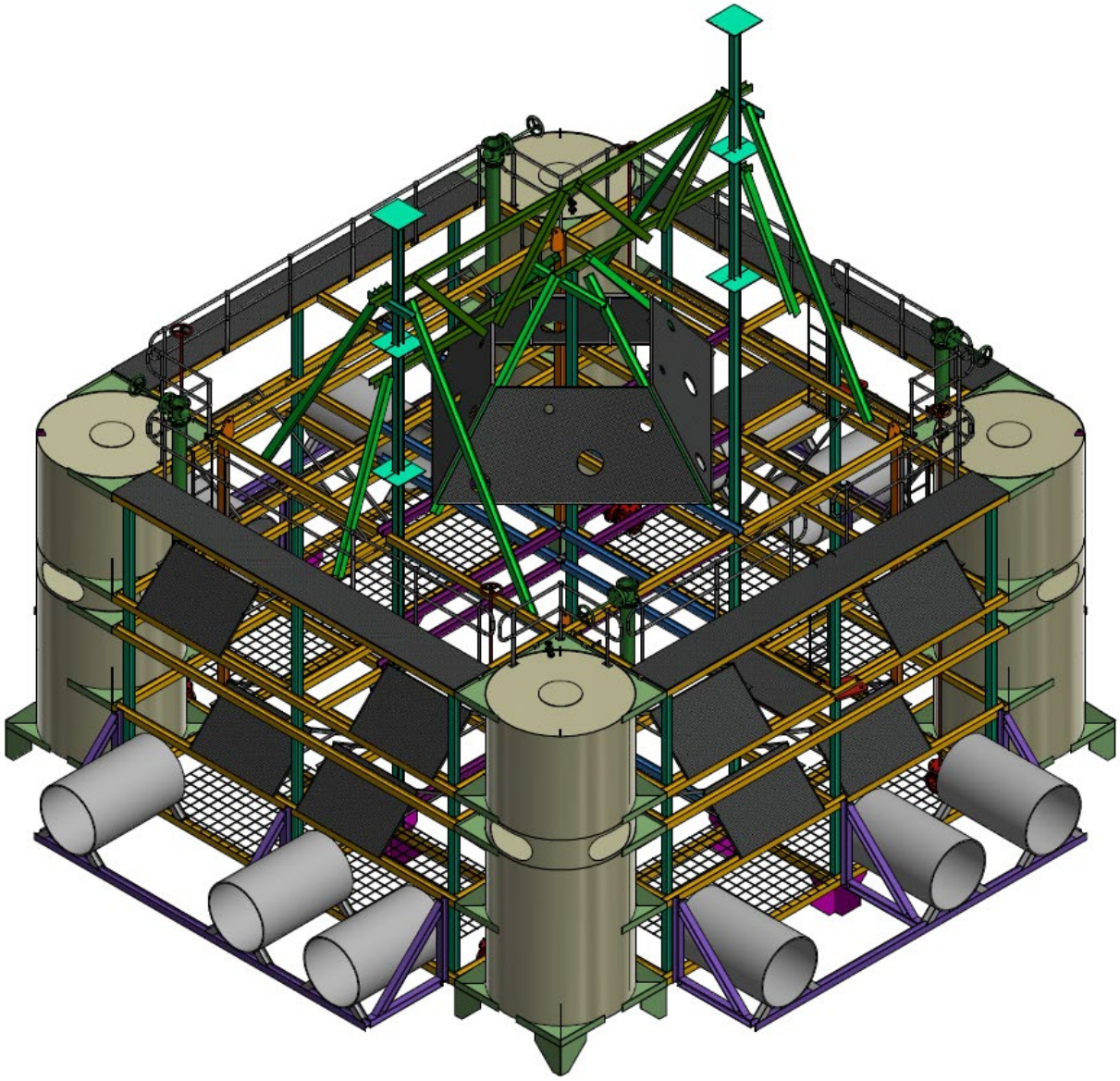
Department of Primary Industries
Department of Regional NSW

Long Term Management Plan - Forster offshore artificial reef

Fisheries and Aquaculture Management

February 2023



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Fisheries Manager – Fisheries Enhancement

fisheries.enhancement@dpi.nsw.gov.au

www.dpi.nsw.gov.au

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Long term management plan

The NSW Department of Primary Industries (DPI) is responsible for the operation, including management, monitoring and maintenance of the Forster offshore artificial reef (OAR). 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 the EA. Assessment of ecological, biological and socio-economic impacts have been considered and are summarised in this plan.

1 Introduction

DPI aims to improve recreational fishing opportunities in NSW through the development of 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 FM Act include promoting 'ecologically sustainable development, including the conservation of biological diversity' and promoting 'quality recreational fishing opportunities.

The Forster region is also afforded an additional layer of environmental protection under the *Marine Estate Management Act 2014* (MEMA). The objectives of the MEMA are to:

a. provide for the management of the marine estate of New South Wales consistent with the principles of ecologically sustainable development in a manner that -
    i. promotes a biologically diverse, healthy and productive marine estate, and
    ii. facilitates -
        - economic opportunities for the people of New South Wales, including opportunities for regional communities
        - the cultural, social and recreational use of the marine estate
        - the maintenance of ecosystem integrity
        - the use of the marine estate for scientific research and education
b. promote the co-ordination of the exercise, by public authorities, of functions in relation to the marine estate, and
c. provide for the declaration and management of a comprehensive system of marine parks and aquatic reserves.

The deployment of artificial reefs as a fisheries enhancement tool is consistent with these objectives.

This proposal is considered an 'activity' under Part 5 of the *NSW Environmental Planning and Assessment Act 1979,* which requires consent from the determining authority. The deployment of the OAR 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. To obtain consent and the resulting licence, the proposal must also gain concurrence from within NSW government departments which administer a range of legislation including DPI Coastal Systems (Marine Estate Management), Threatened Species and Aquatic Biosecurity.

Construction of artificial reefs is further regulated under the Commonwealth *Environment Protection (Sea Dumping) Act 1981* (EP (SD) Act).

Recreational fishing is an important leisure activity for approximately 12% of the NSW population (approximately 849,000 people over the age of 15) and provides significant social and economic

benefits, with an estimated $3.42 billion generated in economic activity in NSW each year, creating approximately 14,000 full-time equivalent jobs.

In NSW, approximately 22% 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 (OAR) will enhance fishing opportunity by creating high relief, complex fish habitats. Artificial reefs 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 assessment of impacts identified components of the marine environment and potential impacts related to those components that require further investigation and potential monitoring. The potential risks identified can 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 DPI is committed to implementing.

1.1 Project planning

DPI has been responsible for the preparation of all documentation, stakeholder consultation, risk analysis, constraints identification and specialist flora and fauna investigations. DPI has coordinated a team of highly qualified environmental consultants who have extensive experience in oceanography and coastal processes of the NSW coast, cultural heritage and hydroacoustic surveying (Figure 1) to provide further expertise where required.

DPI have 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 a monitoring plan and procedures to assess risks relating to threatened species, pest species and fishing related marine debris in the vicinity of the reef post deployment.

DPI engaged the services of:

- Umwelt Pty Ltd to investigate the cultural significance of the site and potential impacts on Aboriginal heritage and to undertake consultation.
- Manly Hydraulics Laboratory (MHL) to provide expertise in coastal processes including wave behaviour, sediment movement and circulation.
- Astute Surveying to complete the acoustic survey of habitats in the vicinity of the proposed OAR location.

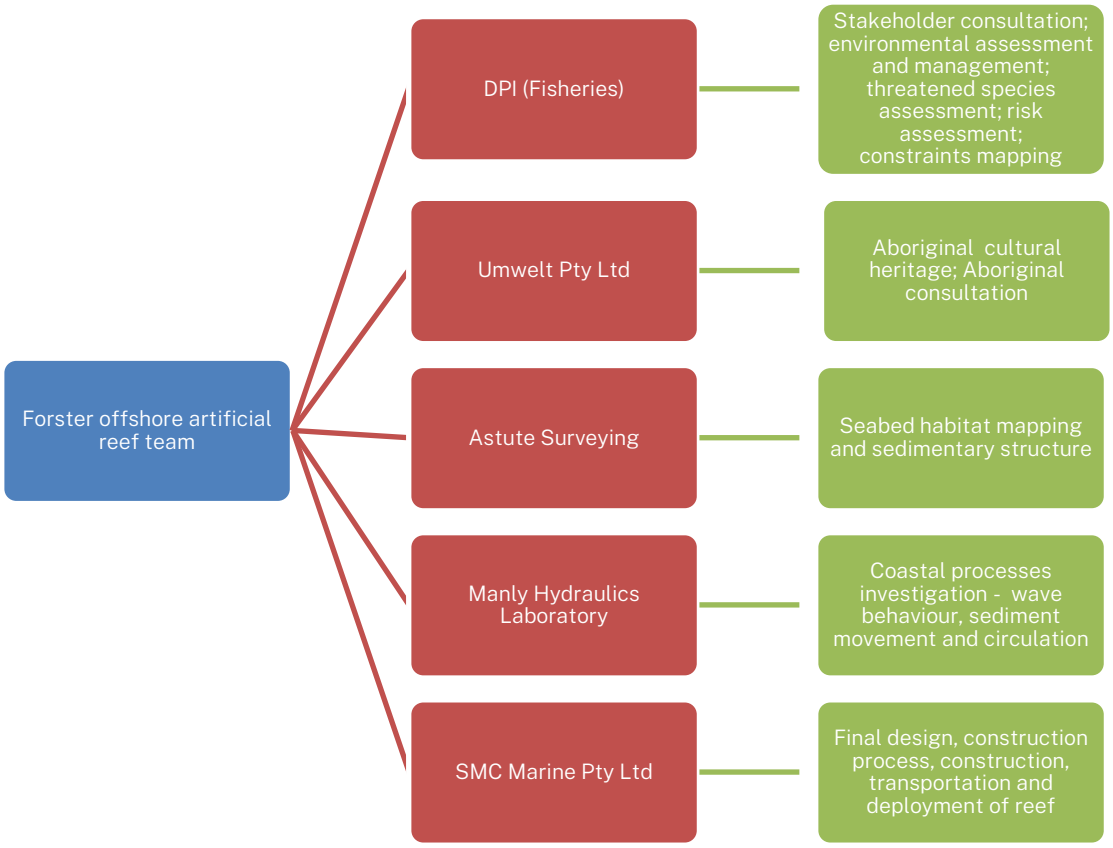

Figure 1 Forster offshore artificial reef project team

1.1.1 Tender Evaluation and Awarded Design

Established in 2011, the NSW DPI artificial reefs project team has worked closely with industry to continually refine the design of high-quality habitat while ensuring structures are built to withstand local oceanographic governing forces in the chosen project area.

Reef design was determined by an open Government tender process. Evaluation of suitable tenders was completed by a panel of subject matter experts chaired by DPI. The evaluation panel comprised senior managers from the project team who have significant experience in reviewing suitable designs to select the highest quality habitat and environmentally responsible construction methods for artificial reef placement (Figure 2).

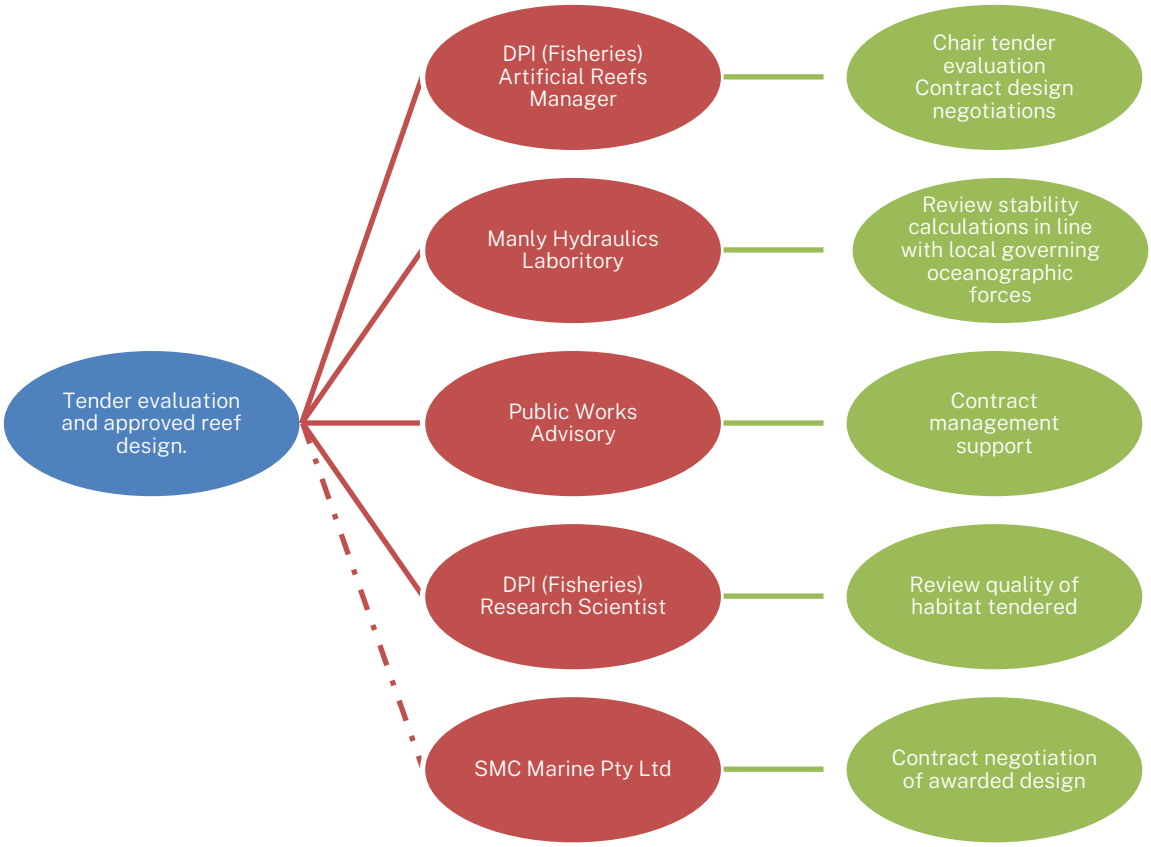

Figure 2 Forster offshore artificial reef Tender Evaluation Team

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

Initial site selection for OAR projects is guided by early preliminary consultation and constraints mapping which are summarised within this LTMP. Previous reef projects have shown early consultation and constraints mapping dramatically reduces the number of stakeholders negatively impacted by the project from inception. As a result, formal consultation periods often reveal relatively few (if any) objections to the scope of the proposal. The feedback received is generally from recreational fishers who are eager to see the project move forward.

Open public consultation for the proposed Forster OAR location resulted in no objections from stakeholder groups engaged. All active commercial fishing businesses and fishers who have fished in the greater region received information on the proposal and did not respond.

Consultation was carried out by email, phone calls and through stakeholder consultation meetings. A community meeting for recreational and charter fishers was held in Forster on 8 February 2022.

On 18 March 2022, the Professional Fishers Association (PFA) published advice from DPI regarding the Forster OAR proposal, which sought comment from the commercial fishing community regarding the proposed deployment site by 29 March 2022. Fisheries enhancement updates and the proposed OAR were also included as agenda items as part of regular stakeholder meetings (e.g. the Recreational Fishing NSW Advisory Council and the Recreational Fishing Saltwater Trust Expenditure Committee). In addition, consultation relating to the Aboriginal Cultural Heritage Due Diligence Assessment was carried out by Umwelt Pty Ltd and outcomes of this consultation were summarised in the corresponding report [1].

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

Stakeholder consultation email letters were distributed by DPI between 1 March 2022 and 29 March 2022 (Table 1). The consultation letters provided the context for the proposed Forster OAR, a brief history of the artificial reef deployment program in NSW and set out the Environmental Assessment process currently being conducted by DPI relating to the proposal. The letters contained DPI contact details and invited comment on the proposal; the objective being to provide an opportunity for community stakeholders to provide any comments on the Forster OAR proposal.

Consultation with independent branches of DPI was also undertaken with Threatened Species, Biosecurity and Coastal Systems teams. This consultation reviewed the respective risk assessment table and mitigation actions in place to ensure the project is delivered in an environmentally responsible manner.

Table 1 DPI stakeholder consultation letter distribution summary

Group	Number
Aboriginal stakeholders (including 31 groups consulted with by Umwelt Pty Ltd)	37
Recreational fishing stakeholders (including line and spear fishing clubs, recreational fishing clubs and associations and charter operators in the Forster region)	30
Commercial fishing stakeholders (including fishing business owners, nominated fishers, professional associations and fishermen's co-operatives)	135
Conservation	9
Diving (retailers, charters)	4
Statutory authorities (including local, state and federal government)	38
Recreational licence agents and fishing tackle outlets	25
Universities	2
Businesses/voluntary organisations	7
Total	**287**

Media coverage of the project has been ongoing since 8 February 2022 when the Minister for Agriculture and Western NSW announced Forster as the next location for artificial reef placement. Since this time updates on the status of the Forster project have been included in broader community consultation including Newscast (DPI's online information bulletin for recreational fishers with >500,000 subscribers), social media and media announcements.

Responses from the statutory and non-statutory groups consulted were received via telephone, email and from the stakeholder consultation meetings. The proposal was well-received in terms of the location, design of the reef and the processes used in selecting these, with no objections raised through the consultation process.

2 Project goals and objectives

2.1 Goals for the activity

The proposed goals for the activity are as follows:

1) to enhance recreational fishing opportunities in the Forster region; and
2) to create new fish habitat in an otherwise barren and unproductive area.

3 Risk assessment

3.1 Introduction

A workshop to review previous risk analyses assessing the impacts of OAR was held on 4 August 2022, attended by DPI representatives who have expertise in artificial reef assessment, monitoring, design and construction. The aim of the workshop was to review existing potential issues/hazards identified during past OAR projects and to identify any new potential hazards with the proposed Forster OAR project. The risk assessment workshop assessed the likelihood of occurrence of such hazards and the consequence to key receptors if these hazards eventuated.

Risk analysis undertaken by DPI and industry professionals for the past nine OARs 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 risk analysis workshop in August 2022 assessed if risks required alteration or if new mitigative tools were required for the Forster OAR based on updated information gained from reef monitoring and post installation operations by DPI. Combined with the constraints mapping process and the coastal processes, swath acoustic mapping and Aboriginal Cultural Heritage consultant advice, the review sought to minimise or eliminate several potential risks associated with existing infrastructure, obstructions and exclusion zones (such as deep-water ocean outfalls, port restrictions, spoil grounds and historical shipwrecks), threatened species by avoiding critical habitats and marine protected areas.

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 [2]. The following risk assessment was based on the principles of Australian Standards for Risk Management 4360:2004 and Fletcher [2].

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 which resulted in avoidance of major biological constraints, such as areas of natural reef and areas of conservation significance, navigational hazards and exclusion zones.
- 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 is based on the proposed reef design.
- The risk analysis is informed by the work completed by DPI over the successful installation of nine OARs since 2011.

The risk matrix (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 structures
Local	400 m x 400 m (16 ha)
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	A1	B1	C1	D1	E1
	2	Major	A2	B2	C2	D2	E2
	3	Moderate	A3	B3	C3	D3	E3
	4	Minor	A4	B4	C4	D4	E4
	5	Minimal	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 Forster offshore artificial reef proposed location

The proposed Forster OAR site is situated approximately 4 km east-north-east of Wallis Lake entrance in State waters. Depth within the reef deployment area ranges from 32-35 m (LAT - Lowest Astronomical Tide) providing a minimum vessel clearance depth of 20 m.

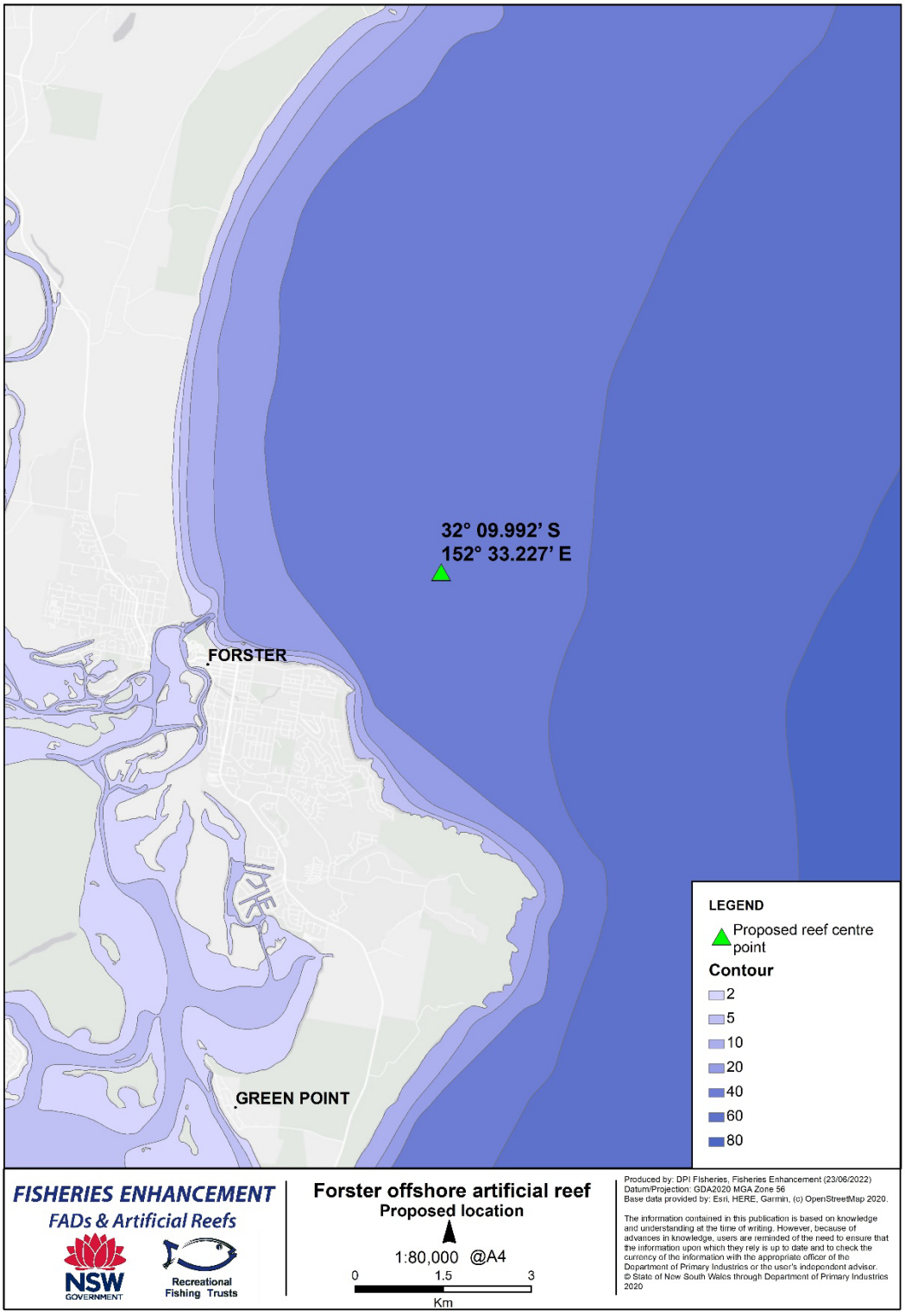

Figure 3 Proposed deployment location of the Forster offshore artificial reef

4.1 Socioeconomic considerations

Approximately 75% of recreational fishing effort in NSW occurs in saltwater (estuarine, inshore and offshore waters), with the majority (66%) occurring within estuaries [3]. The Mid North Coast Fishing zone generally accounts for approximately 25% of all fishing effort in NSW [4]. It is anticipated that the Forster OAR will increase visitation rate in the region; based on the fact that it will be located adjacent to the highest fishing effort region (Forster-Tuncurry townships) and with a large proportion of seasonal tourism-based regional and interstate fishing effort from Victoria, Queensland, Sydney and regions to the west.

