NSW GOVERNMENT | Department of Primary Industries

FISHERIES NSW | FISHERIES ENHANCEMENT PROGRAM

Port Macquarie Offshore Artificial Reef

Artificial Reef Permit Application

PART I - SUMMARY

Name of applicant:

NSW Department of Primary Industries (NSW DPI)

Type of material requiring placement:

Purpose built steel reinforced concrete artificial reef units

Location of disposal site:

The proposed deployment sites for the artificial reef modules are located east of the town of Port Macquarie on the NSW mid-north coast at a depth of approximately 41 m of water. The reef comprises of 5 individual reef groups (patches) (Datum; WGS84):

Table 1. Coordinates of the five proposed reef patches

Corner	Latitude	Longitude
Centre Patch	31º25.044' S	152º58.950'E
Northern Patch	31º25.014' S	152º58.950'E
Eastern Patch	31º25.044' S	152º58.980'E
Southern Patch	31º25.074' S	152º58.950'E
Western Patch	31º25.044' S	152º58.920'E

Dates of proposed disposal operations:

January 2016

Permit required by:

NSW Department of Primary Industries (NSW DPI)

Quantity of material to be disposed:

In total 20 artificial reef units are proposed to be deployed (4 units per reef patch). Each unit has a 4m x 4m x 5m and each unit has a dry-weight of approximately 27 tonne – combined reef weight total is 540 tonne.

Length of permit applied for in this application:

30 years

Details of previous permits applied for (include dates, quantity and whether granted/refused):

DPI has previously applied for permits for the placement of a steel artificial reef into coastal waters off Sydney (SD2008/882) and Shoalhaven Heads (SD2014/2842). Both Permits were granted.

PART II - APPLICANT

Identity of applicant

Name:

NSW Department of Primary Industries (NSW DPI)

Address:

36 Marina Drive

Coffs Harbour Jetty

NSW 2450

Postal address (if different):

PO Box 4291

Coffs Harbour Jetty

NSW 2450

Contact person:

Dr Heath Folpp, Manager Fisheries Enhancement & Occupational Diving,

NSW Department of Primary Industries (Fisheries)

Phone: 02 6691 9673

Email: heath.folpp@dpi.nsw.gov.au

1.1 Identity of the owner of the material to be disposed at sea

As above

NSW GOVERNMENT | Department of Primary Industries

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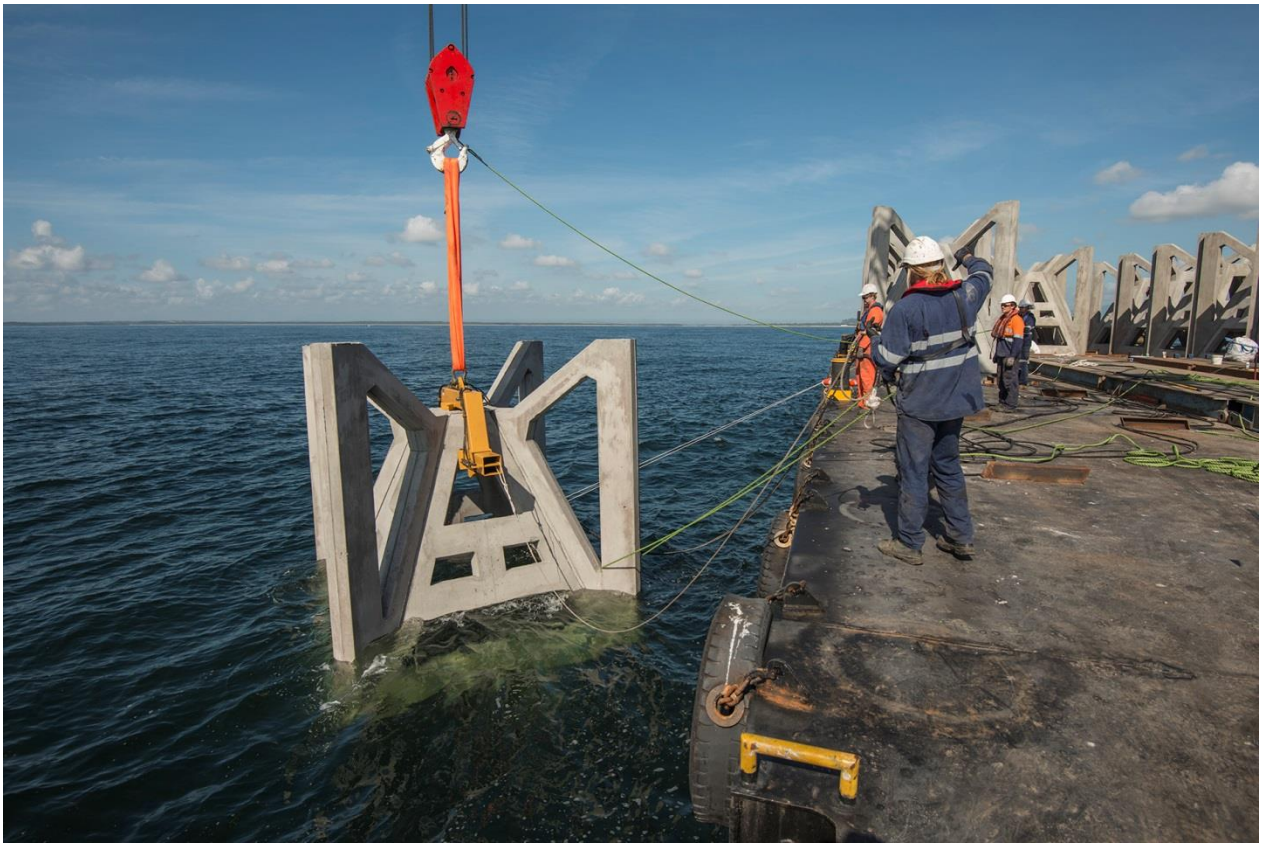
Port Macquarie Offshore Artificial Reef

Part III - Long term management plan (Draft)



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Port Macquarie Offshore artificial reef – Long term management plan (Draft)

First published July 2015

More information

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www.dpi.nsw.gov.au

Cover Image: Installation of the Shoalhaven offshore artificial reef in January 2015 (DPI – Fisheries)

Contents

List of Figures

List of Tables

Long term management plan

The NSW Department of Primary Industries (DPI) is responsible for the operation, including management, monitoring and maintenance of the Port Macquarie 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 DPI is committed to carrying out the mitigation measures outlined in this plan and 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

DPI aims to improve recreational fishing opportunities in NSW through the development of offshore artificial reefs in offshore locations. DPI manages recreational fishing in ocean waters off NSW under the *Fisheries Management Act 1994 (FM Act)* and the Offshore Constitutional Settlement. The primary objective of the FM Act is 'to conserve, develop and share the fishery resources of the State for the benefit of present and future generations'. Further objectives under the Act include promoting 'ecologically sustainable development, including the conservation of biological diversity' and promoting 'quality recreational fishing opportunities'. The deployment of artificial reefs as a fisheries enhancement tool is consistent with these objectives.

Recreational fishing is an important leisure activity for approximately 12% of the NSW population (approximately 800,000 people) and provides significant social and economic benefits, with an estimated $1.6 billion into the NSW economy each year and creates approximately 14,000 jobs.

In NSW, approximately 30% of the total fishing effort takes place between the shoreline and 5 km offshore. The creation of new, high quality fishing areas through the deployment of offshore artificial reefs will enhance fishing opportunity by creating high relief, complex fish habitats. Recreational reefs will provide additional fishing locations and an alternative to heavily fished natural reefs. They also have the potential to increase the abundance and productivity of some demersal and reef species found there.

The proposal is considered an 'activity' under Part 5 of the *NSW Environmental Planning and Assessment Act 1979 (EP&A Act)*. The deployment of the offshore artificial reef structure requires a licence under Section 34 of the *Crown Lands Act 1989*, given the proposed deployment site is located in State waters (within 3 nautical miles) on unzoned land. The proposal also requires a permit under Commonwealth legislation, as the construction of artificial reefs is regulated under the Commonwealth *Environment Protection (Sea Dumping) Act 1981 (EP (SD) Act)*.

In addition to approval under Section 19 of the EP (SD) Act (Commonwealth), other permits and licences required for the project to proceed, may include:

- towing permit from NSW Roads and Maritime Services to transport the reef structure – responsibility of installation contractor;
- aquatic licence from NSW Maritime for exclusive use of the waters for the purposes of sinking and/or monitoring the structures – responsibility of installation contractor and,
- authorisation under Section 13T of the *Maritime Services Act 1935* for buoys or moorings associated with the offshore artificial reefs – for deployment purposes only and are the responsibility of installation contractor.

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 (LTMP). This plan aims to consolidate the mitigation and management measures that the DPI is committed to implementing.

Figure 1. Artist impression of the Port Macquarie 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;

- 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).

- Cardno Pty Ltd to provide technical expertise and participate in the risk assessments for the process and to also compile the Port Macquarie offshore artificial reefs 'Benthic Ecology' report (Technical Report E).

Figure 2. Port Macquarie 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 130 letters were distributed), email, phone calls and through stakeholder consultation meetings (Table 1). 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 [MERCMAC]). 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 webpage specifically relating to the proposed Port Macquarie offshore artificial reef was launched at the beginning of the consultation period on the DPI fisheries webpage (www.fisheries.nsw.gov.au). 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. Consultation letter distribution details

Group	Number
Recreational fishing stakeholders (including fishing clubs, recreational fishing associations and charter operators in the Port Macquarie area)	37
Commercial fishing stakeholders (including fishing business owners, nominated fishers, professional associations and fishermen's co-operatives)	52
Conservation	9
Statutory authorities (including local and state government)	14
Recreational licence agents (in the Port Macquarie area)	18
Total	130

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 are considered in Technical Report B. The key findings were however that the seafloor within the project area is currently between 20 and 40 metres underwater, and is understood to be functionally flat, sandy with no exposed surfaces that may formerly have been ground surface prior to inundation, 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;
- there is a low possibility of Aboriginal objects being transported to the project area by natural or assisted means; and
- if Aboriginal objects are present within the project area, they are likely to have been buried by natural coastal processes.

Technical Report B summarised that it is considered that the project has a very low likelihood of resulting harm to Aboriginal objects. This is a result of the location of the project area off shore and the minimal ground disturbance associated with the project. For further information on the consultation conducted as part of the EA and the results of this refer to Section 5 of the EA.

2 Project goals and objectives`

2.1 Vision for the activity

The long-term vision for the deployment of offshore artificial 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 25 July 2014 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 Port Macquarie 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 3 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	

Scale	
Sub – Local	30 m radius from the reef module
Local	400m x 400m (16HA)
Intermediate	0 – 3 km
Large	3 – 10 km
Regional	> 10 km

			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 Port Macquarie offshore artificial reef management area

The location of the proposed reef deployment site is situated offshore from the mouth of the Hastings River estuary, north-east of Port Macquarie at an approximate depth of 44 m LAT. The size of the deployment and management area is 250 m x 250 m and the centre point of the reef area is 31°25.044 S, 152°58.95 E (WGS84). A licence to occupy the site for the purpose of the artificial reef has been requested from NSW Crown Lands. For individual reef patch centre points coordinates refer Table 4.

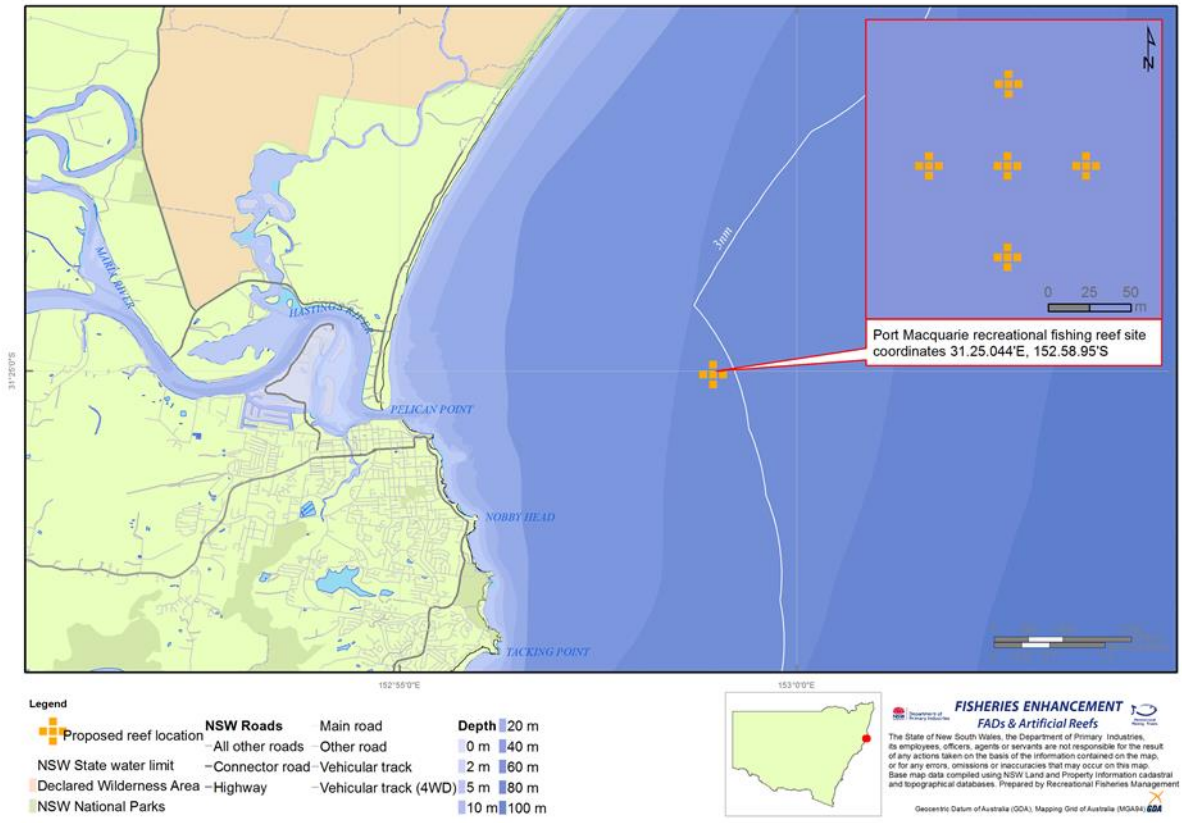

Figure 3. General location for proposed deployment of the reef

4.1 Socioeconomic considerations

In the Port Macquarie region, recreational fishing represents an important leisure activity for the local population, as well as a major tourist attraction for visitors and a significant economic resource for local industries. During school vacation periods, tourist visitation rates to this region are extremely high and add significant numbers to the local population. The high visitation rate reflects the fact that the Port Macquarie region is within 4 hours drive of the major metropolitan areas of Sydney and Newcastle, which have a combined population of well over 5 million. The fishery was split almost evenly between local fishers and visitors who had travelled from outside the immediate region.

The Port Macquarie region provides a wide variety fishing locations across a number of different types of aquatic habitats, including open ocean, ocean beaches, rocky headlands, rivers, coastal lagoons and freshwater streams. The Hastings River which is a recreational fishing haven is also located within the region. The recreational fishing havens have been closed to commercial fishing operations by the NSW Government in order to improve the recreational fishing experience [156].

Trip expenditures by anglers are classified as being either directly attributable to fishing (tackle, bait/berley etc), indirectly attributed (accommodation, travel, boat fuel and hire), and other

expenses (eating out, other entertainment, food and drinks etc). The average expenditure for single day trip anglers has been estimated to be $42 per day in Port Macquarie. For visitors who stayed at least one night, expenditure was approximately $210 per day [155]. The estimates of expenditure associated with anglers who fished in Port Macquarie was $22.8m, with $7.9m coming from locals (34.6%) and $14.8m from visitors (65.4%). Regional economic modelling revealed an expenditure multiplier of 1.5, giving a total impact of $34m with direct employment of 180 persons with an additional flow on of almost an addition 100 jobs. [155]. Results clearly indicate the economic and social importance of recreational fishing to the Port Macquarie community and economy.

An example of the potential visitation rates and usage of offshore artificial reefs can be derived from monitoring results of fishing effort from the Sydney offshore artificial reef with a significant increase is visitation rates over the first two years of the reefs operation associated with the rapid community development of fish on the structure. Greater levels of effort were observed during 2013/14 compared to the previous year, with effort also more evenly distributed across seasons (Figure 4). The trailer-boat ramp survey indicated that most fish harvested from the OAR consist of large reef associated species and pelagics with this pattern consistent during both 2012/13 and 2013/14.

