River	CONCRETE	1	N	Y	N	N	N	N	Y	Y	7.9
Greenwell Point-Bowling Club, Crookhaven River	CONCRETE	1	Y	Y	N	Y	N	N	N	Y	8.8
Orient Point-Crookhaven River	CONCRETE	1	N	Y	N	N	N	N	N	Y	7.9
Greenwell Point-West St, Crookhaven River	CONCRETE	1	N	Y	N	N	N	N	N	N	8.2
Warrain Cres-Currarong	CONCRETE	1	N	N	N	N	N	N	N	N	18.3
Watt St-Callala Bay,Jervis Bay	CONCRETE	1	Y	Y	N	Y	N	N	Y	Y	17.5

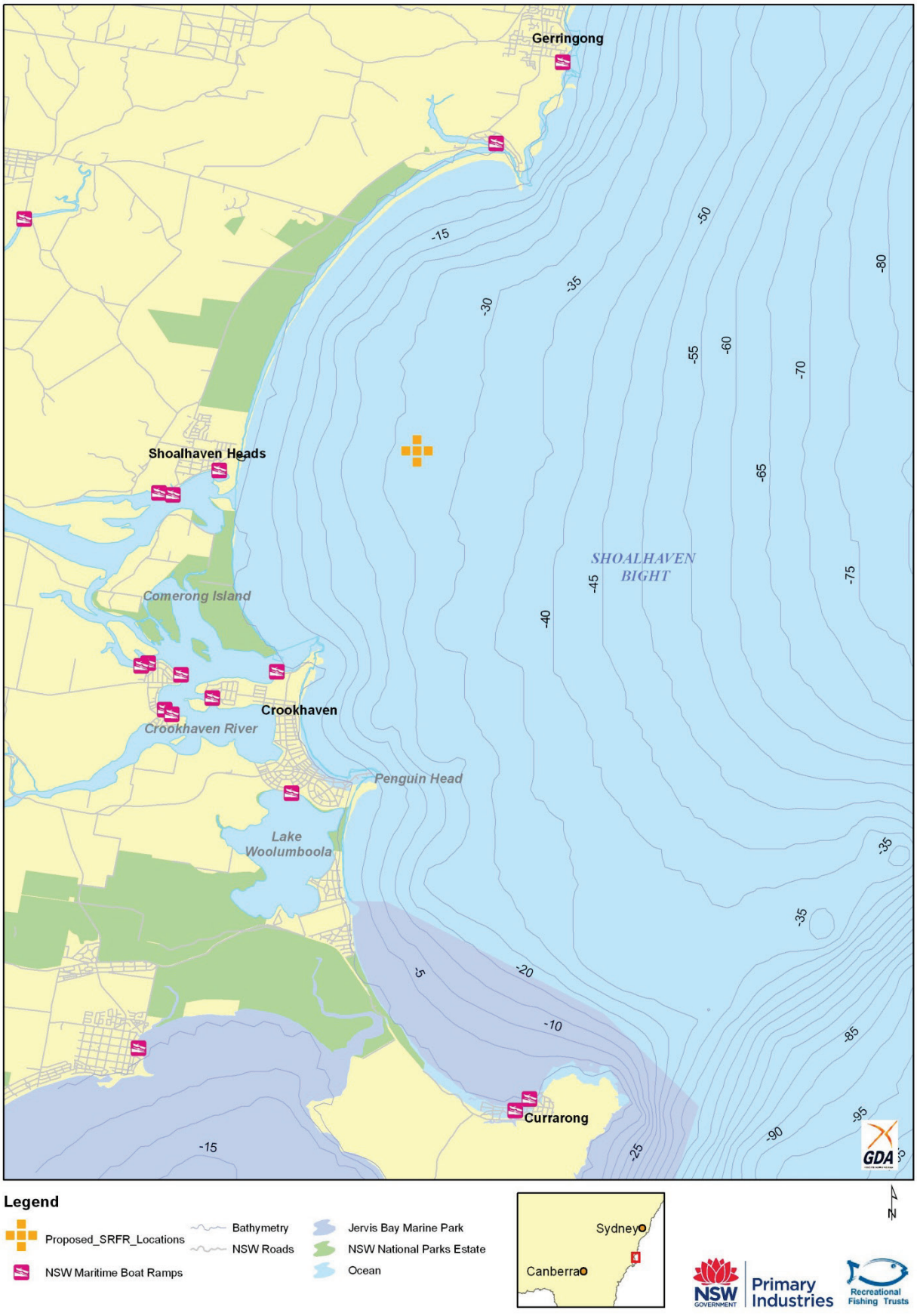

Figure 14. Boat ramps in the study region

5.2.7.2 Navigation

The proposed offshore artificial reef location may impinge on recreational and commercial vessel operations. The potential impacts of the proposed fishing reef on navigation and vessels are listed below.

5.2.7.3 Clearance

There is a potential risk that vessels transiting over the offshore artificial reefs may be damaged or damage the reef structures if their hull or propeller comes into contact with the structures. However, this would be easily mitigated by ensuring sufficient clearance at all tides and in high wave conditions. A minimum of 20 m clearance from the uppermost part of the offshore artificial reef at Lowest Astronomical Tide (LAT) is ensured for the proposed Shoalhaven offshore artificial reef.

Anchoring in the vicinity of the reefs would be strongly advised against. Target user groups would be informed about general boating rules in the vicinity of the reefs and recommended against anchoring in the area.

The potential impact of a vessel striking the reef 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.

Table 7. Risks and mitigation associated with clearance

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Navigation and Safety	Local	Clearance	D2	Sufficient clearance between the upper part of the reef and transiting vessels in severe weather conditions and under Lowest Astronomical Tide (LAT) would be ensured.	Reduce Likelihood	D2

5.2.7.4 Increased vessel traffic

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

A code of conduct and guidelines would be published to promote awareness of boating safety within the reef area and minimise navigational hazards such as anchor fouling and collisions. Recreational fishing vessels should give way to movement of commercial vessels and all other normal RMS boating rules and regulations apply.

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

Table 8. Risks and mitigation associated with increased vessel traffic

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Navigation and Safety	Large	Increased vessel traffic	B4	Accept, user groups are informed of NSW recreational boating rules and regulations. Guidelines and a code of conduct would stipulate that recreational boat users give way to commercial vessels in the area. Mechanisms would be put in place for reporting of incidents.	None	B4
Recreational and Commercial Fishing	Local	Collision from crowding	C4	Observe boating regulations.	None	C4

5.2.7.5 Exploitation of cultural, historic or scientific interest

Conflict with areas of spiritual significance/dreamings

The current coastline was formed when the sea level stabilised approximately 7000 years ago, inundating the project area and any archaeological record of human occupation that may have been present there [19]. The seafloor within the project area is currently approximately 30 m underwater, and is understood to be functionally flat, sandy, with no significant vegetation or other ecological considerations. Given the depth and distance from shore, it is considered that:

- there is negligible potential for the presence of in situ Aboriginal objects within the project area; and
- there is a low possibility of Aboriginal objects being transported to the project area by natural or assisted means. Due to the submerged nature and relatively small footprint of each of the reef units, it is not likely that spiritual significance or Dreamtime stories will be affected during the implementation or operation of the reefs.

The results of cultural heritage investigations and consultations with relevant stakeholders in accordance with the Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW (due diligence code, DECCW 2010), which considered any potential impact the proposal may have on Aboriginal cultural values and activities (such as fishing) in the area (Technical Report B), resulted in the following recommendations. These were made with reference to the requirements of the NPW Act, the NPW Regulation, the due diligence code and consultation with relevant Aboriginal stakeholders:

- The DPI should ensure that all parties involved in the project are aware that it is an offence under Section 86 of the NPW Act to harm or desecrate an Aboriginal object unless that harm or desecration is the subject of an Aboriginal Heritage Impact Permit;
- The project may proceed without any further cultural heritage investigations provided that the impacts and extent of the project are consistent with those discussed in this report; and
- The DPI should inform local Aboriginal groups identified through this assessment process on the completion of the Project.

Additionally, due diligence recommendations usually entail contingency measures to follow in the event that an Aboriginal object (or objects) is uncovered during the project, particularly with regard to potential burial sites, or potential human skeletal material. However, given the negligible potential for Aboriginal objects to be located within the project area or impacted by the project, further detail in this regard is considered unnecessary. If, in the highly unlikely event, an Aboriginal object (or objects) is uncovered during the project, it is recommended that the

proponent contact Jerrinja LALC, a suitably qualified archaeologist, or OEH on 1300 361 967 for further advice.

Table 9. Risks and mitigation associated with conflict with areas of spiritual significance/dreamings

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Heritage	Intermediate	Conflict with areas of spiritual significance/dreaming's	C4	Consultation with relevant stakeholders.	None	C4

Historic shipwrecks

A desktop review of shipwrecks known or potentially occurring in the direct study areas was carried out in April 2013 (Technical Report A). Information was sourced from the NSW Historic Shipwrecks Database ([20]), the Shipwreck Atlas of NSW ([21]), Auschart 808, the Australian Hydrographic Service ([22]), unpublished data ([23]) and the Offshore Artificial Reefs, Location Selection and Constraints Mapping report ([24]) (Table 10).

A significant amount of information has been compiled on the location of shipwrecks that are known or likely to occur within the direct and wider Shoalhaven areas. However, few of the sites have accurate positions. Additionally, positions of a number of wrecks marked on recently published maritime charts may be inaccurate as it is not known how their positions were originally recorded, e.g. by 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 area. It is possible, given the large number of vessels known to have gone missing in the Shoalhaven region, that unidentified wrecks or debris could occur on the seabed throughout the Shoalhaven area. SWATH habitat mapping carried out by OEH (Technical Report D) provided full coverage information on the nature of the seabed in the proposed reef deployment area and did not identify any obstructions or anomalies requiring further investigation for potential historic or cultural significance. 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.

Table 10. Submerged shipwrecks known to occur within the wider study regions

Name	Date wrecked	Location	Depth (AHD)	Description	Latitude	Longitude
Chippewa	1868	Gerringong, drifted onto Seven Mile Beach	Approx. 0–5 m	Sailing vessel	Unknown	Unknown
Karoola	1974	Approx. 35 km offshore Shoalhaven Heads	> 100 m	Submerged power vessel	-34.49	151.29
Koraaga	1931	Gerringong, Black Head, 5 miles east	Unknown	Single screw steamer	Unknown	Unknown
Margaret	1867	Gerringong near Black Head	Unknown	Sailing vessel	Unknown	Unknown
Merimbula	1928	On the rocks, northern shore of Beecroft Head	Approx. 0–5 m	Submerged power vessel (twin screw steamer)	-35.00444	150.8283
Plutus	1882	Crookhaven Bight	Approx. 0–5 m	Submerged power vessel (twin screw steamer)	-35.01	150.8083

Name	Date wrecked	Location	Depth (AHD)	Description	Latitude	Longitude
Samson	1974	Approx. 35 km offshore Shoalhaven Heads	> 100 m	Submerged power vessel	-34.53	151.21
Solon	1860	Ran aground off Crookhaven Head	Unknown	Sailing vessel	Unknown	Unknown
Spec	1697	1.5 miles off Black Head near Gerringong	Unknown	Sailing vessel	Unknown	Unknown
Unique	1934	Approx. 9 km offshore Shoalhaven Heads	Approx. 40 m	Submerged power vessel	-34.8961	150.8721

5.2.7.6 Fishing

Loss of commercial fishing ground

Commercial fisheries likely to be affected by the proposal include the Ocean Trawl and the Ocean Trap and Line fisheries. The fishing reef units at the initially proposed location and configuration would result in the maximum loss of approximately 270 m^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. This is based on consultation with local commercial fishers. Loss of fishing area within the proposed study region is not considered to be a significant issue.