The Mid North Coast region provides a wide variety of fishing locations across several different types of aquatic habitats, including open ocean, ocean beaches, rocky headlands, rivers, coastal embayments and freshwater streams.

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.). Total recreational fishing expenditure is estimated to exceed $130 million annually accounting for 6% of the total NSW spend. Given the small relative population to other coastal region, this represents a significant spent and economic contribution that recreational fishing makes to these local economies [5].

A recent social return on investment study on previously installed artificial reefs in NSW found social returns of 8.8% in Port Macquarie and 9% on the Southern Sydney OAR over the 30-year life of the reef using conservative assumptions (unpublished). Given expenditures by anglers in the Forster region, DPI anticipates similar or greater social return on this investment to the economy.

It was estimated that approximately 2,460 hours of fisher effort were expended on the Sydney OAR during the 2013/14 survey year, equating to a higher levels of recreational usage intensity than many natural NSW estuarine systems [6].

The location and accessibility of the Forster OAR 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;
- tourism and charter operators who base their businesses around the quality of the fishing experience and the abundance of fish; and
- tackle and boating industry that depend on having sustainable fish resources in the Forster region.

4.2 Environmental considerations

The North Coast Bioregion runs up the east coast of NSW from just north of Newcastle to just inside the Qld border. The total area of the bioregion is 5,924,130 hectares and the NSW portion is 5,692,351 hectares or 96% of the bioregion [7]. The NSW portion of North Coast Bioregion occupies 7% of the state [7]. The North Coast Bioregion has proven to be a popular place to live, with hundreds of 'holiday towns' lining the coast and eastern inland, including Port Macquarie, Tweed Heads, Byron Bay, Ballina, Lismore, Coffs Harbour, Yamba, Dorrigo, Taree, Forster-Tuncurry and Port Stephens.

The Tweed, Richmond, Clarence, Coffs Harbour, Bellinger, Nambucca, Macleay, Hastings and Manning River catchments all fall in the North Coast Bioregion. The general trend in this bioregion from east to west is from a sub-tropical climate on the coast with hot summers, through sub-humid climate on the slopes to a temperate climate in the uplands in the western part of the bioregion, characterised by warm summers and no dry season. The soil and vegetation patterns in the bioregion are very complex because of the different substrates, the topographic variation and the climatic differences encountered across and along the bioregion. In the coastal dunes, deep siliceous sands and very well developed podsols can be found.

Artificial reef siting and design should incorporate a variety of biological, economic, and physical sciences and engineering factors [8]. Size, relief, complexity, location and biological factors can all influence assemblages of fishes on artificial reefs [9]. Biological principles that should be considered include habitat limitation [10], habitat complexity [11, 12] and refuge from predators [13]. Physical principles deal with the size of the reef structure [14] 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 [15]. Conversely, greater densities of fish on smaller artificial reefs have also been reported [9]. 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 [16]. Conversely, a study of high-relief reefs found greater diversity on natural reefs than on artificial reefs [17]. Psychological, social and economic aspects of human behaviour are also important when considering reef design, taking into account the requirements of possible end user groups [18-20]. Consideration of all of these factors was taken into account in determining reef location and design.

A detailed investigation of existing information and database searches relating to the study area has shown that there are several critical constraints which required further consideration to identify a suitable reef location. These included the preferred depth requirements, proximity to reef substratum and commercial fishing activities.

Astute surveying was commissioned to undertake a survey to look in detail at the seafloor within the vicinity of the proposed reef deployment site. The survey used a multibeam echo-sounder (MBES) to determine bathymetry, backscatter and MBES derivative surfaces (i.e. aspect, slope) that define the seafloor characteristics of the Forster OAR site. The aims of the survey were to accurately measure the seabed for depth and accurately define any objects above the seabed such as reefs and/or wrecks. This data was then used to aid in selecting an appropriate site for the artificial reefs. The survey resulted in a description of the physical characteristics of the sea floor within the proposed reef deployment area, highlighting the presence of suitable substrata for the artificial reef [21].

The multibeam data enabled the generation of a colour gradient image and seafloor depth contours (Figure 4). The backscatter data was used to produce a geo-referenced mosaic with the overlapping scans identifying a small reef approximately 500 m north of the Forster OAR centre point. A rocky reef present at the location 32° 9.690’ S, 152° 33.290’ E extends approximately 440 m long and 53 m wide in a north-west to south-easterly direction. The surrounding seabed appears to be sandy bottom with large sand waving apparent in the western side of the OAR site with some minor waving at the southern side [21].

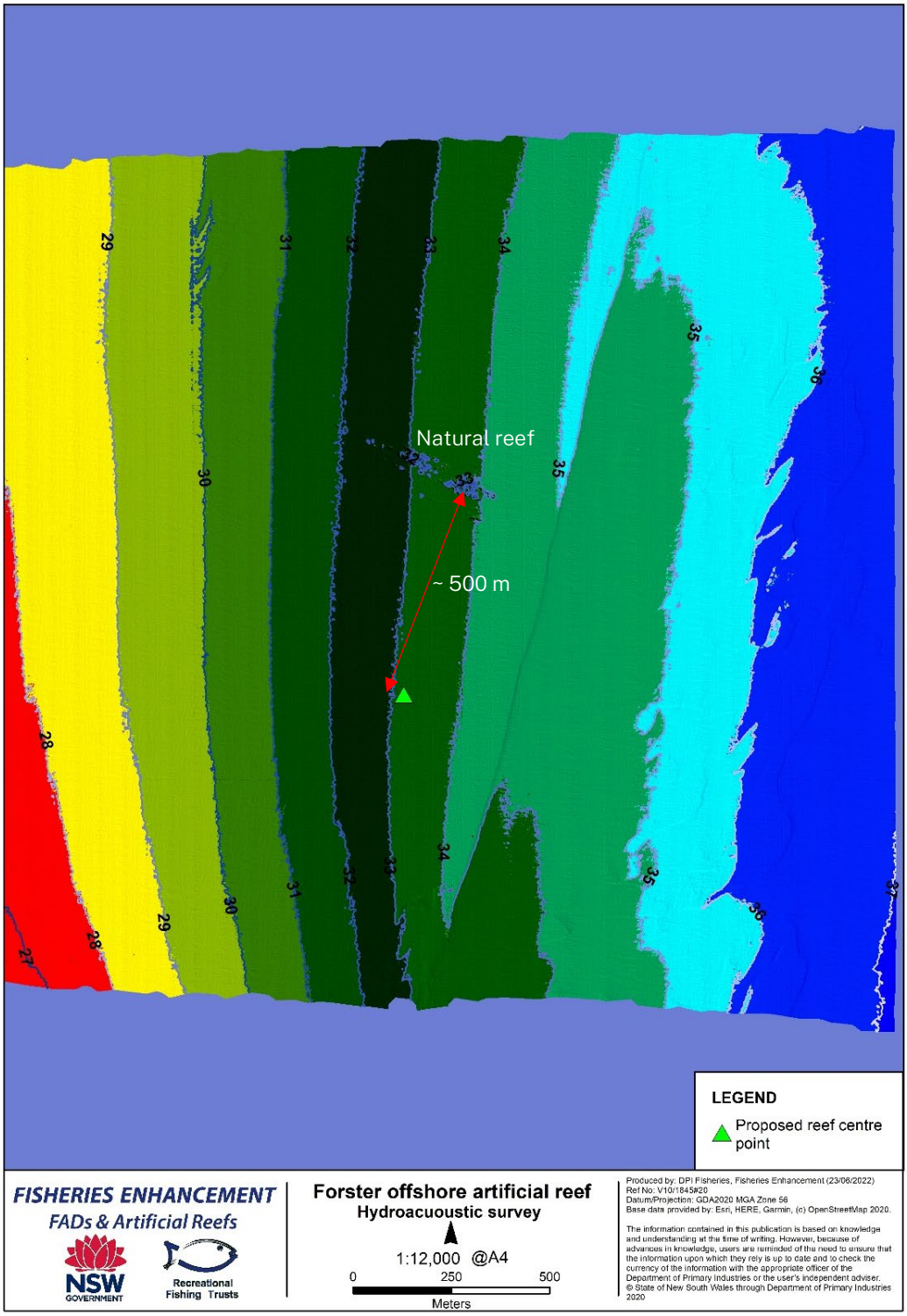

Figure 4 Colour gradient model depicting the depth contours (m) over the survey area and distance to nearest confirmed low-profile reef.

Swath acoustic mapping results illustrated an onshore-offshore depth gradient across the 2.2 km of seafloor surveyed consistent with sediment substrata represented by intermittent increases in depth ranging from 28 m in the centre west through to 37 m in the centre east of the survey area (Figure 5). The bathymetry indicates that the seafloor is predominantly unconsolidated sediments with the presences of sand waving to the south and east of the OAR central point and small ridges extending in a north south direction to the east [21].

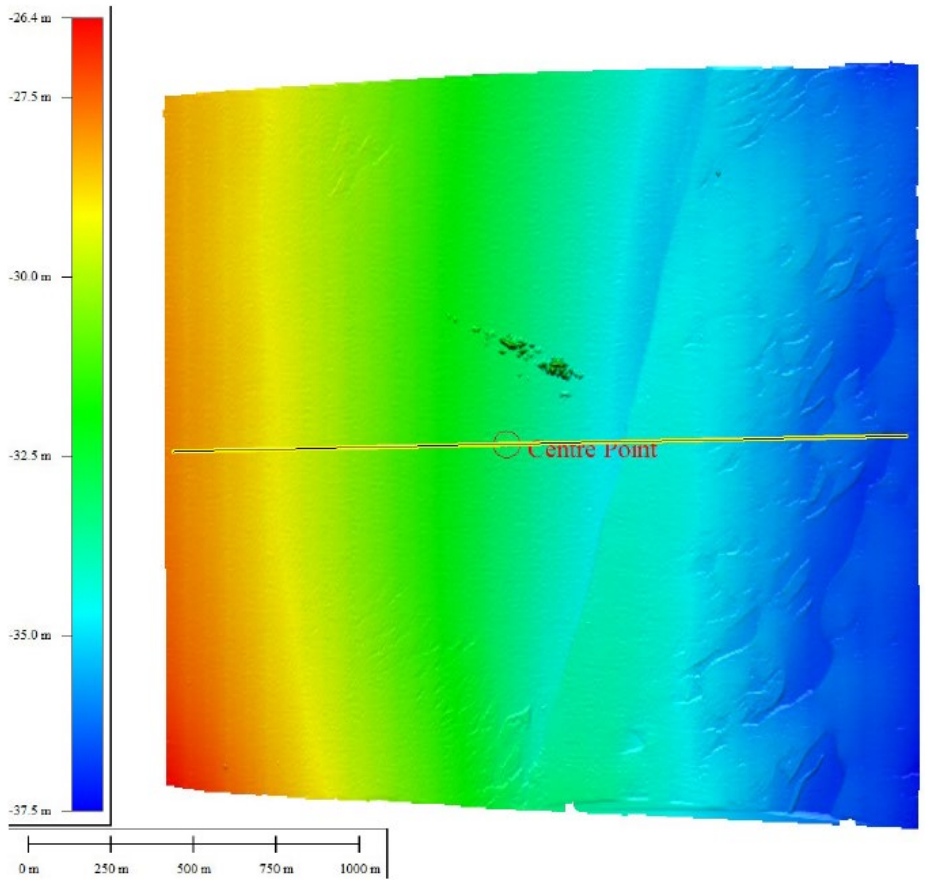

Figure 5 West to east profile through proposed Forster offshore artificial reef site Source: Astute Surveying [21]

4.3 Biological considerations

4.3.1 Soft sediment and rocky reef assemblages

Offshore artificial reefs are most effective when placed on 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. In NSW, a few common groups make up the fish fauna of sandy areas ([13, 22]). 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. The flatheads and whiting were present 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 surveys were conducted by DPI on the proposed Forster OAR deployment site and control sites representative of a natural reef adjacent to the reef deployment area on 2 August 2021. Baited remote underwater video (BRUV) units were set at two sites on natural reef located at 32°9.660'S, 152°33.223'E and 32°9.660'S, 152°33.290'E, and two sites within the immediate vicinity of the proposed OAR location at 32°9.960'S, 152°33.104'E and 32°9.980'S, 152°33.240'E (Figure 6 and Figure 7). A remotely operated vehicle (ROV) camera was used to ground truth nearby natural reef and unconsolidated soft sediments at the proposed reef site. Results from these surveys indicated that the natural rocky reef supported a fish community that was different to the community

identified on the proposed reef deployment site. In total, 35 fish species were identified on the nearby natural reef and seven species within the vicinity the proposed OAR site from BRUV footage collected.

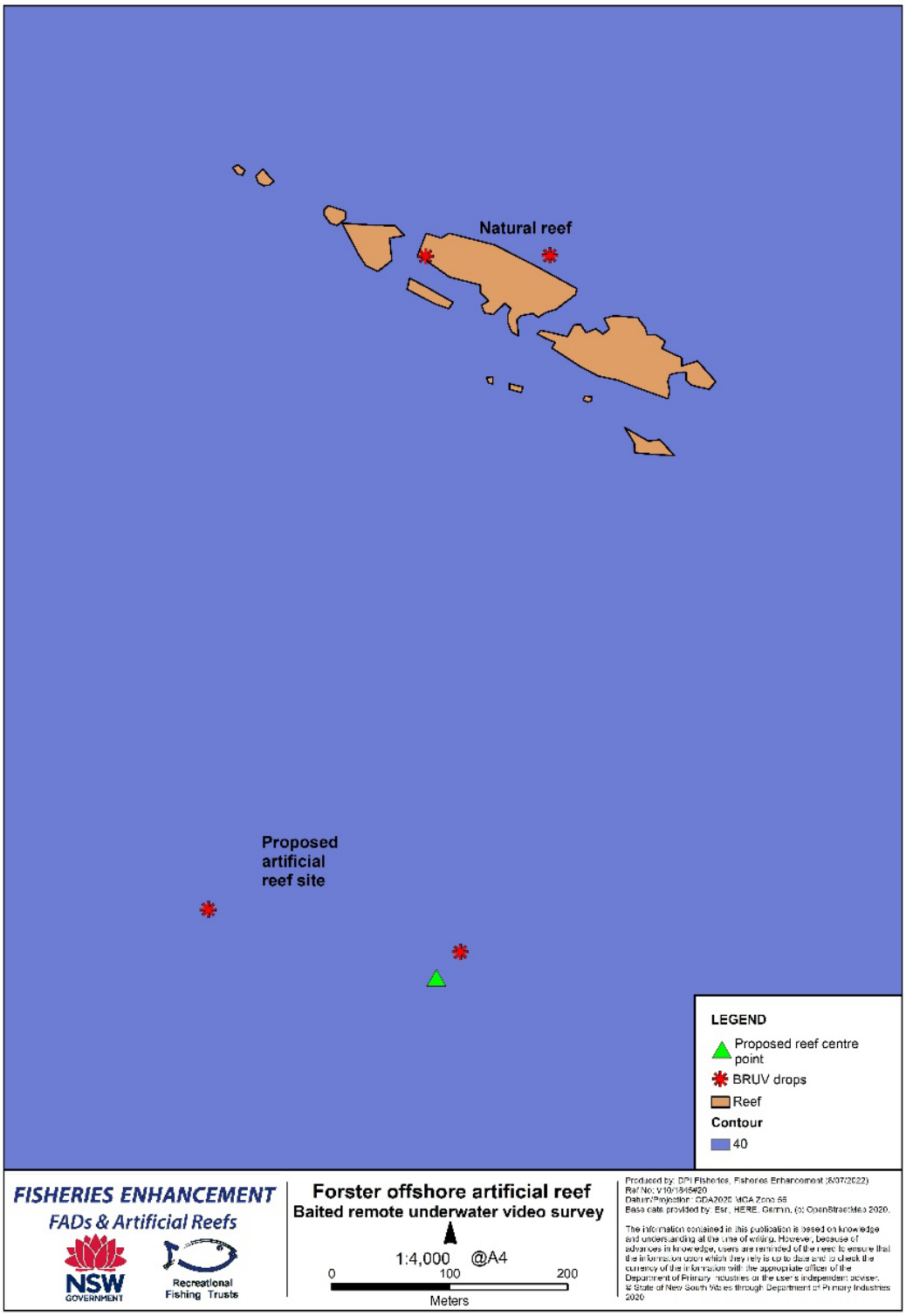

Figure 6 Location of baited remote underwater video (BRUV) deployments on proposed Forster offshore artificial reef site and on adjacent natural reef

The natural reef exhibited a greater number of reef associated species including commercially and/or recreationally important Snapper (*Chrysophrys auratus*), Red Morwong (*Cheildactylus fuscus*), Silver Trevally (*Pseudocaranx georgianus*) and Tarwhine (*Rhabdosargus sarba*). The proposed OAR site showed a greater dominance of soft sediment associated species such as Flatheads (*Platycephalus* spp.), Eastern School Whiting (*Sillago flindersi*), Shovelnose Rays (*Aptychotrema sp.*) and Southern Fiddler Ray (*Trygonorrhina dumerilii*).

The results of BRUV surveys conducted by DPI were consistent with similar surveys at other OAR sites prior to reef construction. They further support the hypothesis that the new OAR will provide the building blocks for a reef habitat for a wide variety of reef associated fish species.

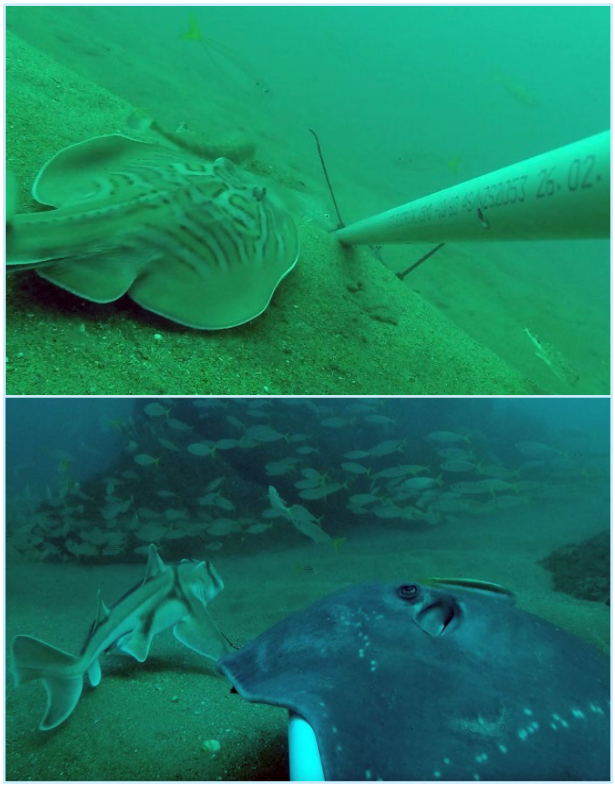

Figure 7 Still images from the baited remote underwater video deployment on the proposed Forster offshore artificial reef site (top) and the adjacent to natural rocky reef site located north of the reef deployment site in the same depth range (bottom)

4.3.2 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 Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the NSW *Biodiversity Conservation Act 2016* (BC Act) and the NSW FM Act were identified within a 50 km radius of the proposed deployment site using the EPBC Act Protected Matters Reporting Tool [23], the Bionet Database [24] and the Atlas of Living Australia, as well as literature relevant to the Forster area in February 2022. A list of all threatened and protected species, populations and endangered ecological communities identified within the search areas are provided in Table 3. It is important to note that data in the searches comes from several different sources, may contain errors and omissions and should therefore be treated as indicative only.

Results of the database searches revealed 40 species of fish (including seahorses, pipefish and ghost pipefish), 32 species of marine mammal (including whales, dolphins and seals) and seven species of marine reptiles (turtles and seasnakes; Table 3). More detailed information is provided in section 5.3.11.

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. A total of 96 bird species were identified that comprised seabirds and birds of prey (Table 3). The main groups of seabirds that were found to occur in the study region included albatrosses, petrels, shearwaters, terns, skuas, prions, gulls and gannets.

New South Wales and Commonwealth registers of critical habitats were also searched within and beyond the study region. The Greynurse Shark is known to aggregate at discrete locations within the Mid North Coast region with the nearest critical habitat location to the proposed Forster OAR

site at The Pinnacle, approximately 8.5 km to the south-south-east (Figure 8). The Pinnacle is afforded the highest level of protection under the *Marine Estate Management Act 2014* and is zoned sanctuary within the Port Stephens - Great Lakes Marine Park zoning plan with no fishing activities permitted. While the region is renowned for Greynurse Sharks (GNS) regularly frequenting The Pinnacle, they are also known to inhabit Latitude Rock, 4.9 km south of the proposed artificial reef site during calmer seas where tagged individuals have been known to stay from a few hours to a few days (Dr Nick Otway pers. comms.). GNS have also been reported to frequent a site known by divers as The Barge (Figure 8), located 1.9 km north-west of the proposed OAR site, on occasions. Past diver survey observations of very low GNS numbers have been supported by very low detections of individual tagged sharks from an acoustic receiver previously placed on The Barge with any occupation suggested to be of short term (i.e. hours rather than days), typical of migrating behaviour (Dr Nick Otway pers. comms.). Similarly, the rocky reef located 500 metres north of the proposed OAR site is not a recognised location for GNS supporting the low likelihood of the species taking up residence.