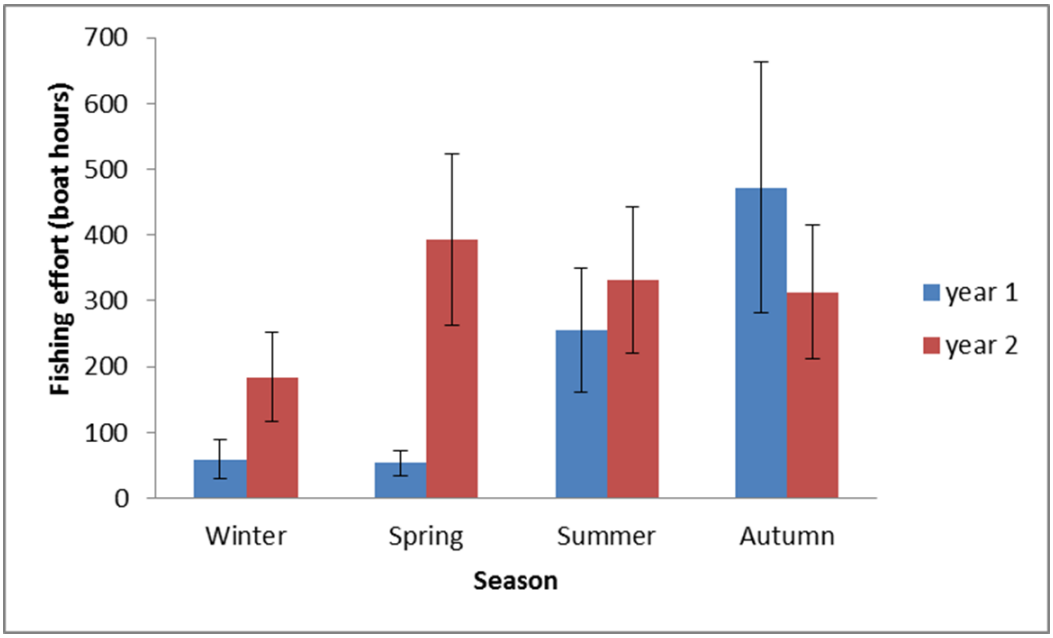

Figure 4. Average (± SE) fishing effort at the OAR site per season for the two sampling years (year 1 is June 2012- May 2013; year 2 is June 2013- May 2014)

The Port Macquarie Offshore artificial reef is expected to deliver similar direct social and broader economic benefits by providing increased 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 Port Macquarie area.

4.2 Environmental considerations

The Manning Shelf Marine Bioregion runs from Nambucca Heads in the north (30°39'S) to north of the Hunter River at Stockton (32°54'S) near Newcastle in the south. It includes all estuarine, coastal and offshore waters to the edge of the continental shelf (approx. 200m) deep. This section deals primarily with the part of the bioregion in NSW waters, out to 3nm or approx. 5.5km offshore [2]

DPI initially undertook a constraints analysis and site selection exercise (Technical Report A) to investigate the suitability of the Port Macquarie region for the deployment of an offshore artificial reef. Specifically, the report was to outline major physical, oceanographic and biological constraints on site selection, including descriptions; provide high-quality maps identifying constraints and suitable deployment sites at appropriate scales; recommend sites either with potential for deployment of the reef or which require further investigation and/or ground truthing, if required.

Reef siting and design should incorporate a variety of biological, economic, and physical sciences and engineering factors ([3]). Size, relief, complexity, location and biological factors can all influence assemblages of fishes on artificial reefs ([4]). Biological principles that should be considered include habitat limitation ([5]), habitat complexity ([6], [7]) and refuge from predators ([8]). Physical principles deal with the size of the reef structure ([9]) 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 ([10]). Conversely, greater densities of fish on smaller artificial reefs have also been reported ([4]). 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 ([11]). Conversely, a study of high-relief reefs found greater diversity on natural reefs than on artificial reefs ([12]). 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 ([13], [14], [15]). Refer to Section 2.4 of the EA for additional information.

In terms of the prevailing south-east wave direction, the proposed reef deployment location is located offshore from Port Macquarie North Beach. Locally generated short period wind waves will not be influenced by the proposed reef structures in greater than 40m water depth. North Beach is oriented to face the east-southeast and is therefore relatively exposed to the incoming wave climate. This area between the Hastings River entrance and Point Plomer is relatively undeveloped and is backed by the Point Plomer Road, which is sealed as far north as the North Shore subdivision before becoming a 4WD track. Nearshore extreme wave height expected at the proposed site are summarised in Table 3. Nearshore extreme wave height

Table 3. Nearshore extreme wave height

Return period	Significant wave height (Hs)
5 years	5.4m
10 years	5.8m
100 years	7.0m

Water movements in the proposed offshore artificial reef deployment area may be caused by a variety of physical processes, including:

- tides;
- winds;
- density flows;
- coastal trapped waves ;

- East Australian Current; and
- nearshore wave processes.

Sediment transport is caused by the water particle motions of waves and currents that lead to a shear stress on the seabed sediment particles. Generally, sediment motion commences when the seabed shear stress exceeds a threshold value, which depends on particle size and density. At shoreline locations, sediment transport may be alongshore and/or onshore/offshore. Where waves break obliquely to the shoreline, a longshore current may cause longshore transport. Offshore transport normally occurs during a storm, with a longer-term onshore transport following storm abatement. The majority of sediment transport along the NSW coast is inshore from the depths under consideration in the current artificial reef proposal. During storms with relatively large waves, beach sand moves offshore to form bars. This process typically occurs over a period of hours to days. When extended periods of calmer waves occur, the material held in these bars migrates onshore to re-build the beach. Depending on the magnitude of the preceding storm, this beach building process can occur over a time scale of days to years.

The 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.

Offshore of Tacking Point, the seabed is characterised by a complex array of patchy reefs that contrasted the bedrock structure offshore of Point Plomer and indicate a different overall geology and geomorphology occurs in this area. The reefs in the area extend to about 15–50 metres in depth and at least 4 kilometres offshore. There is no evidence that the reef was continuous with the shallow reef that extends from the shoreline between Tacking Point and Port Macquarie. The majority of the reef is in water of intermediate depths and contains discrete patches of reef that vary considerably in extent and distribution. The majority of the reef system was slightly sloping, with only very small areas with higher slope [16].

Seabed habitat mapping within Port Macquarie study region was carried out during February 2015 (Technical Report D). The aim of the survey was to provide a complete description of the physical characteristics of the sea floor within the direct study areas, highlighting the presence of unsuitable substratum, i.e. reefs, obstructions, or items of heritage significance e.g. shipwrecks. Complete swath acoustic surveys, using sidescan sonar, were carried out to provide bathymetry, backscatter, slope, and aspect data for the direct study area of at least 10km² of sea floor surrounding the proposed reef location (refer to Section 6.1.1 of the EA for more detailed information). Depths for the survey ranged from 34.5 to 52.0 m below Australian Height Datum (AHD). At the proposed artificial reef site the water depth was ~40-41m but covered a wider range of 43-49m across a 500m (radius) area. The bathymetry indicates natural reefs lie due south of the site at a distance of ~2.5km. These reefs occupy a range of depths from 37-47 m but generally rise no greater than 4-5 m above the surrounding seafloor. The shortest distance between the artificial reef site and the edge of the survey coverage is to the east (~800m). No reef was observed to the north, east or west of the site for this survey.

Both spatial layers of bathymetry and backscatter were imported into ArcGIS v10.1 and converted into raster images. The bathymetry was viewed as a hill-shaded relief (90-120° azimuth and 30-45° elevation) to provide a quasi three-dimensional image to aid interpretation of the images. Backscatter, viewed as a greyscale image, was also used to support the interpretation. Backscatter data assists in the delineation of reef and non-reef in areas based on seabed “hardnesss”. Generally, rocky reef areas are characterised by regions of relief, greyscale

heterogeneity (texture) and higher backscatter intensity (i.e. darker areas). Generally, unconsolidated substrates form regions of low relief, with variable to homogeneous textural complexity and weaker (lighter) backscatter. Slope and aspect raster imagery was generated using ArcGIS Spatial Analyst. Bathymetric data was re-sampled to a grid bin size of 10 metres prior to generating slope and aspect imagery.

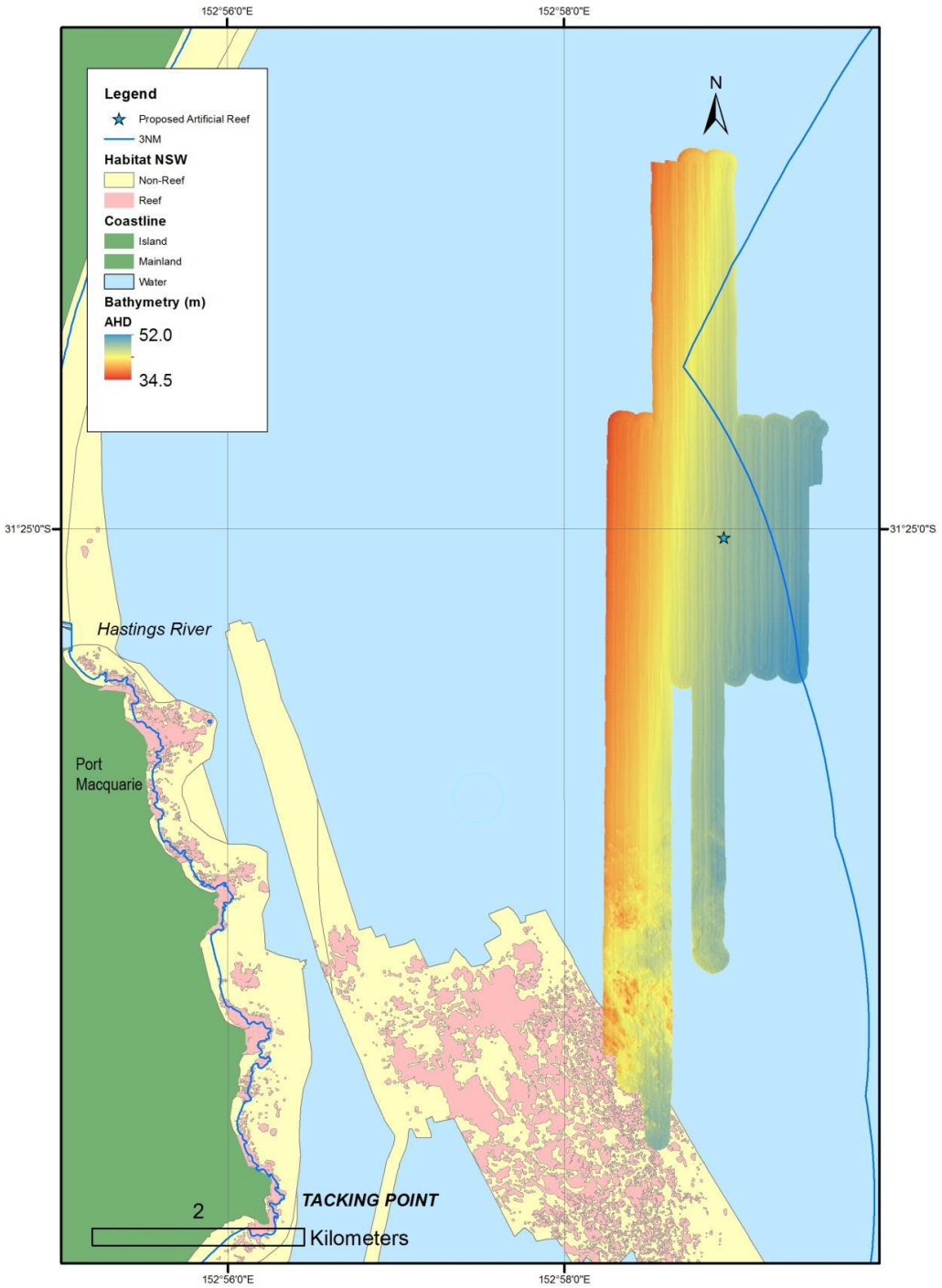

Figure 5. Seabed bathymetry derived from SWATH acoustic mapping (green star represents artificial reef site) (Technical Report D)

4.3Biological considerations

Soft sediment and rocky reef assemblages

Offshore artificial reefs are considered to be most effective when placed in bare, sandy, 'habitat limited' environments. Selection of reef sites has therefore focussed on areas known or likely to consist of sandy substratum away from areas of naturally occurring reef. Soft sediment habitats can support extremely diverse macrofaunal assemblages. Results of the benthic study (Technical Report B) have shown that invertebrate assemblages associated with soft sediment habitats vary significantly at the broad-scale (locational level) i.e. by several kilometres, but not at the fine scale i.e. distances of 100 m (at the site level). Observational field data also suggest that the differences observed between locations may be associated with the coarser grain size which is located to the northern end of the study area. In terms of percentage contribution, crustaceans (62%) were the most numerically abundant of the major taxonomic groups, followed by polychaetes (22%), other worm phyla (9%), molluscs (5%), echinoderms and other phyla (both contributing only 1% of total abundance). It is likely that the Port Macquarie OAR site experiences a greater influence of fine sediment input from the Hastings River Estuary during and after major rainfall events.

In NSW a few common groups make up the fish fauna of sandy areas ([17]). The elasmobranchs are often represented by Urolophid and Rhinobatid rays. There may also be many small planktivorous fishes. Other common and commercially important groups are the flatheads (*Platycephalidae*), which are voracious predators and whiting (*Sillaginidae*), which are benthic feeders. These groups, especially the flatheads, were shown to be abundant across the proposed reef deployment area by site video surveys conducted by DPI.

Offshore artificial reefs are likely to be most effective if habitat is a limiting factor for population growth. Subtidal rocky reefs harbour fishes that depend on this habitat for food, shelter and/or spawning sites at some stage during their lives. Many species are affected by the topography of the reef and are more abundant in areas of greater physical complexity. Some reef fishes may be very active, including wrasses and leatherjackets, and can traverse large areas of reef. There are also many less mobile, reef associated, species, which spend most of their time on or near the bottom and cryptic species that remain within caves, overhangs and crevices.

Fish assemblages on the Sydney offshore artificial reef were assessed using a variety of underwater camera methods for a period of 3 years post installation (October 2011 to October 2014) including benthic baited cameras and towed cameras in the pelagic zone. Fish were found to rapidly colonise the OAR following its deployment and recruitment of new species continued rapidly during 2012 with a total of 49 species identified by the end of 2014. Yellowtail scad (*Trachurus novaezelandiae*) and mado (*Atypichthys strigatus*) were the most abundant species while recreationally important species such as yellowtail kingfish (*Seriola lalandi*), snapper (*Pagrus auratus*) and leatherjacket (Spp.) were also abundant during all years.

Video surveys conducted as part of SWATH mapping surveys ([16]) offshore from Point Plomer at depths between 24 and 43 metres showed the reef offshore of Point Plomer was discontinuous and dominated by low profile reef with patchy boulder and reef outcrops interspersed with sand veneer patches, coarse sand and cobble-filled gutters. Reef habitat offshore from Port Macquarie (Tacking Point) surveyed by the same study ([16]) was dominated by assemblages of mixed algae and sessile invertebrates, consisting primarily of sponges, ascidians, gorgonians, and sea whips. Physically, the reef had a relatively complex profile, with steep gutters, walls, areas of boulders interspersed with sandy areas, and sections of mixed cobble and sand.

Fish surveys were conducted by DPI on the proposed offshore artificial reef deployment site and control sites representative of natural reef found adjacent to the reef deployment area using baited remote underwater video (BRUV) units. Results from these surveys indicated that the

natural rocky reef supported a fish community that was significantly different to the community identified on either of the proposed reef deployment site or representative sandy habitats. Species richness was found to be significantly greater on the natural reef (20 species) as opposed to the proposed reef deployment site and sandy sites (3 species). The natural reef exhibited a greater number of reef associated species including sweep (*Scorpis lineolatus*) and stripeys (*Atypichthys strigatus*) with the offshore artificial reef and sand sites showing a greater dominance of sand associated species such as flatheads (*Platycephalus*). The only commercially and recreationally important species observed at the offshore artificial reef site was the blue spot flathead (*Platycephalus caeruleopunctatus*). On the natural reef sites, snapper (*Pagrus auratus*), yellowtail scad (*Trachurus novaezelandiae*), silver trevally (*Pseudocaranx dentex*), yellowfin bream (*Acanthopagrus australis*), tarwhine (*Rhabdosargus sarba*), blue morwong (*Nemadactylus douglasii*) and pearl perch (*Glaucosoma scapulare*) were all observed.