Table 11. Risks and mitigation associated with loss of commercial fishing grounds

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	Local	Loss of commercial fishing ground	A4	Accept risk, based on outcomes of consultation.	None	A4

Conflict between other user groups

Recreational fishing involves a variety of user groups, including sportfishers, gamefishers, spearfishers and charter boat fishing. The proposed offshore artificial reefs are aimed at all recreational fishers. However, some limited commercial fishing may take place. Some overlap between user groups is therefore likely and the potential for conflict would be addressed through suitable management, including a code of practice for all users which is provided as part of the user guidelines for offshore artificial reefs.

In order to minimise potential conflict between user groups, consultation between sectors would be undertaken to resolve any issues of conflict (or similar).

Table 12. Risks and mitigation associated with conflict between user groups

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	Local	Conflict between other user groups	C4	Education/management.	Reduce Consequence	C5

Risk offshore artificial reef does not achieve goals

The overall effectiveness and success of the reefs can be assessed only by monitoring of user satisfaction, structural integrity and impacts of the reef 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.

Table 13. Risks and mitigation associated with the offshore artificial reef not achieving its goals

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	N/A	Risk offshore artificial reef does not achieve goals	C4	Planning, set defined goals, adaptive management.	Reduce Likelihood	D4

Gear hook-up

Potential safety issues which could occur as a result of recreational or commercial fishing in the direct study area include, but are not limited, to gear hook-up and collision. 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. Vessels may foul their anchors on the offshore artificial reef. This may cause loss of the anchor and anchor line, and possible damage to the reef. In some circumstances, the loss of an anchor may cause consequential impacts on safety such as a disabled vessel drifting towards the coast.

On the Sydney Offshore Artificial Reef commercial divers were contracted by DPI to remove all fouled fishing and boating related gear in October 2013, two years post deployment. Approximately 77.4 m of rope between 5–12 mm in diameter was removed from the reef (assumed to be anchor rope). In addition, approximately 15 m of fishing line was removed and a variety of fishing tackle including lure, sinkers, swivels and hooks (DPI – per comms).

Commercial trawling would not be excluded in the direct vicinity of the offshore artificial reef. However all fishers will be provided with a chart describing the exact location of each of the reef modules, including GPS coordinates. There is a potential risk of gear hook-up on the reef units, which could result in damage to the reef, fishing vessel and safety implications for the vessel. The Australian Hydrographic Office will be notified of the final offshore artificial reef locations, so that a 'Notice to Mariners' can be issued, and the official hydrographic charts can be amended. NSW Maritime will also be notified of the final reef location such that relevant publications and maps are amended to show the location of the offshore artificial reef.

Provided commercial fishing businesses which operate in the region are made aware of the fishing reef location, follow a code of conduct and that structures are marked on the relevant Aus Chart, this potential risk is considered to be low. A dedicated fouled-gear removal strategy will be implemented in the LTMP to address lost gear due to hook-up.

Table 14. Risks and mitigation associated with gear hook-up

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Commercial Fishing	Local	Gear hook-up (commercial)	D3	Dedicated gear removal strategy/education/monitor /hydrographic charts.	None	D3
Recreational Fishing	Local	Gear hook-up (recreational)	A4	Dedicated gear removal strategy/education/monitor /hydrographic charts.	None	A4

Impacts on commercial fish stocks

It is considered highly unlikely that the proposed offshore artificial reef would contribute to a reduction in commercially fished populations in the wider area. It is possible that species most vulnerable to fishing mortality could be affected within the direct reef deployment area, but this is unlikely to have impacts at a population level.

Table 15. Risks and mitigation associated with impacts on commercial fish stocks

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	Regional	Impacts on commercial fish stocks	D5	Accept/monitoring/education/existing fisheries regulations/adaptive management.	Reduce Consequence	D5

Injury or drowning (spearfishing)

It is anticipated that freedivers and spearfishers would utilise the reefs. The majority of spearfishers would benefit from accessing pelagic species aggregating above the units in the top 15–20 m. There is however, a risk that spearfishers/freedivers would attempt to dive to depths beyond their limits.

Scuba diving in the vicinity of the offshore artificial reef 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 including, but not limited to, the risk of gear fouling and risks to spearfishers cannot be mitigated but can be managed through education. The User Guidelines would aim to provide the best possible information to inform different user groups on best practice and safety within the reef area.

Table 16. Risks and mitigation associated with injury or drowning (spearfishing)

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	Local	Injury or drowning (spearfishing)	D1	Accept, education and awareness strategies.	None	D1

5.2.7.7 Endangered, rare or migratory species

Threatened and protected species, populations and endangered ecological communities

Threatened and protected species, populations and endangered ecological communities listed under relevant schedules of the Commonwealth EPBC Act, New South Wales TSC Act and the FM Act were identified using the EPBC Environmental Reporting Tool ([25]), the Bionet Database ([26]) and the Atlas of Living Australia, as well as literature relevant to the Shoalhaven area. Searches for species of aquatic invertebrates, fish, marine mammals and marine reptiles likely to occur in the Shoalhaven and Illawarra LGAs were carried out in April 2013 by Cardno Pty Ltd (Technical report A). A list of all threatened and protected species, populations and endangered ecological communities that have previously been recorded within the search areas are provided (Table 17). It is important to note that data in the searches comes from a number of different sources, may contain errors and omissions and should therefore be treated as indicative only.

Results of the database searches indicate that there are 9 species of fish, 20 species of syngnathids (including seahorses, pipefish and ghost pipefish), 24 species of marine mammal (including whales, dolphins and seals) and 6 species of marine reptiles (including turtles and

seasnakes). In the search area 3 seabirds were listed as 'endangered', 11 species as 'protected', and 15 species listed as 'vulnerable'.

Searches for seabirds likely to forage offshore and in the proposed reef deployment area were also carried out. Intertidal and wading birds, such as sandpipers, curlews and plovers, 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 study region included albatrosses, petrels, shearwaters, terns, skuas, gulls and gannets.

Table 17. Threatened and protected species in the Shoalhaven area

Scientific Name	Common Name	Status under TSC/FM Act	Status under EPBC Act
1. Fish			
Anampses elegans	Elegant wrasse	P	
Carcharias taurus (East Coast)	Grey nurse shark	CE	CE
Carcharodon carcharias	Great white shark	V	V, M
Epinephelus daemelii	Black cod	V	V
Thunnus maccoyii	Southern bluefin tuna	E	CD
Pristis zijsron	Green sawfish	PE	V
Lamna nasus	Mackerel shark		M
Paraplesiops bleekeri	Bleekers devil fish	P	
Rhincodon typus	Whale shark		M,V
Acentronura tentaculata	Hairy pygmy pipehorse	P	L
Heraldia nocturna	Upside-down pipefish	P	L
Hippocampus abdominalis	Eastern potbelly seahorse	P	L
Hippocampus breviceps	Short-head seahorse	P	L
Hippocampus whitei	White's seahorse	P	L
Histiogamphelus briggsii	Briggs' crested pipefish	P	L
Kimblaeus bassensis	Trawl pipefish	P	L
Lissocampus runa	Javelin pipefish	P	L
Maroubra perserrata	Sawtooth pipefish	P	L
Notiocampus ruber	Red pipefish	P	L
Phyllopteryx taeniolatus	Weedy seadragon	P	L
Solegnathus spinosissimus	Spiny pipehorse	P	L
Solenostomus cyanopterus	Blue-finned ghost pipefish	P	L
Solenostomus paegnius	Robust ghost pipefish	P	L
Stigmatopora argus	Spotted pipefish	P	L
Stigmatopora nigra	Wide-bodied pipefish	P	L
Syngnathoides biaculeatus	Double-ended pipehorse	P	L

Scientific Name	Common Name	Status under TSC/FM Act	Status under EPBC Act
Urocampus carinirostris	Hairy pipefish	P	L
Vanacampus margaritifer	Mother-of-pearl pipefish	P	L
Vanacampus phillipi	Port Phillip pipefish	P	L
2. Marine Mammals			
Arctocephalus forsteri	New Zealand furseal	V,P	L
Arctocephalus pusillus doriferus	Australian furseal	V	L
Arctocephalus tropicalis	Sub-Antarctic fur seal	P	V
Balaenoptera acutorostrata	Dwarf minke whale	P	Cet
Balaenoptera edeni	Bryde's whale	P	Cet, M
Balaenoptera musculus	Blue whale	E,P	Cet, E, 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	E,P	Cet, E, M
Globicephala macrorhyncus	Long-finned pilot whale	P	Cet
Globicephala melas	Short-finned pilot whale	P	Cet
Grampus griseus	Risso's dolphin	P	Cet
Hydrurga leptonyx	Leopard seal	P	L
Hyperoodon planifrons	Southern bottlenose whale	P	Cet
Kogia breviceps	Pygmy sperm whale	P	Cet
Lagenorrhycus obscurus	Dusky dolphin	P	Cet, M
Lissodelphis peronii	Southern right whale dolphin	P	Cet
Megaptera novaeangliae	Humpback whale	V,P	Cet, V, M
Mesoplodon grayi	Gray's beaked whale	P	Cet
Mesoplodon layardii	Strap-toothed beaked whale	P	Cet
Orcinus orca	Killer whale		Cet, M
Physeter macrocephalus	Sperm whale	V,P	Cet, M
Tursiops aduncus	Long-beaked bottlenose dolphin	P	Cet, M
Tursiops truncatus	Bottlenose dolphin	P	Cet
3. Marine Reptiles			
Caretta caretta	Loggerhead turtle	E	E,M
Chelonia mydas	Green turtle	V	V,M
Eretmochelys imbricata	Hawksbill turtle	P	V,M