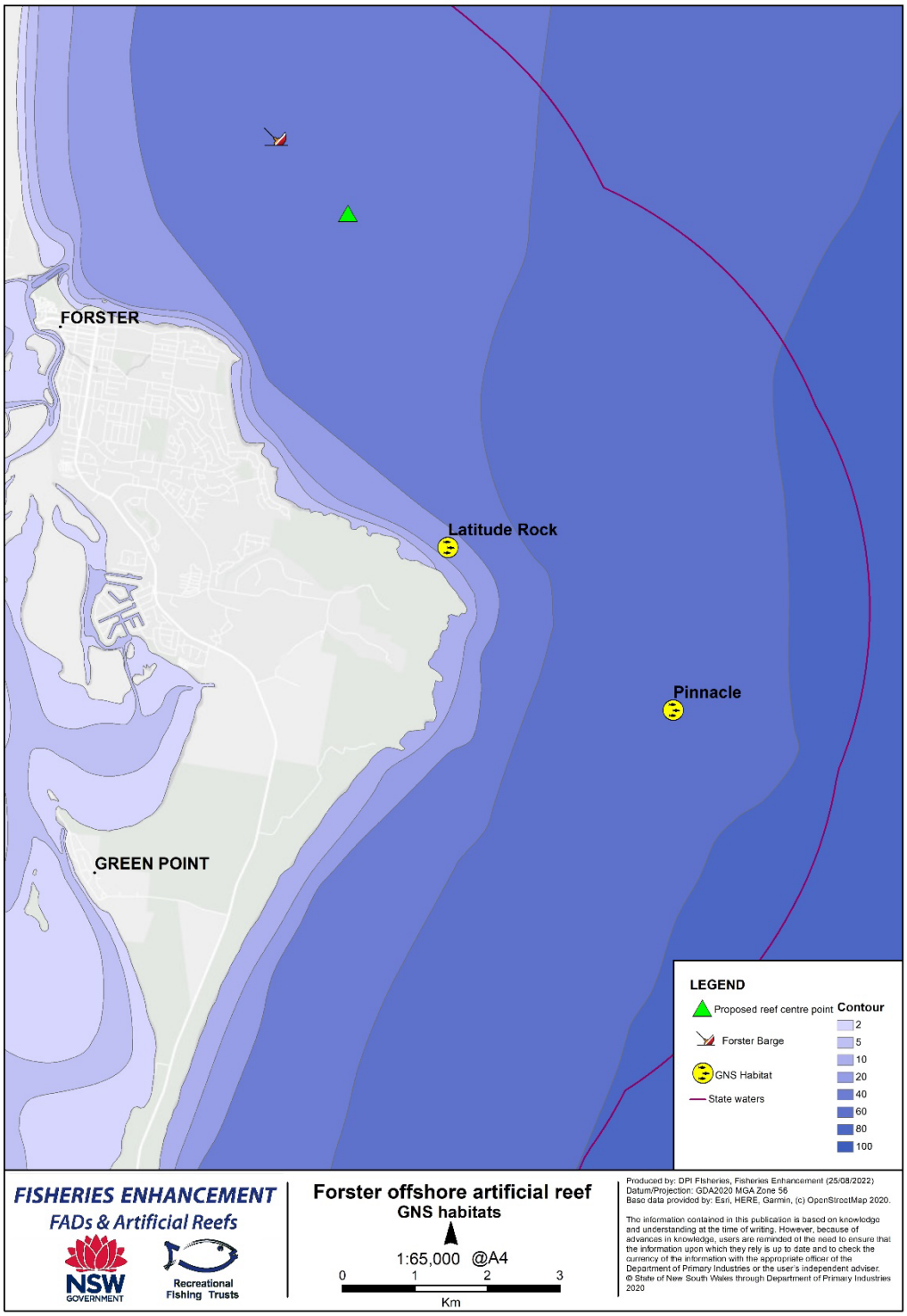

Figure 8 Greynurse Shark Habitat within the Forster offshore artificial reef greater study area

A threatening process is something that threatens, or could potentially threaten, the survival or evolutionary development of a species, population or ecological community [25]. Key Threatening Processes (KTPs) identified as being potentially relevant to the proposal are entanglement or ingestion of anthropogenic debris in marine and estuarine environments Threatened Species Conservation Act 1995; injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (EPBC Act); and hook and line fishing in areas important for the survival of threatened fish species (FM Act).

The risk assessment considered that the incidental capture of seabirds was very unlikely on the OAR. Presently, no interactions with seabirds have been reported from the Sydney, Shoalhaven, Port Macquarie, Southern Sydney, Merimbula, Newcastle, Wollongong, Tweed and Eurobodalla (formerly Batemans) OARs. For this reason, no direct mitigation measure is required. If increased interactions

with seabirds is reported and verified by DPI, an appropriate management response including but not limited to restrictions to some fishing practices (e.g. floating of surface baits) may be considered.

The OARs may potentially increase the risk of lost fishing gear and harmful 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. To reduce this potential impact on seabirds, education using the reef user guidelines and existing DPI education programs will be provided that highlight the impacts of marine debris on marine life and the responsible disposal of litter and discarded fishing gear.

Following deployment of the OAR, it is proposed for any incidents, recorded or reported interactions with threatened or protected fish species to be reported 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 BRUVs, unbaited video drops, ROV; and
- any interaction that involves the death of a threatened or protected seabird, mammal or reptile species will be immediately reported to NSW Environment and Heritage

DPI provides 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 (www.dpi.nsw.gov.au/fishing/recreational/resources/artificial-reef/guidelines). This educational information will be published as part the Forster OAR 'User Guidelines'.

Table 3 Threatened and protected species in the Forster area listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the NSW *Biodiversity Conservation Act 2016* (BC Act) and the F*isheries Management Act 1994* (FM Act).

Class	Scientific name	Common name	Status under BC & FM Act	Status under EPBC Act
Aves	*Anous stolidus*	Common Noddy		LM, M
Aves	*Apus pacificus*	Fork-tailed Swift		LM, M
Aves	*Ardenna bulleri*	Buller's Shearwater		LM
Aves	*Ardenna carneipes*	Flesh-footed Shearwater	V	LM, M
Aves	*Ardenna grisea = Puffinus griseus*	Sooty Shearwater		LM, M
Aves	*Ardenna pacifica = Puffinus pacificus*	Wedge-tailed Shearwater		LM, M
Aves	*Ardenna tenuirostris = Puffinus tenuirostris*	Short-tailed Shearwater		LM, M
Aves	*Calidris acuminata*	Sharp-tailed Sandpiper		LM, M
Aves	*Calidris canutus*	Red Knot, Knot		LM, M
Aves	*Calonectris leucomelas*	Streaked Shearwater		LM, M
Aves	*Catharacta skua*	Great Skua		LM
Aves	*Chlidonias hybrida*	Whiskered Tern		LM, M
Aves	*Chlidonias leucopterus*	White-winged Tern, White-winged Black Tern		LM, M
Aves	*Chroicocephalus novaehollandiae*	Silver Gull		LM
Aves	*Daption capense*	Cape Petrel		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	*Falco subniger*	Black Falcon	V	
Aves	*Fregata ariel*	Lesser Frigatebird		LM, M
Aves	*Fregata minor*	Great Frigatebird, Greater Frigatebird		LM, M
Aves	*Fregetta grallaria grallaria*	White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian)	V	V
Aves	*Fulmarus glacialoides*	Southern Fulmar		LM
Aves	*Garrodia nereis*	Grey-backed Storm-Petrel		LM
Aves	*Gelochelidon nilotica*	Gull-billed Tern		LM, M
Aves	*Gygis alba*	White Tern	V	LM
Aves	*Haliaeetus leucogaster*	White-bellied Sea-Eagle		LM, M
Aves	*Haliastur indus*	Brahminy Kite		LM
Aves	*Haliastur sphenurus*	Whistling Kite		LM
Aves	*Halobaena caerulea*	Blue Petrel		V, M
Aves	*Hieraaetus morphnoides*	Little Eagle	V	
Aves	*Hydroprogne caspia*	Caspian Tern		LM, M
Aves	*Larus pacificus*	Pacific Gull		LM
Aves	*Limosa lapponica*	Bar-tailed Godwit		LM, M
Aves	*Limosa lapponica baueri*	Easter Bar-tailed Godwit		V
Aves	*Lophoictinia isura*	Square-tailed Kite	V	
Aves	*Macronectes giganteus*	Southern Giant-Petrel	E	E, LM, M

Class	Scientific name	Common name	Status under BC & FM Act	Status under EPBC Act
Aves	*Macronectes halli*	Northern Giant-Petrel	V	V, LM, M
Aves	*Morus serrator*	Australasian Gannet		LM
Aves	*Oceanites oceanicus*	Wilson's Storm-Petrel		LM, M
Aves	*Onychoprion fuscata*	Sooty Tern	V	LM
Aves	*Pachyptila belcheri*	Slender-billed Prion		LM
Aves	*Pachyptila desolata*	Antarctic Prion		LM
Aves	*Pachyptila salvini*	Salvin's Prion		LM
Aves	*Pachyptila turtur*	Fairy Prion		LM
Aves	*Pachyptila vittata*	Broad-billed Prion		LM
Aves	*Pandion cristatus = haliaetus*	Eastern Osprey	V	LM, M
Aves	*Pelagodroma marina*	White-faced Storm-Petrel		LM
Aves	*Pelecanus conspicillatus*	Australian Pelican		LM
Aves	*Pelecanoides urinatrix*	Common Diving-Petrel		LM
Aves	*Phaethon lepturus*	White-tailed Tropicbird		LM
Aves	*Phoebetria fusca*	Sooty Albatross	V	V, LM, M
Aves	*Procellaria cinerea*	Grey Petrel		LM, M
Aves	*Procellaria westlandica*	Westland Petrel		LM, M
Aves	*Procelsterna cerulea*	Grey Ternlet	V	LM
Aves	*Pseudobulweria rostrata*	Tahiti Petrel		LM
Aves	*Pterodroma cervicalis*	White-necked Petrel		LM
Aves	*Pterodroma cookii*	Cook's Petrel		LM
Aves	*Pterodroma lessonii*	White-headed Petrel		LM
Aves	*Pterodroma leucoptera leucoptera*	Gould's Petrel	V	E, LM
Aves	*Pterodroma macroptera*	Great-winged Petrel		LM
Aves	*Pterodroma mollis*	Soft-plumaged Petrel		V, LM
Aves	*Pterodroma neglecta neglecta*	Kermadec Petrel (western)	V	V, LM
Aves	*Pterodroma nigripennis*	Black-winged Petrel	V	LM
Aves	*Pterodroma solandri*	Providence Petrel	V	LM
Aves	*Puffinus carneipes*	Flesh-footed Shearwater, Fleshy-footed Shearwater		LM, M
Aves	*Puffinus gavia*	Fluttering Shearwater		LM
Aves	*Puffinus griseus*	Sooty Shearwater		LM, M
Aves	*Puffinus huttoni*	Hutton's Shearwater		LM
Aves	*Puffinus leucomelas*	Streaked Shearwater		LM, M
Aves	*Stercorarius longicaudus*	Long-tailed Jaegar, Long-tailed Skua		LM, M
Aves	*Stercorarius parasiticus*	Arctic Jaegar, Arctic Skua		LM, M
Aves	*Stercorarius pomarinus*	Pomarine Jaegar, Pomarine Skua		LM, M
Aves	*Stercorarius skua*	Great Skua		LM
Aves	*Sterna hirundo*	Common Tern		LM, M
Aves	*Sterna paradisaea*	Arctic Tern		LM
Aves	*Sterna striata*	White-fronted Tern		LM
Aves	*Sternula albifrons*	Little Tern	E	LM, M
Aves	*Sula leucogaster*	Brown Booby		LM, M
Aves	*Thalassarche bulleri*	Buller's Albatross, Pacific Albatross		V, LM, M
Aves	*Thalassarche bulleri platei*	Northern Buller's Albatross, Pacific Albatross		V, LM
Aves	*Thalassarche carteri*	Indian Yellow-nosed Albatross		V, LM, M

Class	Scientific name	Common name	Status under BC & FM Act	Status under EPBC Act
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 chlororhynchos*	Atlantic Yellow-nosed Albatross		LM, M
Aves	*Thalassarche chrysostoma*	Grey-headed Albatross		E, 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	*Arctocephalus tropicalis*	Subantarctic Fur-Seal		V, LM
Mammalia	*Balaenoptera acutorostrata*	Minke Whale		Cet
Mammalia	*Balaenoptera borealis*	Sei Whale		V, Cet, M
Mammalia	*Balaenoptera edeni*	Bryde's Whale		Cet, LM
Mammalia	*Balaenoptera musculus*	Blue Whale	E	E, Cet, LM
Mammalia	*Balaenoptera physalus*	Fin Whale		V, Cet, M
Mammalia	*Caperea marginata*	Pygmy Right Whale		Cet, LM
Mammalia	*Delphinus delphis*	Common Dolphin, 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	*Kogia breviceps*	Pygmy Sperm Whale		Cet
Mammalia	*Kogia sima*	Dwarf Sperm Whale		Cet
Mammalia	*Lagenorhynchus obscurus*	Dusky Dolphin		Cet, M
Mammalia	*Lobodon carcinophagus*	Crab-eater Seal		LM
Mammalia	*Megaptera novaeangliae*	Humpback Whale	V	V, Cet, M
Mammalia	*Mesoplodon densirostris*	Blainville's Beaked Whale, Dense-beaked Whale		Cet
Mammalia	*Mesoplodon ginkgodens*	Ginko-toothed Beaked Whale		Cet
Mammalia	*Mesoplodon grayi*	Gray's Beaked Whale		Cet
Mammalia	*Mirounga leonina*	Southern Seal		V, LM
Mammalia	*Orcinus orca*	Killer Whale, Orca		Cet, M
Mammalia	*Peponocephala electra*	Melon-headed Whale		Cet
Mammalia	*Physeter macrocephalus*	Sperm Whale	V	Cet, M
Mammalia	*Pseudorca crassidens*	False Killer 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	*Acentronura tentaculata*	Shortpouch Pygmy Pipehorse	P	LM
Pisces	*Anampses elegans*	Elegant Wrasse	P	
Pisces	*Carcharias taurus* (east coast population)	Greynurse Shark (east coast population)		CE

Class	Scientific name	Common name	Status under BC & FM Act	Status under EPBC Act
Pisces	*Carcharias taurus Rafinesque*	Greynurse Shark	CE	
Pisces	*Carcharodon carcharias*	Great White Shark	V	V, M
Pisces	*Centrophorus harrissoni*	Harrisson's Dogfish, Endeavour Dogfish, Dump Gulper Shark, Harrisson''s Deepsea Dogfish	CD	CD
Pisces	*Centrophorus zeehaani*	Southern Dogfish, Endeavour Dogfish, Little Gulper Shark	CD	CD
Pisces	*Cosmocampus howensis*	Lord Howe Pipefish	P	LM
Pisces	*Epinephelus coioides*	Estuary Cod	P	
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	*Girella cyanea*	Bluefish	P	
Pisces	*Heraldia nocturna*	Upside-down Pipefish, Eastern Upside-down 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	*Lissocampus runa*	Javelin Pipefish	P	LM
Pisces	*Maroubra perserrata*	Sawtooth Pipefish	P	LM
Pisces	*Mobula alfredi = Manta alfredi*	Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray		M
Pisces	*Mobula birostris = Manta birostris*	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray		M
Pisces	*Paraplesiops bleekeri*	Eastern Blue Devil	P	
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	*Seriolella brama*	Blue Warehou		CD
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 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 argus*	Spotted Pipefish, Gulf Pipefish, Peacock Pipefish	P	LM
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

Class	Scientific name	Common name	Status under BC & FM Act	Status under EPBC Act
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, LM = listed marine, Cet = cetacean and P = protected (FM Act). Note: All native birds, reptiles, amphibians and mammals in NSW are protected by the *National Parks and Wildlife Act 1974*.

5 Structure design, reef configuration and construction

5.1 Preparation of materials

Similar to the Sydney and Eurobodalla OARs, the structures will be constructed of new Australian standard structural steel components which will be raw, unpainted and ungalvanized (Figure 9). No substances from Annex 1 or 2 (under schedule 1 of the EP (SD) Act) will be used in the fabrication of reef structures.

Figure 9 Eurobodalla offshore artificial reef, 2021

5.2 Reef design and construction

The two steel tower structures are identical in design, with weights of approximately 50 tonnes, footprints of approximately 15.6 x 15.6 m and heights of 12 m. The awarded concept design is shown in Figure 10 and has undergone final stability calculations which have been reviewed and approved by Manly Hydraulics Laboratory to withstand local oceanographic forces described in Table 23.

The reefs will be of a modular design, allowing safe and efficient fabrication, transport and assembly. The structural steel welded sections will be bolted together, and all critical joints welded once assembled.

Assembly and welding of materials will be completed at SMC Marine, Sydney Ports Secure Area, White Bay, Rozelle. Qualified and experienced tradesmen shall conduct the fabrication work in accordance with SMC's standard weld operation procedures and job specifications.

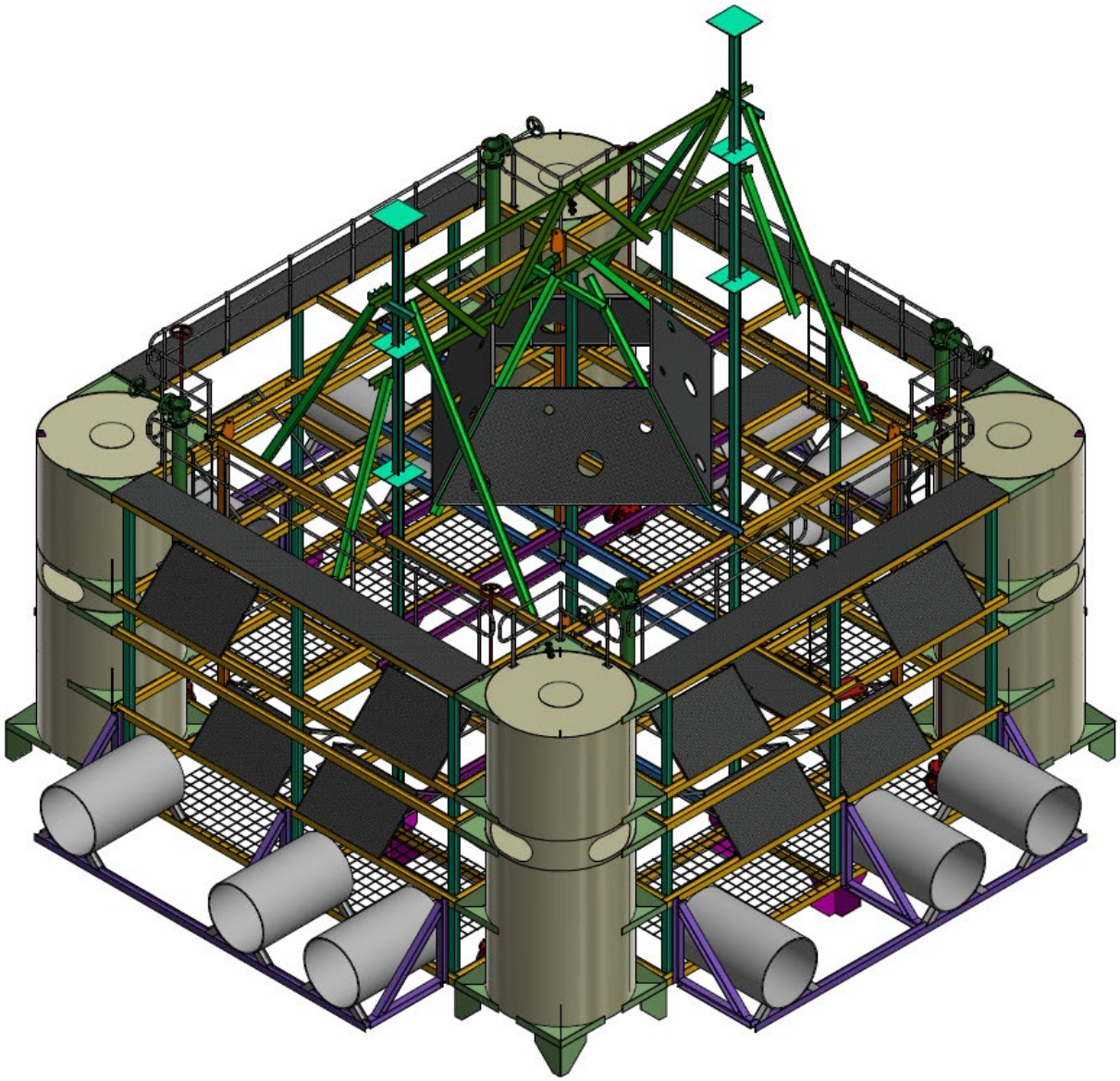

Figure 10 Final design of Forster offshore artificial reef steel structure

Dr Iain Suthers and Dr. Hayden Schilling, marine oceanographers, fisheries scientists and artificial reef experts from the Australian Institute of Marine Science, previously reviewed SMC Marine's artificial reef structural design and significant modifications were undertaken to develop the Batemans OAR design which forms the basis for the Forster OAR. These design improvements increased structural stability, increased areas of shelter for fish and surfaces for algae growth, current flow diversion via angled panels and features of interest for targeted fish species.

The design includes buoyancy chambers mounted in the four corners of the reef body (Figure 10). These chambers enable the reef to float during marine transport. Once in location for sinking, the chambers will be opened, venting all air and allowing the reefs to sink to the sea floor.

The design has been checked for the assembly, launch, tow and installation load cases which are the most onerous design conditions.

The following design features and criteria have been included in the design:

- Complexity and structural integrity are achieved by using large structural members.

- Large permeable base allowing for benthic foraging and minimising disturbance of soft sediments during deployment.
- Tall profile to attract pelagic fish.
- Open skeletal structure that is ideal for mobile sand substrate environment.
- Steel thickness great enough to allow for corrosion.
- Structural complexity of steel beams and plates for a greater variety of habitats.

No Annex I or II substances (other than virgin steel) (under Schedule 1 of the EP (SD) Act) will be used in the design or construction of the reef structures.

5.3 Reef deployment site

Following the review of existing information and mapping of key characteristics of the study area and surrounds, constraints analysis identified a potential OAR deployment area to the east-north-east of Forster (Figure 11). This is the area where, based on existing information, reef deployment would be suitable and unlikely to conflict with the physical, biological and regulatory constraints investigated. The analysis was limited to using the information available and was subject to revision once further data or field investigations of the seabed and consultation had been undertaken.