Threatened and protected species, populations and endangered ecological communities

Results of the database searches indicated that there are 37 species of fish (including seahorses, pipefish and ghost pipefish), 20 species of marine mammal (including whales, dolphins and seals) and seven 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 of the EA). Overall, 6 species of fish, 3 species of marine turtle, 3 species of cetacean and 3 pinnipeds were assessed according to OEH and the DPI threatened species assessment guidelines.

A threatening process is something that threatens, or could potentially threaten, the survival or evolutionary development of a species, population or ecological community [18]. 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).

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.

The risk assessment considered that the incidental capture of sea birds was very unlikely on the offshore artificial reef. From experience from the Sydney and Shoalhaven offshore artificial reefs, zero reports of interactions with sea birds have been reported. For this reason, no direct mitigation measure is considered to be required. If increased interactions with sea birds is reported and verified by DPI, an appropriate management response including but not limited to the limitation of some fishing practices (i.e. floating of surface baits) may be considered.

The artificial reef 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 species including seabirds can ingest or become entangled in marine debris, such as plastics. In order to reduce this potential impact on seabirds, 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 and discarded fishing gear (refer Table 18).

Following deployment of the reef, 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. Incidents involving threatened and/or protected species include:

- Reports from reef users of incidental capture;
- Visual identification reports from reef users;
- Interaction with any of the DPI monitoring protocols including baited remote video, unbaited video drops, ROV, diver census or acoustic interactions of tagged animals with the VR4 receiver attached to the reef;
- Any interaction that involves the death of a threatened or protected species will be immediately reported to the NSW Office of Environment and Heritage (OEH).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 recreational fishing reef 'User Guidelines'.

Table 4. Threatened and protected species in the Port Macquarie area

Class	Scientific Name	Common name	Status under TSC/FM Act	Status under EPBC Act
Aves	*Ardenna carneipes*	Flesh-footed Shearwater	V	LM, M
Aves	*Ardenna pacificus*	Wedge-tailed Shearwater		LM, M
Aves	*Ardenna tenuirostris*	Short-tailed Shearwater		LM, M
Aves	*Catharacta skua*	Great Skua		LM
Aves	*Chroicocephalus novaehollandiae*	Silver Gull		LM
Aves	*Diomedea epomophora epomophora*	Southern Royal Albatross		V, LM, M
Aves	*Diomedea epomophora sanfordi*	Northern Royal Albatross		E, LM, M
Aves	*Diomedea exulans antipodensis*	Antipodean Albatross	V	V, LM, M
Aves	*Diomedea exulans exulans*	Tristan Albatross		E, LM, M
Aves	*Diomedea exulans gibsoni*	Gibson's Albatross	V	V, LM, M
Aves	*Diomedea exulans (sensu lato)*	Wandering Albatross	E	V, LM, M
Aves	*Eudyptula minor*	Little Penguin		LM
Aves	*Falco cenchroides*	Nankeen Kestrel		LM
Aves	*Fregetta grallaria grallaria*	White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian)	V	V
Aves	*Haliaeetus leucogaster*	White-bellied Sea-Eagle		LM, M

Aves	*Haliastur indus*	Brahminy Kite		LM
Aves	*Haliastur sphenurus*	Whistling Kite		LM
Aves	*Macronectes giganteus*	Southern Giant-Petrel	E	E, LM, M
Aves	*Macronectes halli*	Northern Giant-Petrel	V	V, LM, M
Aves	*Morus serrator*	Australasian Gannet		LM
Aves	*Onychoprion fuscata*	Sooty Tern	V	LM
Aves	*Pachyptila turtur*	Fairy Prion		LM
Aves	*Pandion cristatus = haliaetus*	Eastern Osprey	V	LM, M
Aves	*Pelecanus conspicillatus*	Australian Pelican		LM
Aves	*Pterodroma leucoptera leucoptera*	Gould's Petrel	V	E, LM
Aves	*Pterodroma neglecta neglecta*	Kermadec Petrel (western)	V	V, LM
Aves	*Puffinus carneipes*	Flesh-footed Shearwater, Fleshy-footed Shearwater		LM, M
Aves	*Puffinus leucomelas*	Streaked Shearwater		LM, M
Aves	*Sternula albifrons*	Little Tern	E	LM, M
Aves	*Thalassarche bulleri*	Buller's Albatross, Pacific Albatross		V, LM, M
Aves	*Thalassarche cauta*	Shy Albatross	V	V, LM, M
Aves	*Thalassarche cauta salvini*	Salvin's Albatross		V, LM, M
Aves	*Thalassarche cauta steadi*	White-capped Albatross		V, LM, M
Aves	*Thalassarche eremita*	Chatham Albatross		E, LM,M
Aves	*Thalassarche melanophris*	Black-browed Albatross	V	V, LM, M
Aves	*Thalassarche melanophris impavida*	Campbell Albatross		V, LM, M
Aves	*Thalasseus bergii*	Crested Tern		LM
Mammalia	*Arctocephalus forsteri*	New Zealand Fur-seal	V	LM
Mammalia	*Arctocephalus pusillus doriferus*	Australian Fur-seal	V	LM
Mammalia	*Balaenoptera acutorostrata*	Minke Whale		Cet
Mammalia	*Balaenoptera edeni*	Bryde's Whale		Cet, LM
Mammalia	*Balaenoptera musculus*	Blue Whale	E	E, Cet, LM
Mammalia	*Caperea marginata*	Pygmy Right Whale		Cet, LM
Mammalia	*Delphinus delphis*	Common Dophin, Short-beaked Common Dolphin		Cet

Mammalia	*Dugong dugon*	Dugong	E	LM, M
Mammalia	*Eubalaena australis*	Southern Right Whale	E	E, Cet, M
Mammalia	*Grampus griseus*	Risso's Dolphin, Grampus		Cet
Mammalia	*Hydrurga leptonyx*	Leopard Seal		LM
Mammalia	*Lagenorhynchus obscurus*	Dusky Dolphin		Cet, M
Mammalia	*Megaptera novaeangliae*	Humpback Whale	V	V, Cet, M
Mammalia	*Orcinus orca*	Killer Whale, Orca		Cet, M
Mammalia	*Peponocephala electra*	Melon-headed Whale		Cet
Mammalia	*Sousa chinensis*	Indo-Pacific Hump-backed Dolphin		Cet, M
Mammalia	*Stenella attenuata*	Spotted Dolphin		Cet, M
Mammalia	*Stenella coeruleoalba*	Striped Dolphin		Cet
Mammalia	*Tursiops aduncus*	Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin		Cet
Mammalia	*Tursiops truncatus*	Bottlenose Dolphin		Cet
Pisces	*Girella cyanea*	Bluefish	P	
Pisces	*Paraplesiops bleekeri*	Eastern blue devil fish	P	
Pisces	*Anampses elegans*	Elegant wrasse	P	
Pisces	*Epinephelus coioides*	Estuary cod	P	
Pisces	*Acentronura tentaculata*	Shortpouch Pygmy Pipehorse	P	LM
Pisces	*Carcharias taurus (east coast population)*	Grey Nurse Shark (east coast population)		CE
Pisces	*Carcharias taurus Rafinesque*	Grey Nurse Shark	CE	
Pisces	*Carcharodon carcharias*	Great White Shark	V	V, M
Pisces	*Epinephelus daemelii*	Black Rockcod, Black Cod, Saddled Rockcod	V	V
Pisces	*Epinephelus lanceolatus*	Giant Queensland groper	P	
Pisces	*Festucalex cinctus*	Girdled Pipefish	P	LM
Pisces	*Filicampus tigris*	Tiger Pipefish	P	LM
Pisces	*Heraldia nocturna*	Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish	P	LM
Pisces	*Hippichthys heptagonus*	Madura Pipefish, Reticulated Freshwater Pipefish	P	LM
Pisces	*Hippichthys penicillus*	Beady Pipefish, Steep-nosed Pipefish	P	LM
Pisces	*Hippocampus whitei*	White's Seahorse, Crowned Seahorse, Sydney Seahorse	P	LM
Pisces	*Histiogamphelus briggsii*	Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish	P	LM
Pisces	*Lamna nasus*	Porbeagle, Mackerel Shark		M

Pisces	*Lissocampus runa*	Javelin Pipefish	P	LM
Pisces	*Manta birostris*	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray		M
Pisces	*Maroubra perserrata*	Sawtooth Pipefish	P	LM
Pisces	*Phyllopteryx taeniolatus*	Weedy seadragon	P	LM
Pisces	*Pristis zijsron*	Green Sawfish, Dindagubba, Narrowsnout Sawfish	PE	V
Pisces	*Rhincodon typus*	Whale Shark		V, M
Pisces	*Solegnathus dunckeri*	Duncker's Pipehorse	P	LM
Pisces	*Solegnathus spinosissimus*	Spiny Pipehorse, Australian Spiny Pipehorse	P	LM
Pisces	*Solenostomus cyanopterus*	Robust Ghostpipefish, Blue-finned Ghost Pipefish,	P	LM
Pisces	*Solenostomus paegnius*	Rough-snout Ghost Pipefish	P	LM
Pisces	*Solenostomus paradoxus*	Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish	P	LM
Pisces	*Sphyrna lewini*	Scalloped Hammerhead Shark	E	
Pisces	*Sphyrna mokarran*	Great Hammerhead Shark	V	
Pisces	*Stigmatopora nigra*	Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish	P	LM
Pisces	*Syngnathoides biaculeatus*	Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish	P	LM
Pisces	*Thunnus maccoyii*	Southern Bluefin Tuna	E	CD
Pisces	*Trachyrhamphus bicoarctatus*	Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish	P	LM
Pisces	*Urocampus carinirostris*	Hairy Pipefish	P	LM
Pisces	*Vanacampus margaritifer*	Mother-of-pearl Pipefish	P	LM
Reptilia	*Caretta caretta*	Loggerhead Turtle	E	E, LM, M
Reptilia	*Chelonia mydas*	Green Turtle	V	V, LM, M
Reptilia	*Dermochelys coriacea*	Leatherback Turtle, Leathery Turtle, Luth	E	E, LM, M
Reptilia	*Eretmochelys imbricata*	Hawksbill Turtle		V, LM, M
Reptilia	*Hydrophis elegans*	Elegant Seasnake		LM
Reptilia	*Natator depressus*	Flatback Turtle		V, LM, M
Reptilia	*Pelamis platurus*	Yellow-bellied Seasnake		LM

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.

5 Indicative module design, reef configuration and construction

Final reef module design, project staging and load out facilities will be confirmed following completion of a public design and construct tender by DPI. A summary of the fabrication an installation process is provided below based on experiences gained from the successful installation and operation of the Sydney and Shoalhaven offshore artificial reefs.

5.1 Material

The preferred module design to be used for the Port Macquarie offshore artificial reef will 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, tenders by prospective design, fabrication and deployment contactors will need to be detailed and address all tender specifications set my DPI. For example, the winning reef modules design for the Shoalhaven offshore artificial reef (won and executed by Subcon Technologies Pty Ltd) resulted in the development of the ReefTemple™ module that optimised fabrication and installation parameters while maintaining its performance in terms of structural stability and biological attributes 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.

A minimum 28 day curing period during fabrication is used to ensure full structural strength for the 50MPa concrete and stabilised pH prior to deployment.

The contractors design, construct and install management team contracted by the DPI for this project will be required to demonstrate extensive experience in Offshore Construction, Marine Science, Concrete Fabrication and Offshore Installation to provide the highest safety and quality standards for marine operations based on industry best practices.

Figure 6. The ReefTemple™ artificial reef modules being installed off Shoalhaven Heads in January 2015

5.1.1 Indicative reef design and module dimensions

Final modules numbers and dimensions will be known following completion of the D&C tender. Specifications for the reef design will provide for a multicomponent reef with between 20-40 modules with a 1600m^3 total volume arranged in 5 clusters (Figure 6).

The module will be required to be constructed from appropriately reinforced 50MPa concrete to AS3600 for marine environments designed to withstand a 1 in 100 year storm event. The modules will be require to provide vertical relief whilst providing a highly complex habitat for permanently recruiting nearshore finfish species including: yellowtail scad, yellowtail kingfish, mulloway and snapper.

The modules will need to create shade and modify lateral water flow as demonstrated by tank tests at University of Western Australia (UWA) (Figure 7) on the Reef Temple design and will be required to operate effectively in a mobile sand substrate environment. 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 to be used in the fabrication of the modules.

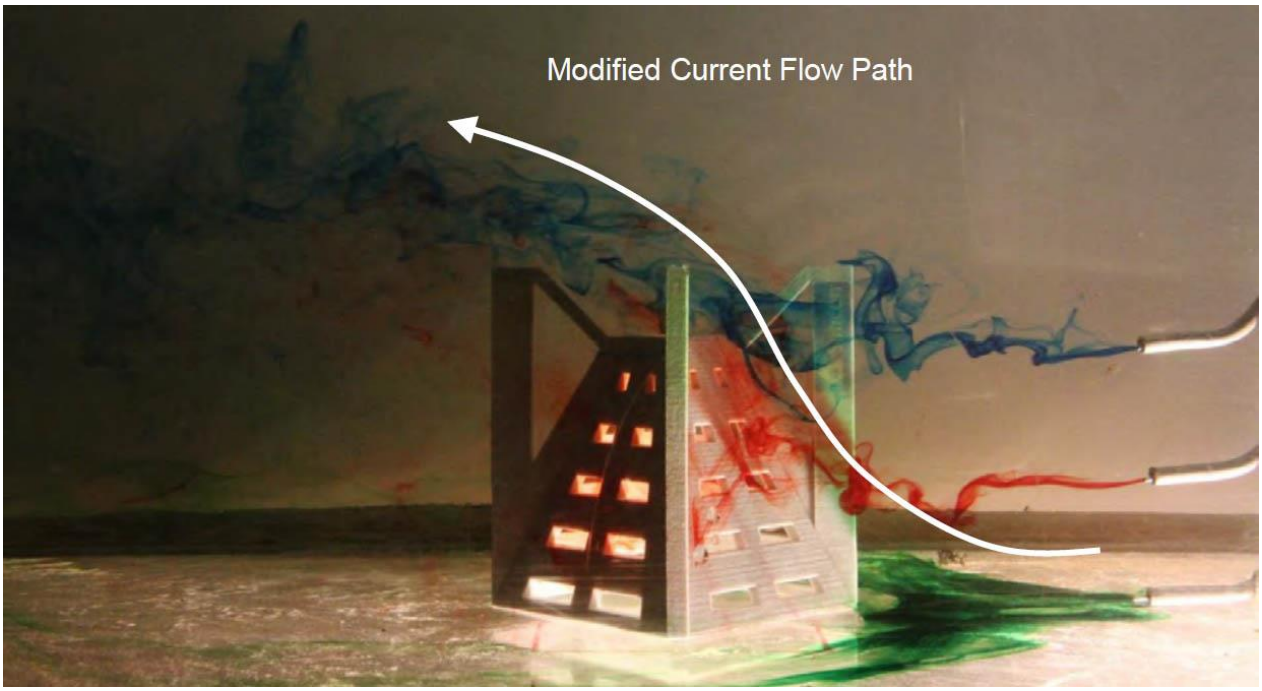

Figure 7. Flow modification testing of the Reef Temple at the University of WA, Flume Tank

5.1.2 Indicative reef construction and staging methodology

The following is a guide to the anticipated fabrication and deployment process. Following the public release of an open Request for Tender (RFT) by DPI for the design, construction and deployment of the proposed offshore artificial reef and subject to DPI approval, one contractor will be appointed to undertake and oversee all stages of the project. This would include:

- selection of an appropriate site for the fabrication of the structures;
- pre-construction inspection and planning;
- fabrication;
- loading and transportation;
- deployment; and
- decommissioning of the land-based construction site.

Figure 8. Fabrication 'hard-stand' reef module site at Port Kembla in December 2014

5.1.3 Fabrication hardstand and inspection site

The units will be prefabricated on land at an approved construction and fabrication yard, close to the load out facility. Post fabrication, each unit will be independently inspected and certified fit for use.

Once fabrication and certification are complete, the units would be loaded onto a barge for transportation to the offshore location. The method of load out shall be at the contractor's discretion and the contractor would be fully responsible for the structural integrity of the structures during this process.

It is estimated that the load out and subsequent transportation and deployment of the units would occur over a 1 week period (weather dependent). If the load out location is located within 20 km of the site, it is feasible that once load out is completed, the units could be transported and installed within 3–4 days. If the fabrication and load out facility is situated a larger distance from the Port Macquarie reef site, a greater deployment period may be required.