Scientific Name	Common Name	Status under TSC/FM Act	Status under EPBC Act
Dermochelys coriacea	Leatherback turtle	V	E,M
Natator depressus	Flatback turtle	P	V,M
Pelamis platurus	Yellow-bellied seasnake	P	L
4. Marine Birds			
Ardenna carneipes	Flesh-footed shearwater	V	M
Ardenna pacificus	Wedge-tailed shearwater	P	M
Ardenna tenuirostris	Short-tailed shearwater	P	M
Chroicocephalus novaehollandiae	Silver gull	P	
Diomedea antipodensis	Antipodean albatross	V	V, M
Diomedea exulans	Wandering albatross	E	V, M
Diomedea exulans amsterdamensis	Amsterdam albatross		E, M
Diomedea exulans exulans	Tristan albatross		E, M
Diomedea gibsoni	Gibson's albatross	V	V, M
Eudyptula minor	Little penguin	P	
Fregetta grallaria	White-bellied Storm-Petrel	V	V
Gygis alba	White tern	V	
Larus dominicanus	Kelp gull	P	
Macronectes giganteus	Southern giant petrel	E	E, M
Macronectes halli	Northern giant petrel	V	M
Microcarbo melanoleucos	Little pied cormorant	P	
Morus serrator	Australasian gannet	P	
Onychoprion fuscata	Sooty tern	V, P	
Pelecanus conspicillatus	Australian pelican	P	
Phalacrocorax carbo	Great cormorant	P	
Phalacrocorax sulcirostris	Little black cormorant	P	
Phoebetria fusca	Sooty albatross	V, P	V, M
Pterodroma leucoptera leucoptera	Gould's petrel	V, P	M
Pterodroma neglecta neglecta	Kermadec petrel (west Pacific subspecies)	V, P	V
Pterodroma nigripennis	Black-winged petrel	V, P	
Pterodroma solandri	Providence petrel	V, P	M
Puffinus assimilis	Little shearwater	V, P	
Puffinus leucomelas	Streaked shearwater		M
Sternula albifrons	Little tern	E, P	M

Scientific Name	Common Name	Status under TSC/FM Act	Status under EPBC Act
Sternula nereis nereis	Fairy tern (Australian)		V
Sula dactylatra	Masked booby	V	
Thalassarche cauta	Shy albatross	V	V
Thalasseus bergii	Crested tern	P	
Thalassarche bulleri	Buller's albatross		V, M
Thalassarche impavida	Campbell albatross		V, M
Thalassarche melanophris	Black-browed albatross	V	V, M
Thalassarche salvini	Salvin's albatross		V, M
Thalassarche steadi	White-capped albatross		V, M

PE = presumed extinct, CE = critically endangered, E = endangered, V = vulnerable, CD= conservation dependent, M = migratory, L = listed, Cet = cetacean and P = protected (FM Act/NP&W Act). Note: All native birds, reptiles, amphibians and mammals in NSW are protected by the *NSW National Parks and Wildlife Act* (NP&W Act).

New South Wales and Commonwealth registers of critical habitats were also searched and none were identified within the study area.

Only threatened species (from the initial search) that were known or considered likely to occur in the wider Shoalhaven area (based on general species distribution databases) and/or known to utilise habitat in the area, were considered for further Assessment of Significance. These species were assessed according to OEH and DPI threatened species assessment guidelines ([27, 28]). 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.

Assessments of significance (State)

Individual species assessments are given in Appendix 6. Overall, 5 species of fish, 3 species of marine turtle, 4 species of cetacean and 2 pinnipeds were assessed according to OEH and DPI threatened species assessment guidelines ([27, 28]).

Fish

The proposal was not considered to have a significant impact on any of the species identified in Table 17, hence Species Impact Statements (SIS) were not required.

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 reef long enough to be vulnerable to the potential impacts identified.

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

The grey nurse shark is known to aggregate at discreet locations within the wider area. 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 reef area. 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 ([29]). 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 reef 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 reef area are properly managed and monitored, potential risks would be minimised or addressed before they become problematic.

Marine Turtles

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

Cetaceans

The proposal was not considered to have a significant impact on any species of cetacean, such that a Species Impact Statement (SIS) would be required. 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

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

Seabirds

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.

Matters of national environmental significance (Commonwealth legislation)

Listed Threatened and Protected Species

The Department of the Environment EPBC Act database ([30]) and the NSW government 'BioNet' database ([31]) were searched for listed threatened and migratory species, populations and communities listed in relevant Schedules of the EPBC Act that are likely or predicted to occur in the Shoalhaven region. Note that threatened species assessed under the EPBC Act include only those listed as 'extinct in the wild', 'critically endangered', 'endangered', 'vulnerable' or 'migratory'.

Note that a species may be classed as both a 'cetacean' and a 'migratory species' in addition to its protected status, e.g, the southern right whale (*Eubalaena australis*) which is listed as 'endangered', but is also protected as a 'migratory cetacean' is only assessed once in Appendix 7.

Searches were carried out for seabirds likely to forage offshore and in the direct area of the proposed reef. Intertidal and wading birds such as sandpipers, curlews and plovers 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 study region were albatrosses, petrels, shearwaters, terns, skuas, gulls and gannets. In the Shoalhaven area, 3 species were listed as 'endangered', 4 listed as 'vulnerable', 8 as 'migratory' and 9 as 'vulnerable' and 'migratory' (Table 17) under the EPBC Act.

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

were considered for further impact assessment. Impact assessments are contained within 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 3–200 nautical miles from the coast.

The proposed Shoalhaven offshore artificial reef is proposed to be located within State waters approximately 1.6 km (0.86 nm) west of the 3 nm limit.

Key threatening processes

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

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

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 ([32]). 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 such as:

- 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; and
- 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 ([33]).

A number of threatened marine species (including marine turtles, seals and cetaceans) and a number of marine birds have been found to have ingested or become entangled in 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 ([33]). Department of the Enviornment has developed a draft Threat Abatement Plan to address the impacts of this KTP ([34]).

5.2.7.8 Sensitive habitats

For the purpose of this assessment, areas of conservation significance include areas declared as critical habitats under the NSW FM and TSC Acts and Marine Protected Areas (which include Marine Parks, Aquatic Reserves and Nature Reserves). Distances of areas of conservation significance in relation to the proposed offshore artificial reefs, are listed in Table 18.

Table 18. Distances of proposed offshore artificial reef to areas of conservation significance

Area of conservation significance	Designation	Distance to the proposed reef (km)
Jervis Bay	Marine Park	12.71
Comerong Island Nature Reserve	Nature Reserve	4.55
Saltwater Swamp Nature Reserve	Nature Reserve	14.25
Brundee Swamp Nature Reserve	Nature Reserve	14.08
Worrigee Nature Reserve	Nature Reserve	16.22

Within the wider Shoalhaven region, one nature reserve and one marine park are considered relevant to the proposal. The Comerong Island Nature Reserve is located approximately 8.5 km west of the proposed reef site and encompasses part of the Shoalhaven Estuary, which is an internationally recognised habitat for a range of shorebirds and waders ([37]). The Reserve comprises a collection of islands in the Shoalhaven delta as well as the beds of Comerong Bay, Comerong Lagoon and the channels between the islands. It is one of the most important NSW havens for migratory wading birds. The reserve is a significant habitat for a number of threatened species including hooded plovers, sooty oyster-catchers, broad-billed sandpipers, blue-billed ducks, black-tailed godwits and black bitterns. The Shoalhaven estuary is of international or national significance for Pacific golden plovers, double-banded plovers, eastern curlews, whimbrels, pied godwits, greenshanks and red-necked stints.

Jervis Bay Marine Park is approximately 180 km south of Sydney and 20 km southeast of Nowra in the Batemans marine bioregion. It spans over 100 km of coastline and adjacent ocean extending from Kinghorn Point in the north, to Sussex Inlet in the south, and includes most of Jervis Bay. Some of the most extensive seagrass beds in NSW are found in Jervis Bay. Several threatened shorebirds use habitat within the marine park for foraging, roosting or nesting, including sooty and pied oyster-catchers and the hooded plover. In all, over 120 species of resident and migratory birds including shorebirds, waders, waterfowl, birds of prey occur in the region.

Marine mammals are a common sight in the marine park. Humpback and southern right whales attract many spectators during their seasonal migrations and often enter the bay with young calves to rest. The northern-most colony of Australian and New Zealand fur seals can be found at Drum and Drumsticks and bottlenose and common dolphins are also regularly observed throughout the marine park ([35]).

Figure 15. Location of areas of conservation significance in relation to the proposed Shoalhaven offshore artificial reef

5.2.8 Ocean currents, tides and prevailing weather conditions

The existing environment in relation to coastal processes is described in detail in technical report C and includes the local wind and wave climate, prevailing currents, water levels and processes that affect sediment transport. Impacts relating to coastal processes are listed and discussed below.

Nearshore wave climate

In order to investigate the wave climate at the site and assess the potential impacts of the proposed reef on the nearshore wave conditions, a wave model was established using the industry standard Simulating Waves Nearshore (SWAN) wave model software.

Conservative assumptions regarding the reef element dimensions and drag coefficients were adopted in order to derive an upper-bound estimate of the impacts.

The SWAN wave model was used to provide estimates of the design wave parameters, e.g. wave height, period, direction and wave-related orbital velocities, at the artificial reef site. Incoming swell boundary conditions for the regional wave model were obtained from the NOAA global WaveWatch III model (http://polar.ncep.noaa.gov/waves/download.shtml). Wind boundary conditions were derived from the NOAA NCEP, Climate Forecast System Reanalysis (CFSR) ([38]).

A nested high resolution SWAN model also simulated the transformation of waves into the coastal zone of Shoalhaven Bight. The local model results were used to predict the impact of the reefs on nearshore wave conditions. A 20 m grid resolution was used for the detailed SWAN model, which is larger than an individual reef element but is of similar aerial dimension to a ‘cluster’ of reef elements. Additional wave energy dissipation mechanisms, due to the wave orbital motion drag on the reef elements, was simulated using a combination of enhanced bottom friction and ‘vegetation’ energy losses.

Modelling the reef blocks in the high resolution wave model was undertaken using the energy loss due to vegetation module in SWAN (version 40.91). The wave energy damping due to the blocks in ~28 m of water depth will be governed by the pressure differential rather than by the drag due to friction.

Using the above approach, the modelled wave field impacts would be due to slightly changed refraction behaviour (due to the locally raised bathymetry) as well as the simulated wave energy damping due to the reef elements.

A typical wave event (1.6 m, 8 sec south-easterly swell condition) was used to force the regional 400 m SWAN model within which the local SWAN model was nested and the model results (base case, developed case and impacts). Despite the conservative assumptions, the impact of the proposed reef deployment is predicted to be negligibly small given the proposed cluster density and depth of ~28 m.

A relatively large wave event (3 m, 12 sec south easterly swell condition) was used to force the regional 400 m SWAN model within which the local SWAN model was nested and the model results (base case, developed case and impacts) (Figure 16). The impact of the proposed reef deployment is also negligible for the larger and longer period wave condition.