The corner point co-ordinates (GDA2020) for the 400 x 400 m reef deployment area are situated at:

NW	32° 09.907’ S, 152° 33.090’ E	NE	32° 09.908’ S, 152° 33.472’ E
SW	32° 10.232’ S, 152° 33.089’ E	SE	32° 10.233’ S, 152° 33.470’ E

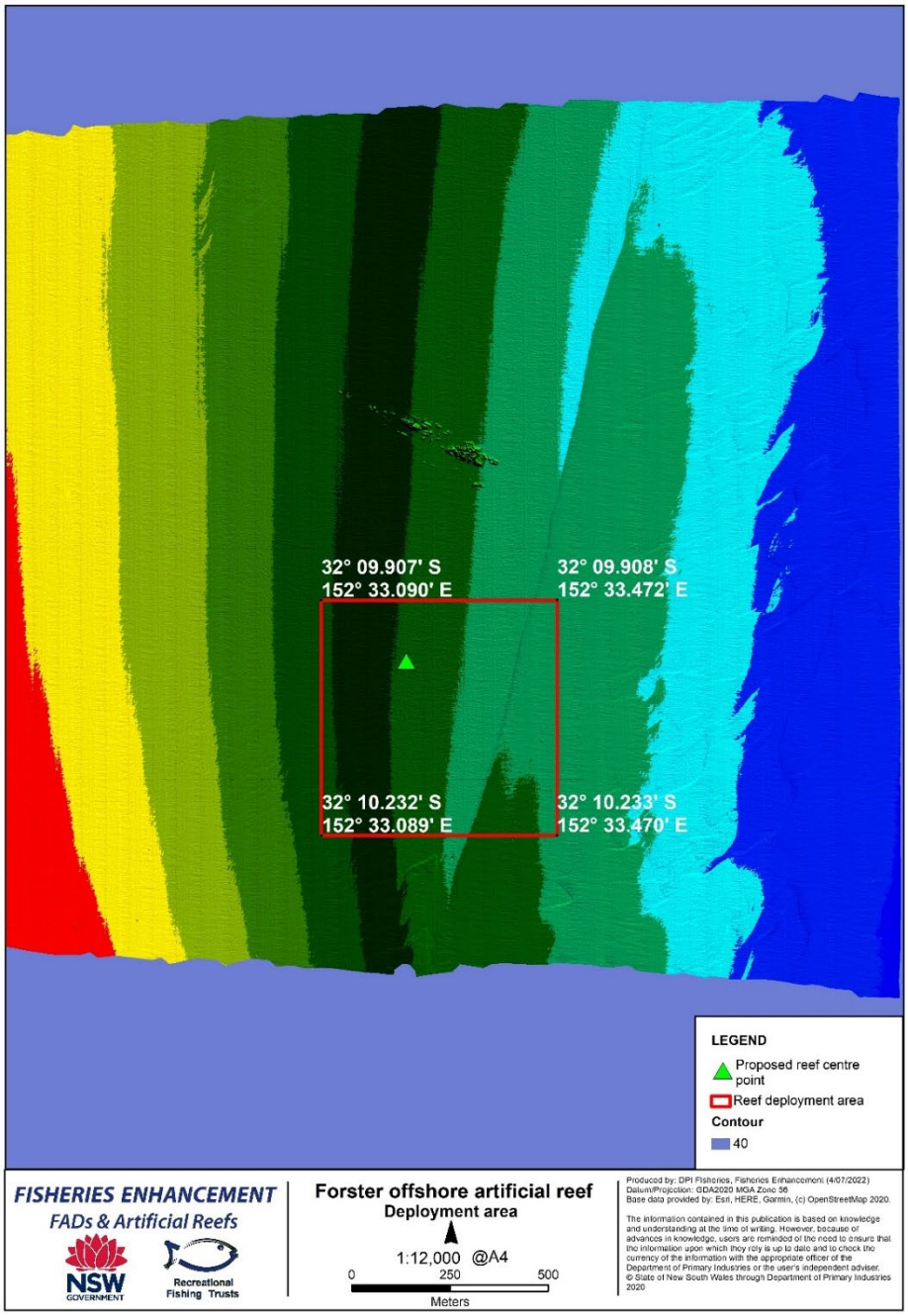

Figure 11 Forster offshore artificial reef deployment area

5.3.1 Map of deployment site

The location of the proposed Forster OAR deployment site is shown in Figures 11 and 12. The deployment site falls within the waters displayed in Australian Hydrographic Chart AUS810.

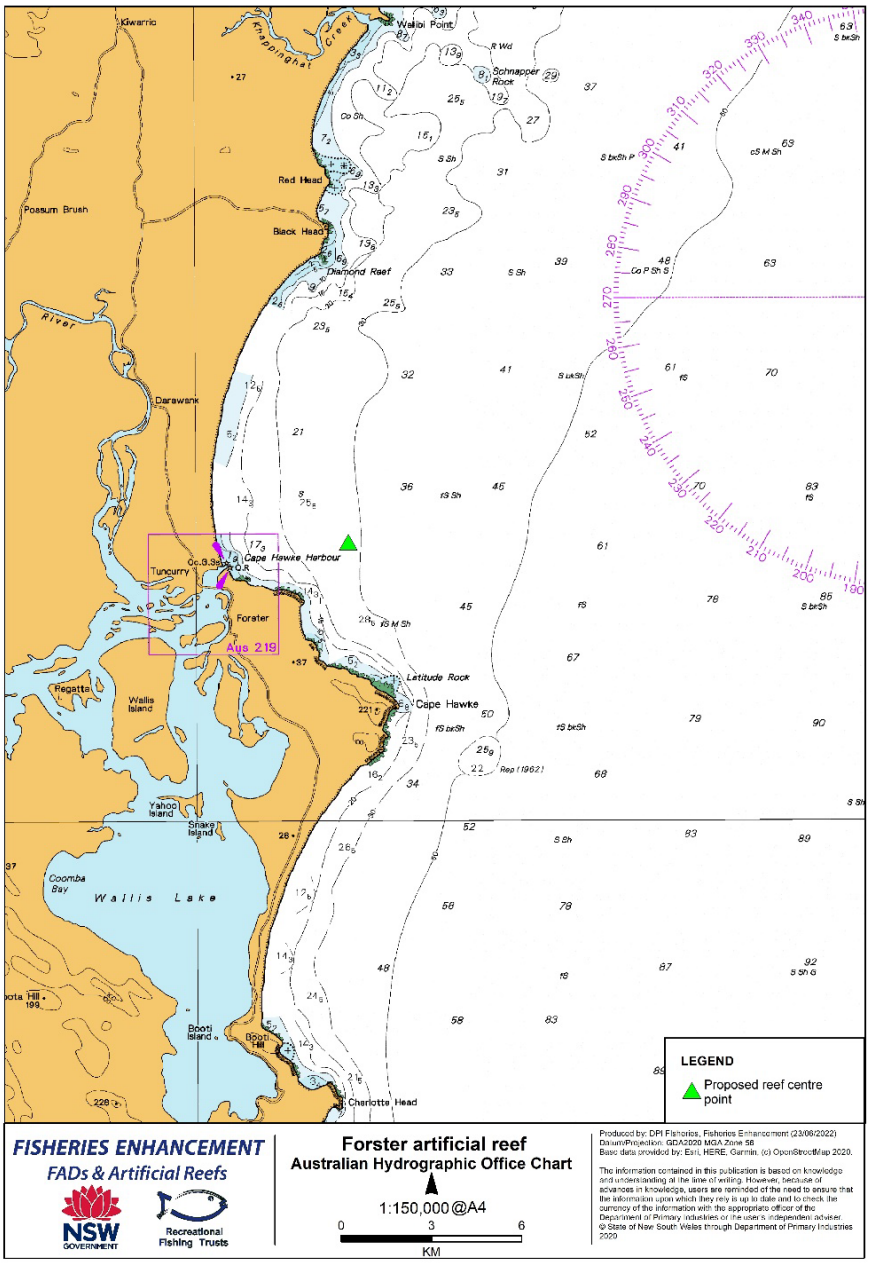

Figure 12 Forster offshore artificial reef management area shown on Australian Hydrographic Office Chart AUS810

5.3.2 Photographs and/or video of the proposed site prior to deployment

Underwater surveys were conducted by DPI on 02 August 2021 at the proposed OAR centre point and at a control site representative of natural reef found to the north of the reef deployment area using ROV and BRUV units (Figure 6, Figure 7 and Figure 13). Results from these initial surveys indicated that the natural rocky reef supported a fish community that was different to the community identified on the proposed reef deployment site (See section 4.3.1).

The site-specific surveys conducted by DPI consistently supported the hypothesis that it is expected the new OAR 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 associated species.

Figure 13 A still image of the substrate from remotely operate vehicle at the proposed Forster offshore artificial reef site. (Image: DPI – August 2021)

5.3.3 Geographical position (latitude and longitude)

Figure 14 displays the geographical arrangement of the Forster OAR within the reef deployment area. On the day of deployment, accurate localised currents will be measured on site to ensure the structures align with the prevailing East Australian Current (EAC) influence to maximise fishers' drift across the OAR structures. The structures will be placed approximately 80 m apart and 40 m either side of the OAR centre point to maximise biological value between structures (Figure 14).

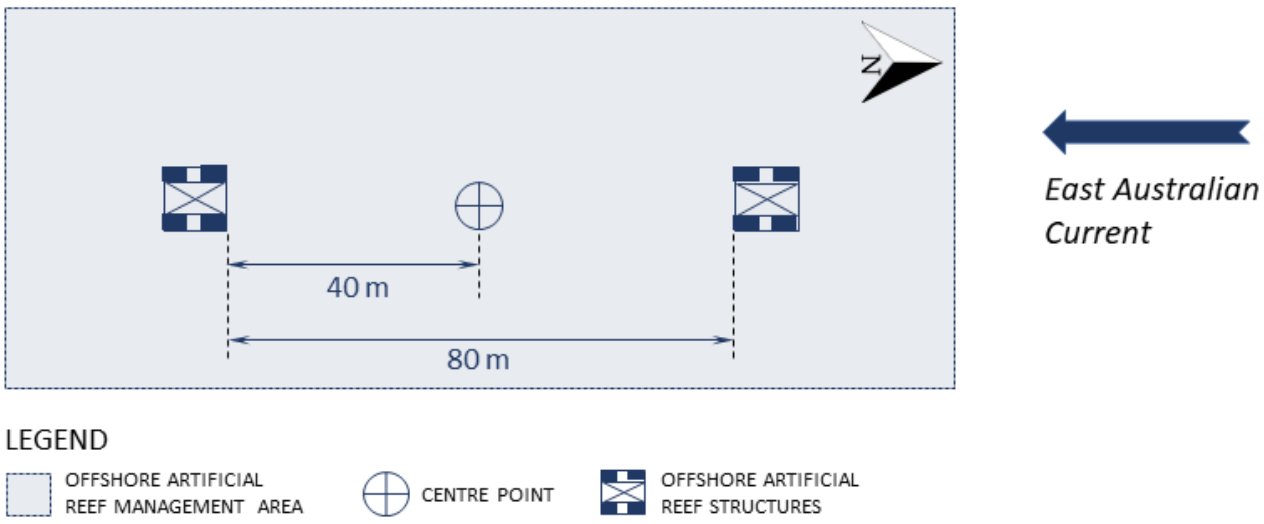

Figure 14 Forster offshore artificial reef structures arrangement

5.3.4 'As-built' location confirmation

Differential GPS (DGPS) will be used for surface positioning of the vessel and for subsea positioning of the structures. The final 'as-built' survey will be conducted and a post deployment report will be prepared for the Department of Climate Change, Energy, Environment and Water (DCCEEW).

5.3.5 Depth of water over the reef

Suitable depth is important to avoid creating a navigational hazard and for the stability of the structures (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. The Forster OAR centre point is located within 33 - 35 m bathymetry with a minimum clearance depth over the artificial reef post deployment of no less than 20 m (LAT Figure 15). This will be confirmed post reef deployment.

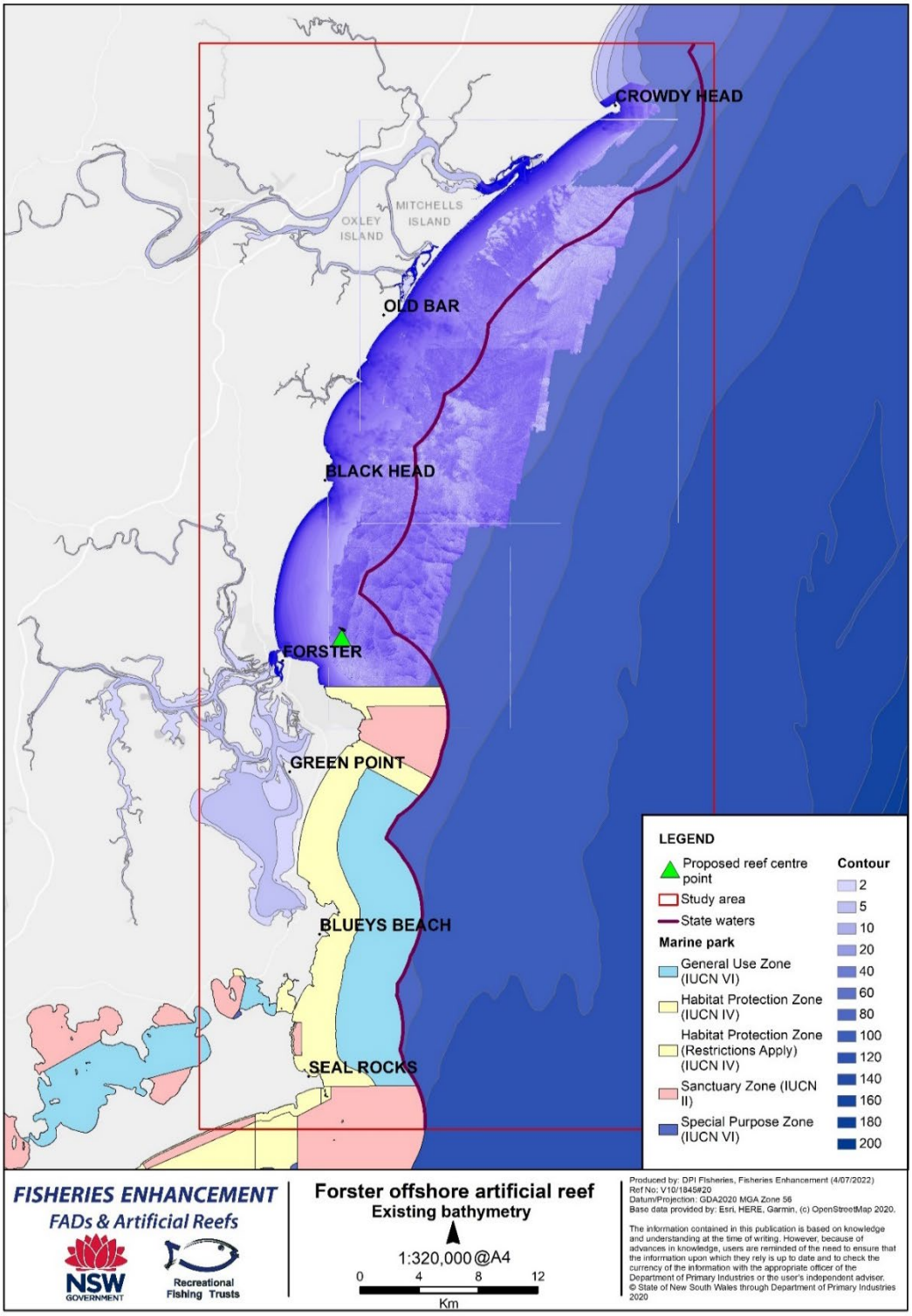

Figure 15 Forster offshore artificial reef centre point located north of Port Stephens - Great Lakes Marine Park

5.3.6 Distance from nearest land

The Forster OAR centre point is to be located within State waters approximately 2.5 km north-east from Bennetts Head, approximately 500 m south of the closest natural reef and approximately 3 km north of the Port Stephens – Great Lakes Marine Park Boundary (Figure 16).

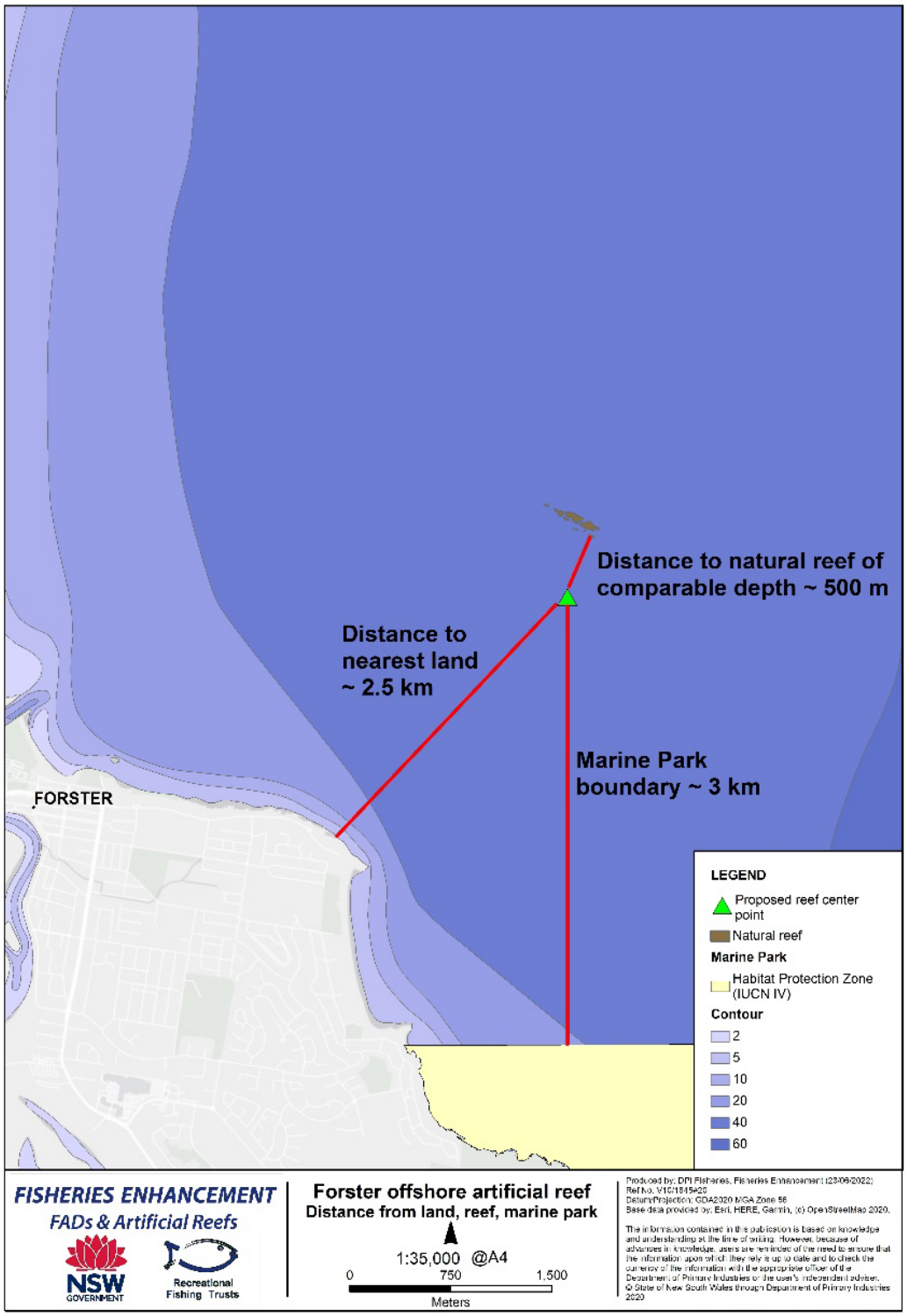

Figure 16 Location of proposed Forster offshore artificial reef centre point showing distance from land, natural reef and Marine Parks

5.3.7 Biological characteristics

The proposed deployment site consists of unconsolidated soft sediments. 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 (typically a nominated distance of no less than 0.5 km). Natural reef habitats, habitats unique within an area or locations known to support diverse benthic/epibenthic communities should therefore be avoided (Figure 17). 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 proposed Forster OAR deployment site has been chosen approximately 500 m south of the nearest natural reef (Figure 16) to reduce the effect of 'draw-down' (that is individuals readily moving from the natural reef onto the artificial reef). Open sand/sediment expanses present a perceived impassable barrier to many demersal reef-associated fish species. Biological considerations were presented in detail in section 4.3.

5.3.8 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 illustrated an onshore-offshore depth gradient across the 2.2 km of seabed surveyed consistent with sediment substrata represented by intermittent increases in depth from 28 m to 37 m (Figure 5). This indicates that the seafloor consists predominantly of unconsolidated sediments with the presences of sand wavings and ridges, as evidenced by camera surveys (Figure 13).

5.3.8.1 Impacts on soft sediment assemblages

Offshore artificial reefs are 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.

Initial deployment of the OAR units would 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. If the base of the structures were impermeable, a large proportion of animals living within the direct footprint of where individual structures are placed would also be lost through smothering. This would be a total area of ~300 m^2, however the bases of the structures for the Forster OAR will be permeable to the sea floor, minimising the impact and leaving the sediment open to benthic foraging for the life of the reef. Once colonised, the habitat will continue to support a wide variety of marine organisms and provide greater habitat heterogeneity allowing a potentially diverse assemblage to establish.

Soft-bottom habitats adjacent to Forster OARs 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 due to 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 and the subsequent risk following mitigative measures is considered acceptable within the wider study area (Table 4).

Table 4. 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	A4	Careful selection of habitat type for deployment location. Efficient open/permeable design of OAR base to minimise smothering/loss of sedimentary habitat.	Accept	A4
Benthos	Sub-Local	Change to benthic fauna from changes to sedimentary characteristics	C4	Accept	Accept	C4
Benthos	Sub-Local	Changes to infaunal assemblages	B4	Accept	Accept	B4
Benthos	Sub-Local	Increased predation by fishes from the OAR on benthos	A4	Accept	Accept	A4

5.3.8.2 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 OAR structures from existing natural reef was aimed for as part of the constraints mapping to minimise potential draw-down effects. Natural reef areas with a 500 m buffer are represented in Figure 17 (except for the isolated strip of reef which lies 500 m to the north of the OAR site for scale purposes only. For a visual representation of the distance between the OAR and isolated reef 500 m to the north see Figure 16). The convenience and likely popularity of the OAR 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 due to the deployment of the artificial 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 and following mitigative measures, risk on adjacent natural reef flora and fauna is considered acceptable (refer to Table 5). In summary, the site-specific surveys conducted by DPI supported the hypothesis that it is expected the new OAR 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 associated species.