The contractor would consult the weather forecast for NSW coastal waters to ensure weather conditions are suitable for deployment. Deployment of the units would not be permitted unless the current sea state and its direction is less than the maximum safe values determined by the transport stability analysis and unit lift analysis. Once the units have reached the offshore location, the units will be inspected to ensure no damage has occurred prior to deployment. If any damage has occurred, it may be necessary to return the units to shore to carry out repairs or, alternatively, minor repairs could be conducted on board the barge.

Once the units have reached the reef site the barge would be anchored in position at the required coordinates using DGPS and an anchor handling tug (Figure 10). Once the barge is secured in position, the units would be lifted by crane and lowered into the sea to their final resting position on the seabed. A surface remote camera inspection would then be carried out to ensure the units are in the required position. During the lifting procedure, appropriate temporary

navigational aids would be provided on the structure and surrounding vessel. Anchor buoys would also be positioned at the anchor locations. Within 2 weeks of completion of the reef installation, a hyrographic survey of the reef site will be completed including a detailed bathymetry map with safe vessel clearances (LAT) will be supplied to the Naval Hydrographic Office for inclusion in coastal marine chart updates and release as a Notice to Mariners. This information will also be supplied to the NSW Roads and Maritime Service.

Figure 9. Tug setting deployment barge anchors at the Shoalhaven offshore artificial reef site in January 2015

5.2 Reef Deployment site

The location of the proposed reef deployment is situated just offshore of the mouth of the Hastings River estuary, north-east of Port Macquarie at an approximate depth of 44 m LAT. The size of the deployment and management area is 250 m x 250 m and the centre point of the reef area is 31°25.044 S, 152°58.95 E (WGS84) (Figure 10).

5.2.1 Geographical position (latitude and longitude)

Table 5. Geographical position of the proposed reef patches*

Corner	Latitude	Longitude	Latitude (Dec. Deg.)	Longitude (Dec.Deg.)
Centre Patch	31º25.044’ S	152º58.950’E	-31.4174	152.9825
Northern Patch	31º25.014’ S	152º58.950’E	-31.4169	152.9825
Eastern Patch	31º25.044’ S	152º58.980’E	-31.4174	152.9830
Southern Patch	31º25.074’ S	152º58.950’E	-31.4179	152.9825

Western Patch	31º25.044’ S	152º58.920’E	-31.4174	152.9820

*Coordinates are in Datum WGS84

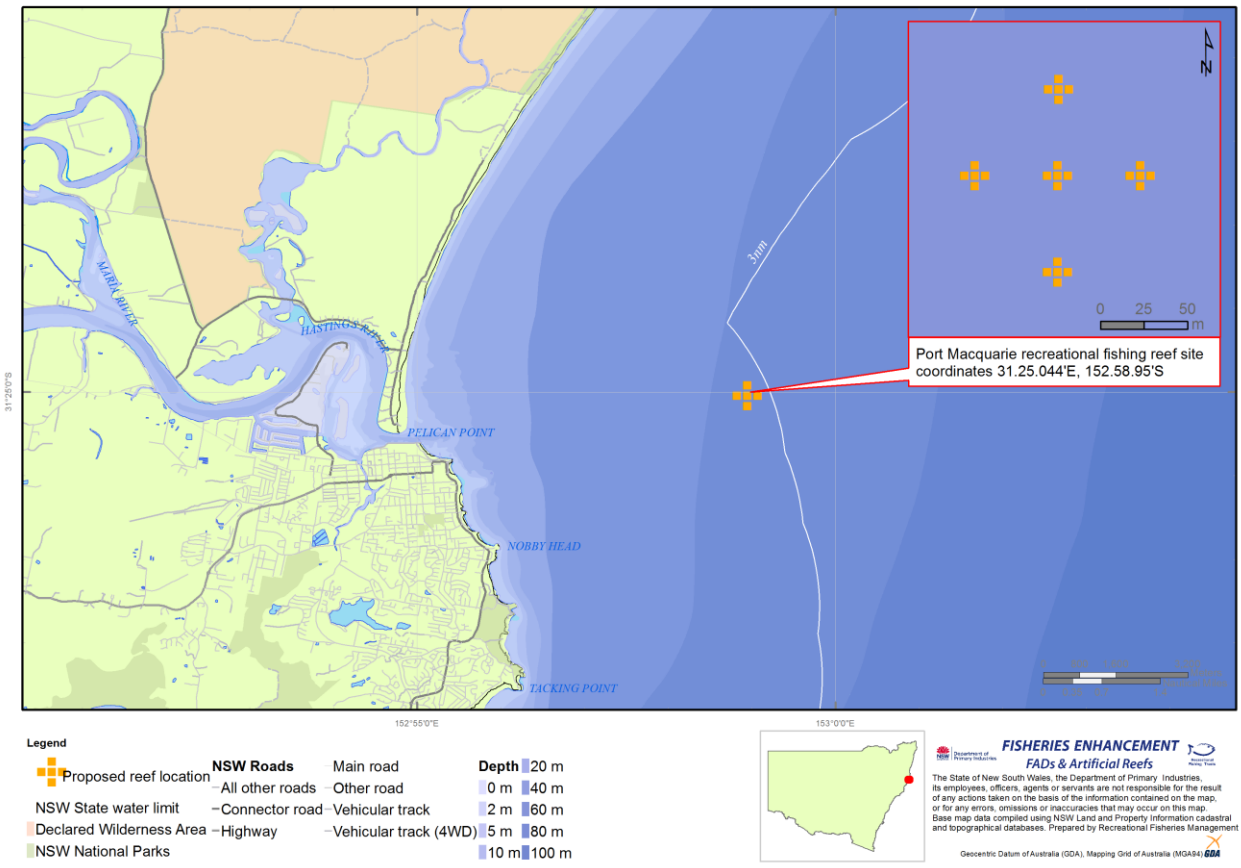

Figure 10. Map of geographical locations for each of the proposed reef modules

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 20–50 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 3.2.1 ‘Constraints mapping and site selection’ in the EA for further information.

5.2.4 Distance from nearest land

The location of the proposed reef deployment site is situated offshore of the mouth of the Hastings river 6.3km east of the river mouth, 7.37km north east of Tacking Point and 10.5km south west of Point Plummer as shown in Figure 11.

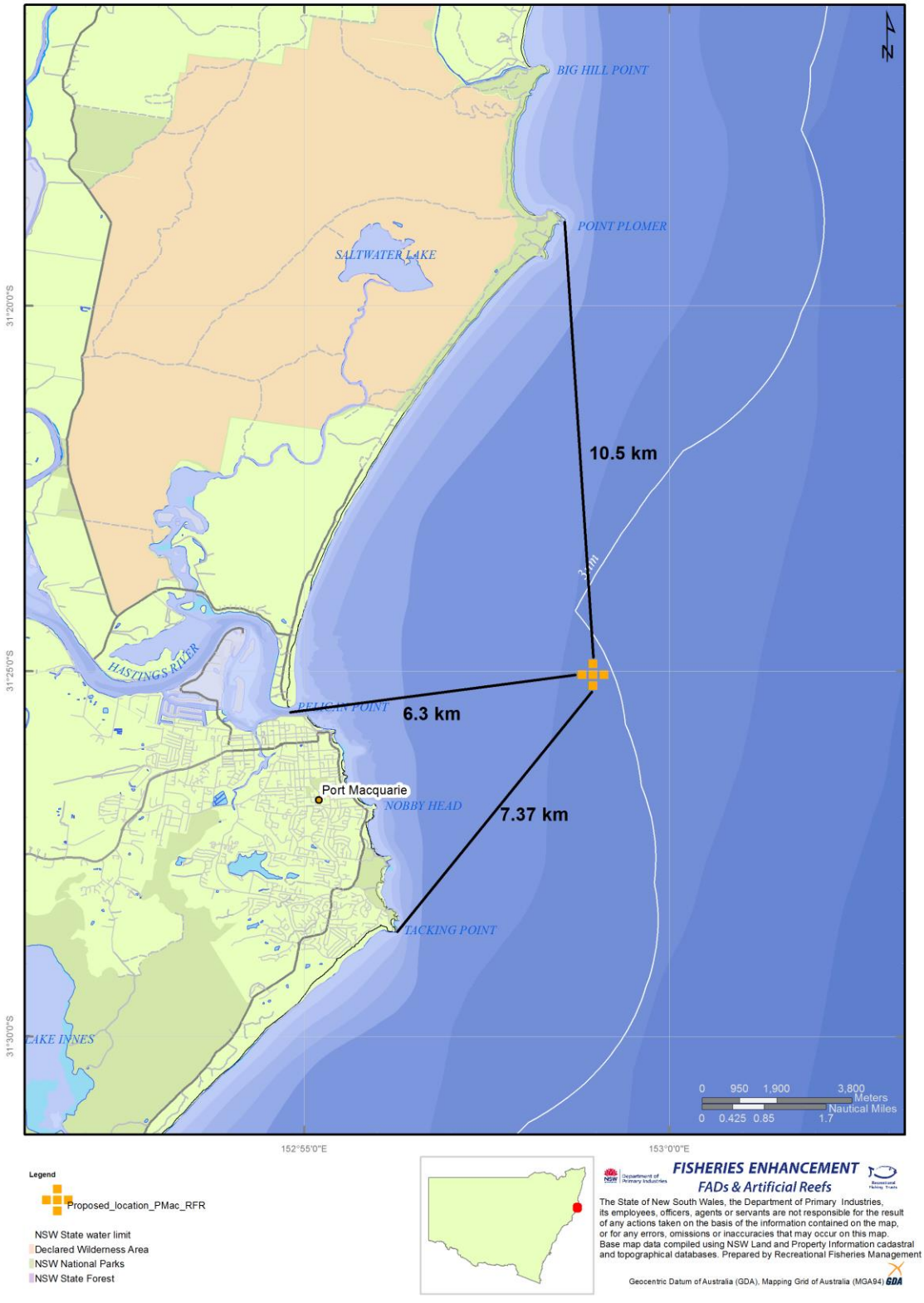

Figure 11. Map showing proposed reef location and distances to nearest land

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.

The nearest natural reef is located approximately 2.5km SSW of the reef deployment site. An adequate buffer of approximately 0.5km between the existing natural reef and artificial reef sites in order to reduce the effect of 'draw-down' (that is individuals readily moving from the natural reef onto the artificial reef) is required as open sand/sediment expenses present a perceived impassable barrier to many demersal reef associated fish species.

Refer to section 3.2.1 '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

SWATH acoustic mapping results from the backscatter mosaic of bottom hardness data described 3 distinct textural (substrate) types across the survey area off Port Macquarie. Reef was described by highly variable backscatter or range of backscatter intensities over a small (10s of m) area. In greyscale these features appear as areas of mottled appearance ranging from dark-grey to white. A second substrate type covered the largest proportion (northern and central sections) of the survey and was observed as areas of relatively high scatter-low seabed return (light-coloured grey to white) within the mosaic. Irregular areas of relatively stronger seabed returns (medium to dark grey) described a third textural type. These areas of moderate backscatter were observed in the south in areas of seafloor lying in between reefs. These are likely to describe areas of harder seabed and intermediate (coarse sand, gravel, pebble, cobble) substrate types. From these results the proposed deployment area for the offshore artificial reef is dominated by soft sediments (sand, shell grit and finer sediments) of an unspecified depth likely to be in excess of 5 metres in depth. This presents a perfect site for reef installation located an adequate distance from natural reef with no underlying rocky reef identified.

Impacts on Soft sediment assemblages

Offshore artificial reefs are considered to be most effective when placed in bare, sandy, 'rocky-reef habitat limited' environments. Selection of reef sites has therefore focussed on areas known or likely to consist of sandy substratum away from areas of naturally occurring reef. Soft sediment habitats can support extremely diverse macrofaunal assemblages. Results of the benthic study (Technical Report E) have shown that invertebrate assemblages associated with soft sediment habitats vary significantly at the broad-scale (locational level) i.e. by several kilometres, but not at the fine scale i.e. distances of 100 m (at the site level). Observational field data also suggest that the differences observed between locations may be associated with the coarser grain size which is located to the northern end of the study area. In terms of percentage contribution, crustaceans (62%) were the most numerically abundant of the major taxonomic groups, followed by polychaetes (22%), other worm phyla (9%), molluscs (5%), echinoderms and other phyla (both contributing only 1% of total abundance). It is likely that the Port Macquarie OAR site experiences a greater influence of fine sediment input from the Hastings River Estuary during and after major rainfall events.

Initial deployment of the OAR units is expected to cause localised disturbance and re-suspension of sandy sediment in the area where the units are installed which may result in mobile macroinvertebrates being temporarily displaced. A large proportion of animals living within the direct footprint of where individual modules are placed would also be lost through smothering. This would be limited to an area of <500sq. m. This loss of sandy habitat occupied by the reef modules, would, however, be negligible when considered in context with the extensive areas of similar habitat within the reef installation area. Soft-bottom habitats adjacent to artificial reefs would be partially affected by current patterns and some minor scouring and deposition which may consequently affect grain size. It is possible that species numbers and/or diversity in sandy habitat adjacent to the reefs may decrease as a result of increased predation by benthic and demersal fish or decapods attracted to and/or growing on the reef, feeding in the adjacent sandy habitat. This effect is known as a 'feeding halo'. Halo effects of reefs may be confined to areas very close to a reef (within a few metres) or extend over a much larger area and may depend on the size of the reef and/or the trophic structure of fish occupying it. Furthermore, the habitat will continue to support a wide variety of marine organisms found living on or over soft sandy substrata. Increased predation on benthos is therefore not considered to have a significant impact within the wider study area.

Table 6. Risk assessment of soft sediment assemblages considered in the reef assessment

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Flora and Fauna						
Benthos	Sub-Local	Direct loss of habitat	A5	Accept risk, Efficient design of footprint to minimise loss of sedimentary habitat.	None	A5
Benthos	Local	Change to sedimentary characteristics	B5	Accept risk.	None	B5
Sediments and Water	Local	Leaching of contaminants	D5	Australian Standard marine concrete to be used.	Reduce Likelihood	D5

Impacts on adjacent rocky reef assemblages

It is considered likely that initial increases in fish numbers would be a result of attraction and aggregation, but that over time (once the reef has become established), the reefs would contribute to overall production. The extent of impact on neighbouring natural reef may also depend on the size of the natural reef with impacts likely to be greater for a smaller neighbouring reef than a larger one. As a precautionary measure, maximum separation of the offshore artificial reef units from existing natural reef was aimed for as part of the constraints mapping in order to minimise potential draw-down effects. The convenience and likely popularity of the offshore artificial reefs could attract more recreational fishers, increase participation and length of time fishing and thus increase fishing effort rather than simply redistributing it. However it is much more likely that fishing effort would not increase as a result of the deployment of the reef. Rather, it would merely transfer from other areas as access to the reef would be limited to boat based fishers. This transfer of fishing effort could result in an increase in fishing pressure on a localised scale but would in turn potentially offer some relief to other areas that would have previously been fished. Therefore an increase in fishing effort is not considered to have a significant impact within the wider study area. In summary, the site specific surveys conducted by DPI supported the hypothesis that it is expected that the new offshore artificial reef will

support a wide variety of reef associated fish species. However, the community is likely to be made up of a larger number of species with greater diversity as the structure will likely provide ample space for both sand and reef associate species. Impacts on soft sediment and rocky reef assemblages are discussed in detail in Section 8.2.2 of the EA.

Table 6. Risk assessment of rocky reef assemblages 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	B5	Accept risk.	None	B5
Benthos	Local	Increased predation by fishes from the offshore artificial reef on benthos	B5	Accept risk.	None	B5
Benthos	Regional	Commercial trawling in areas not previously trawled	C5	Not a major trawl area, but mitigate through adaptive management	Reduce Likelihood	D5
Proximal Natural Reef	Intermediate	Changes to benthic assemblages	C5	Offshore artificial reef will be positioned several kms away from existing reef Swath mapping will be carried out to confirm the presence of reef habitat	Reduce Likelihood and Consequence	E4
	Intermediate	Drawdown effects	A5	Accept but monitor.	None	A5
	Intermediate	Increased fishing effort leading to increased fish mortality	B4	Existing bag and catch limits and surveillance.	None	B4

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 Port Macquarie area and surrounds are listed in Table 7 and their locations indicated in Figure 12. There are a total of 7 boat ramps within 20 km of the proposed offshore artificial reef site. This list includes a ramp at Point Plomer, and 6 ramps located within the Hastings River.