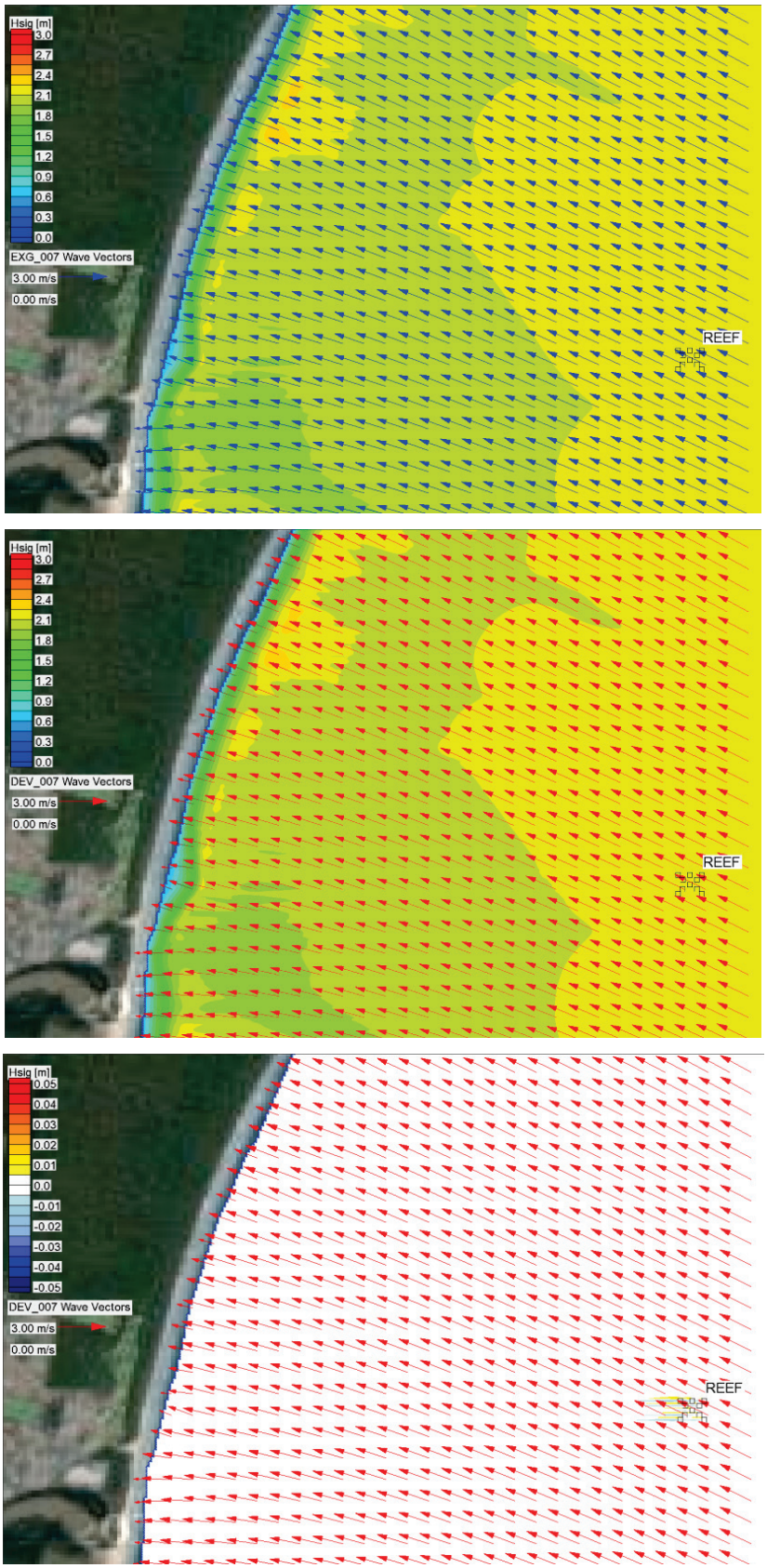

Figure 16. Impacts of reef structures on wave field for a 3 m, 12s, SE wave condition. Base case (top); developed case (middle); impacts (bottom)

Water flow (current) investigations

In order to define an ambient current climate at the site, the regional hydrodynamic model was used to simulate 12 months of 3D hydrodynamics corresponding to the 2012 calendar year. In order to understand the prevailing and extreme currents that may occur at the site, a 3D hydrodynamic model was established using the TUFLOW-FV software ([39]). The hydrodynamic model was configured with forcing from tides and atmospheric wind, as well as ocean current forcing. The model extends approximately from Ulladulla in the south to Port Kembla in the north and around 45 km offshore. The model resolution ranges from approximately 2.7 km in the vicinity of the offshore boundary to approximately 200 m within the Shoalhaven Bight study area. The TUFLOW-FV hydrodynamic model vertical discretisation was based upon a hybrid z-coordinate scheme with ≤2 m thick layers down to a depth of 35 m. In addition, 5 selected storm events were simulated to provide additional insight into currents during extreme wind and wave events.

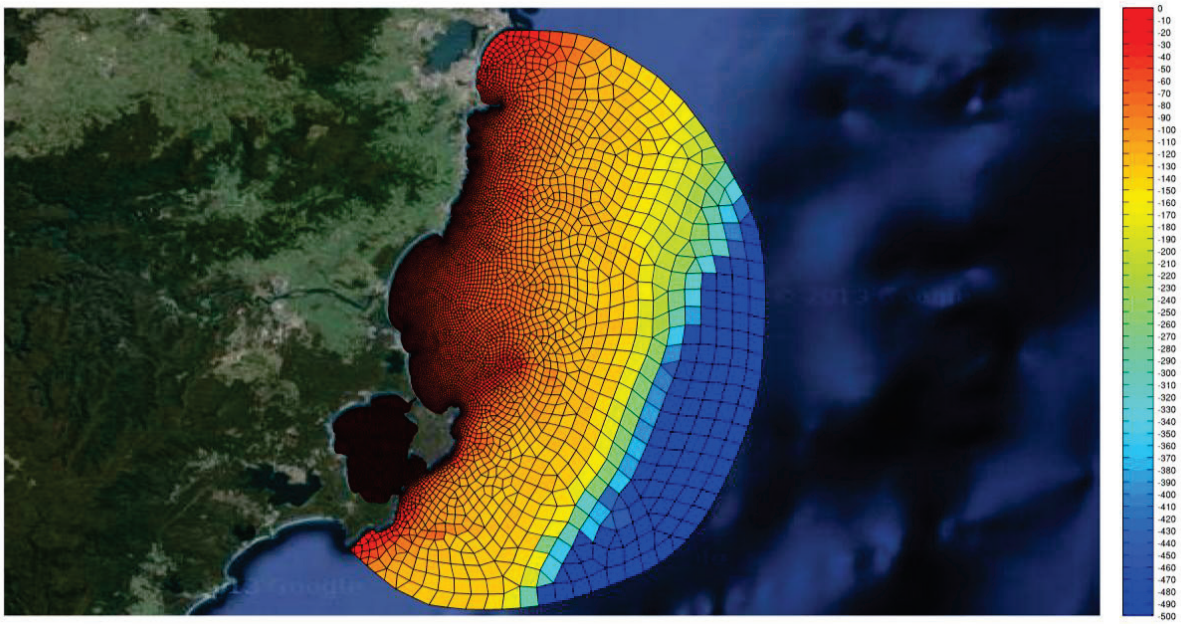

Figure 17. Regional TUFLOW-FV hydrodynamic model

A nested high resolution TUFLOW-FV model was developed in order to undertake detailed assessments of the reef structure impacts. A nested 2.7 km diameter circular domain was developed for this purpose. A central high resolution region with mesh cell dimensions of 2.5 x 2.5 m was used in order to represent the reef clusters in the model geometry. Individual reef modules were represented as 5 m cubic impermeable. The overall footprint of the reef clusters covered an area in the model of approximately 200 x 200 m. Modelled 3D current fields from the regional-scale model were extracted as boundary conditions for steady-state high resolution simulations.

A 12 month simulation of hydrodynamics was performed for calendar year 2012. The modelled surface and near-bed current speed and direction time series at the proposed reef deployment location displayed current behaviour and the dominance of the residual ocean currents over the semi-diurnal tidal current signal. The near-bed current speeds are typically approximately 50% of the surface current speeds and there often appears to be significant vertical variation in the current directions, particularly during periods of relatively weak forcing.

Peak surface current speeds of approximately 0.6 m/s (and bottom currents of approximately 0.3 m/s) were predicted during a period of strong EAC forcing in late September 2012. A snapshot of the surface currents during this ‘event’ is shown (Figure 18).

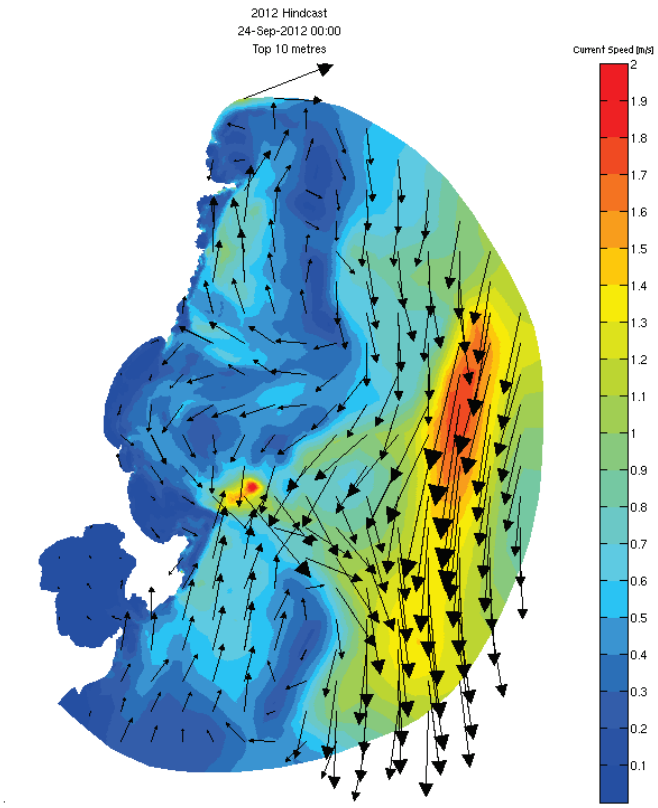

Figure 18. Regional scale surface currents during a strong EAC 'event'

Six storm events were simulated using the Regional 3D Hydrodynamic model (Table 19). In contrast to the local wave heights, the predicted peak current speeds do not generally correlate with the event ranking (based on offshore wave height). This is likely due to the combination of conditions that force currents; including tide, wind and, importantly, the ocean currents (EAC). In some instances, these combined forcing conditions may act to reinforce each other, while in other cases they may act to cancel one another. The peak current speeds for the selected storm events do not substantially exceed the maximum current speeds predicted during the strong EAC event in late September 2012 (Figure 18), reinforcing the importance of this mechanism in driving currents in this depth of water (~28 m).

Table 19. Predicted Storm event peak current speeds

Event	Peak Surface Current Speed (m/s)	Peak Near-bed Current Speed (m/s)
11/05/1997	0.32	0.14
06/06/2012*	0.61	0.28
28/07/2001	0.38	0.17
26/09/1995	0.63	0.30
26/02/2004	0.40	0.19
04/03/1995	0.22	0.12

Near-field impacts on current flow

Near-field hydrodynamic modelling was performed to quantify the impacts of the proposed reef structures on the current fields. The reef structures were conservatively modelled as solid 5 m x 5 m 'blocks' represented in the model bathymetry.