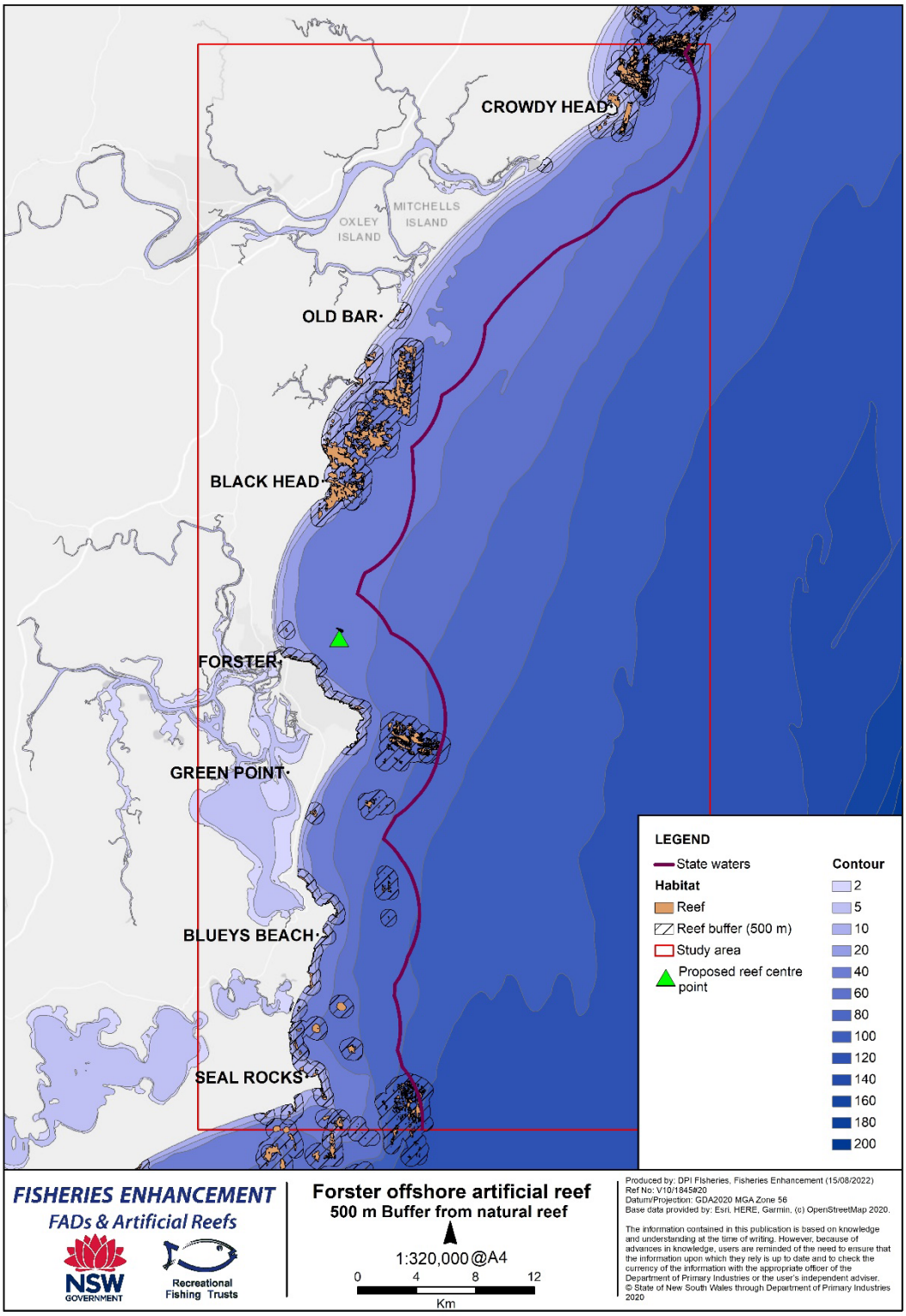

Figure 17 Natural reef mapped with a 500 m buffer zone

Table 5. 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						
Proximal natural reef	Intermediate	Drawdown effects – reduction in abundance/diversity of reef assemblages	C3	Careful selection of location and design. Swath mapping to confirm presence of reef habitat. Careful site selection to provide adequate buffer from natural reef.	Reduce likelihood	D3
Proximal natural reef	Local	Changes to demersal assemblages	A4	Careful selection of location and design. Careful site selection to provide adequate buffer from natural reef.	Accept	A4
Proximal natural reef	Local	Changes to plankton assemblages	A4	Accept.	Accept	A4
Proximal natural reef	Local	Changes to pelagic assemblages	A4	Careful selection of location and design. Careful site selection to provide adequate buffer from natural reef.	Accept	A4
Proximal natural reef	Intermediate	Changes to epibenthic assemblages	B5	Careful selection of location and design. Swath mapping to confirm presence of reef habitat. Careful site selection to provide adequate buffer from natural reef.	Reduce likelihood	C5

5.3.9 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)

There are numerous boat ramps and amenities in the Forster region with 9 public boat ramps known to Roads and Maritime Services (RMS) within 25 km by water of the proposed OAR site (Table 6 and Figure 18). It is anticipated that most boaters will use ramps from within Wallis Lake to access the OAR.

Table 6 Boat ramps and facilities within 25 km of the proposed Forster offshore artificial reef site

Name	Waterway	Access	Concrete Y/N	Condition	No. lanes	No. trailer spaces	Fee payable	Lighting	Waste bins	Fish cleaning	Pontoon	BBQ	Toilets
Bohnock	Manning River	All times	Y	Fair	2	0-10	N	Y	Y	Y	Y	N	N
Saltwater Road	Khappinghat Creek	Shallow at times	Y	Good	1	0-10	N	N	Y	N	N	Y	Y
Blackhead Beach	Ocean	All times	Y	Fair	1	0-10	N	Y	Y	N	N	N	N
Forster Boat Harbour	Wallis Lake	All times	Y	Good	4	51+	N	Y	Y	Y	Y	N	N
Tuncurry Point Road	Wallis Lake	All times	Y	Good	4	21-50	N	Y	Y	Y	Y	Y	N
Little Street	Wallis Lake	Shallow at times	Y	Fair	1	0-10	N	Y	Y	N	Y	N	Y
Elizabeth Parade	Pipers Creek	All times	Y	Good	2	0-10	N	N	Y	Y	N	Y	Y
Elizabeth Beach	Ocean	Shallow at times	Y	Poor	1	0-10	N	N	Y	N	N	N	N
Pacific Palms	Wallis Lake	All times	Y	Good	2	0-10	N	N	N	N	Y	N	N

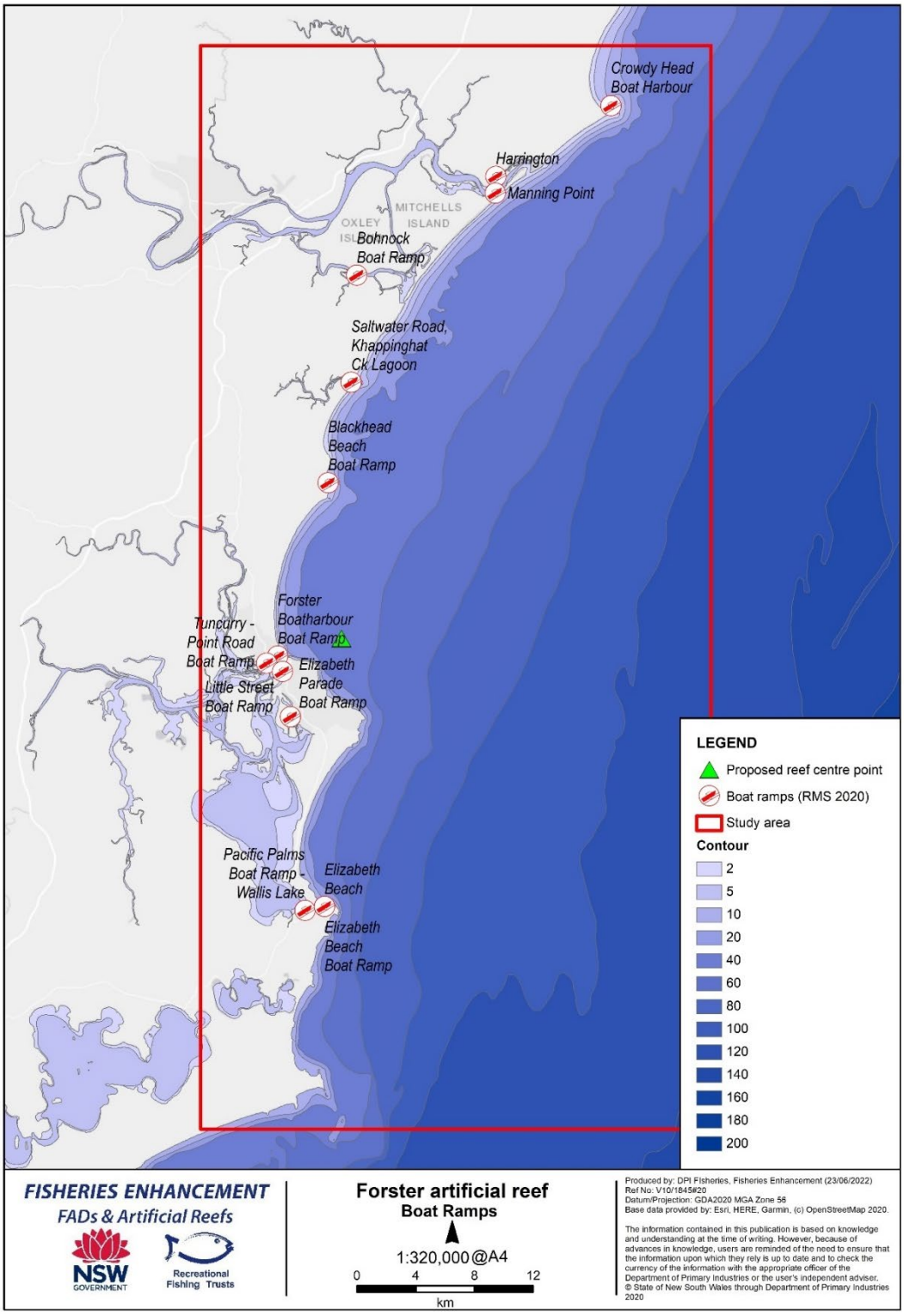

Figure 18 Boat ramps in the Forster region that may be used to access the offshore artificial reef

5.3.9.1 Navigation

The proposed OAR has the potential to impinge on recreational and commercial vessel operations. The potential risks of the proposed fishing reef on navigation and vessels are listed below and considered within Tables 7 and 8.

Clearance

There is a potential risk that vessels transiting over the OAR may be damaged or damage the reef structures if the hull or propeller contacts the structures. However, this would be mitigated by ensuring sufficient clearance at all tides and in high wave conditions. Adequate safe vessel clearance will be provided with a minimum of 20 m clearance from the uppermost part of the offshore artificial reef at LAT ensured for the proposed Forster OAR.

The potential risk of a vessel striking the reef has been prevented by implementing mitigative measures (Table 7) to ensure 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 individual recreational boat operators are difficult to control.

Table 7. Risks and mitigation associated with clearance

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Navigation and Safety	Local	Clearance	D4	Sufficient clearance between the upper part of the reef and transiting vessels in severe weather conditions and under Lowest Astronomical Tide (LAT) would be ensured through constraints mapping process and swath mapping. Appropriate site selection, consultation and mapping on navigation charts.	Reduce likelihood	E4

Increased vessel traffic

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

A code of conduct and guidelines will be published to promote awareness of boating safety within the reef area, therefore reducing risks associated with increased vessel traffic to acceptable levels (Table 8). Recreational fishing vessels should always give way to commercial vessels and adhere to all RMS boating rules and regulations.

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

Table 8. Risks and mitigation associated with increased vessel traffic

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Navigation and safety	Local	Increased vessel traffic	A4	Accept	Accept	A4
Navigation and safety	Local	Collision from crowding	C3	Observe boating regulations. Spread effort through reef design/layout. Education.	Reduce likelihood	D3

5.3.9.2 Exploitation of cultural, historic or scientific interest

Conflict with areas of spiritual significance/dreamings

As discussed within DPI's Indigenous Fisheries Strategy and Implementation Plan – December 2002, Aboriginal people have strong cultural connections with the ocean and coast. Fishing has represented an integral part of their cultural and economic lives for thousands of years. Fishing has been an important source of food, a basis for trade and an important part of cultural and ceremonial life; the act of fishing is itself an important cultural practice and a key part of the cultural identity of Aboriginal fishing communities [26].

The project area falls within the traditional lands of the Biripi and Worimi people. The Biripi and Worimi tribes, occupied territory extending from Port Stephens in the south to Forster/Tuncurry in the north and west to Gloucester [27].

Roberts [28] notes the ongoing importance of fishing to Aboriginal communities throughout New South Wales, stating that fishing represents a cultural (as opposed to purely subsistence/recreational) activity that 'became a crucial means of survival when other traditional practices were undermined by colonisation' and has remained a largely accessible activity as compared to land-based activities. It is also noted that fishing remains an important activity for Aboriginal people today, despite the changes that have occurred in the environment and regulatory requirements over the intervening period.

It is widely accepted that Aboriginal people have inhabited the Australian landscape for the past 60,000 years. During that time, variations in climatic conditions would have exposed and inundated low-lying areas, such as the East Coast of Australia. Prior to 7,000-8,000 years ago there was substantial variation in sea level changing the location of the active coastline. As the sea level gradually rose, land was inundated. Whilst the project area may have been exposed prior to 7,000 years ago and would have been part of a landscape utilised by Aboriginal people, when sea levels rose to around current levels the project area and any archaeological record of human occupation that may have been present were subject to inundation. Over the subsequent 1,000s of years, the project area has been subject to ongoing deposition of sand and other materials. However, recent archaeological discoveries suggest that if offshore underwater Aboriginal significant sites are not disturbed they may persist [29].

Umwelt Pty Ltd was engaged by DPI to undertake an Aboriginal Due Diligence Assessment that included an Aboriginal Heritage Information Management System database search of the project area, which identified 115 Aboriginal archaeological sites in the region. Presently, of the 112 sites that remain valid, two of which were registered sites, 72 were shell and artifact sites and individual shell and artifact categories comprised 17 and 8 sites respectively. The majority of sites were located along the coastline, or along the Coolongolook River and its tributaries. However, no Aboriginal archaeological sites were identified within the proposed Forster OAR deployment area. As suggested by Umwelt Pty Ltd, this absence may be due to the lack of archaeological assessment at this offshore location [1].

Additionally, Umwelt Pty Ltd sent letters to 32 Aboriginal stakeholders that detailed the proposed Forster OAR and sought information of local Aboriginal cultural values that might be impacted by the project. Four emails were received noting letter receipt and registering interest in the project. One stakeholder raised concerns of the possibility of remnant cultural material present at the proposed site. However, their concerns were alleviated when a DPI representative ensured that the project area would be inspected using underwater video cameras prior to deployment of the OAR structures. No further concerns were raised.

The report from Umwelt Pty Ltd recommended that given the depth and distance from shore to the Forster OAR deployment site, it was considered that:

- there is low to negligible potential for the presence of *in situ* Aboriginal objects with the project area;
- there is a low possibility of Aboriginal objects being transported to the project area by natural or assessed means; and
- if Aboriginal objects are present within the project area, they are likely to have been buried by natural coastal depositional processes [1].

The seafloor within the proposed reef deployment area offshore from Forster Beach is currently approximately 33 m underwater, and is relatively flat and sandy, with a small low relief rocky reef located approximately 500 m north-north-west of the location. It is considered that if any Aboriginal objects remain at the project site due to its use prior to inundation, they are likely to have been buried by coastal processes and will not be impacted by the project. Appropriate site selection and due-diligence assessment of Aboriginal cultural heritage undertaken by DPI during the consultation process has reduced risk of impact to very low (Table 9).

Table 9. 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	Impacts on submerged Aboriginal deposits	C4	Appropriate site selection identified through consultation and Aboriginal cultural heritage due diligence assessment.	Reduce likelihood	E4
Heritage	Intermediate	Conflict with areas of spiritual significance/dreaming	C4	Appropriate site selection identified through consultation and Aboriginal cultural heritage due diligence assessment.	Reduce likelihood	E4

Historic shipwrecks

A desktop review of shipwrecks known or potentially occurring in the proposed deployment region was carried out in February 2022 from the NSW Historic Shipwrecks Database [25]. Table 11 and Figure 19 display shipwreck details and locations within the greater study area.

Several historic shipwrecks have been confirmed within the boundaries considered in the constraints analysis. A total of 14 shipwrecks have been confirmed or believed to be present within the greater study area (Crowdy Head to Seal Rocks). The closest known shipwrecks to the proposed OAR site are the Jap, Osprey and Otus (Figure 19). The Jap, a steamer, became stranded on the Cape Hawke bar in 1943. Following salvage operations, the Jap broke up and wrecked on the Tuncurry breakwall. The Osprey, following breaking from its mooring was washed onto the rocks on Forster Main Beach after breaking from its mooring and was wrecked on 1 June 1897. The Otus, a 27 m wooden hull screw steamer was wrecked on Forster Main Beach on 17 January 1923 (not shown in Figure 19 as its location was not available within the NSW Heritage website). Another sunken vessel known as The Barge is located 1.9 km north-west of the proposed OAR site (not available within the NSW Heritage website).

Undiscovered wrecked vessels from within the Forster area pose a potential deployment concern for the OAR as the placement of the reef must not impede upon a historical shipwreck. It is possible that unidentified wrecks or debris could occur on the seabed throughout the area. The multibeam echo sounder survey carried out by Astute Surveying provided full coverage information on the nature of the seabed in the proposed OAR deployment area. The survey did not identify any anomalies requiring further investigation. A follow up underwater camera survey of the site confirmed the hydroacoustic survey's findings.

Table 10 Risks and mitigation associated with impact of historical wrecks

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Heritage	Local	Direct impact to maritime heritage items (including shipwrecks)	C2	Appropriate site selection identified through consultation with Maritime Heritage. Constraints mapping. Hydroacoustic survey to confirm location of maritime heritage items and adequate distance from OAR site.	Reduce likelihood and consequence	D3

Table 11. Submerged shipwrecks known to occur within the Forster region

Shipwreck	Vessel type	Year wrecked	Wreck location	Latitude (DDM)	Longitude (DDM)
Catterthun	Steamer screw	1895	2-3 miles north Seal Rocks	-32° 25.570'	152° 34.380'
Dan	Fetch	1912	Coolongolook bar	-32° 12.843'	152° 34.767'
Edwin	Schooner	1816	Cape Hawke	-32° 18.080'	152° 34.030'
Forest Queen	Ketch	1894	Charlotte Head	-32° 20.441'	152° 32.628'
Governor Hunter	Schooner	1816	Forster	-32° 20.060'	152° 34.020'
Harvester	Barquentine	1900	Hallidays Point, Black Head	-32° 04.819'	152° 32.514'
Jay	Steamer	1934	Tuncurry breakwall	-32° 10.500'	152° 30.700'
K-IX	Submarine	1945	Submarine Beach, Seal Rocks	-32° 27.881'	152° 28.288'
Lightning	Ketch	1868	6 miles SW of Seal Rocks	-32° 31.512'	152° 36.167'
Osprey	Smack	1897	Forster Beach	-32° 10.595'	152° 30.713'
Otus	Steamer screw	1923	Forster Beach		
Rainbow	Steamer paddle	1864	Sugarloaf Point, Seal Rocks Bay	-32° 25.996'	152° 31.631'
Satara	Steamer screw	1910	Treachery Head, Seal Rocks	-32° 28.833'	152°31.183'
Trio	Steamer paddle	1870	Seal Rocks Bay	-32° 26.093'	152° 31.847'

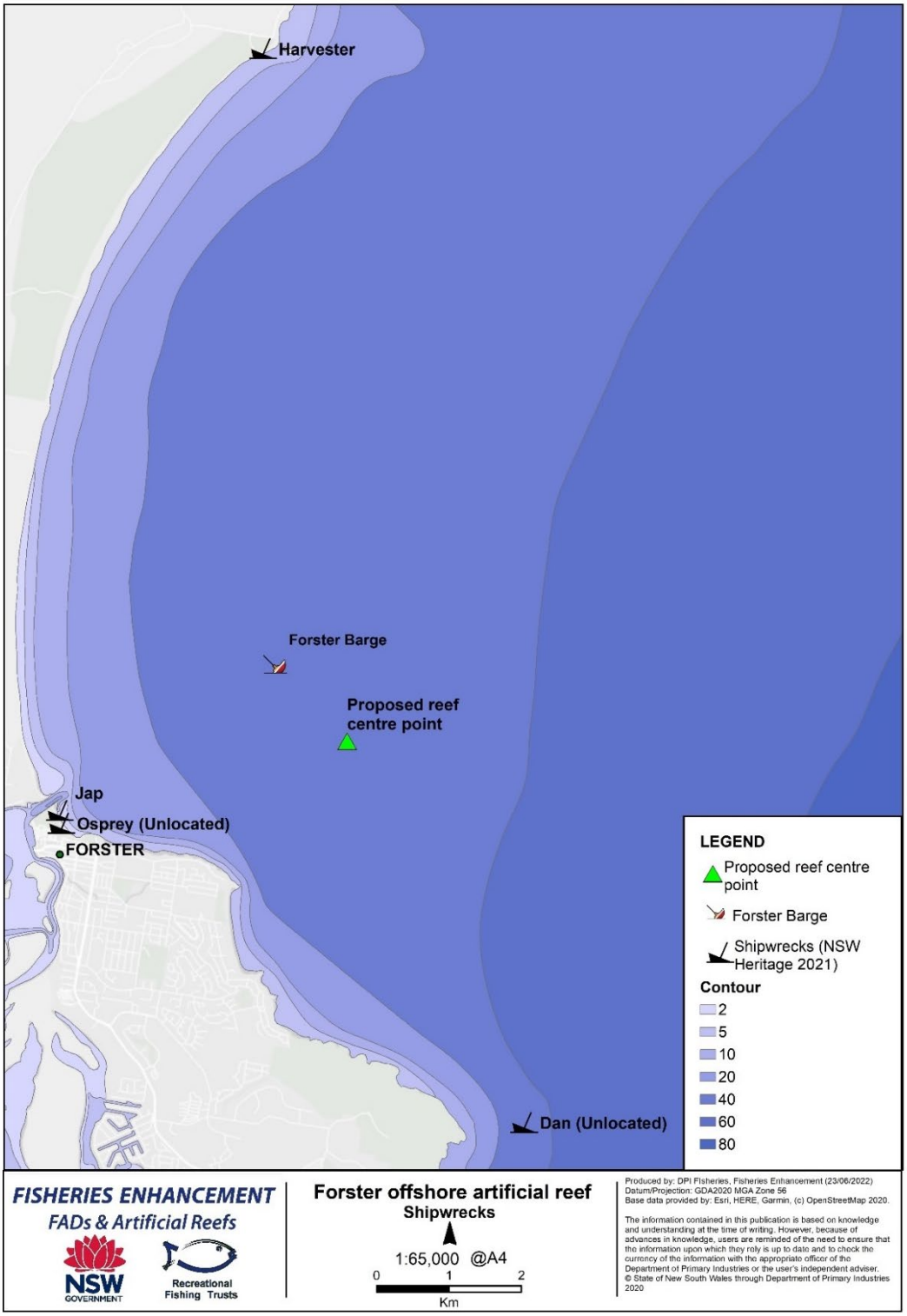

Figure 19 Shipwrecks within the Forster offshore artificial reef greater study area

5.3.9.3 Fishing

Loss of commercial fishing ground

It is considered highly unlikely that the proposed Forster OAR 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. The positive impacts on secondary production of the Sydney OAR have been demonstrated by ecological modelling [30].