Table 7. Boat ramps and facilities within 20 km of the proposed reef site

NAME	FEE PAYABLE	WATERWAY ACCESS	DISABLED ACCESS	CONSTRUCTION	CONDITION	SIZE LANES	VESSEL WASH DOWN	LIGHTING	PUMP OUT	FISH CLEAN	FUEL	KIOSK	BBQ	TOILETS
Point Plomer (offshore)	×		×			0	×	×	×	×	×	×	✓	✓
Sea Rescue ramp Pt Mac-Hastings River	×	All times	×	Concrete	Good	1	×	✓	×	×	×	×	×	×
Plaza Car park Pt Mac-Hastings River	×	All times	×	Concrete	Good	2	×	✓	×	✓	×	✓	×	×
West Port Park Pt Mac-Hastings River	×	All times	✓	Concrete	Excellent	3	✓	✓	×	✓	×	×	×	✓
McInherny Park, Settlement Point – Hastings River	×	Shallow at times	×	Concrete	Good	1	×	×	×	✓	×	✓	✓	✓
Blackmans Point – Hastings River	×	Shallow at times	×	Concrete	Poor	1	×	×	×	×	×	×	×	×
Fernbank Creek – Hastings river	×	Shallow at times	×	Concrete	Poor	2	×	×	×	×	×	×	×	×

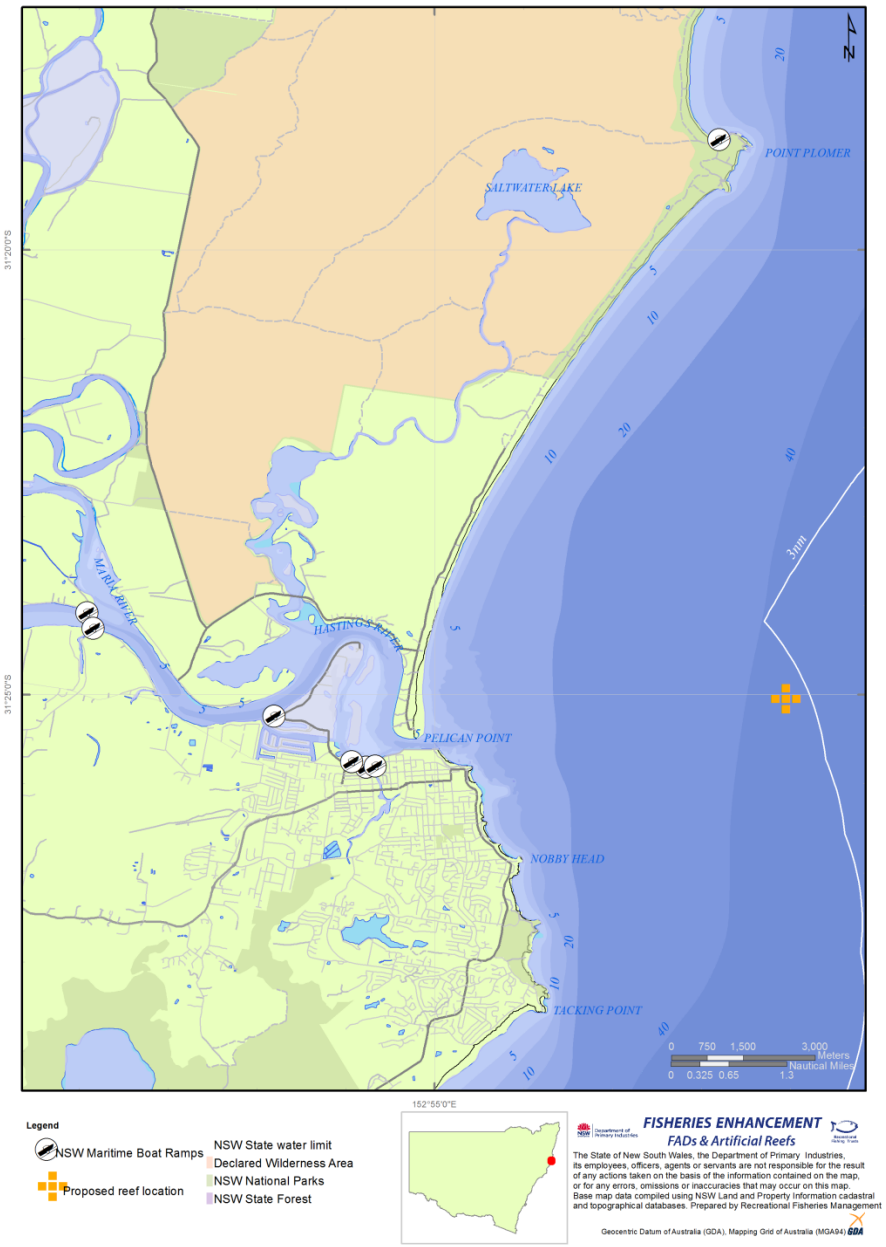

Figure 12. Boat ramps in the study region

5.2.7.2 Navigation

The proposed offshore artificial reef location has the potential to 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 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 Port Macquarie offshore artificial reef. Actual clearance is expecte to be >30 metres (LAT).

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 8. Risks and mitigation associated with clearance

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Navigation and Safety	Local	Clearance	E2	Appropriate site selection and mapping on navigation charts.	Reduce Likelihood	E2

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 9. Risks and mitigation associated with increased vessel traffic

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Recreational and Commercial Fishing	Local	Collision from crowding	C4	Surveillance, monitoring and education (user guidelines and code of practice), adaptive management.	None	C4

5.2.7.5 Exploitation of cultural, historic or scientific interest

Conflict with areas of spiritual significance/dreaming's

The current coastline was formed when the sea level stabilised approximately 7,000 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 between 20 and 40 metres underwater, and is understood to be functionally flat, sandy with no exposed surfaces that may formerly have been ground surface prior to inundation, 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;
- there is a low possibility of Aboriginal objects being transported to the project area by natural or assisted means; and
- if Aboriginal objects are present within the project area, they are likely to have been buried by natural coastal processes.

Technical Report B summarised that it is considered that the project has a very low likelihood of resulting harm to Aboriginal objects. This is a result of the location of the project area off shore and the minimal ground disturbance associated with the project.

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 OEH (North-East Directorate) for further advice.

Table 10. Risks and mitigation associated with conflict with areas of spiritual significance/dreaming's

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Heritage	Intermediate	Conflict with areas of spiritual significance/dreaming's	C3	Appropriate site selection identified through consultation and background research (specialist report)	None	E3

Historic shipwrecks

A desktop review of shipwrecks known or potentially occurring in the direct study areas was carried out in the constraints analysis report (Technical Report A). Information was sourced from database search of the Australian National Shipwreck Database [20] (Table 11).

40 vessels have been wrecked near the proposed deployment area, however there are only four of these 40 wrecked vessels mapped, these vessels are:

- the Ballina which was wrecked at the mouth of the Hastings River in 1879 the ship was a side wheel paddle streamer that ran aground; no lives were lost in the collision. The wreck is protected by the *New South Wales Heritage Act 1977*
- the Wotonga which was wrecked near Tacking Point in 1882 and was a twin screw steamer that was wrecked due to a navigational error; no lives were lost during the accident. The Wotonga is protected by *Commonwealth Historic Shipwrecks Act 1976*.
- the Black Jack which was wrecked off the bar at Port Macquarie in 1822 the ship was made from wood and was wrecked due to pilots neglect; no lives were lost in the incident. The wreck is protected by the *Commonwealth Historic Shipwrecks Act 1976.*
- the Mary Ann was driven onto the rocks south of Port Macquarie in 1825 the ship was made from wood and was wrecked due to the collision with the rocks; no lives were lost in the collision. The wreck is protected by the *Commonwealth Historic Shipwrecks Act 1976.*

These shipwrecks are protected by heritage protection legislation and fall some distance outside of the proposed deployment area such that no modification to the deployment area is necessary to avoid impact or interaction with either of the historical wrecks.

The 36 unfound wrecked vessels from within the Port Macquarie area pose a potential deployment concern for the offshore artificial reef as the placement of the reef must not impede upon a historical shipwreck. SWATH acoustic mapping of the proposed final deployment site further confirmed that there are no unreported or undiscovered historic sites within the deployment area.

Table 11. Submerged shipwrecks known to occur within the wider study regions

Vessel name	Vessel type	Year wrecked	Wreck location
Admiral Gifford	Sailing vessel	1914	Port Macquarie, Big Hill, nth of Point Plummer
Aleda	Side wheel paddle steamer	1879	Port Macquarie, entrance to Hastings River
Ballina	Sailing vessel	1891	Port Macquarie, north spit
Barrangarry	Sailing vessel	1823	Port Macquarie, off bar
Black Jack	Sailing vessel	1879	Port Macquarie Heads

Bronzewing	Sailing vessel	1832	Port Macquarie bar
Dart	Unknown	1948	Port Macquarie, 30 mls north of
Devare	Sailing vessel	1833	Port Macquarie/Trial Bay, off
Deveron	Sailing vessel	1880	Camden Haven and Port Macquarie, between
Emmeline	Sailing vessel	1834	Sydney to Port Macquarie, between
Fairy	Sailing vessel	1864	Port Macquarie, Point Plummer, near ? (Loney)
Guiding Star	Single screw steamer	1937	Port Macquarie bar
Hastings	Sailing vessel	1824	Port Macquarie, off
Isabella	Sailing vessel	1898	Port Macquarie bar
Jessie Sinclair	Single screw steamer	1885	Port Macquarie bar, near gaol
Josephine	Sailing vessel	1917	Port Macquarie, Tacking Pt, on bch to south
Korora	Sailing vessel	1886	Port Macquarie, Tacking Pt, 1.5 mls Nth of
Lizzie Davis	Twin screw steamer	1884	Port Macquarie, off
Madjus	Sailing vessel	1825	Port Macquarie, southward
Mary Ann	Sailing vessel	1881	Port Macquarie, 50mls east of
Metaris	Sailing vessel	1880	Port Macquarie, off
Minnie Lowe	Sailing vessel	1860	Port Macquarie 16-30mls SE of
Mousam	Sailing vessel	1880	Port Macquarie, seen near
Naomi	Single screw steamer	1933	Port Macquarie
Narani	Sailing vessel	1878	Crowdy Head, off (12mls off Port Macquarie)
Octoroon	Sailing vessel	1835	Port Macquarie, ashore
Port Macquarie Packet	Single screw steamer	1884	Port Macquarie, inside the bar
Richmond	Sailing vessel	1825	Port Macquarie, entrance
Sally	Trawler	1931	Woody Head, near Hat Head nth of Port Macquarie
Sea Lark	Motor vessel	1946	Port Macquarie
Somaki	Twin screw steamer	1923	Port Macquarie to Crescent Head
Sumatra	Single screw steamer	1907	Port Macquarie bar, north side
Trilby	Sailing vessel	1903	Port Macquarie, Tacking Point, off
Triumph	Sailing vessel	1866	Port Macquarie bar, rocks near Pilot Station
Vixen	Sailing vessel	1906	Port Macquarie bar
Wanderer	Sailing vessel	1851	Port Macquarie, Gaol Point
Wanderer	Twin screw steamer	1943	Port Macquarie, Crescent Head
Wollongbar	Sailing vessel	1866	Port Macquarie, Tacking Pt, beached near? (Loney)
Woodpecker	Twin screw steamer	1882	Port Macquarie near Tacking Point

5.2.7.6 Fishing

Loss of commercial fishing ground

Commercial fisheries with the potential to be affected by the proposal include the Ocean Trap and Line, Estuary General, Ocean Trawl, Ocean Haul and the Lobster Fishery. 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 12. 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	C4	Not major trawl area Consultation with main commercial operators and avoid important areas.	None	D4

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 13. 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 and adaptive management	Reduce Consequence	D4

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.

The reef is considered to be a success based on three primary objectives:

(i) Fish and benthic community development: the community identified to reside on the structure, although expected to be structurally different in terms of species diversity should be comparable in terms of species richness to adjacent natural reef communities;

(ii) Structural integrity and module stability: the reef remains intact and structurally sound throughout its design life (30 years);

(iii) Stakeholder acceptance: the installation of the reef results in angler satisfaction reflected by high visitation rates.

If one or all of these objectives fail to be met, a number of mitigative actions may be required. For example, if following the deployment of the reef the community is identified to be mono-specific in terms species richness with a clear dominance of a small suit of species including aggregation of a threatened or protected species, input controls such as gear or seasonal restrictions may require implementation. Depending on the species in question, restrictions may

include the exclusion of bottom fishing with live bait and wire trace (aimed at reducing the likely hood of incidental capture of threatened species such as the greynurse shark (*Carcharias Taurus*) or the temporary closure of the reef during peak spawning periods in-line with key target species (e.g. early winter for inshore snapper - Pagrus auratus).

Regular inspections of the reef during the initial 3 year post deployment period followed by periodic inspections over the design life of the reef will be implemented to investigate structural integrity of the reef and to identify any potentially detrimental issues related to the stability of the modules. Inspections will look for any obvious physical damage either from anchor damage or following a large storm events that produce a significant wave height (Hs) in excess of 4.1 metres (i.e. cracks that may allow saltwater ingress) or evidence of module movement (sliding or over turning). If any of these impacts are identified, further investigations by the reef manufacturer (during the defects liability period) or by an appropriatly qualified engineering would be used to identify a suitable mitigative response. Responses may include reef repositioning in the event of module movement or removal on the event of salt water ingress and the risk this poses for concrete 'cancer' and the structural integrity of a specific module identified as being compromised.

Angler satisfaction is directly related to the useability and accessibility of the reef and the resultant community which takes up residence on the structures. Considerable attention been applied to the site selection process of the reef to ensure it is located in an area where there is strong support for the reef initiative and where stakeholers (e.g. recreational fishers) can safely access the reef from suitable boating infrastructure (e.g. boat ramps) and where natural reef is limiting (of which there is very little east of Port Macquarie). Documenting the development of the fish community and dissemination of these results through meetings, online media (DPI website), social media (Facebook) and popular press (including newspaper and fishing magazines) will ensure stakeholders are well informed as to the development of the reef. Angler satisfaction will be directly related to visitation rates and usage. If usage rates are low, increased distribution of information regarding the effectiveness of the structures may need to be adopted by the DPI.

Table 14. 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	D4	Implementation of long term monitoring plan (will include surveillance and creel surveys to report on usage). Reporting and dissemination of monitoring outcomes to stakeholders.	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 15. 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)	C3	Offshore artificial reef to be marked on nautical charts, and commercial operators to be consulted and notified of final position	None	D3
Recreational Fishing	Local	Gear hook-up (recreational)	A4	Surveillance and removal of debris when required. Education (user guidelines)	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 16. 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.	Reduce Consequence	D5

Injury or drowning (spearfishing)

It is anticipated that freedivers and spearfishers may 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. There is no provision to manage SCUBA diving activities under the current *Fisheries Management Act* or *Regulations*.

Safety issues including, but not limited to, the risk of gear fouling and risks to spearfishers and SCUBA divers cannot be mitigated but can be managed through education. The User Guidelines aim to provide the best possible information to inform different user groups on best practice and safety within the reef area.

Table 17. 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)	E1	Accept, education and awareness strategies.	None	E1

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 ([21]), the Bionet Database ([22]) and the Atlas of Living Australia, as well as literature relevant to the Port Macquarie area in May 2014. 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 4). 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.

Only threatened species (from the initial search) that were known or considered likely to occur in the wider Port Macquarie region (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 ([23, 24]). 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, 7 species of fish, 3 species of marine turtle, 3 species of cetacean, 1 sirenian, 2 pinnipeds and 13 species of seabird were assessed according to OEH and DPI threatened species assessment guidelines ([23, 24]).

Fish

The proposal was not considered to have a significant impact on any of the species identified in Table 4, hence Species Impact Statements (SIS) were not required.

Management of fishing related actives in NSW includes the implementation of a range of bag and size limits aimed at ensuring fisheries resources are managed in a consistent and sustainable manner state-wide. Current Fisheries Regulations make provisions for the exclusion of the harming or taking of protected or threatened species. Proper management of these regulations by compliance activities in the Shoalhaven region will ensure these regulations are adhered to by fishers. It is therefore unlikely that the artificial reef would pose an inflated threat to listed threatened and protected species.