The impact assessment was undertaken for a steady-state condition corresponding to the EAC current event in late September 2012 (Figure 18) as these were the strongest currents simulated at the deployment site during both the 2012 and additional storm simulations.

The developed case results show a region of reduced current speeds in the immediate vicinity of the reef structures (Figure 19). The difference between the developed case and existing case near-bed current fields shows the region of slightly reduced near-bed current speeds in the vicinity of the structures and immediately 'down-drift' (Figure 19). Very slightly increased near-bed current speeds are predicted either side of the reef clusters. Note that the magnitude scale of the current impacts plot is very small and that these results support a conclusion that the proposed reef deployment will have a negligible effect on currents, except in their immediate vicinity, within a proximity of up to 10 m. Fine scale effects due to flow around individual structure elements is considered further as part of the local scour assessment.

Regional impacts of scouring and deposition

Morphological investigations were undertaken in order to analyse the potential impacts of the proposed scheme on sediment transport and morphological processes, at both regional and local scale. The regional scale assessment considered the potential impact of the structures on surrounding morphological evolution and, in particular, sediment transport processes that control the evolution of the shoreline between Shoalhaven Heads and Gerroa.

The local scour assessment considered the potential for the proposed structures to generate scour of the seabed in the immediate vicinity of the structure. This investigation was based upon the previously derived current and wave climates. Sediment transport potentials and scour impacts were analysed for the following range of conditions:

- Typical (median) conditions; and;
- Conditions expected to be exceeded once a year.

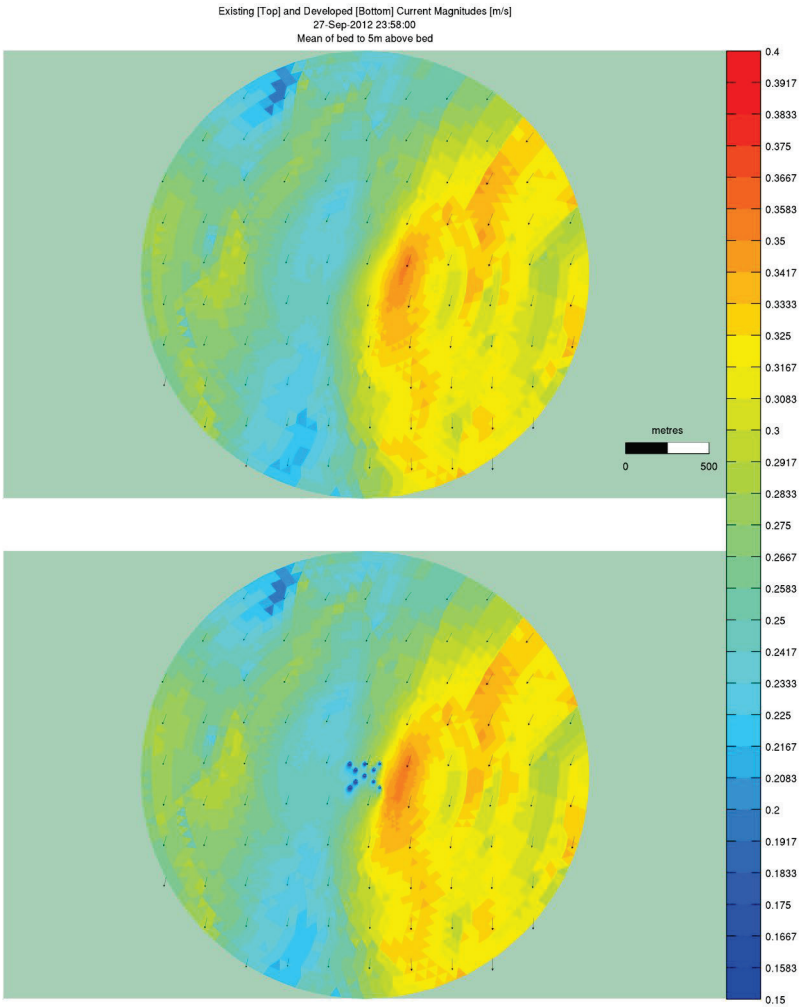

Figure 19. Base case (top) and developed case near-bed current fields

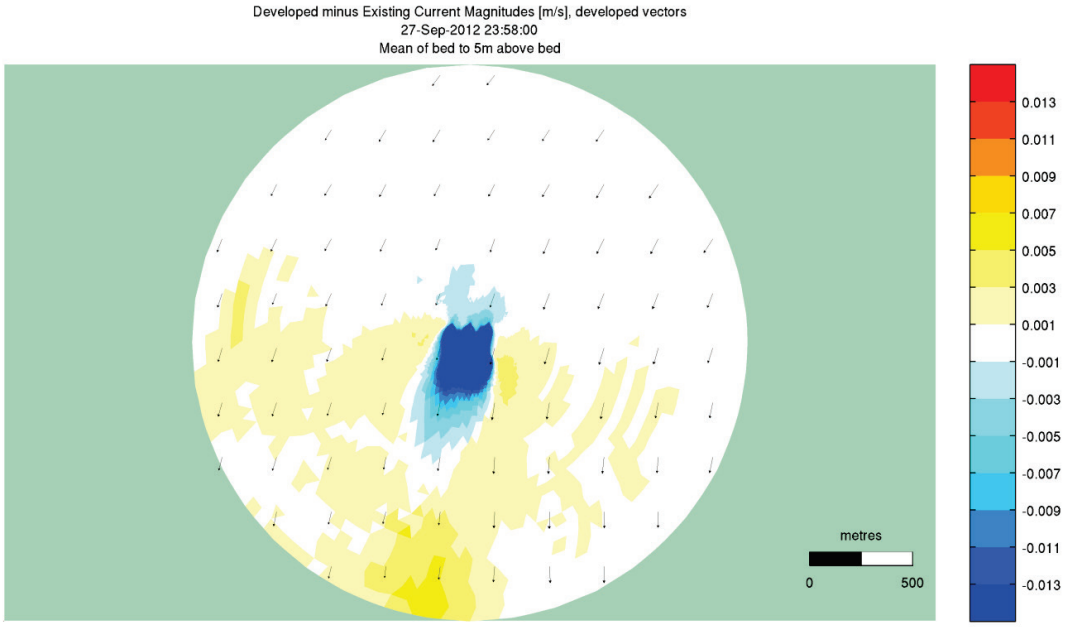

Figure 20. Impacts of reef structures on near-Bed current field

Morphological processes are driven by local current and wave conditions, and therefore the assessment of morphological impacts on a regional scale is based upon the wave and

hydrodynamic modelling impact assessments. These assessments determined that the proposed reef deployment will have negligible impacts on currents and wave fields (heights and directions) except in the immediate vicinity of the structures (within approximately 10–100 m). Based upon the results of these modelling assessments it can be concluded that there would be no significant regional scale morphological impacts due to the proposal.

In particular, the littoral zone sediment transport processes that drive the continuous evolution of shoreline position, are in turn primarily driven by the nearshore wave conditions. Figure 20 demonstrates the negligible impact of the reef structures on the nearshore wave conditions, from which it can be concluded that there will be no material impact from the proposed development on the adjacent shoreline between Shoalhaven Heads and Gerroa.

Local impacts of scour and deposition

When a structure is placed in a marine environment, the presence of the structure will change the flow pattern (associated with currents and passing waves) in its neighbourhood. This can result in local increases in the current speed, the formation of vortices and generation of turbulence as the flow is partially diverted around the structural elements (Figure 19 & Figure 20). These local changes in the flow pattern can increase the bed shear stress and, consequently, increase the sediment transport capacity.

To assess the potential for scour around the proposed reef modules, the wave and current-induced bed shear stresses were modelled during a 12-month period and the potential for sediment transport assessed for the situation without structures, i.e. undisturbed bed.

Bed shear stresses along the undisturbed bed are dominated by wave-induced flows. Analysis of the bed shear stresses suggest that such stresses at the site (without presence of reef structures) are frequently (>28%) strong enough to initiate sediment transport.

Owing to these frequent active-bed conditions, it is likely that local scour will be experienced around the base of the proposed reef structures. Where local scour occurs, the spatial extent of the scour will be relatively small. The local scour holes are not expected to extend beyond 5 m of the base of the structure. However, the local scour process may have the potential to (partially) bury the reef modules.

5.2.9 Summary of the reasons for selection of proposed site

Constraints analysis was undertaken to assist in identifying zones within the study area likely to be most suitable for artificial reef deployment. Following the review of existing information and mapping of key characteristics of the study area and surrounds, a ‘potential reef deployment area’ was mapped (Figure 21). This is the area where, based on existing information, artificial reef deployment would be suitable and unlikely to conflict with the physical, biological and regulatory constraints investigated. The following analyses aims to assist in prioritising zones within the potential reef deployment area, where the success of the reef and benefit to the recreational fishing community might be maximised.

Based on the available information, five zones (1 – 5) running from north to south were demarcated within the potential deployment area (Figure 21).

For each zone identified, the following criteria were used to rank and prioritise the five zones in terms of their suitability:

1. Wave Climate. Locations that are exposed to waves are less suitable than sheltered areas. This is firstly because OAR modules deployed in sheltered areas are less likely to become unstable or displaced, or reduce the effectiveness of the module as an artificial reef. Although artificial reef modules will be designed and weighted to withstand significant storm events (e.g. at a 50 to 100 year ARI) locating them in a more sheltered environment is

preferable where possible. In terms of amenity, it is also preferential to locate the modules in calmer waters, susceptible to swell.

2. Exposure to Wind Induced Currents. Currents will influence the amount of scouring and erosion around the base of the modules and may impact on long term stability. Scouring and erosion may also result in the partial build-up of sediment and burial in other areas or parts of the reef. For this reason it is preferential to avoid high current areas.
3. Distance from Natural Reef. As discussed there are several reasons for locating artificial reefs away from existing natural reef. This is mainly to create new and alternative fishing opportunities and help spread equity of the resource - which is less likely to be achieved if located near to existing reef where fishing already occurs. Locating reef modules in areas of otherwise bare sandy substratum is more likely to provide new habitat for recruitment of encrusting organisms and fish, thus adding to local productivity rather than drawing fish from existing natural reef where they may become more susceptible to capture. Bare sandy substratum also provides a firm stable base on which the reef units can sit.
4. Distance from Existing Recreational Fishing Locations. For reasons similar to above, the program aims to spread the equity of resources and create new fishing opportunity.
5. Accessibility. The accessibility of the artificial reef will be important in ensuring its success and should therefore be located within a reasonably short distance from boat ramps and towns where bait and other supplies can be sourced. This measure uses both the number of boat ramps within a specified radius and the distance of the nearest boat ramp as measures of accessibility.
6. Potential for Conflict with Other Activities. The main activity likely to influence site selection will be commercial fishing, particularly the ocean trawl fishery, although some trap and line fishing may also occur in the potential deployment area. It is generally considered that zones 1, 2, and 3, offshore of Seven Mile Beach would be most likely to be utilised by trawlers and some trap and line fishing might also take place in zones adjacent to reef habitat.