Based on the footprints of OARs built to date in NSW, a maximum loss of up to 300 m^2 of fishing ground is expected. Given the area of similar habitat in the area, this loss is likely to be minimal. This assessment is based on receiving no objections from the commercial fishing sector during the consultation period. Loss of fishing area within the proposed study region is not considered to be a significant issue due to careful site selection with the OAR to be located 500 m south of natural reef on ground not used by local trawl fishers (Table 12; Figure 17).

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	B3	Consultation with commercial operators and careful site selection to avoid important areas.	Reduce consequence and likelihood	D4

Conflict between other user groups

Recreational fishing involves a variety of user groups, including sportfishers, gamefishers, spearfishers and charter boat fishing. The proposed OAR is aimed at all recreational fishers. 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 OARs.

To minimise potential conflict between user groups, consultation between sectors will be completed to resolve any issues of conflict (or similar) to an acceptable level (Table 13).

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	B4	Education, consultation and adaptive management by implementing controls where applicable. Establish a complaint register to monitor conflict.	Reduce likelihood	C4

Gear hook-up

Potential safety issues which could occur due to 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 OAR. This may cause loss of the anchor and anchor line, and possible damage to the OAR. In some circumstances, the loss of an anchor may cause consequential impacts on safety such as a disabled vessel drifting towards the coast. Educational material including user guidelines and hydrographic charts will help to reduce risk of recreational gear hook-up (Table 14).

Commercial fishers in the area will be provided with the exact location of each of the reef structures, including DGPS coordinates via text message. However, a potential risk remains of gear hook-up on the reef units, which could result in damage to the OAR, fishing vessel and safety implications for the vessel. The Australian Hydrographic Office will be notified of the final OAR 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 OAR location so that relevant publications and maps are amended to show the location of the OAR.

Provided commercial fishing businesses that operate in the region are made aware of the OAR location, follow a code of conduct and that structures are marked on the relevant AUS Chart, this potential risk is considered low (Table 14).

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

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Commercial fishing	Local	Gear hook-up (commercial)	C2	Consultation, education, notice to mariners. Reef to be marked on nautical charts and NSW Maritime notified for inclusion in relevant publications. Commercial operators notified of 'as built position'.	Reduce likelihood	D2
Recreational fishing	Local	Gear hook-up (recreational)	A4	Education (user guidelines), monitor, hydrographic charts. Removal of debris when required.	Reduce consequence	A5

Impacts on commercial fish stocks

It is considered highly unlikely that the proposed OAR 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 OAR deployment area, but this is unlikely to have impacts at a population level (Table 15). The positive flow-on-effects on secondary production of the other OAR have been demonstrated by ecological modelling [30].

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

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Recreational and commercial fishing	Regional	Impacts on commercial fish stocks	E5	Accept	Accept	E5

Injury from boat strike or drowning (spearfishing)

It is anticipated that freedivers and spearfishers may infrequently utilise the reefs.

The activity of SCUBA diving in the vicinity of the OAR is strongly discouraged in the User Guidelines and Code of Conduct because of the potential safety risks and conflict with recreational fishing activities. The use of SCUBA is not a lawful fishing method in NSW waters.

Safety issues including, but not limited to, the risk of gear fouling and risks to spearfishers cannot be mitigated but can be managed through education (Table 16). The user guidelines would aim to provide the best possible information to inform different user groups on best practice and safety within the OAR area.

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

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Navigation and safety	Local	Injury or drowning (spearfishing)	C1	Site selection typically beyond diving limits. Education and awareness through user guidelines.	Reduced likelihood	D1

5.3.10 Invasive marine pests and diseases

There is potential for the spread of marine pests or diseases during the project with the key vector/pathway being the transport of vessels or equipment between ports. Vessel ballast water and biofouling of hulls or vessel niche areas, and the movement of vessels or infrastructure from

other locations (with different risk profiles) can present translocation risk. In addition, the OAR structures will be newly constructed and free from any pests and disease. There is a possibility of transferring larvae or aquatic pathogens/disease agents between ports in ballast water, however this can be mitigated by exchanging ballast water at sea or by using a ballast water treatment system if available.

The proposed Forster OAR structures could provide a substratum or habitat suitable for invasive marine pests (also referred to as 'introduced', 'alien' or 'non-indigenous' species). Invasive marine pests are defined as organisms (usually transported by humans) which successfully establish themselves and then overcome or displace otherwise intact, pre-existing native ecosystems [31]. Although there is evidence that many exotic species establish populations more easily on artificial structures [32], the risk of increased potential for pest and disease issues associated with installation of the OAR is considered to be small due to the isolated location of the structures in the open ocean rather than in estuarine environments as noted by the aforementioned study. Similarly, the risk to threatened species from invasive marine pests associated with the OAR is considered very small (Table 17).

Comparison of video observations over a three-month period following deployment of the Sydney OAR showed that most of the structure had been covered by encrusting organisms, including serpulid polychaetes, barnacles, filamentous algae, bryozoans and hydroids. No introduced marine pests were observed [33]. Likewise, no marine pests have been observed on the subsequent eight OARs installed by DPI between Merimbula and Tweed Heads.

Ships' ballast water is a major vector for introduced species. Fouling of ships' hulls, aquaculture, the aquarium industry and bait industries are also potential vectors. Major ports and estuaries are potential hotspots for invasive species. Whilst the proposed OAR 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.

The Forster OAR structures will be monitored for colonisation by marine pests. If invasive introduced marine pests are identified on the structures, the extent of the pest incursions will be defined noting affected area, species type, abundance and potential for further spread. Requirements for removal of marine pests (according to Biosecurity NSW) would depend on the extent and nature of the incursion. Biosecurity NSW have been consulted and provided advice on mitigative measures to reduce the risk of invasive species spreading during transport and installation of OAR structures as detailed in Table 17.

Table 17. Risks and mitigation associated with invasive marine pests

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Invasive marine pests and diseases	Regional	Spread of invasive marine pests or aquatic disease agents during transport and installation	C3	Ensure equipment and vessels used during transport and installations are clear of all biofouling before making way to Forster OAR site. Release and exchange ballast water or other storage/water tanks (if used) from vessel/s at sea, or treat using a ballast water treatment system, prior to movement between regions or ports of different biosecurity risk. Move directly to and from the port or berth and the work site, to reduce the uptake of any marine pest or disease agent. Follow Biosecurity – Aquatic fieldwork hygiene procedures [34].	Reduce likelihood	D3

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Invasive marine pests	Local	Colonisation by invasive (noxious) marine pests	C3	Notify and follow NSW Aquatic Biosecurity advice if marine pests are identified.	Reduce consequence	C4

5.3.11 Endangered, rare or migratory species

5.3.11.1 Threatened and protected species, populations and endangered ecological communities

A list of all threatened and protected species, populations and endangered ecological communities identified from various databases and literature within the 50 km radius search area of the site are provided in Table 3.

Only threatened species (from the initial search) that were known or considered likely to occur in the wider Forster 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 NSW Environment and Heritage and DPI threatened species assessment guidelines [35, 36] . 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)

Overall, seven species of fish, three species of marine turtle, four species of cetacean, two pinnipeds and dugong were assessed according to NSW Environment and Heritage and DPI threatened species assessment guidelines. Additionally, the NSW DPI Threatened Species Unit Manager and leading Greynurse Shark (*Carcharias taurus*) scientific researcher Dr Nick Otway were engaged to review the Assessment of Significance for threatened species, populations and communities within the Forster region under the FM Act. They concluded that impacts of the installation of the Forster OAR are unlikely to be significant to threatened and protected species that may be present at times in the region. A summary of the assessment is provided below.

Fish

The proposal was not considered to have a significant impact on any of the species identified in Table 3, hence Species Impact Statements (SIS) were not required.

Management of fishing related activities 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 threatened or protected species. Proper management of these regulations by compliance activities in the Mid North Coast region will ensure these regulations are adhered to by fishers. It is therefore unlikely that the OAR 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*) and Greynurse Shark (*Carcharias taurus*) are highly migratory and the transient nature of these species means that although they may pass in the vicinity of the OAR, they are unlikely to remain on the reef long enough to be vulnerable to the potential fishing related impacts identified. The reporting requirement for incident involving threatened and protected species provided to the DPI Threatened Species Unit will ensure assessment of numbers of threatened species are evaluated independently outside of the DPI Fisheries and Aquaculture Management group. In addition, any serious incidents involving threatened and protected seabird, mammal or reptile species will be reported to the NSW Environment and Heritage.

Greynurse Sharks are known to frequent the greater Forster region and may occasionally forage away from aggregation sites over open sandy habitat particularly during migrations [37]. This considered, it is possible that individual Greynurse Shark could be at risk of incidental capture as a result of the proposal. However, based on observations of the species on other artificial reefs in NSW and known behaviour of the species, there is no evidence to support that the species will take up residence at the proposed OAR site or that it will become a key aggregation site (Dr Nick Otway pers. comms.). Therefore, it is unlikely that potential impacts associated with the OAR would affect the life cycle of a viable local population to such an extent that the species is placed at the risk of extinction. Furthermore, providing that fishing activities in the direct OAR area are properly managed, potential risks would be minimised or addressed before they become problematic.

The Scalloped Hammerhead Shark (*Sphyrna lewini*) and Great Hammerhead Shark (*S. mokarran*) have been reported to occur throughout tropical and warm temperate coastal and offshore waters. It is possible that the OAR site could represent foraging habitat for these species. Increased incidental capture of these species could occur due to the deployment of the Forster OAR. However, the guide to fishers provides details on appropriate handling and release techniques to minimise fish mortality. Additionally, the department publication 'identifying sharks and rays - A guide to commercial fishers' (https://www.dpi.nsw.gov.au/fishing/commercial/fisheries/otl-fishery/identifying-sharks-and-rays) is designed to assist fishers with the correct identification of sharks and rays that occur in NSW waters. The department has also developed an online reporting tool that fishers can contribute to that enables the monitoring of the numbers, location and distribution of threatened species. These tools are designed to reduce the threat to the risk of extinction of these and other vulnerable species. It considered highly unlikely that the incidental capture of these species at the Forster OAR site would disrupt the species' life cycle or place any local population at risk of extinction.

The Black Rockcod (*Epinephelus daemelii*) inhabits coastal and estuarine rocky reefs throughout the NSW coastline. While adult Black Rockcod are territorial and unlikely to utilise the new OAR habitat, the pelagic dispersal of eggs and larvae may lead to juveniles recruiting on the reef structures and there is a subsequent risk of incidental capture of individuals. However, it is considered unlikely that the potential impacts associated with the OAR would affect a viable population to the extent that it would be placed at risk of extinction.

The Offshore Artificial Reef user guidelines 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 to further minimise impacts on threatened fish species.

Marine Turtles

For the species identified, the proposal was not considered to have a significant impact such that a SIS is required. This was mainly due to the transient nature of these 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 SIS is required. This was mainly due to the transient nature of the species and the absence of important, mating, feeding or resting areas within the wider study area.

Pinnipeds

Although seals may forage within the study area, the proposal was not considered to have a significant impact such that a SIS is necessary. It is considered highly unlikely that the artificial reef would disrupt the life cycle of pinnipeds or place any local population at risk of extinction.

Dugongs

The proposal was not considered to have a significant impact on Dugongs, such that a SIS would be necessary. This is mainly due to the Dugong's dependency on seagrass which is restricted to coastal habitats and the absence of seagrass meadows in deeper offshore waters.

Seabirds

The proposal was not considered to have a significant impact on any species of seabird, such that a SIS would be necessary.

Matters of national environmental significance (Commonwealth legislation)

Listed threatened and protected species

Overall, ten species of fish, six species of marine turtle, eleven species of cetacean and one pinniped were assessed individually under the EPBC Act. 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'.

Only threatened species that were known or considered likely to occur in the wider study area (based on their geographical distributions) and/or known to utilise habitat in the study area, were considered for further impact assessment. It was concluded that provided the OAR is properly managed, monitored and mitigation measures implemented, the OAR proposal is unlikely to have any detrimental impacts on listed threatened and protected species.

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

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 Forster OAR is proposed to be located within State waters (Figure 3).

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);
- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (EPBC Act); and
- hook and line fishing in areas important for the survival of threatened fish species (FM Act).

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

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 [38]. 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;
- 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 plastics are the main causes of injury or mortality in marine wildlife [35]. Several 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 [39]. DCCEEW has developed a Threat Abatement Plan to address the impacts of this KTP [40].

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

Hook and line fishing refers to the use of a combination of lines and hooks for catching fish, including lines composed of microfilament, wire and cord, with attached lures, hooks and jigs. Hand line, set line, rod and reel fishing, trolling, lure fishing and fly fishing are all included in the activities identified as a KTP. This definition includes catch and release, not just the ‘taking’ of fish [41]. Areas that are used for feeding and breeding are considered important for the survival of a threatened species and with the exception of GNS, such areas are poorly defined, if at all, for the majority of threatened species considered in these assessments. Following identification, some of these areas may be declared as critical habitat, such as the GNS aggregation sites along the NSW coast. The GNS and Black Rockcod are considered particularly vulnerable to this KTP [41]. Even when accidentally captured, hooks caught in fishes’ mouths can result in damage that can impact on feeding behaviour and success. The effects of fish hooks can be more serious over a longer time if retained in the mouth, throat and stomach of fishes and sharks, and could ultimately lead to death [41]. It is recognised that listing all hook and line fishing throughout NSW waters as a KTP would be unpractical and unwarranted. However, where known aggregation sites, spawning areas, important juvenile habitats and feeding areas are concerned, activities that could kill or adversely affect threatened fish species should be considered a threatening process and managed accordingly. A threat abatement plan is yet to be developed for this KTP.

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 OAR, it is proposed for any incidents, recorded or reported interactions with threatened or protected species to be reported to the DPI Threatened Species Unit for further assessment as detailed in this plan. A series of trigger points relating to threatened species have been established as part of the environmental management of the OAR. As such, if aggregation of any given threatened species or a key non-threatened species within the OAR area increases by an amount deemed 'of concern' by the DPI Threatened Species Unit, this may require a modification to the management of the OAR. These measures are deemed to potentially reduce the consequences of an aggregation of threatened species from a moderate risk to a low risk (Table 18).

The DPI artificial reef user guidelines provide information 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 to further minimise impacts on threatened and protected species.

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	C3	Reporting and education. Angler education on best practice and fish release guidelines. Report incidences. Manage/regulate as appropriate (seasonal closures/gear types etc.). Report sightings. Utilising input controls as required.	Accept	C3
	Local	Aggregation of threatened or protected species	C2	Consultation with threatened species experts during site selection.	Reduce likelihood	D2
	Regional	Interruption of movement corridors (e.g. Greynurse Shark)	C4	Consultation with threatened species experts during site selection. Reporting interactions. Utilising input controls as required.	Reduce likelihood	D4
	Sub-Local	Loss of habitat	D3	Consultation with threatened species experts during site selection. Careful selection of habitat type for deployment location.	Reduce likelihood	E3
Marine Turtles	Local	Incidental capture/entanglement from marine debris	C3	Reporting and education Removal of debris when required.	Accept	C3
	Local	Increased risk of boat strike	C3	Education	Accept	C3
	Intermediate	Increased risk of acoustic disturbance	C4	Accept	Accept	C4
	Large	Interruption of movement corridors	E5	Accept	Accept	E5

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Intermediate	Loss of habitat	E4	Accept	Accept	E4
Cetaceans	Local	Increased risk of boat strike	C3	Education regarding acceptable approach distances to cetaceans via national guidelines for whale and dolphin watching. Reporting and education of existing regulations.	Reduce likelihood	D3
	Intermediate	Increased risk of acoustic disturbance from boat traffic	C4	Follow national guidelines for whale and dolphin watching.	Accept	C4
	Large	Interruption of movement corridors	D5	Accept	Accept	D5
Pinnipeds and Sirenians	Sub-Local	Incidental capture/entanglement from marine debris	C3	Report marine debris and remove as per Long Term Management Plan Removal of debris when required.	Reduce likelihood	D3
	Local	Boat strike (sirenians only)	E3	Accept	Accept	E3
	Intermediate	Increased risk of acoustic disturbance from boat traffic	D4	Accept	Accept	D4
	Large	Interruption of movement corridors	E5	Accept	Accept	E5
Seabirds	Local	Incidental capture	D3	Reporting and education. Encourage reporting to WIRES.	Accept	D3
KTPs	Intermediate	Harm from marine debris and pollution (KTPs)	C3	User reports of fouled gear. Removal of debris when required.	Reduce consequence	D3

5.3.12 Areas of conservation significance

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 [42]. Nature reserves are generally terrestrial, but there are some with associated marine components.

National parks (Figure 20) are areas of land protected due to their unspoilt landscapes, outstanding or representative ecosystems, native plants and animals, and places of natural or cultural significance. National parks provide opportunities for public nature appreciation, well-being, enjoyment and scientific research in addition to their role in conservation [43].

Aquatic reserves are marine areas managed to conserve marine biodiversity and support marine science, recreation and education. The type of fishing activities that are allowed in an aquatic reserve depend on the biodiversity values of the individual reserve. All aquatic reserves provide for boating, SCUBA diving, snorkelling and swimming. Fishing is permitted in some aquatic reserves as long as bait is not collected. In other aquatic reserves, however, fishing is prohibited in all or part of the reserve to help conserve all types of marine life in that area.

Marine Parks are areas set aside to conserve biodiversity and ecosystem integrity. Marine Parks in NSW comprise spatial management zones which manage fishing and other activities to zoned areas

within the park. Fishing is permitted within general use zones and habitat protected zones of NSW marine parks but excluded in sanctuary zones. The Port Stephens – Great Lakes Marine Park (Figure 20), which extends south from Cape Hawke Surf Life Saving Club, Forster (32° 11.793'S) to the west of Anna Bay (32° 49.109'S) and includes The Pinnacle and Seal Rocks Sanctuary Zones. DPI also has a policy in place to provide for the installation of OAR within general use zones of NSW Marine Parks.

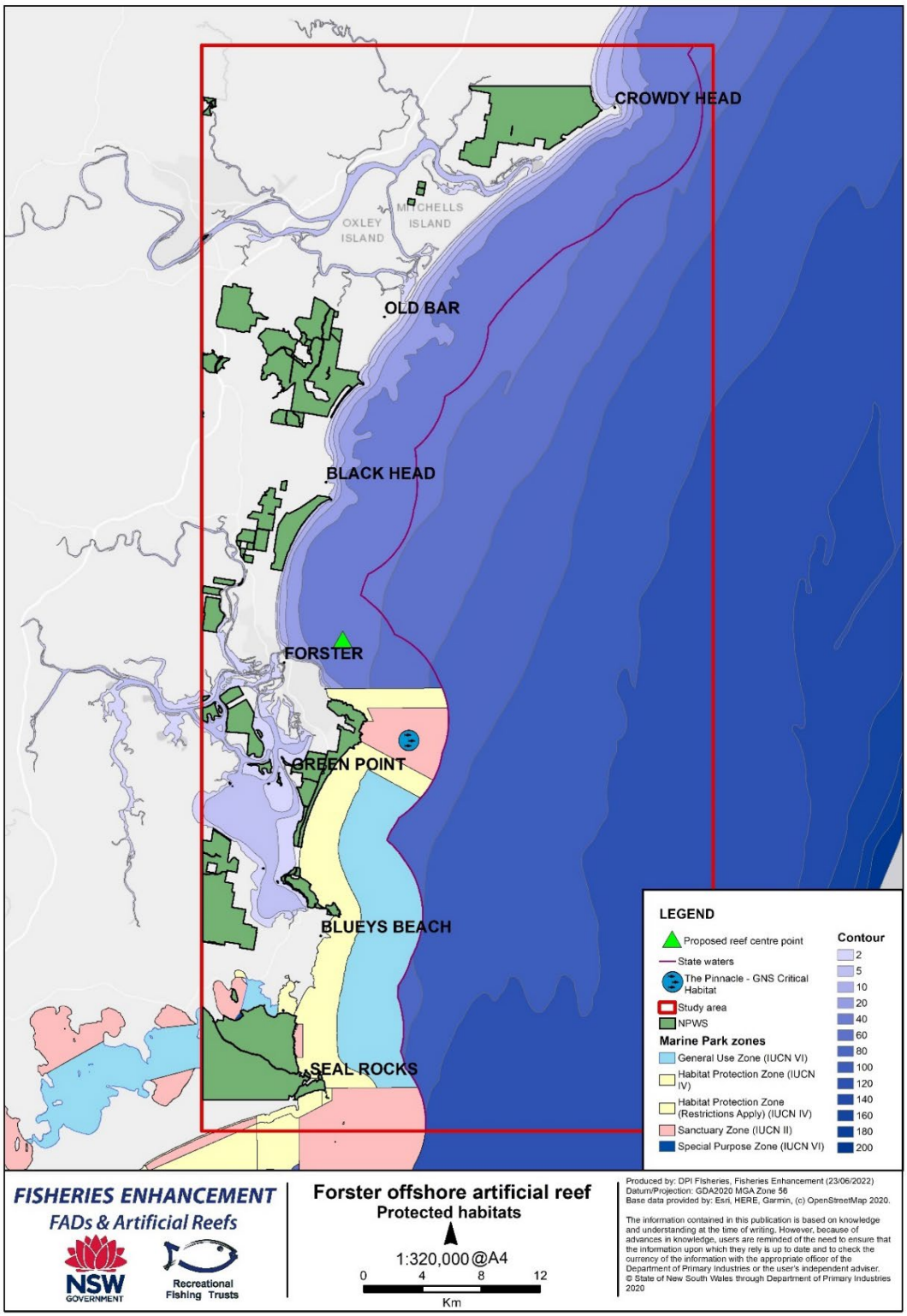

Figure 20 Sensitive habitats within the Forster offshore artificial reef greater study area

Historic sites or heritage places are areas of cultural significance which protect and promote cultural heritage values [44]. They may be an area of significance to Aboriginal culture, include areas associated with a person or event in history, or include areas containing a building, place, feature or landscape of cultural significance.