Fish species considered most at risk from fishing related activities such as incidental capture including the great white shark (*Carcharodon carcharias*), grey nurse shark (*C. Taurus*) and southern bluefin tuna (*Thunnus maccoyii*) are highly migratory and the transient nature of these species means that although they may pass in the vicinity of the reef they are unlikely to remain

on the reef long enough to be vulnerable to the potential fishing related impacts identified. Passive and active monitoring of the reef through bait video, acoustic tagging and diver census will give adequate resolution by which the occurrence of these species will be identified. The reporting register for threatened and protected species provided to the DPI TSU at 6 monthly intervals will ensure assessment of numbers of threatened species are evaluated independently outside of the recreational and indigenous fisheries unit In addition, any serious incident involving threatened and protected species will be reported to the NSW Office of Environment and Heritage (OEH).

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. The nearest aggregation areas to the study area are Mermaid Reef, Diamond Head (near Laurieton) and Green Island and Fish Rock (near South West Rocks). 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 migrate past and forage outside of aggregation sites over open sandy habitat ([25]). This considered, it is possible that individual he Grey Nurse Shark could be at risk of incidental capture as a result of the proposal. Even if the 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.

The Offshore Artificial Reef User Guide contains information on how to identify and report sightings of threatened or protected species and how to properly release unwanted fish species safely and with as little impact on the individual as possible.

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 Port Macquarie area, the proposal was not considered to have a significant impact, such that a Species Impact Statement (SIS) would be necessary.

As part of the Environmental Assessment, a risk analysis workshop was held on 28 May 2013 and attended by representatives of Cardno (Ecology Lab) Pty Ltd including Dr Marcus Lincoln-Smith and the DPI (A detailed description of this risk assessment process can be found in Section 8 of the environmental assessment).

The aim of the workshop was to identify potential issues/hazards associated with the proposed Shoalhaven offshore artificial reef, to assess the likelihood of occurrence of such hazards and the consequence to key receptors if these hazards eventuated. Likely hazards facing pinnipeds and sirenians were deemed to include incidental capture, boat strike, acoustic disturbance and interruption to movement corridors. Based on the know distribution of these animals and the results from the Sydney offshore artificial reef, monitored in detail between October 2011 and October 2014 the risk of these threats were collectively agreed to be low to very low risk. No negative interaction with either pinnipeds or sirenians were recorded with only one identified pinniped being found on the reef over the three year monitoring period – an individual which was seen for a single monitoring day in March 2013.

Human activities in the ocean can affect seals by competing with them for prey, by entanglement (i.e. with fishing gear) and through noise. The threat to seals from the proposal comes from the expected increase in boating activity whereby there is potential for collision, entanglement in discarded fishing gear and increased noise disturbance. Australian fur-seals may use the reef area for occasional foraging, although the disturbance to the seals is considered to be relatively minor and unlikely to disrupt the life cycle of this species such that a viable local population of the species is placed at risk. The reef was not considered to represent a significant threat to the Australian fur-seal as there are no significant seal colonies in the proposed area and provided that management measures such as marine debris removal is adopted the level of risk presented to pinnipeds by the reef is very low.

In addition, existing restrictions on the distances of approach and interaction with marine mammals are regulated under the *NSW National Parks and Wildlife Regulation (2009)*.

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 ([26]) and the NSW government 'BioNet' database ([27]) 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 Port Macquarie 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 Port Macquarie area, 5 species were listed as 'endangered', 2 listed as 'vulnerable',7 as 'migratory' and 11 as 'vulnerable' and 'migratory' (Table 4) 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 Port Macquarie offshore artificial reef is proposed to be located within State waters approximately 450 m (0.24 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 ([28]). 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 ([29]).

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 ([29]). Department of the Environment has developed a draft Threat Abatement Plan to address the impacts of this KTP ([30]).

The majority of impacts identified are relevant to threatened or protected species only if they were to move and/or recruit into the direct study area. Threatened or protected species, populations or endangered ecological communities that are most likely to be affected by the deployment of the reef are those that would compete directly with the target fish or crustaceans for the same food or the newly created habitat. 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. A series of trigger points relating to threatened species has been established as part of the environmental management of the reef. As such, if aggregation of any given threatened species or a key non-threatened species within the reef area increases by an amount deemed 'of concern' by the DPI threatened species unit, this may require a modification to the management of the reef. These measures are deemed to potentially reduce the consequences of an aggregation of threatened species from a moderate risk to a low risk.

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 8 of the EA).

Table 18 Risk assessment of threatened and protected species considered in the risk assessment

Environmental Aspect	Scale	Risk Description	Risk Level	Mitigative Measure	Treatment Type	Risk Level
Threatened and Protected Species						
Fish	Local	Incidental capture	C4	Monitor incidences/tagging/listening stations, encourage reporting and angler education on best practice release guidelines.	Reduce Consequence	C4
	Local	Aggregation of threatened or protected species	C4	Monitor incidences/tagging/listening stations, encourage reporting and angler education on best practice release guidelines.	Reduce Consequence	C4
	Sub-Local	Loss of habitat	D5	Accept	None	D5
Marine Turtles	Local	Incidental capture	D4	Monitor incidences/tagging/listening stations, encourage reporting and angler education on best practice release guidelines.	None	D4
	Local	Increased risk of boat strike	D4	Monitor incidences/tagging/listening stations, encourage reporting and angler education on best practice release guidelines.	None	D4

	Intermediate	Increased risk of acoustic disturbance	E5	Monitor incidences/tagging/listening stations, encourage reporting and angler education on best practice release guidelines.	None	E5
	Large	Interruption of movement corridors	E5	Accept	None	E5
	Intermediate	Loss of habitat	E5	Accept	None	E5
Cetaceans	Local	Increased risk of boat strike	C4	Education regarding acceptable approach distances to cetaceans.	None	C4
	Intermediate	Increased risk of acoustic disturbance	D5	Education regarding acceptable approach distances to cetaceans.	None	D5
	Large	Interruption of movement corridors	D5	Education regarding acceptable approach distances to cetaceans.	None	D5
Pinnipeds and Sirenians	Local	Incidental capture/entanglement	D5	Accept	None	D5
	Local	Increased risk of boat strike (sirenians only)	D5	Accept	None	D5
	Intermediate	Increased risk of acoustic disturbance	D5	Accept	None	D5
	Large	Interruption of movement corridors	E5	Accept	None	E5
Seabirds	Local	Incidental capture or ingestion of marine debris	D5	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 and discarded fishing gear	None	D5
KTPs	Intermediate	Harm from marine debris and pollution (KTPs)	C3	Monitor for fouled gear and remove if necessary.	Reduce Consequence	D3
Invasive Marine Pests	Local	Colonisation by invasive (noxious/pest) marine pests	C4	Surveillance as part of other monitoring and adaptive management.	Reduce Likelihood & consequence	C5

5.2.7.8 Areas of conservation significance

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 reef, are listed in Table 19.

Table 19. Distances of proposed offshore artificial reef to areas of conservation significance

Area of conservation significance	Designation	Distance to the proposed reef (km)
Limeburners Creek Nature Reserve	Nature Reserve	7.76

Macquarie Nature Reserve	Nature Reserve	6.31
Sea Acres Nature Reserve	Nature Reserve	6.31
Woregore Nature Reserve	Nature Reserve	7.27
Limeburners Creek	Wilderness Area	7.98

The term 'wilderness' is used to describe large, natural areas of land that, together with their native plant and animal communities, remain essentially unchanged by modern human activity. Wilderness areas represent the largest, most pristine areas in the state's reserve system. The Wilderness Act 1987 affords declared wilderness the most secure level of protection, requiring it to be managed in a way that will maintain its wilderness values and pristine condition by limiting activities likely to damage flora, fauna and cultural heritage [31].

Nature reserves are areas of predominantly untouched land in a natural condition and are considered to have high conservation value. Their primary purpose is to protect and conserve outstanding, unique or representative ecosystems, native plant and animal species or natural phenomena ([32]). Nature reserves are generally terrestrial, but there are some with associated marine components.

Within the wider Port Macquarie region, there are four nature reserves and one Wilderness area considered relevant to the proposal.

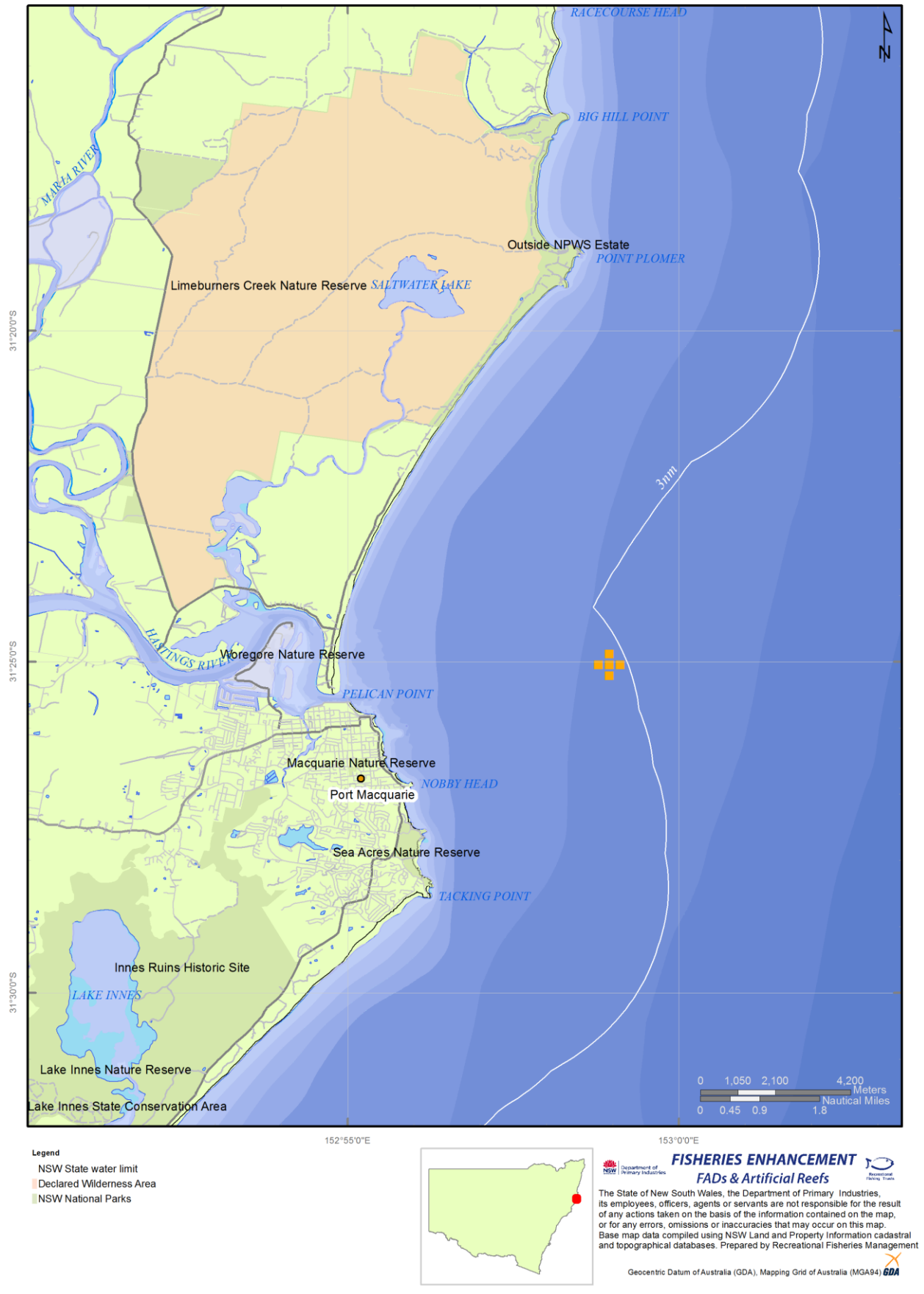

Figure 13. Location of areas of conservation significance in relation to the proposed Port Macquarie offshore artificial reef

5.2.8 Ocean currents, tides and prevailing weather conditions

The existing environment in relation to coastal processes is described in detail in Section 6.1.1 of the EA 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. Overall though, the outcomes of the coastal processes study demonstrated that the proposed reef structure deployment would be sustainable in terms of coastal processes and cause no identifiable changes, other than in the immediate vicinity of each structure.

5.2.8.1 Inshore 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.

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.

A regional wave model was developed in order to simulate the regional transformation of waves from deepwater into the nearshore coastal zone. The regional wave model domain had a uniform grid resolution of approximately 400m.

The wave model was forced with offshore wave conditions taken from recorded data at the Crowdy Head waverider. Wind boundary conditions were derived from the NOAA NCEP, Climate Forecast System Reanalysis (CFSR) ([33]).

A nested high-resolution SWAN model was also developed in order to simulate the transformation of waves into the coastal zone of Port Macquarie. The local model results were used to predict the impact of the reefs on nearshore wave conditions. A 20m 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. Being a phase-averaged spectral energy model, SWAN is not capable of resolving the wave interactions on spatial scales that are much less than the incident wavelength. The reef element clusters were represented in SWAN as an average 0.9m high rise in the local bathymetry (averaged over the 20x20m cell). 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, as detailed in Section 3.5.

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 loss due to damping by the reef blocks is outside the scope of the theory for the bottom friction model due to the length of the blocks being relatively small compared to the wavelength of the waves. The wave energy damping due to the blocks in ~43m 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 (1.6m, 8 sec south easterly swell condition) was used to force the regional 400m SWAN model within which the local SWAN model was nested. 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 ~43m.

A relatively large wave event (3m, 12 sec south easterly swell condition) was used to force the regional 400m SWAN model within which the local SWAN model was nested and the model

results (base case, developed case and impacts). The impact of the proposed reef deployment is also negligible for the larger and longer period wave condition (Figure 14).

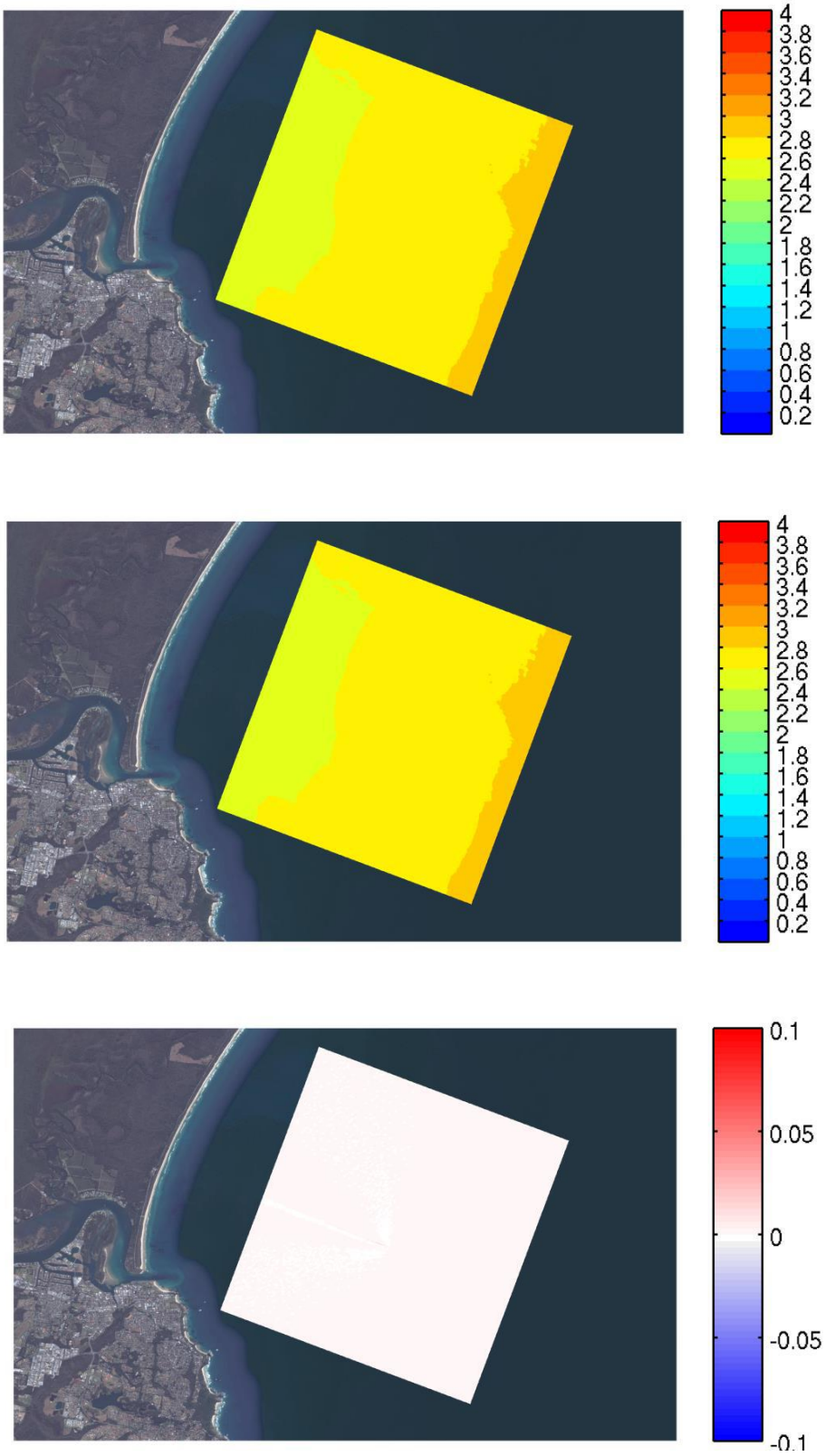

Figure 14. Impacts of reef structures on wave field for a 3 m, 12s, SE wave condition. Base case (top); developed case (middle); impacts (bottom) (Technical Report C)

Table 20. Risks and mitigation associated with inshore wave climate and change to beach erosion/deposition

Environmental Aspect	Scale	Risk Description	Initial Risk Level	Mitigative Measure	Treatment Type	Residual Risk Level
Nearshore coastal	Large	Inshore wave climate	D4	Detailed coastal process assessment to be undertaken Avoid placement where there is risk of impacts to coastal processes	Reduce likelihood	E4
Nearshore coastal	Large	Change to beach erosion/deposition	D4	Detailed coastal process assessment to be undertaken Avoid placement where there is risk of impacts to coastal processes	Reduce likelihood	E4

5.2.8.2 Water flow (current) investigations

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 ([34]). The hydrodynamic model was configured with forcing from tides and atmospheric wind, as well as ocean current forcing. The model extends approximately from Crowdy Head in the south to Smokey Cape in the north and around 52km offshore (Figure 15). The model resolution ranges from around 3.3km in the vicinity of the offshore boundary to around 200m within the Port Macquarie nearshore study area. The TUFLOW-FV hydrodynamic model vertical discretisation was based upon a hybrid z-coordinate scheme with 16 layers down to a depth of 50m and up to 44 layers in the deepest sections of the model domain.