The simple scoring system used to assess each specific criterion and results are presented in Table 20.

Results of the Constraints Analyses suggest that zone 2, offshore of Seven Mile Beach should be prioritised for final site selection. Zone 3, offshore of Comerong Island is also likely to be suitable. While zones 1, 4 and 5 (offshore of Black Head, Culburra Beach and Kinghorn Point), are not likely to be altogether unsuitable, the proximity to natural reefs and greater exposure to wave and wind driven current conditions mean these locations were ranked lower in the analyses.

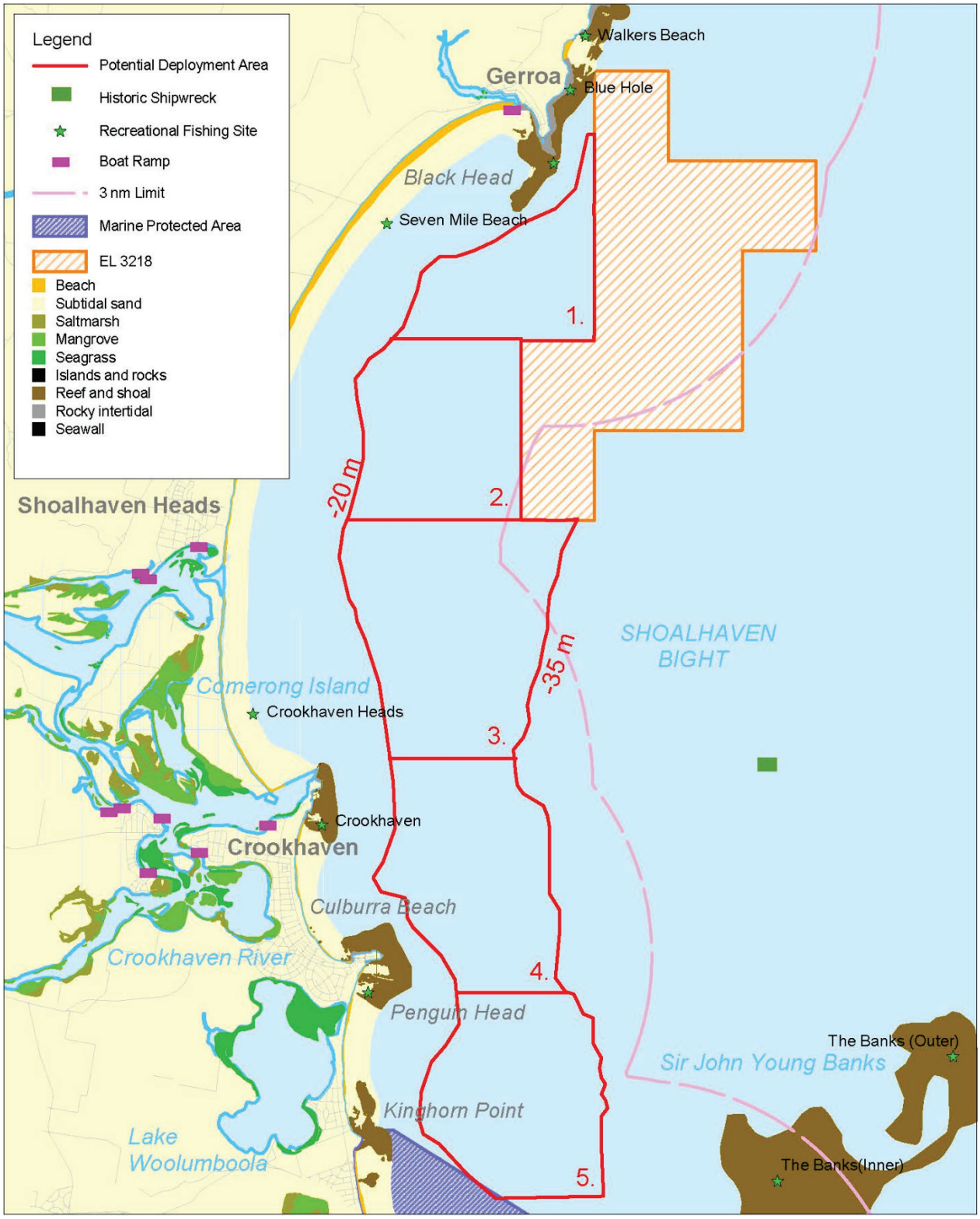

Figure 21. Potential reef deployment sites

Table 20. Constraints analyses criteria and scores

Criteria	Score		Zone				
			1	**2**	**3**	**4**	**5**
			Black Head	Seven Mile Beach	Offshore Comerong Island	Offshore Culburra Beach	Offshore Kinghorn Point
Wave Climate	1	Exposed	1	3	3	2	1
(based on omni directional wave heights along 20 m contour)	2	Moderately exposed					
	3	Least exposed					
Currents	1	Exposed	3	2	1	2	2
(based on 20 yr ARI wind induced currents from the north)	2	Moderately exposed					
	3	Least exposed					
Proximity to Natural Reef	1	0 - 2 km from centrepoint	1	3	3	1	3
	2	2 - 3 km from centrepoint					
	3	> 3 km from centrepoint					
Number of Fishing Locations in 5 km radius	1	>3	1	2	2	2	2
	2	1 - 3					
	3	none					
Number of Boat Ramps in 10 km Radius	1	0 -1	2	3	3	3	3
	2	2 - 5					
	3	> 5					
Distance to Nearest Boat Ramp	1	> 6 km	2	2	2	2	1
	2	3 - 6 km					
	3	< 3 km					
Potential for Conflict with other Activities	1	Likely	2	1	1	2	2

Criteria	Score		Zone				
			1	**2**	**3**	**4**	**5**
	2	Possible					
	3	Unlikely					
Total Score			12	16	15	14	14
Total Rank			**4**	**1**	**2**	**3**	**3**

6 Scope, Duration and Timeframes for Monitoring

This section describes research and monitoring aspects related to the Shoalhaven offshore artificial reef that are designed to provide information that will lead to continuous improvements in the way the reef is managed and future reefs deployed.

6.1 Priorities

The research priorities for the Shoalhaven offshore artificial reef (outlined in Table 21), are categorised into two levels depending on the relevance to the risks identified in the EA and information required to support the objectives of the reef:

Level 1 (initial monitoring): Commencement scheduled upon installation of the reef and reviewed within three years of commencement.

Level 2 (supportive monitoring): Commencement scheduled for within three years of the installation of the reef.

Table 21. Research priorities and description

Research Topic	Priority	Short description of research project and expected outcomes
1. Colonisation of the reef & community development: *BRUV*/ROV**/midwater unbaited camera*	Level 1	BRUV's and midwater unbaited cameras will be deployed on the reef a minimum of 4 times a year. This would allow the monitoring of fish assemblages and the documentation of the development of the fish community.
2. Threatened species, fish residency and connectivity: diver *survey/BRUV/midwater unbaited camera; acoustic listening station (Vemco VR4)*	Level 1	An acoustic listening station would be placed on the reef (Figure 22) which would allow for the monitoring of fish assemblages, threatened species, and pelagic species with acoustic tags. Data collected would again be incorporated into DPI databases where relevant and is likely to provide information regarding the interaction with natural reefs and the potential risks associated with draw down effects. Data collected by remote video (BRUV/ROV) will be used to supplement this data set. Any threatened species information will be incorporated in to the Threatened species unit's database.
3. Reef stability & structural integrity: *diver surveys/ROV surveys*	Level 1	Diving and/or ROV surveys (where appropriate) would be conducted by staff a minimum of 4 times a year; these surveys will allow a visual inspection of the reef to document reef stability and structural integrity. The results of the survey would be included in DPI databases where relevant
4. Benthic assemblages (including pest identification): *diver surveys/BRUV/ROV*	Level 2	Within the first 3 years post deployment, a replication of the baseline benthic survey will be undertaken to assess the level of impact that the reef has had. Note: A quarterly visual record of benthic development on the reef will be recorded by BRUV, diver surveys & photographic record/ROV/midwater unbaited camera for a perid of 3 years.
5. Accumulation of marine debris: *diver survey/BRUV/ROV/midwater unbaited camea*	Level 1	The level of gear hook up will be assessed using diver surveys/ROV/surface deployed cameras; if there is a build-up of marine debris on the reef structures which poses an entanglement hazard, the Fouled gear removal strategy wil be employed to remove the debris.

*BRUV = baited remote underwater video; **ROV = remotely operated vehicle

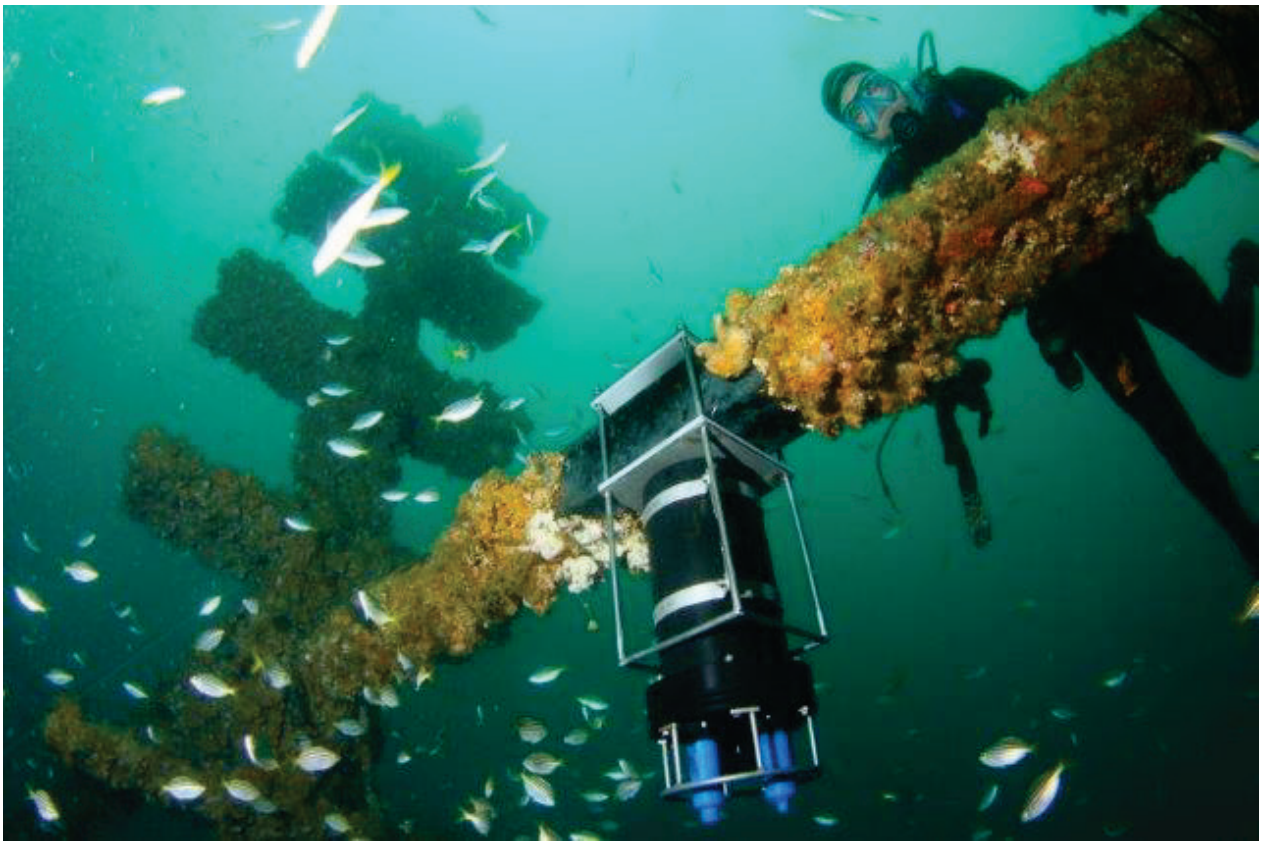

Figure 22. Vemco VR4 with a 10 year battery life and remote download capabilities fitted to the Sydney offshore artificial reef