For the purpose of this assessment, areas of conservation significance include areas declared as critical habitats under the FM Act, BC Act and Marine Protected Areas (which include Marine Parks, Aquatic Reserves and Nature Reserves). With the exception of the proposed site residing adjacent to Port Stephens – Great Lakes Marine Park (see section 1) and the Greynurse Shark critical habitat at discussed in sections 4.3 and 5.3.11, no other areas of conservation significance are present within the study area.

5.3.13 Ocean waves, currents and tides

Water movements in the proposed Forster OAR 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.

The use of existing datasets and hydrodynamic modelling is of particular importance when considering an artificial reef location. The wave height vs wave direction rose from measured wave data collected from the waverider buoy at Crowdy Head (Figure 21) shows the dominant wave direction for the greater region comes from the south to south-east sector. This direction is dominant both in terms of the highest wave heights and the longest wave periods originating from the south-south-east direction.

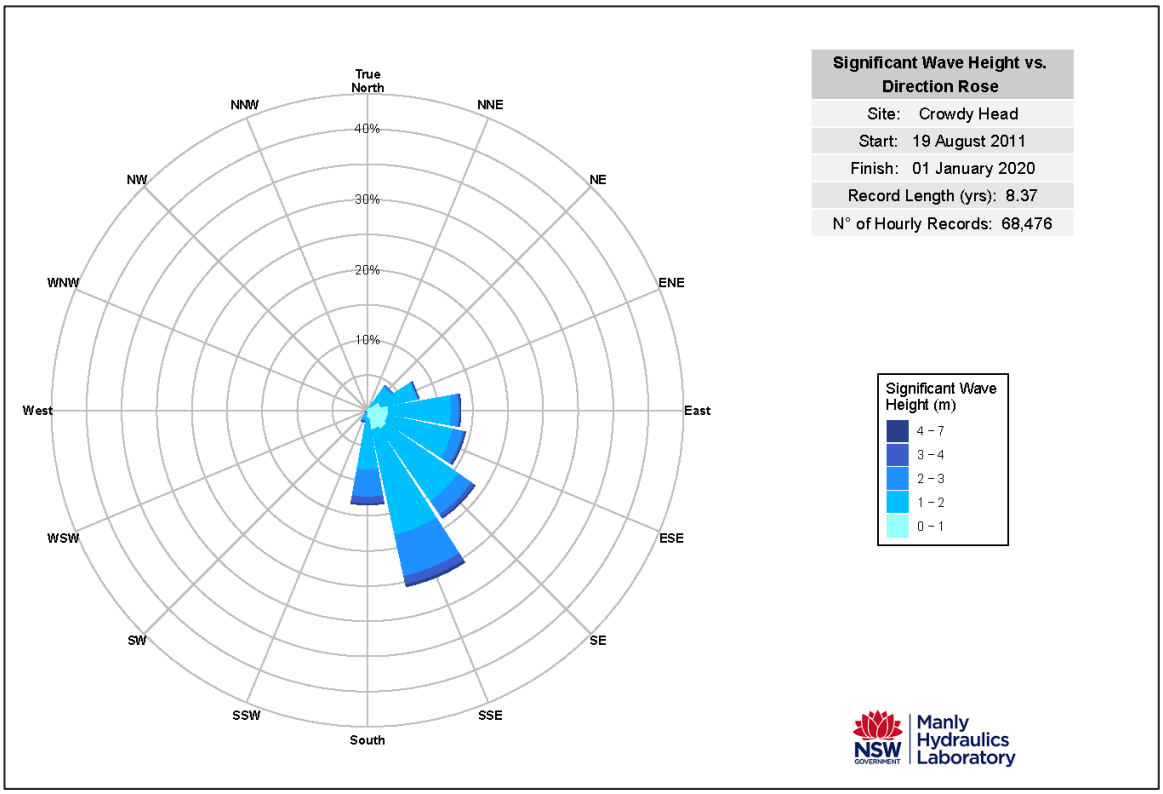

Figure 21 Wave rose of Crowdy Head offshore wave dataset

Extreme wave analysis modelling indicates that storm events with a return interval of 100 years are expected to produce a significant wave height offshore of Forster of 8.4 m (Hs) (Table 19). This parameter is to be taken into consideration as a primary design specification for the reef structures. The highest peak significant wave height recorded at the Crowdy Head buoy was 7.35 m on 4 March 1995 during a major storm event from 2-5 March when an individual maximum wave height (Hmax) of 12.5 m was recorded. At that time, the Waverider buoy was an earlier non-directional model and hence no definitive wave direction information is available. However, an east-south-east wave direction has been hindcast based on Bureau of Meteorology weather charts available for the period of the storm event.

Table 19 Crowdy Head Waverider buoy extreme wave analysis results. Source: Manly Hydraulics Laboratory 2021 [45]

Extreme wave analysis results per durations										
ARI (yrs)	1 hour		3 hours		6 hours		12 hours		24 hours	
	Hsig (m)	CI (±m)	Hsig (m)	CI (±m)	Hsig (m)	CI (±m)	Hsig (m)	CI (±m)	Hsig (m)	CI (±m)
1	5.4	0.2	5.0	0.2	4.7	0.2	4.3	0.1	3.7	0.1
2	5.8	0.2	5.4	0.2	5.1	0.2	4.7	0.2	4.1	0.2
5	6.5	0.3	6.0	0.2	5.6	0.2	5.2	0.2	4.4	0.2
10	6.9	0.3	6.4	0.3	6.0	0.3	5.5	0.3	4.7	0.3
20	7.4	0.3	6.8	0.3	6.3	0.3	5.9	0.3	4.9	0.3
50	7.9	0.4	7.3	0.4	68	0.4	6.3	0.4	5.3	0.3
100	8.4	0.4	7.7	0.4	7.2	0.4	6.6	0.4	5.5	0.4

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. Most sediment transport along the NSW coast is inshore from the depths under consideration in the current OAR 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. By implementing mitigative measures including a detailed coastal processes assessment and carefully considering OAR placement, the risks of altering inshore wave climate and changes to beach erosion in the area are considered low (Table 20).

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

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Nearshore coastal	Large	Inshore wave climate	C3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce likelihood and consequence	E5

The primary driving mechanism for currents off the Forster coastline is the East Australian Current (EAC) that typically flows south year-round. The EAC is a complex and highly energetic western boundary system in the south-western Pacific Ocean off eastern Australia [46]. The EAC is typically greater than 30 km wide, 200 m deep and flows up to 2 m/s off the NSW north coast and can be described in four stages in Deep-Sea Research (2011): the formation in the south Coral Sea (15-24^0 S); the intensification of the current and flow along the coast of south-east Queensland and northern NSW (22-35^0 S) and then declining to eddies off southern NSW and coastal fingers off Tasmania. During intensification the current strengthens, especially off Smoky Cape (31^0 S) where the shelf is at its narrowest (~15 km). Thereafter most of the current separates from the coast, forming the Tasman Front, which flows eastward towards Lord Howe Island and New Zealand, leaving behind a coastal southward flow and a series of large warm core and cold core eddies [47].

Cyclonic (clockwise current movement) eddies are characterised by cold, dense cores with a depressed surface level relative to the surrounding waters while anticyclonic eddies have warm, elevated cores. Cyclonic eddies tend to increase stratification at the core (and vice versa for anti-cyclonic eddies), however this phenomenon is probably not a factor at the coast, which is generally at the extremity of such eddies, and interactions of the current with the coastline dominate.

The relative scale and influence of local catchment flows, tidal currents, wind, storm waves and the EAC on the proposed OAR deployment site can only be determined by careful measurement of the relevant physical parameters and modelling with an appropriate hydrodynamic and water quality model that has been adequately validated with these data. For the purposes of the coastal processes investigation included in this project, results from the Integrated Marine Observing System (IMOS) project have been reviewed. IMOS is one of the national research infrastructure capabilities currently supported under the Australian Government's National Collaborative Research Infrastructure Strategy. It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as lead agent (www.imos.org.au). Since 2006, IMOS has been routinely operating a wide range of observing equipment throughout Australia's coastal and open oceans including a network of current meters at different depths in various locations.

Figure 22 displays an example of the IMOS sea current and sea surface temperature charts corresponding to the CH070 deployment site which is located north of Coffs Harbour in water depth of 70 m. This monitoring station, which has been collecting continuous currents data through the full water column since 2009, indicates maximum southbound currents of over 1 m/s near the water surface and on occasion just under 1 m/s at the seabed. The CH070 site is located approximately 220 km north of the proposed Forster OAR location and it is considered that, in general, ocean currents at the CH070 site would be of a slightly higher magnitude than in the shallow waters at the OAR location where they are expected to be in the range of 0.5 to 0.7 m/s.

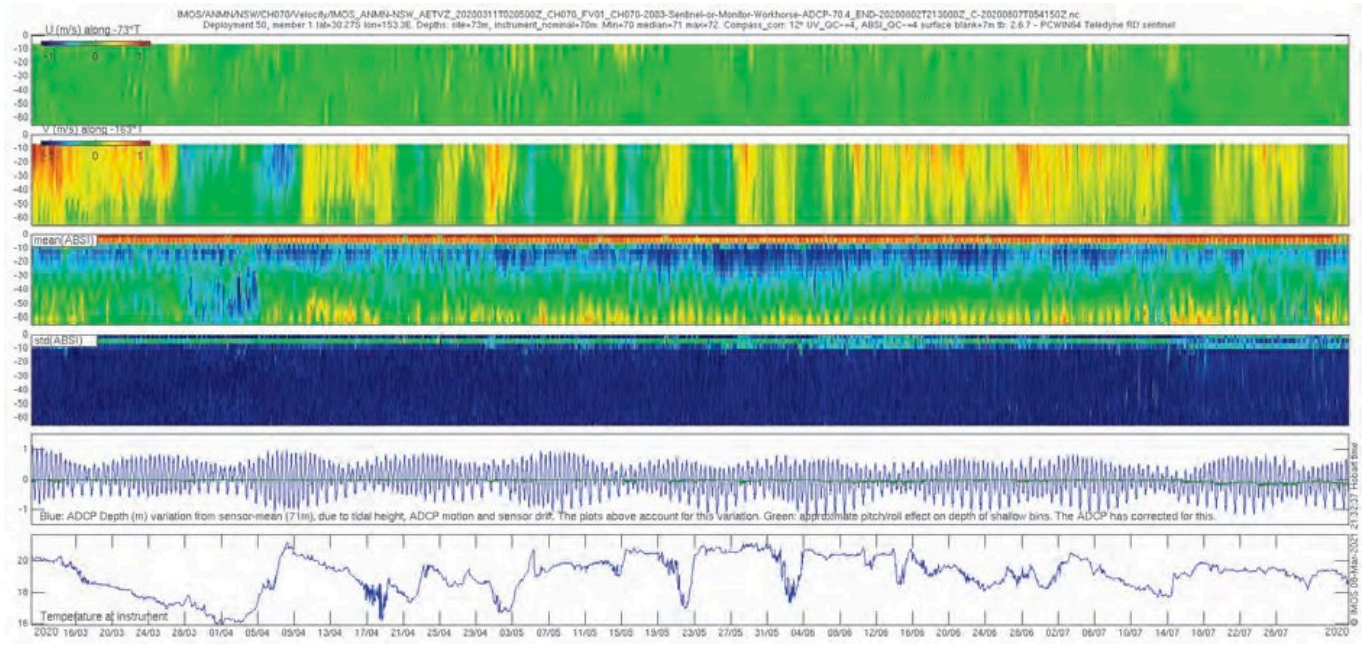

Figure 22 Ocean current and sea temperature for the IMOS CH070 (12/3/2020 – 30/07/2020) station Source: IMOS Data Portal

Another data source for ocean current and sea surface temperature for the Tasman Sea off the NSW coast is from daily regional charts available for download from the IMOS data portal. These charts are based on numerical modelling with dense data integration to provide ocean currents and surface temperatures across the Tasman Sea. It should be noted that landward boundaries are difficult areas for these types of numerical models to accurately characterise and they are truncated to approximately 10 km off the coast. Nevertheless, the charts are valuable, allowing an assessment of the ocean currents and sea surface temperatures offshore from the NSW coast. Ocean currents at the proposed reef site (in 30–40 m depth) are generally expected to be lower than the offshore currents due to such land effects (Refer to Figure 23 for example).

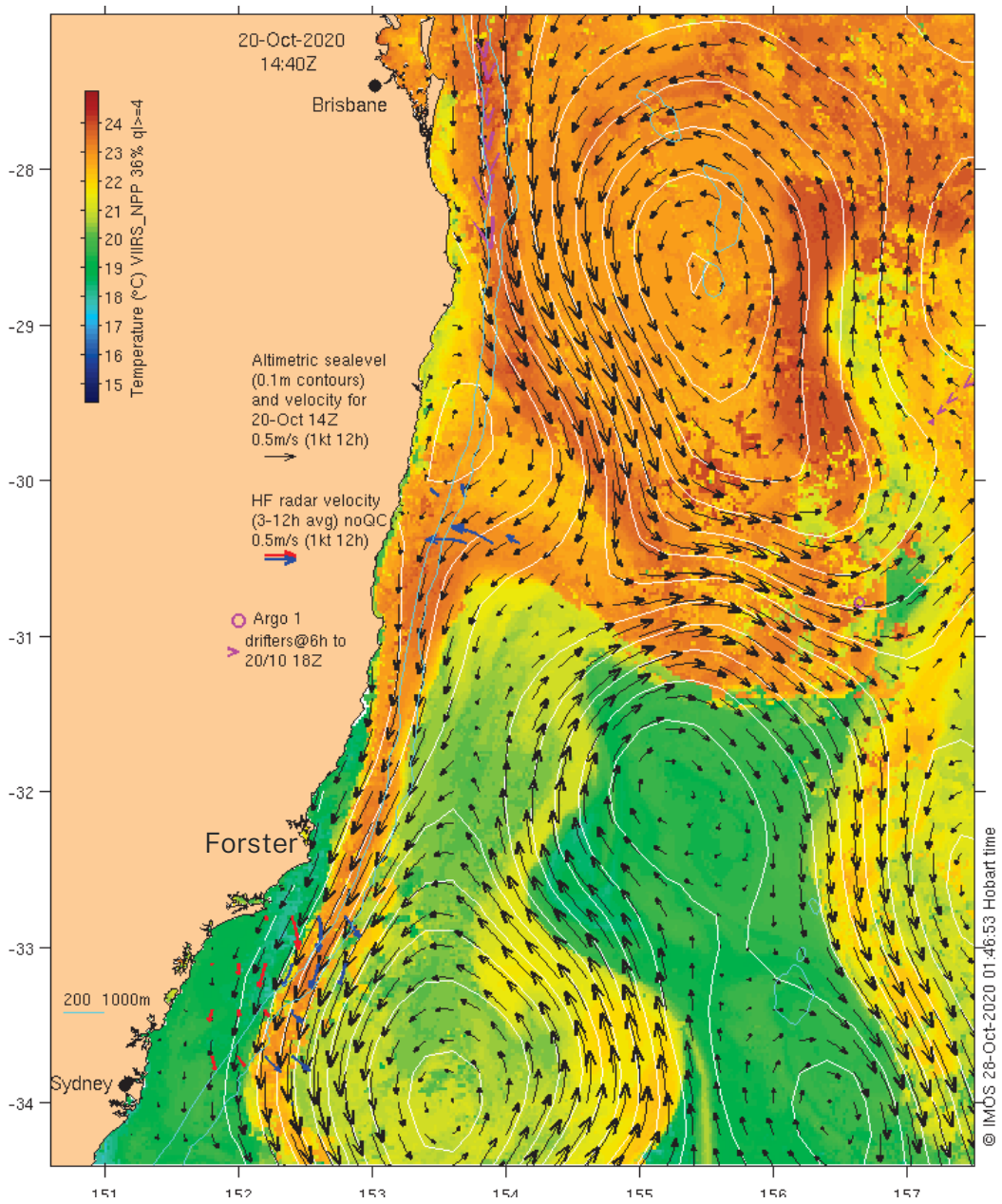

Figure 23 Tasman Sea currents and sea temperatures for 20 October 2020

The coastal processes investigation report [45] concluded that the proposed installation of an OAR comprised of steel structures is considered unlikely to have any significant detrimental impacts on coastal processes at either the immediate deployment site or within the Forster-Tuncurry embayment more broadly.

The coastal processes investigation conducted by MHL identified the following results:

- The proposed reef installation is expected to have little to no impact on the wave climate at the site or within the Nine Mile (Tuncurry) Beach embayment more broadly, with no subsequent expected impact on coastal processes or sediment transport at the nearby shoreline and beaches.
- The proposed reef installation is expected to have no discernible impact on currents at the nearby Nine Mile Beach, Forster Main Beach and Pebbly Beach, with only minor localised impacts expected to occur in the immediate vicinity of the reef structure and the base of the reef structures.

Manly Hydraulics Laboratory also prepared conservative values for oceanographic forces relevant to reef stability. These values formed reef structure design constraints and were included in the scope of requirements for the reef design and are shown in Table 23.

Table 21 Risks and mitigation associated with local currents and sediment transport causing local scouring/deposition around offshore artificial reef structures

Environmental aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Local seabed	Sub-local	Local scouring/deposition around units	B3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce consequence	B5
Nearshore coastal	Large	Change to beach erosion/deposition	C3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce likelihood and consequence	E5

The main factor that contributes to still water level movement offshore from the east coast of Australia is astronomical tide. Tides along the NSW coastline are semi-diurnal with significant diurnal inequality in NSW coast tides, i.e. a difference in height of the two high waters or the two low waters of each tidal day. Tidal planes to datum lowest astronomical tide (LAT) are presented in Table 22 from the Australian National Tide Tables 2022. Barometric pressure changes also affect oceanic water levels amongst other oceanographic effects and water levels may vary day to-day from predicted tide levels by up to 0.2 m.

Table 22 Tidal ranges expected at the OAR site

Tidal plane	Height (m LAT)
Highest Astronomical Tide (HAT)	2.1
Mean High Water Springs (MHWS)	1.6
Mean High Water Neaps (MHWN)	1.4
Mean Sea Level (MSL)	1.0
Mean Low Water Neaps (MLWN)	0.6
Mean Low Water Springs (MLWS)	0.3

Table 23 Oceanographic parameters for Forster offshore artificial reef structures design constraints

Design parameter	Design value	Comments
Waves		
Significant Wave Height (Hsig)	7.8 m	Equivalent deepwater Hsig = 8.4 m. Equates to a 100-year ARI for a storm duration of 1 hour
Maximum Wave Height (m)	14.0 m	Expected maximum wave height associated with a 7.8 m significant wave height
Wave Period (TP1)	14.0 s	Typical wave period during major storm event
Wavelength	215 m	Wavelength for 14.0 s wave period in 30 m water depth
Currents		
Wave Orbital Current Velocity	1.8 m/s	Orbital current velocity at seabed 30 m water depth
East Australian Current Velocity	0.7 m/s	Maximum East Australian Current velocities at IMOS Coffs Harbour 70 m depth mooring 1 m/s. Lower velocities expected at artificial reef depth of 30 m.
Combined current velocity	2.5 m/s	Combined conservative moderate storm waves orbital velocity and East Australian Current

Offshore artificial reefs and significant East Coast Lows (ECLs)

An intense ECL hit the NSW coast between 20-23 April 2015, 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 3pm on 21 April was 15 m, approximately the height of a five-story building. The waves also exceeded 6 m for 30 hours, the longest duration of such high waves since 1987. Post storm inspections (Figure 24 A, B) of both the Sydney and Shoalhaven artificial reefs were carried out in May 2015 in line with inspection conditions of respective Sea Dumping Permits (SD2008/882 & SD2014/2842). DPI used surface deployed cameras to undertake the inspections. No damage was identified to either the single large Sydney reef unit or any of the 20 multiple structures which form the Shoalhaven reef. In addition, no significant scour or deposition was identified in the vicinity of either reef [33].

More recently, in April 2022, the Batemans Bay Wave Data buoy recorded maximum seas of 15.58 m during an intense storm event that resulted in extreme coastal weather conditions from Grafton to Batemans Bay. Inspection of Swansea OAR in May 2022 indicated no impact to the two structures. Additionally, SMC Marine conducted video inspection of the Eurobodalla OAR in July 2022, video footage and still images show that the two OAR structures have not moved from deployment locations and were not compromised in any way by the extreme sea conditions of April 2022 (Figures 24 C, D).

Figure 24 Inspections of A) Sydney (7 May 2015), B) Shoalhaven (18 May 2015) and C, D), Eurobodalla (July 2022, Credit: SMC Marine) offshore artificial reefs following intense east coast low events that produced waves over 15 m (Hmax).

5.3.14 SCUBA divers

The NSW DPI OAR program is funded by the Recreational Fishing Trust. Therefore, OAR installations are purpose built for NSW recreational fishing licence holders. The user guidelines expressly state "The artificial reef is not designed as a SCUBA diving site."

The OAR site is beyond recommended recreational dive limits and there are no hatches, swim throughs, voids, or compartments to explore.

5.3.15 Summary of all project risks

Table 24 provides a full list of project risks and associated mitigation measures and residual risk ratings from the risk assessment process.