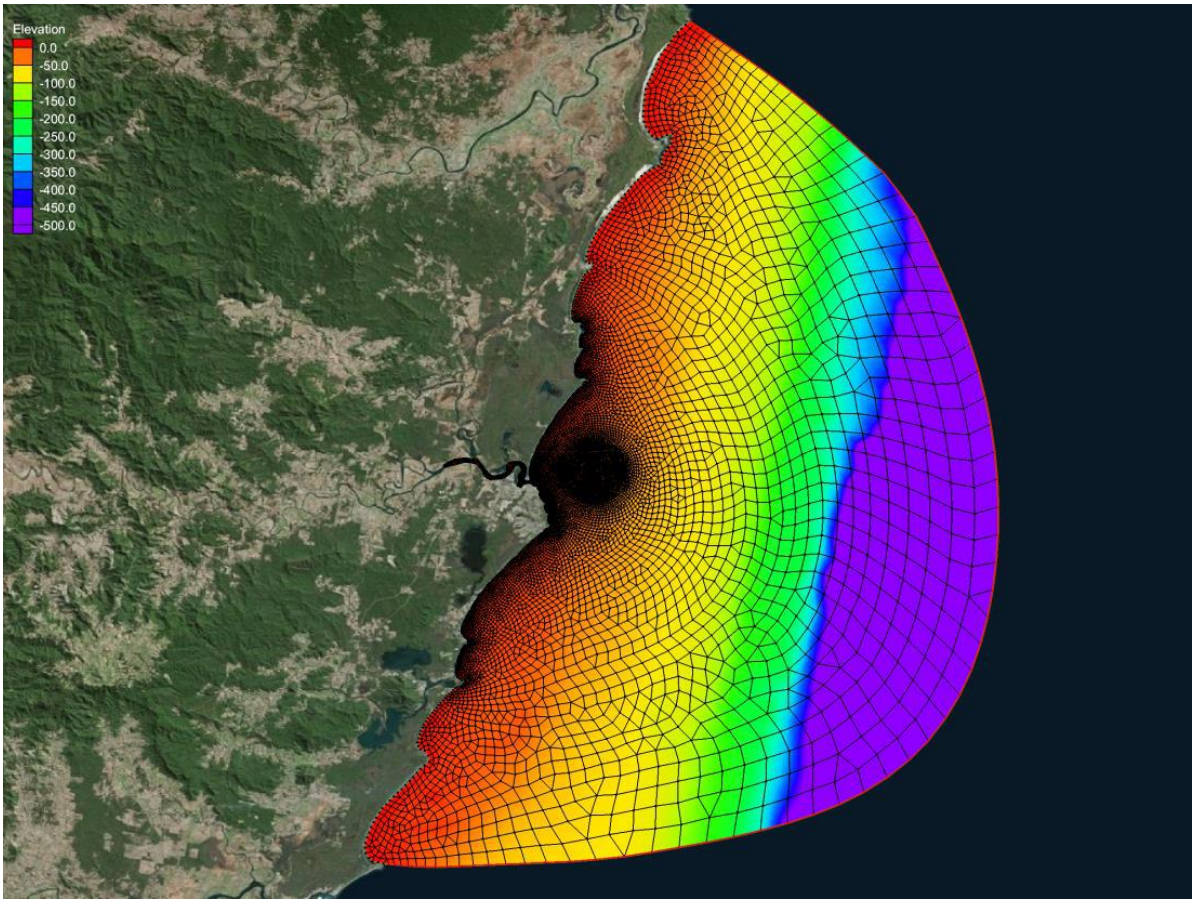

Figure 15. Regional TUFLOW-FV hydrodynamic model (Technical Report C)

Due to the proposed reef location in approximately 40m water depth, it is likely that forcing from the East Australia Current (EAC) may be significant. For this reason this ocean current forcing was included in the assessments.

A nested high-resolution TUFLOW-FV model was also developed in order to undertake detailed assessments of the reef structure impacts. A nested 2.7km diameter circular domain was developed for this purpose. A central high resolution region with mesh cell dimensions of 2.5x2.5m was used in order to represent the reef clusters in the model geometry. Individual reef modules were represented as 5 m cubic impermeable blocks and were arranged in ten clusters comprising three reefs each. The overall footprint of the reef clusters covered an area in the model of approximately 200x200m. 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. These simulations combine the effects of tide, wind and ocean currents.

Features of the modelled current behaviour are the dominance of the residual ocean currents over the semi-diurnal tidal current signal. The near bed current speeds are typically around 50% of the surface current speeds and there often appears to be significant vertical variation in the current directions, in particular during periods of relatively weak forcing.

Peak surface current speeds of around 1.8 m/s (and bottom currents of around 0.8 m/s) are predicted during a period of strong EAC forcing in late November 2012. A snapshot of the surface currents during this “event” are shown in (Figure 16).

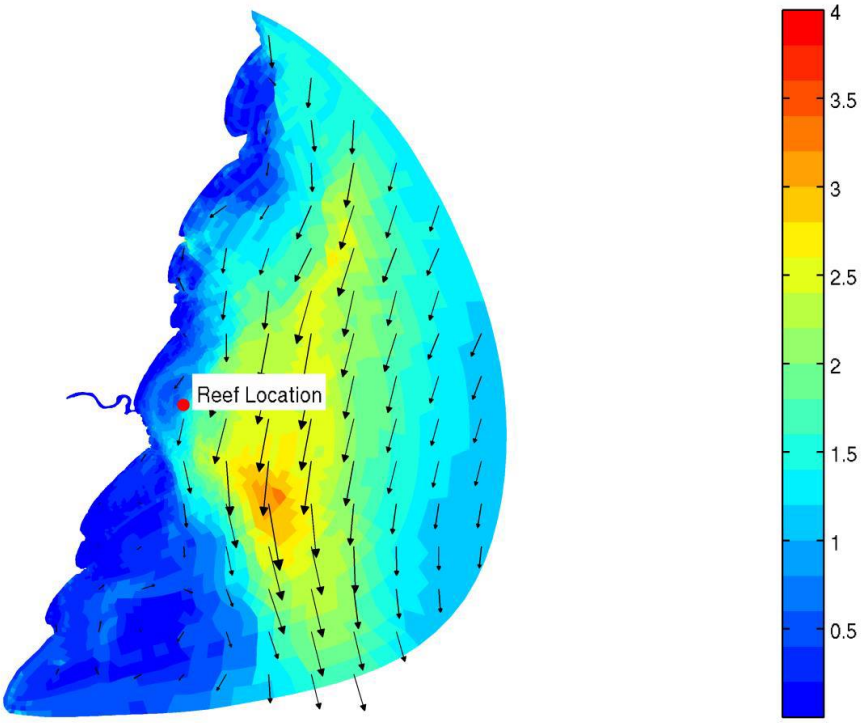

Figure 16. Regional scale surface currents during a strong EAC ‘event’ (Technical Report C)

The 5 storm events selected were simulated using the Regional 3D Hydrodynamic model, with peak surface and near-bed currents at the proposed reef site are summarised in Table 13. 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 are typically less than the maximum current speeds predicted during the strong EAC event in early November 2012, which reinforces the importance of this mechanism in driving currents in this depth of water (~40m) at Port Macquarie.

Table 21. Predicated storm event peak current speeds

Event	Peak Surface Current Speed (m/s)	Peak Near-bed Current Speed (m/s)
28/01/2013	1.55	0.82
22/02/2013	1.58	0.79
22/05/2009	1.34	0.69
06/06/2012	0.78	0.38
24/05/2012	1.14	0.69

5.2.8.3 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 5mx5m “blocks” represented in the model bathymetry.

The impact assessment was undertaken for a steady-state condition corresponding to the EAC current event in November 2012 (refer Figure 16) as these were the strongest currents simulated at the deployment site during both the 2012 and additional storm simulations.

The modelled existing case and developed case near-bed current fields (averaged between the existing case bed level and 5m height above the bed) are shown in Figure 17. The developed case results show a region of reduced current speeds in the immediate vicinity of the reef structures. The difference between the developed case and existing case near-bed current fields is shown in Figure 18 and shows the region of slightly reduced near-bed current speeds in the vicinity of the structures and immediately “down-drift”. 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, i.e. within proximity of up to 10 m.

5.2.8.4 Regional impacts

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 24 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 Tacking Point and Point Plomer.

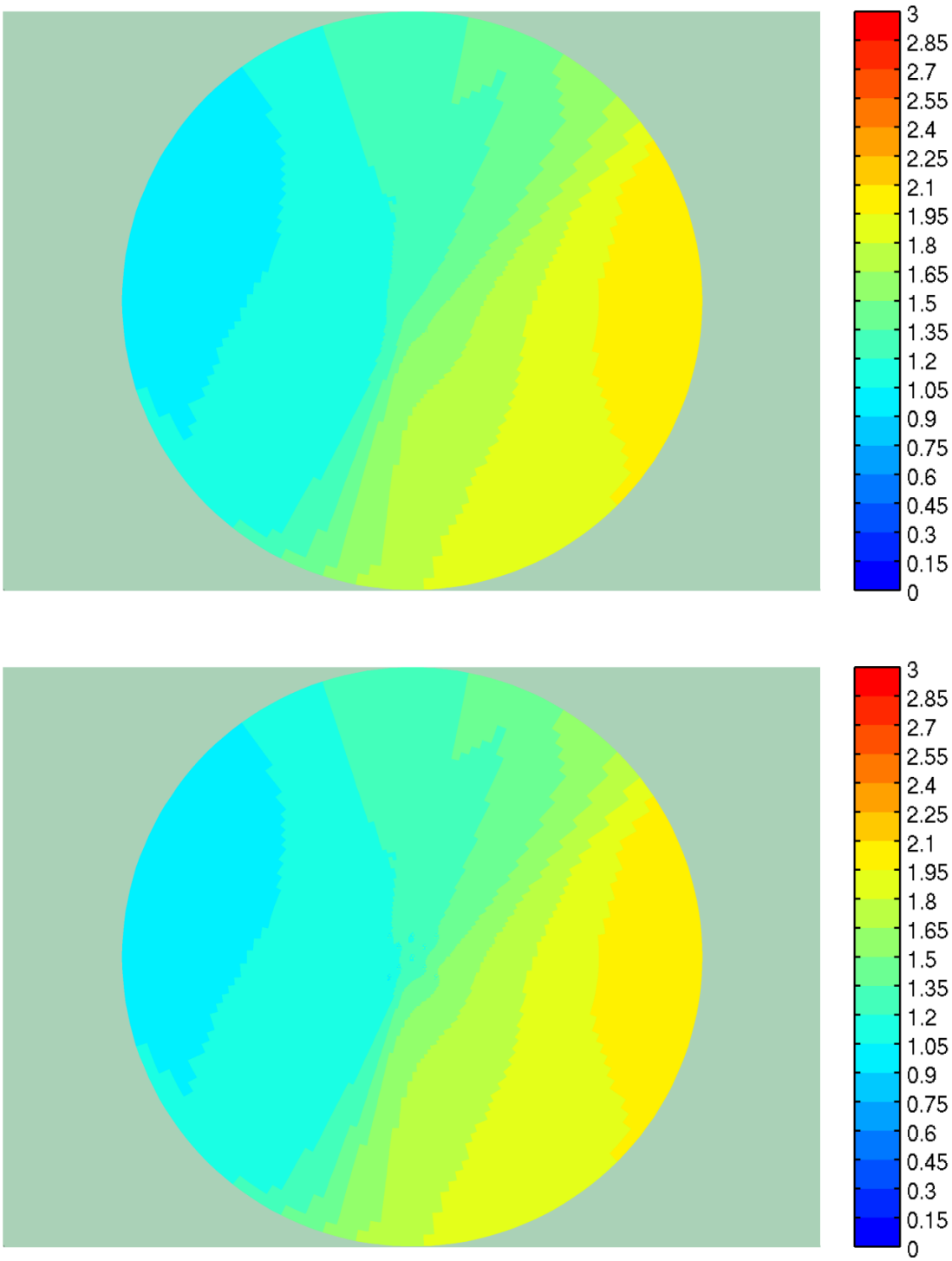

Figure 17. Base case (top) and developed case near-bed current fields (Technical Report C)

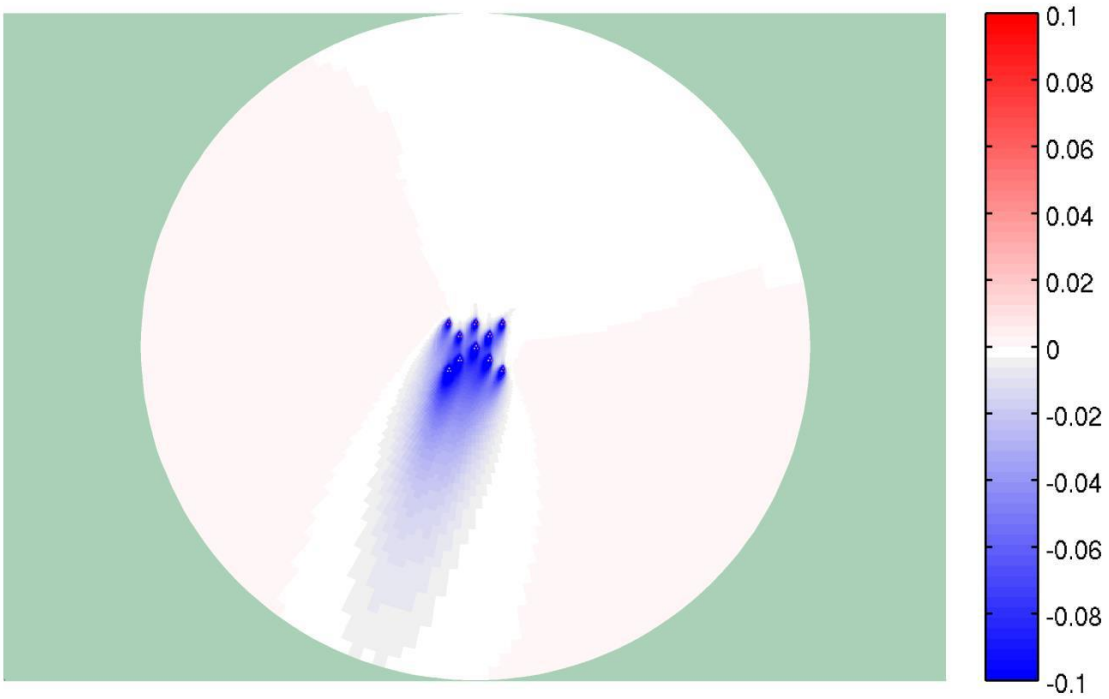

Figure 18. Impacts of reef structures on near-Bed current field (Technical Report C)

Table 22. Risks and mitigation associated with local scouring/deposition around units

Environmental Aspect	Scale	Risk Description	Initial Risk Level	Mitigative Measure	Treatment Type	Residual Risk Level
Local Seabed	Sub-Local	Local scouring/deposition around units	A5	Detailed coastal process assessment to be undertaken Avoid placement where there is risk of impacts to coastal processes	Reduce likelihood & consequence	E4

5.2.8.5 Local scour

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. 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.