6.2 Monitoring Timeframes

Environmental monitoring programs outline procedures to monitor potential changes in significant components of the marine environment and assess the structural integrity of the reef infrastructure, marine fauna interactions and environmental impacts (Table 22). The preliminary 3 year timeframe was selected based on the results from the Sydney Offshore Artificial reef surveys (refer SD2008/882). Development of a monitoring strategy to meet objectives relating to interaction with threatened and protected species and quantifying the impact of the reef system with the broader ecological community requires a time frame that is consistent with the rate of recruitment to the artificial reef system and the ecological factors which drive this process. Previous work associated with both estuarine and offshore reef systems has indicated that the fish communities remain dynamic over the first 2-3 year period post deployment. A three year monitoring program will provide an adequate time frame to understand longer term trends in the nature of the fish assemblage associated with artificial reef systems (including interactions with threatened and protected species), physical forces acting on the structural integrity and stability of the reef while providing insight into the level of variation between seasons and years. It is proposed to review monitoring timeframes 3 years post reef installation based on these results from monitoring conducted.

Table 22. Environmental monitoring and timeframes proposed on the Shoalhaven offshore artificial reef

Issue	Monitoring Actions	Frequency	Responsibility
Colonisation of the reef & community development	Before reef installation monitoring was conducted at the Shoalhaven reef site using BRUVs and surface deployed tow cameras (September 2013). BRUV's and midwater unbaited cameras will be deployed on the reef a minimum of 4 times a year post reef installation to monitor fish assemblages and	Quarterly every 12 months • for 3 consecutive years and then will be reviewed	DPI

Issue	Monitoring Actions	Frequency	Responsibility
	colonisation of the reef community; presence of threatened species; allow for potential identification of pest species and will be compared with nearby natural reef control locations.		
Benthic environment	Collect benthic sediment samples before, and after reef installation. A dedicated benthic assessment of the reef deployment site was conducted by Bioanalysis Pty Ltd in October 2013 (EA – Technical Report B). These results will be used to monitor changes in sedimentation and benthic community structure.	Samples to be taken 3 years post reef installation for comparisons with pre deployment baseline benthic surveys	DPI
Marine fauna interactions including threatened species interactions	Record all observations of marine fauna and threatened species interactions with infrastructure and vessels during installation; and, Record potential ongoing interactions with threatened & protected species, boat strikes, behavioural changes, entanglements etc	During the installation phase and then on a biannual basis thereafter – ongoing for the design life of the reef (≤ 30 years)	DPI, Successful tenderer and reef users
Structural integrity and stability of infrastructure	Inspections and maintenance of reef infrastructure e.g. faults, damage Monitor the effectiveness and suitability of the reef design	Regular scheduled inspections & maintenance annually: • quarterly every 12 months for 3 consecutive years post installation, then; • a minimum of every 5 years for the remainder of the reef design life or following large storm events which produce a significant wave height ≥ 4.1 m)	DPI
Marine debris	Removal of debris build up in a timely manner (dependant on water conditions)	Regular scheduled inspections & dedris removal when required: • annually for 3 consecutive years, then reviewed based on needs from results of preliminary 3 consecutive year post installation surveys for the design life of the reef – ≤ 30 years.	DPI
Benthic fouling including Invasive Pest identification	Regular inspections of reef for pests to ensure early detection Record pests - contribute to the species inventory for NSW waters	Quarterly visual inspections of reef every 12 months for 3 consecutive years and then will be reviewed.	DPI

6.2.1 Structural integrity and stability monitoring

The structural integrity and stability monitoring will be used to undertake inspections of the reef infrastructure to determine its structural integrity and stability. Evidence of faults, damage, and excessive debris build-up will be the focus of the inspections which will be followed by appropriate maintenance. Inspections will be particularly important after a large storm event, and the cleaning of infrastructure in order to minimise marine fauna entanglements. Routine visual inspections will be undertaken quarterly every 12 months for 3 years (then reviewed) with a minimum inspection period of every 5 years for the remainder of the reef design life or following large storm events which produce a significant wave height ≥ 4.1 m).

The inspection checklist includes:

- Date and type of observation conducted (diver vs. camera);

- Location and description of faults identified including: significant scouring or sedimentation; module damage including cracks, splits or breakages and the location (GPS coordinate) of the module.
- a list of proposed actions to be undertaken (if any) including the contracting of third part assessment;

The structural integrity and stability monitoring will assess the effectiveness and suitability of the module design, such as whether it adequately withstands the sea conditions in the Shoalhaven Bight as designed.

6.2.2 Benthic environment monitoring

Benthic environment monitoring using standard methodology will be established [226], using a standard BACI (Before vs. After - Control vs. Impact) sampling design [227, 228] with multiple control sites and multiple sampling times to enable an estimate of natural temporal and spatial variation of the environment to be obtained [229]. Such estimates can then be used to determine if impacts from the reef are causing greater variation in the environment than would occur naturally through time [230].

6.3 Performance Monitoring and Review

6.3.1 Performance Indicators

Performance indicators provide the most appropriate indication of whether the offshore offshore artificial reef is meeting its objectives. A number of monitoring programs and existing DPI programs are to be used in conjunction with each other to gather information to measure performance indicators.

With the implementation of the new research, advisory and information management programs for the reef, a broader information base relating to the activity and its impacts will enable more precise performance indicators to be developed over time if required.

6.3.2 External Drivers

External drivers are factors that are known to potentially impact on the performance of the reef but which are outside of the control of DPI (e.g. environmental conditions, social changes etc.). Any external influences that may contribute to a trigger being breached will be identified during monitoring of the reef and, if necessary, referred to any relevant managing agency for action.

6.3.3 Trigger Points

Trigger points specify when a performance indicator has reached a level that suggests there is a problem with the activity and a review is required. Table 23 establishes the performance indicators and trigger points that will be used to measure whether each of the mitigation measures described in Chapter 9 of the EA are being attained.

Table 23. Trigger points

Incidental capture of threatened species		
Risk Description	Trigger point	Justification/comments
Incidental capture from recreational fishing gear could potentially affect threatened fish, pinnipeds and seabirds that forage in the surface waters	Increases of incidental capture of threatened species or key non threatened species within reef area increases by an amount deemed 'of concern' by the threatened species unit of DPI following reporting of the incident as specified in the project reporting section.	Increased incidences of capture of threatened species or key non threatened species within the reef area may indicate a change in species interactions or species interactions with the reef. This may require a modification to the management of the reef.
Data required	Availability/monitoring programs	
Incidences of threatened species capture within the	Information on threatened species or key non threatened species is available from DPI and other	

Incidental capture of threatened species		
Risk Description	Trigger point	Justification/comments
reef area	government agencies (e.g. OEH) and through the Bionet database as well as through the diver/ROV surveys and BRUV/midwater unbaited cameras as well as through the angler advisory campaigns. This information would be sent to the DPI threatened species unit (TSU) every six months for review.	

Aggregation of threatened or protected species		
Risk Description	Trigger point	Justification/comments
Aggregation of threatened or protected species	Aggregation of threatened species or key non threatened species within reef area increases by an amount deemed 'of concern' by the threatened species unit of DPI.	Increased aggregations of threatened species or key non threatened species within the reef area may indicate a change in species interactions. This may require a modification to the management of the reef.
Data required	Availability/monitoring programs	
Information on the residency of threatened and protected species within the reef area.	Information on threatened species or key non threatened species is available from DPI and other government agencies (e.g. OEH) and through the Bionet database as well as through the diver surveys and BRUV as well as through the angler advisory campaigns. This information would be sent to the TSU every six months for review.	

Alteration/interruption of movement corridors		
Risk Description	Trigger point	Justification/comments
Cetaceans and some 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 offshore artificial reefs.	Movement corridors of threatened species or key non threatened species within reef area alters by an amount deemed 'of concern' by the threatened species unit of DPI or other relevant government agency.	Changes in movement patterns and corridors of threatened species or key non threatened species within the reef area may indicate a change in species interactions and behavioural patterns. This may require a modification to the management of the reef.
Data required	Availability/monitoring programs	
Information on the migration routes and patterns of threatened and protected species within the reef area.	Information on threatened species or key non threatened species is available from DPI and other government agencies (e.g. OEH) and through the Bionet database as well as through the diver surveys and BRUV as well as through the angler advisory campaigns. This information would be sent to the TSU every six months for review.	

Harm from marine debris and pollution (KTPs) / Gear hook up		
Risk Description	Trigger point	Justification/comments
Increased risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed offshore	Debris build up on the reef by an amount that the Recreational Fisheries Unit believes is 'of concern'	Ongoing build-up of marine debris on the reef may require a modification to the management of the reef.

Harm from marine debris and pollution (KTPs) / Gear hook up		
Risk Description	Trigger point	Justification/comments
artificial reefs.		
Data required	Availability/monitoring programs	
Diver and remote camera inspection of the reef to assess the debris build up.	Annual reef monitoring and observance program and other DPI research projects/programs operating within the reef area.	

Invasive Marine Pests		
Risk Description	Trigger point	Justification/comments
The proposed reef structures could provide a substratum or habitat suitable for invasive marine pests (also referred to as' introduced', 'alien' or 'non-indigenous' species).	An incidence of a novel disease or pest within the reef area	Pests and diseases can pose significant risks to the environment. This indicator ensures that the reef and its management are appropriately responding to pest and disease issues. There are potential external drivers in this trigger point such as the introduction of pests and diseases through other aquatic or land based activities
Data required	Availability/monitoring programs	
Ongoing monitoring of the reef area, pests and records of responses to pest or disease incursions	Disease and pest notification procedures (in line with DAFF) and DPI Biosecurity	

7 Environmental Management

The following provides an overview of the proposed Environmental Management developed to provide guidelines for the operation of the offshore artificial reef.

7.1 Marine fauna interaction management

The marine fauna interaction management aims to identify and mitigate potential impacts on marine fauna through direct and indirect interactions. The plan includes a marine fauna entanglement avoidance protocol and the observer protocol.

The marine fauna entanglement avoidance protocol has been successfully used on marine based aquaculture farms in NSW and was developed in consultation OEH. The protocol aims to minimise the threat of entanglement and entrapment of marine fauna in reef infrastructure, as well as implement prompt and appropriate management if incidences occur in order to maximise successful releases and minimise injuries and stress to marine fauna. Any entanglement events will be recorded in the Marine fauna entanglement report form and reported to DPI which will monitor the implementation and effectiveness of this protocol.

There are a series of requirements that the DPI and reef users must adhere to in order to comply with the Marine fauna entanglement avoidance protocol. Requirements and/or objectives of this protocol include:

- The DPI and reef users must take all reasonable action to remedy, alleviate and reduce the incidence of marine fauna entanglements;
- The DPI will undertake routine visual inspections quarterly every 12 months for 3 years (then reviewed) with a minimum inspection period of every 5 years for the remainder of the reef design life or following large storm events which produce a significant wave height ≥ 4.1 m).

Debris build up will be removed annually for the first three years post reef installation then an appropriate time period for removal will be determined based on these results. .

- The DPI and reef users must immediately notify relevant government agencies, including the NSW OEH, if an entanglement incident occurs, including events where the entangled or entrapped animal may have been released (assisted or self-released);
- The DPI and reef users must document any incidence of death or injury to marine fauna associated with the infrastructure and activities of the reef, including a statement of how the incident occurred and any action taken.

If marine fauna become entangled or entrapped, the main priority with is to assess their condition and determine the most appropriate and safe release method, as well as whether the animal needs to recuperate and further treatment under veterinary supervision. In the unlikely event of deceased animals, the carcasses of dead marine fauna will be disposed of appropriately after consultation with OEH. The method of disposal will be determined largely by the size of the carcase. Some carcasses may be kept for scientific purposes (e.g. Australian Museum or other authorised research institutions). The Coordinator, Wildlife Management (NSW OEH) will be contacted to ensure all relevant procedures have been carried out e.g. incident has been record in Marine Fauna Database.

An incident report detailing the time, location, species and the entanglement circumstances, will be prepared and presented to relevant authorities. The protocol and any incident reports will be periodically reviewed to identify any issues of concern or areas of inadequate management, as well as to enable modifications to be made based on field experiences and/or professional advice.

7.2 Environmental Reporting

Environmental reporting requirements for the Shoalhaven offshore artificial reef will include the following:

- Colonisation and community development;
- Inspections of reef infrastructure , structural integrity and stability (conducted annually);
- Observations of marine fauna interactions (from the Marine Fauna Interaction Register);
- Benthic monitoring;
- Marine fauna interactions;
- Threatened species interactions

Checklists will be maintained by the DPI for environmental inspections and environmental audits.

7.2.1 Logs and Registers

A number of registers will be maintained by the DPI as part of the operation of the reef. A summary of the matters within the registers will be included in environmental management reports. The registers will include but are not limited to the following:

Complaints register

A complaints register will be maintained by the DPI. The register will list information such as the following for each complaint:

- Date;
- Person/s receiving the complaint;
- Name, address and contact phone number of person/s making the complaint;
- Specific details of the nature of the complaint; and

- Action undertaken in response to the complaint.

Marine fauna interaction register

The marine fauna interaction register will list information such as the following (See Attachment 1):

- Date;
- Time;
- Fauna species (if known);
- Number of individuals;
- Approximate size;
- Nature of interaction;
- Description of displayed behaviour;
- Management issue; and
- Management actions.

7.3 Offshore artificial reef user education and awareness guidelines

Offshore artificial reef user education and awareness guidelines have been produced to form the basis of the offshore artificial reefs advisory/education campaign (Attachment A of this Management Plan & Appendix 9 of the EA). The guidelines provide information important for user groups to ensure minimal environmental impact and promote safety within the reef management area.

These guidelines are available via the DPI website and in print as required for distribution to relevant recreational fishing associations and clubs.

7.4 Fouled gear (debris) removal strategy

The installation of the Shoalhaven offshore artificial reef will result in the concentration of, and increase in, recreational fishing activity in the immediate vicinity of the reef. This may potentially increase the risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed reef. Threatened marine species, particularly marine turtles, pinnipeds, small cetaceans and seabirds, can ingest or become entangled in marine debris, such as plastics. This fouled gear removal strategy aims to ensure marine debris which poses an entanglement hazard is removed.

A commitment has been made by DPI that periodic inspection of marine debris will be maintained on the reef for its design life (≤ 30 years) based on the outcome of the first 3 years of monitoring.

7.4.1 Inspection timing

Twelve scheduled inspections will be conducted over the first 3 years post reef installation to document the accumulation of any fishing or non-fishing related marine debris. The first inspection will be conducted within 3 months of the reefs installation being completed and the first debris removal will be conducted within 12 months of the reef being installed and annually thereafter for a period of up to 3 years

At the conclusion of this initial 3 year assessment period, the results will be used to identify a suitable level of assessment required to identify and respond to marine debris accumulation. For example of debris build up remains consistent over the first 3 years, annual removal and inspections may be required to be maintained. However, if limited debris is recorded with a trend towards a reduction in debris inspections may be further reduced to 3-5 year intervals for the remaining design life of the reef (up to 30 years).

7.4.2 Inspection

A combination of diver survey, remote video (ROV and surface deployed cameras) will be used to provide an ongoing debris log. This log will be maintained by the DPI and will include the following detail:

- date
- type of material identified (e.g. fishing line [mono or braid], anchor line, trap or net);
- approximate amount seen (length and diameter of lines) and distance the material extends (i) vertically; and, (ii) laterally from the reef;
- location of the debris (including GPS coordinates [where possible] and reef patch group);
- proposed removal methods (diver, barge/winch, other);
- threat presented by the debris.

7.4.3 Debris removal triggers

If the build-up of marine debris on the reef structures is identified to pose a engagement hazard or if 'free floating' (i.e. lines tethered to the reef which extend into the upper water column above the structures) are identified this removal strategy will be implemented. *Although commercial fishing is not expected to be undertaken on the reef, in the event of a net or fish trap being identified on the reef a team will immediately be mobilised to assess and remove the objects(s) in question.*

7.4.4 Debris removal

If the amount of material identified can be safely removed by divers using a single knife only, a DPI commercial dive team (2815.1 qualified in accordance with minimum standards set by AS/NZ2299.1 Commercial Diving Standard) may be used to remove the hazard (*note: special permission from the DPI – Fisheries NSW Occupational Diving Officer will be required*).

If the hazard poses an entanglement or entrapment hazard to divers, the DPI will contract an external commercial diving contractor with surface-supply capacity (as per AS/NZ2299.1) to complete the removal.

If the hazard cannot be safely retrieved by divers (e.g. commercial trawl net or large commercial fish trap), suitably experience and qualified salvage contractors are to be sought by the DPI to provide salvage advice.

Significant entanglement hazards which pose an immediate threat to marine mammals are to be reported to the NSW Office of Environment and Heritage (OEH) under the *NSW National Parks and Wildlife Regulation (2009).*

7.5 Contingency Measures

In addition to the circumstances outlined above, the Executive Director NSW Fisheries may order a review and/or make a modification to the Shoalhaven offshore artificial reef in circumstances declared by the Minister as requiring contingency action, or upon the recommendation of DPI staff.

These circumstances may include (but are not limited to) food safety events, environmental events, and results of research programs or unpredictable changes on or around the reef over time. Notwithstanding the above, the Executive Director DPI may also make amendments to the operation of the Shoalhaven offshore artificial reef that the Executive Director considers to be minor in nature at any time.

7.6 Emergency Contacts and Response

The emergency response plan enables prompt and effective responses to emergency situations. The emergency response plan includes qualified personnel, specific actions to be undertaken in response to different emergency situations and reporting requirements.

If at any time during the deployment or operation of the reef an environmental risk/incident occurs, the DPI will immediately implement measures to mitigate the risk or the impact. The situation will be reported in writing within 24 hours Department of the Environment (and any other relevant Government Agency or Authority), with a full report detailing:

i) the environmental incident that occurred and/or 'non-compliance' detected;

ii) the mitigation measures taken, and;

iii) The success of these measures in addressing the environmental incident that occurred and/or 'non-compliance' detected and any additional measures that are proposed to be taken.

Emergency contacts:

1) Manager Fisheries Enhancement – DPI

Ph: (02) 6691 9673 (office hrs), 1300 550 474 (24hrs)

Email: fisheries.enhancement@dpi.nsw.gov.au

Other relevant emergency contacts include:

i) ORRCA Whale and Dolphin Rescue - Ph: (02) 9415 3333

ii) Fisheries Watch - for reporting illegal fishing – Ph: 1800 043 536

iii) For ALL other emergencies (NSW Police, Maritime, Fire, Ambulance) – Ph: 000

7.7 Decommissioning

The nominal operational lifespan of the Shoalhaven reef is estimated to be 30 years. It is likely, however, that the structures would remain operational for longer than this. 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 reef 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 reef then 'Option A' would be the most likely method of decommissioning. 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 of their removal.

7.8 Project Reporting

Updates on the Shoalhaven offshore artificial reef will be placed on the DPI Offshore artificial reefs webpage (www.fisheries.nsw.gov.au) and will be reported as required to other statutory agencies and Departments.

Within 10 working days from completion of the reef installation, the DPI will provide a report that:

- details the date and time of the placement of the Shoalhaven offshore artificial reef;
- confirmation of the placement site boundaries to Two decimal places of a minute (WGS84);
- the estimated maximum depth over the Shoalhaven reef units (LAT), and the date and time of the observation; and confirmed that the highest point of the reef is no less than 20 m below sea level (LAT);
- details of inspection dive and any items removed or hazards rectified;
- proof of written notification to the Australian Hydrographic Office and NSW maritime.

An annual Environmental Monitoring Report will be issued annually on or before the completion date of reef installation (for a period of up to 3 years or as agreed by relevant consenting authority[s]) and will include, but no be limited to the following:

- identify the standards and performance measures of the project;
- describe all works carried out over the previous 12 months;
- a summary of complaints and make a comparison to previous years;
- records of maintenance checks and activities;
- a summary of post deployment monitoring activities and preliminary results;
- ‘non-compliance’ and/or environmental incidents recorded or responded to in the previous year; including those that specifically involved threatened and/or migratory species (including signings and/or incidental captures;

7.9 Long term management plan review

Review of this plan will be conducted as required from the date of approval and is the responsibility of the recreational fisheries management team. Issues relating to the operation and implementation of the plan will be collated by the DPI Manager Fisheries Enhancement for review and reporting and approval.

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