Analysis of the bed shear stresses suggest that bed shear stresses at the site (without presence of reef structures) are occasionally (around 1% of the time) strong enough to initiate sediment transport.

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 19). 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.

The simple scoring system used to assess each specific criterion and results are presented in Table 23.

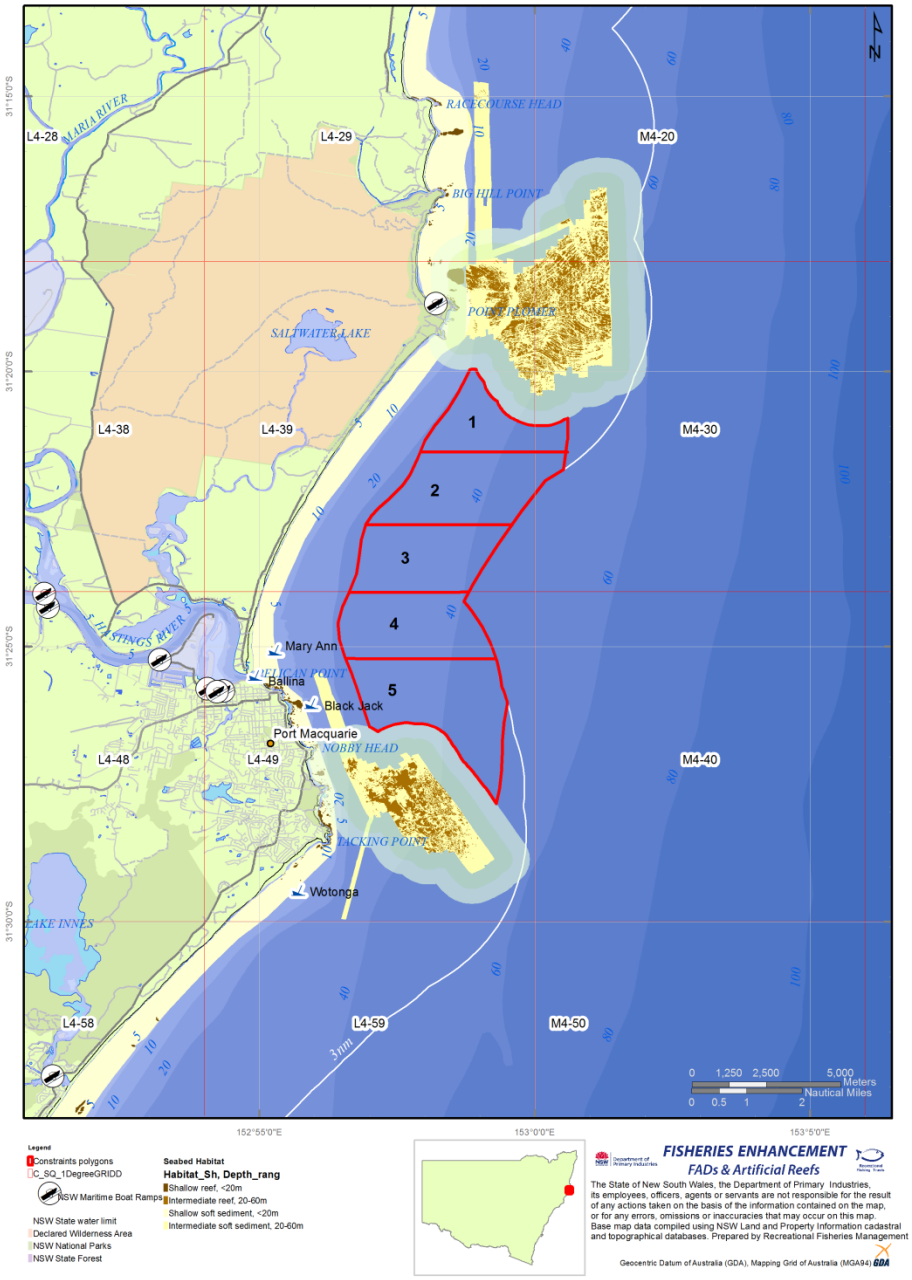

Figure 19. Potential reef deployment sites

Table 23. Constraints analyses criteria and scores

Port Macquarie							
Criteria	**Score**		**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**
Wave Climate (based on omni directional wave heights along 20 m contour)	Least exposed	1					
	Moderately exposed	2					
	Exposed	3					
Currents (based on 20 yr ARI wind induced currents from the north)	Least exposed	1					
	Moderately exposed	2					
	Exposed	3					
Proximity to shipwrecks	> 8 km from centrepoint	1	1	1	2	3	3
	6 - 8 km from centrepoint	2					
	4 - 6 km from centrepoint	3					
	2 - 4 km from centrepoint	4					
	< 2 km from centrepoint	5					
Proximity to Natural Reef	> 4 km from centrepoint	1	4	2	1	2	3
	3 - 4 km from centrepoint	2					
	2 - 3 km from centrepoint	3					
	1 - 2 km from centrepoint	4					
	< 1 km from centrepoint	5					
Commercial fishing present in zone	No	0	1	1	1	1	1
	Yes	1					
Indigenous heritage present in zone	No	0	0	0	0	0	0
	Yes	1					
Proximity to Conservation areas	> 8 km from centrepoint	1	4	4	3	3	3
	6 - 8 km from centrepoint	2					
	4 - 6 km from centrepoint	3					
	2 - 4 km from centrepoint	4					
	< 2 km from centrepoint	5					
Distance to Nearest Boat Ramp	< 2 km from centrepoint	1	3	4	4	3	3
	2 - 4 km from centrepoint	2					
	4 - 6 km from centrepoint	3					
	6 - 8 km from centrepoint	4					
	> 8 km from centrepoint	5					
Number of boat ramps in a 10km radius	> 5 ramps	1	5	1	2	2	2
	4 ramps	2					
	3 ramps	3					
	2 ramps	4					
	1 ramp	5					
Total Score			18	13	13	14	15
Total Rank			5	1	1	3	4

6 Scope, duration and timeframes for monitoring

This section describes research and monitoring aspects related to the Port Macquarie 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. 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.

The duration of the initial detailed monitoring at quarterly intervals for 3 years was considered sufficient based on the results of past and existing artificial reef research projects undertaken by the DPI. In addition, this was the time period previously stipulated by the Department of the Environment when approval was granted for the Sydney Offshore artificial reef project (SD2008/882) and Shoalhaven offshore artificial reef (SD2014/2842).

6.1 Priorities

The research priorities for the Port Macquarie offshore artificial reef (outlined in Table 24), 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 24. Research priorities and description

Research Topic	Priority	Short description of research project and expected outcomes
1. Colonisation of the reef & community development: *BRUV*/unbaited surface deployed camera*	Level 1	BRUV's and unbaited surface deployed 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 20) 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 (eg BRUVs) 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/ unbaited surface deployed camera surveys*	Level 1	Diving and/or camera 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*	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, surface deployed camera, diver surveys & photographic record for a period of 3 years.
5. Accumulation of marine debris: *diver survey/BRUV/surface deployed camera*	Level 1	The level of gear hook up will be assessed using diver surveys/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 will be employed to remove the debris.

*BRUV = baited remote underwater video

Figure 20. 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 25). The preliminary 3 year timeframe was selected based on the results from the Sydney and Shoalhaven offshore rrtificial reef surveys (refer SD2008/882 & SD2014/2842 respectively). 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 25. Environmental monitoring and timeframes proposed on the Port Macquarie offshore artificial reef

Issue	Monitoring Actions	Frequency	Responsibility
Colonisation of the reef & community development	Before reef installation, monitoring was conducted at the Port Macquarie reef site using BRUVs and surface deployed tow cameras (March 2015). BRUV's and surface deployed cameras will be deployed on the reef a minimum of 4 times a year post reef installation to monitor fish assemblages and 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.	Quarterly every 12 months • for 3 consecutive years and then will be reviewed	DPI
Benthic environment	Collect benthic sediment samples before, and after reef installation. A dedicated benthic assessment of the reef deployment site was conducted by Cardno Pty Ltd in December 2014 (EA – Technical Report E). 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 & debris 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 severe 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 offshore of Port Macquarie as designed.

An intense East Coast low hit the NSW coast between April 20-23 which produced gale force winds (>45 knots) and huge seas, with the most extreme effects felt along the Hunter-Sydney coast with strong winds, flooding rains and massive seas. The largest wave recorded at 3 pm on 21 April was 15 m, approximately the height of a 5 story building. The waves also exceeded 6 m for 30 hours, the longest duration of such high waves since 1987. Post storm inspections of both the Sydney and Shoalhaven artificial reefs were carried in May 2015 in line with inspections conditions of respective sea dumping permits (SD2008/882 & SD2014/2842). DPI used surface deloyed cameras to undertake the inspections. No damage was identified to either the single large Sydney reef unit or any of the 20 multiple modules which form the Shoalhaven reef. In addition, no significant scour or deposition was identified in the vicinity of either reef (Figure 21).

Figure 21. Inspections of the Sydney (upper image - 7 May 2015) and Shoalhaven (lower image - 18 May 2015) OARs following an intense east coast low that produced waves up to 15m (Hsig)

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]. The benthic assessment conducted by Cardno Pty Ltd as part of the preliminary data set used for the environmental assessment provided comprehensive baseline data for the undisturbed reef site. This assessment will be replicated following the first 3 years post reef installation to investigate and document changes to the benthic community in the immediate sediments around and adjacent to the installed reef.

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. A number of external influences may contribute to trigger points being reached. For example, the NSW Office of Environment and Heritage (OEH) administer interactions with marine mammals under the *NSW National Parks and Wildlife Regulation (2009)* and the *NSW National Parks and Wildlife Amendment (Marine Mammals) Regulation 2006*, introduced to protect marine mammals such as whales and dolphins while allowing people to appreciate them in the wild. These existing regulations specify the distances of approach and interaction with marine mammals. If interactions between reef users and cetaceans, pinnipeds etc were found to increase significantly post installation of the reef, then in addition to the DPI TSU being notified of these interactions, the NSW OEH would also be independently briefed. Management actions would require a combined approached from both the DPI and OEH to ensure a consistent method to addressing the issue. A passive approach such as increased education an awareness campaign coordinated between the two agencies may suffice. However, if impacts continue to escalate, increased monitoring and compliance patrols combined with temporal exclusions zones may require consideration.

Build-up of marine debris identified during the monitoring of the reef to be as a result of purposeful dumping of material on or adjacent to the reef site is another external influence. If increased marine debris is entering the marine environment in the vicinity of the proposed artificial reef which is of a deliberate nature (i.e. intentional dumping of waste from vessels) than the NSW Roads and Maritime Service (RMS) would be notified and action taken under the *Marine Pollution Regulation 2006*. As current Fisheries Management Regulations do not manage this activity, an appropriate management response would be for DPI to administer a combined on-water operations with the RMS Boating Service Officers (BSO's) to target offenders and enforce these regulations.

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 26Table 26 establishes the performance indicators and trigger points that will be used to measure whether each of the mitigation measures described in Chapter 8 of the EA are being attained. No numbers for interactions with threatened species has been defined, instead a threshold for 'of concern' was implemented. The reasoning behind this is that the types of threatened species and degree to which they are threatened is highly variable in regard to the operation of the reef. This has been determined in consultation with the DPI Threatened Species Unit (TSU).

By not defining a set point/number at which management measures would be imposed upon the operation of the reef it allows the TSU to assess not only numbers of interactions with threatened species on the reef but other aspects of threatened species management which may be relevant such as;

- the level of the threat that is or has occurred;
- the type of interaction;
- the frequency of the interactions;
- the season that the interaction is occurring (breeding/calving);

- any potential change in the threatened status;
- how much harm as a result of the interaction was occurring;
- sightings vs. hookings/entanglements; and,
- if the species is recovering and numbers are increasing.

Without imposing numbers/thresholds on the interactions with threatened species the LTMP is more fluid it and is more in line with current impact assessment that is being undertaken. When assessing matters of National Environmental Significance numbers are not used to assess the level of impact instead the process relies on professional judgement.

The 6 month reporting schedule and involvement of the DPI TSU (which is independent to recreational management) allows for an independent judgement of these levels of interaction. Also any significant interaction such as mortality would immediately be reported to the TSU.

In regards to potential management measures which would be imposed upon the reef, if the level of interaction was to become 'of concern' these could include gear restrictions, closed seasons, fishing times, a restricted fishery, restrictions on the type of fishing, and DPI as an agency would have to come up with an appropriate management response in relation to the interaction, but again this is not defined as there are so many variables it is seem as more important to deal with the interactions appropriately as they arise.

Harm from Marine Debris: The proposal is likely to result in the concentration of, and increase in, recreational fishing activity in the direct reef area. This potentially increases the risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed recreational fishing reefs. Threatened marine species, particularly marine turtles, pinnipeds, small cetaceans and seabirds, can ingest or become entangled in marine debris, such as plastics. Potential harm to marine animals from build-up of marine debris such as lost fishing tackle, anchor lines and other pollution is being monitored quarterly each year over the first 3 years post reef installation.

A commitment has been made by DPI that periodic inspection of marine debris will be maintained on the reef for its design life of 30 years based on the outcome of the first 3 years of monitoring. Annual debris removal has been scheduled for 3 years (i.e. 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). This is deemed to be an appropriate management response and mitigative measure based on the unknown level of build-up. If an obvious entanglement hazard is identified outside scheduled maintenance and debris removal (including but not limited to free floating rope [discarded anchor lines]), removal by DPI or contracted commercial divers will be facilitated as soon as practical.

In order to further reduce the impact of this KTP, 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 and discarded fishing gear.

Invasive Marine Pests: 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). Although there is evidence that many exotic species establish populations more easily on artificial structures, the risk of increased potential for disease associated with biota at the recreational fishing reef is considered to be extremely small due to their isolation in the open ocean rather than in estuarine environments. Similarly, the risk to threatened species from invasive marine pests associated with the reef is considered very small.

Invasive marine pest species including the Japanese and yellowfin gobies and New Zealand screw shell are generally associated with soft or unconsolidated sediments in bays and estuaries and would be unlikely to occur offshore. These 3 species are not worth considering, primarily because of the location of the Port Macquarie offshore artificial reef. For example CSIRO modelling of potential range of NZ screwshell (based on temp tolerance) indicates it is very unlikely to survive north of Merimbula. As stated, the gobies are estuarine and not known to be north of Sydney.

Whilst the proposed reef site is potentially at risk from colonisation by invasive marine pests, the scale of the potential impact is small and would be unlikely to have any significant impact on the marine environment. Depending on the species identified a variety of management responses may be required. In the first instance, reef user groups would be informed of boating guidelines to minimise the spread of marine pests and a revised monitoring plan would need to be implemented in order to better document the extent of the incursion. Requirements for removal of marine pests (according to National Introduced Marine Pest Information System - NIMPIS) would depend on the extent and nature of the incursion but is likely to involve manual removal by divers in the first instance. This would be facilitated by the DPI in consultation with the Biosecurity Unit.

Table 26. 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 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/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 artificial reefs.	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.
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 Port Macquarie 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 DPI for environmental inspections and environmental audits.

7.2.1 Logs and registers

A number of registers will be maintained by 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 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:

- 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 (Appendix 8 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 Port Macquarie 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 (e.g. surface deployed cameras) will be used to provide an ongoing debris log. This log will be maintained by 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 an 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, 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 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 Port Macquarie 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 Port Macquarie 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 Port Macquarie 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 Port Macquarie offshore artificial reef will be placed on the DPI Offshore artificial reefs webpage (www.fisheries.nsw.gov.au), via social media (e.g. Facebook) 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 Port Macquarie offshore artificial reef;
- confirmation of the placement site boundaries to two decimal places of a minute (WGS84);
- the estimated maximum depth over the Port Macquarie 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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