Table 24 Summary of all project risks

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Risks associated with construction, transport and deployment						
Land based construction activities	Intermediate	Run-off/noise/air quality/waste/transport	B4	Appoint appropriately qualified/certified contractor through a thorough procurement process. Contractor responsible for meeting relative legislative requirements (POEO Act) and Environmental Management Plans (including construction and erosion and sediment control). Onsite QA/QC/HSE and QMS.	Reduce consequence	B5
Transport by barge	Regional	Safety, noise/emissions/ traffic/risk of losing units	C3	Appoint appropriately qualified/certified contractor through a thorough procurement process. Develop Transport Management Plan including planning for weather and ocean conditions and use of appropriate methods to secure units prior to and during transport. Appropriate weather contingency plans for extended voyage.	Reduce consequence	C4
Deployment	Intermediate	Safety associated with lifting units during deployment	D1	Appoint appropriately qualified/certified contractor through a thorough procurement process. Contractor to seek external third-party weather advice. Develop a Deployment Management Plan. On site QA/QC. Remove and relocate if required.	Reduce likelihood	E1

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Intermediate	Units in wrong location or loss during deployment	C3	Appoint appropriately qualified/certified contractor through a thorough procurement process. Use of DGPS to increase accuracy. Contractor to seek external third party weather advice. Develop a Deployment Management Plan. On site QA/QC. Remove and relocate if required.	Reduce likelihood	D3
	Local	Risk of impact or negative interaction with marine mammals during deployment	D3	If any marine species are sighted in the monitoring zone (300m), deployment of modules will not commence in the monitoring zone until 20 minutes after the last marine species is observed in the monitoring zone	Reduce likelihood	E3
Invasive marine pests and diseases	Regional	Spread of invasive marine pests or aquatic disease agents during transport and installation	C3	Ensure equipment and vessels used during transport and installations are clear of all biofouling before making way to Forster OAR site. Release and exchange ballast water or other storage/water tanks (if used) from vessel/s at sea, or treat using a ballast water treatment system, prior to movement between regions or ports of different biosecurity risk. Move directly to and from the port or berth and the work site, to reduce the uptake of any marine pest or disease agent. Follow Biosecurity – Aquatic fieldwork hygiene procedures [34]	Reduce likelihood	D3
Risks associated with long term operation						
Coastal processes & oceanography						
Nearshore coastal	Large	Inshore wave climate	C3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce likelihood and consequence	E5

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Large	Change to beach erosion/deposition	C3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce likelihood and consequence	E5
Local seabed	Sub-local	Local scouring/deposition around units	B3	Detailed coastal processes assessment to be undertaken. Avoid placement where there is risk of impacts to coastal processes.	Reduce consequence	B5
Structural integrity and stability	Sub-Local	Loss of structural integrity e.g. from corrosion or excessive marine growth	C4	Factor the use of materials appropriate to Australian Standards for marine concrete into design specifications. On site QA/QC and certification prior to transport and deployment. Visual inspections as part of long term environmental monitoring.	Reduce likelihood and consequence	D5
	Sub-Local	Risk of sliding or overturning	C4	Factor design and placement appropriate to coastal conditions into detailed design criteria. Ensure the reef is designed to withstand maximum wave heights (100 year ARI). Design criteria and modelling to be carried out and verified by appropriately qualified coastal engineers.	Reduce likelihood	D4
Flora and fauna						
Benthos	Sub-Local	Direct loss of habitat	A4	Careful selection of habitat type for deployment location. Efficient open/permeable design of OAR base to minimise smothering/loss of sedimentary habitat.	Accept	A4
	Sub-Local	Change to benthic fauna from changes to sedimentary characteristics ie grain size.	C4	Accept	Accept	C4
	Sub-Local	Changes to infaunal assemblages	B4	Accept	Accept	B4

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Sub-Local	Increased predation by fishes from the OAR on benthos	A4	Accept	Accept	A4
Proximal natural reef	Intermediate	Drawdown effects – reduction in abundance/diversity of reef assemblages	C3	Careful selection of location and design. Swath mapping to confirm presence of reef habitat. Careful site selection to provide adequate buffer from natural reef.	Reduce likelihood	D3
	Local	Changes to demersal assemblages	A4	Careful selection of location and design. Careful site selection to provide adequate buffer from natural reef.	Accept	A4
	Local	Changes to plankton assemblages	A4	Accept.	Accept	A4
	Local	Changes to pelagic assemblages	A4	Careful selection of location and design. Careful site selection to provide adequate buffer from natural reef.	Accept	A4
	Intermediate	Changes to epibenthic assemblages	B5	Careful selection of location and design. Swath mapping to confirm presence of reef habitat. Careful site selection to provide adequate buffer from natural reef.	Reduce likelihood	C5
Threatened and protected species						
Fish	Local	Incidental capture	C3	Reporting and education. Angler education on best practice and fish release guidelines. Report incidences. Manage/regulate as appropriate (seasonal closures/gear types etc.). Report sightings. Utilising input controls as required.	Accept	C3
	Local	Aggregation of threatened or protected species	C2	Consultation with threatened species experts during site selection.	Reduce likelihood	D2
	Regional	Interruption of movement corridors (e.g. Greynurse Shark)	C4	Consultation with threatened species experts during site selection. Reporting interactions. Utilising input controls as required.	Reduce likelihood	D4

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Sub-Local	Loss of habitat	D3	Consultation with threatened species experts during site selection. Careful selection of habitat type for deployment location.	Reduce likelihood	E3
Marine Turtles	Local	Incidental capture/entanglement from marine debris	C3	Reporting and education Removal of debris when required.	Accept	C3
	Local	Increased risk of boat strike	C3	Education	Accept	C3
	Intermediate	Increased risk of acoustic disturbance	C4	Accept	Accept	C4
	Large	Interruption of movement corridors	E5	Accept	Accept	E5
	Intermediate	Loss of habitat	E4	Accept	Accept	E4
Cetaceans	Local	Increased risk of boat strike	C3	Education regarding acceptable approach distances to cetaceans via national guidelines for whale and dolphin watching. Reporting and education of existing regulations.	Reduce likelihood	D3
	Intermediate	Increased risk of acoustic disturbance from boat traffic	C4	Follow national guidelines for whale and dolphin watching.	Accept	C4
	Large	Interruption of movement corridors	D5	Accept	Accept	D5
Pinnipeds and Sirenians	Sub-Local	Incidental capture/entanglement from marine debris	C3	Report marine debris and remove as per Long Term Management Plan Removal of debris when required.	Reduce likelihood	D3
	Local	Boat strike (sirenians only)	E3	Accept	Accept	E3
	Intermediate	Increased risk of acoustic disturbance from boat traffic	D4	Accept	Accept	D4
	Large	Interruption of movement corridors	E5	Accept	Accept	E5
Seabirds	Local	Incidental capture	D3	Reporting and education. Encourage reporting to WIRES.	Accept	D3
KTPs	Intermediate	Harm from marine debris and pollution (KTPs)	C3	User reports of fouled gear. Removal of debris when required.	Reduce consequence	D3

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Invasive marine pests	Local	Colonisation by invasive (noxious) marine pests	C3	Notify and follow NSW Aquatic Biosecurity advice if marine pests are identified.	Reduce consequence	C4
Marine protected areas	Regional	Inconsistency with objectives from other management frameworks	E2	Constraints mapping and consultation.	Reduce consequence	E5
Commercial fishing	Local	Loss of commercial fishing ground	B3	Consultation with commercial operators and careful site selection to avoid important areas.	Reduce consequence and likelihood	D4
	Local	Gear hook-up (commercial)	C2	Consultation, education, notice to mariners. Reef to be marked on nautical charts and NSW Maritime notified for inclusion in relevant publications. Commercial operators notified of 'as built position'.	Reduce likelihood	D2
	Regional	Impacts on commercial fish stocks	E5	Accept	Accept	E5
Recreational fishing	N/A	Risk offshore artificial reef does not achieve goals	D1	Monitor stakeholder feedback.	Reduce likelihood and consequence	E4
	Local	Gear hook-up (Recreational)	A4	Education (user guidelines), monitoring, hydrographic charts. Removal of debris when required.	Reduce consequence	A5
Recreational and commercial fishing	Local	Conflict between other user groups	B4	Education, consultation and adaptive management by implementing controls where applicable. Establish a complaints register to document and manage conflict.	Reduce likelihood	C4
	Regional	Commercial fishing in areas not previously targeted	D5	Accept	Accept	D5
Commercial	Local	Negative impacts on diving and fishing charter operators	D4	Appropriate site selection through constraints mapping and consultation.	Reduce likelihood	E4
	Local	Impacts on future mineral extraction operations	D4	Appropriate site selection through constraints mapping and consultation.	Reduce likelihood	E4

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
Navigation and Safety	Local	Clearance	D4	Sufficient clearance between the upper part of the reef and transiting vessels in severe weather conditions and under Lowest Astronomical Tide would be ensured through constraints mapping process and swath mapping.	Reduce likelihood	E4
	Local	Increased vessel traffic	A4	Accept	Accept	A4
	Local	Collision from crowding	C3	Observe boating regulations. Spread effort through reef design/layout. Education.	Reduce likelihood	D3
	Local	Injury or drowning (spearfishing)	C1	Site selection typically beyond diving limits. Education and awareness through user guidelines.	Reduce likelihood	D1
	Large	Increased encounters with dangerous marine animals by swimmers	D2	Selection of deployment location.	Reduce consequence	D3
	Large	Consumption of pollutants accumulated by fish at the OAR site	C3	Selection of deployment location through constraints mapping.	Reduce likelihood and consequence	E4
Infrastructure	Large	Congestion/crowding at boat ramps	D4	Infrastructure planning. Constraints mapping to identify suitable existing infrastructure with adequate access.	Accept	D4
	Large	Lack of amenities at boat ramps	D4	Infrastructure planning. Constraints mapping to identify suitable existing infrastructure with adequate amenities.	Accept	D4
Heritage	Intermediate	Impacts on submerged Aboriginal deposits	C4	Appropriate site selection identified through consultation and Aboriginal cultural heritage due diligence assessment.	Reduce likelihood	E4
	Intermediate	Conflict with areas of spiritual significance/dreaming	C4	Appropriate site selection identified through consultation and Aboriginal cultural heritage due diligence assessment.	Reduce likelihood	E4
	Intermediate	Negative impacts on aesthetic amenity	A5	Accept	Accept	A5

Environmental Aspect	Scale	Risk description	Risk level	Mitigative measure	Treatment type	Risk level
	Local	Direct impact to maritime heritage items (including shipwrecks	C2	Appropriate site selection identified through consultation with Maritime Heritage. Constraints mapping. Hydroacoustic survey to confirm location of maritime heritage items and adequate distance from OAR site	Reduce likelihood and consequence	D3
Work health and safety	Local	Injury or loss of life during maintenance or monitoring inspections	C1	Use of SWMS and only appropriately qualified and experienced staff adhering to DPI risk management frameworks or suitably qualified subcontractors to undertake inspections or maintenance.	Reduce likelihood	D1

5.3.16 Summary of the reasons for selection of proposed site

A detailed investigation of existing information and database searches relating to the study area has shown that there are several critical constraints which would preclude the deployment of an offshore artificial reef at depths of 30-50 m over a large proportion of the study area offshore of the Forster region. These included the Port Stephens – Great Lakes Marine Park zoning plan, the preferred depth requirements and proximity to natural reef substratum.

Following the review of existing information and mapping of key characteristics of the study area and surrounds, constraints analysis identified a potential artificial reef deployment area offshore of Forster-Tuncurry (Figure 25). This is the area where, based on existing information, reef deployment would be suitable and unlikely to conflict with the physical, biological and regulatory constraints investigated. The analysis was limited to using the information available and was subject to revision once further data or field investigations of the seabed and consultation had been undertaken.

A desktop review of known historic shipwrecks in the region revealed wrecks to the north (Black Head) and south (Seal Rocks) of the Forster OAR site. There were no active mining or exploration tenements, ocean outfalls, critical infrastructure or areas of conservation significance identified within the potential deployment area. A swath acoustic survey of the potential deployment area was completed, and bathymetry and habitat type determined. A 500 m buffer was applied from the natural reef. Additional investigations including an Aboriginal cultural heritage due diligence assessment and a coastal processes study further confirmed the suitability of the potential deployment area.

Depths of 30-40 m were considered for the project. A suitable reef deployment area was identified covering depths of 30-40 m with a reef centre point depth of 33 m located approximately 4.2 km offshore from Forster Beach (Figure 25). This depth range was preferable for tower style reef designs that aim to maximise vertical relief and attract pelagic species, while still providing for safe vessel clearance (>20 m) above the structures. This location is also accessible to boat-based fishing from the Forster-Tuncurry region. Notification letters were sent to relevant stakeholders, no objections or concerns within the scope of the proposal were raised.

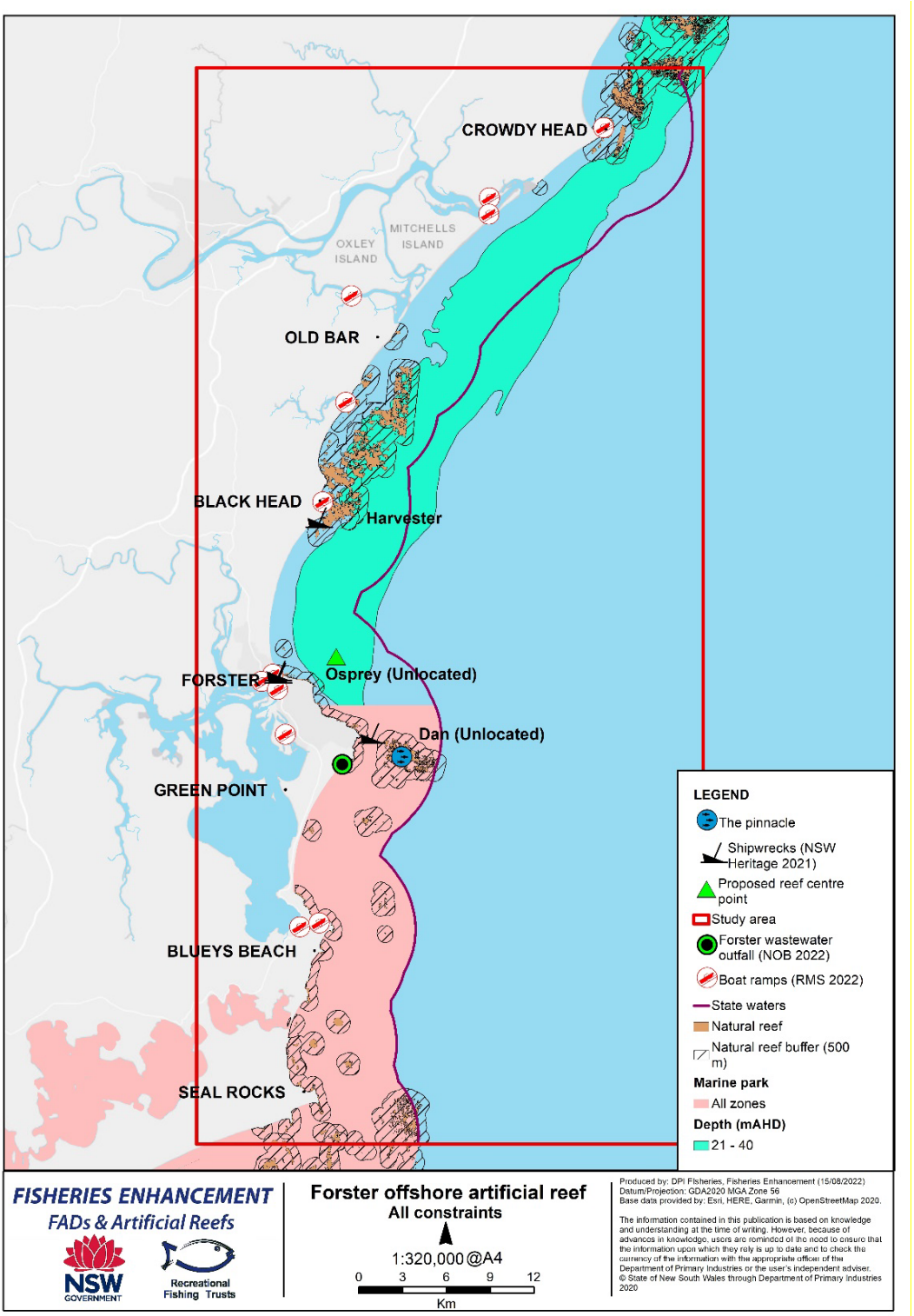

Figure 25 Potential Forster offshore artificial reef deployment site identified through constraints analysis

6 Scope, duration and timeframes for monitoring

The monitoring objectives have been developed to validate the goals for this activity have been achieved.

The proposed goals for the activity are as follows:

1) to enhance recreational fishing opportunities in the Forster region; and

2) to create new fish habitat in an otherwise barren and unproductive area.

The monitoring timeframes and objectives outlined in this LTMP have meet DDEEW most recent requirements.

Development of monitoring objectives to validate the project goals requires a time frame that is consistent with the rate of recruitment to the artificial reef system and the ecological factors that drive this process.

Previous work associated with both estuarine and offshore artificial reef systems has indicated that fish communities remain dynamic over the first two to three-year period post deployment.

As directed by DCCEEW the monitoring frequency for the Forster OAR will be undertaken:

- annually for the first five years,
- at a minimum of every five years over the remaining design life of the AR,
- otherwise as triggered by major storm events (to be conducted within 6 weeks), and
- at the end of planned life (i.e. a final inspection), intended to inform decommissioning options.

The responsibility for all monitoring lies with DPI.

BRUVS will consist of 2 camera frames dropped adjacent to the reef structures for a soak time of 30mins.

ROV inspections will comprise of three laps in total. One at the base, one in the middle and one around the top of the structures.

6.1 Monitoring commitments and mitigative actions

The monitoring objectives outlined in this LTMP address the most recent requirements of the *Environment Protection (Sea Dumping) Act 1981* for the Forster OAR. In compliance with recommendations outlined in previous permits and this document, DPI is committed to carry out the monitoring objectives listed in Table 25.

Table 25 Monitoring, triggers and mitigative actions

Reporting area	***Objective***	***Monitoring method***	***Risk***	***Trigger values***	***Mitigative actions***
Threatened and protected species.	Observe GNS on OAR structures. Record captures, observations and reports of all threatened and protected species.	BRUVS and ROV.	Based on evidence from 11 years of AR in NSW and consultation with Dr Nick Otway and DPI Threatened species branch this risk is unlikely.	2 confirmed GNS sighted on any single occasion	Build awareness of GNS presence through social media posts and Fisheries advisory activities.
				5 or more confirmed individuals are consistently found on the OAR throughout the year (as per the GNS recovery plan aggregation site definition).	Build awareness of GNS presence through social media posts and Fisheries advisory activities; and Review residency data (number of individuals, duration of visit, season etc.) against risk of impacts on GNS with key GNS experts including Dr Nick Otway, DPI Threatened Species Branch and DCCEEW. If GNS expert panel deem risks of recreational fishing impacts have increased and may result in significant impacts to the GNS population, introduce one or more of the following: • Gear restrictions • Fishing closure

Reporting area	*Objective*	*Monitoring method*	*Risk*	*Trigger values*	*Mitigative actions*
Marine debris.	Identify marine debris.	BRUVS and ROV.	Based on evidence from 11 years of AR in NSW this risk is unlikely.	Identification of marine debris.	Annual removal of marine debris.
Invasive pests.	Identify marine pests.	BRUVS and ROV.	Based on evidence from 11 years of AR in NSW and DPI Biosecurity Branch advice this risk is unlikely.	Identification of a marine pest.	Report and develop strategy in consultation with DRNSW Biosecurity branch to manage or eliminate risk.
Confirm community development of reef structures / reef performance.	Observe community development. Observe recreationally targeted species.	BRUVS and ROV.	Based on evidence from 11 years of AR in NSW this risk is rare.	Community development not consistent with previous OARs.	Reconsider which aspects of design are favouring a single species / restricting expected community development. Modify reef to provide habitat for community deficit.
Structure location, stability and integrity.	Ensure structures are not moving, breaking up or leaning over. Ensure location is within Zone of Confidence (ZOC) tolerances as per AHP20 and as required by the Australian Hydrographic Office (AHO).	BRUVS, ROV and GPS referenced echosounders.	Based on evidence from 11 years of OARs in NSW and AHO reports of dozens of OARs Australia wide there have been no reported cases of OARs moving. Therefore, this risk is rare. NSW DPI's conservative design specifications and factors of safety applied throughout the tender and design phase significantly reduce this risk.	Structure has moved outside assessed deployment area.	New environmental assessment to be undertaken at new location and relocated if risks/impacts are too great at new location.
				Structure is breaking up within service life.	Structure to be remediated to a stable condition.
				Structure has >45 degree lean.	Assessment and review by a naval architect/structural engineer. Structures lean to be remediated to a stable condition as determined by naval architect/structural engineer.
Storm events – location, stability, integrity.	Ensure structures are not moving, breaking up or leaning over after	BRUVS, ROV and GPSgeferenced echosounders.	Based on evidence from 11 years of OARs in NSW and AHO reports of dozens of OARs Australia wide there have been	Structure has moved outside assessed deployment area.	New environmental assessment to be undertaken at new location and relocated if risks/impacts are too great at new location.

Reporting area	*Objective*	*Monitoring method*	*Risk*	*Trigger values*	*Mitigative actions*
	the first 1/20-year ARI conditions and first 1/50 year ARI conditions. Ensure location is within Zone of Confidence (ZOC) tolerances as per AHP20 and as required by the AHO.		no reported cases of OARs moving. Therefore, this risk is rare. NSW DPI conservative design specifications and factors of safety applied throughout the tender and design phase significantly reduce this risk.	Structure is breaking up within service life.	Structure to be remediated to a stable condition.
				Structure has >45 degree lean.	Assessment and review by a naval architect/structural engineer. Structure's lean to be remediated to a stable condition as determined by naval architect/structural engineer.

BRUV = baited remote underwater video, ROV = remotely operated vehicle

6.1.1 External drivers

External drivers are factors that are known to potentially impact on the performance of the OAR, 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, NSW Environment and Heritage 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 Threatened Species Unit (TSU) being notified of these interactions, NSW Environment and Heritage would also be independently briefed. Management actions would require a combined approach from both DPI and NSW Environment and Heritage to ensure a consistent method to address the issue. A passive approach such as increased education and 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 and determined to be 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 OAR which is of a deliberate nature (e.g. intentional dumping of waste from vessels) then Transport for NSW - Maritime 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 combined on-water operations with the Maritime Boating Safety Officers to target offenders and enforce these regulations.

6.1.2 Key threatening processes

Harm from Marine Debris: An accumulation of recreational fishing gear on the OAR is conceivable. This potentially increases the risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed artificial 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 the build-up of marine debris such as lost fishing tackle, anchor lines and other pollution is being monitored each year over the first three years post OAR installation.

To further reduce the impact of this KTP, education using the OAR 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 OAR 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 OAR is likely 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 OAR 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. Therefore, they are unlikely to be of concern, primarily due to the location of the proposed Forster OAR. CSIRO modelling of the potential range of NZ Screw Shell

(based on temperature tolerance) indicates it is very unlikely to survive north of Merimbula in southern NSW.

Whilst the proposed OAR 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, OAR 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 to better document the extent of the incursion. Requirements for removal of marine pests (according to National Introduced Marine Pest Information System) 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 DPI upon advice from the DPI Biosecurity Unit.

6.2 Emergency contacts

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

- the environmental incident that occurred and/or 'non-compliance' detected;
- the mitigation measures taken; and
- 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:

DPI Fisheries Manager (Fisheries Enhancement)

Ph: 0457 664 062 (during office hrs), 1300 550 474 (24 hrs)

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

Other relevant emergency contacts include:

- ORRCA Whale and Dolphin Rescue – Ph: (02) 9415 3333
- Fisheries Watch - for reporting illegal fishing – Ph: 1800 043 536
- For ALL other emergencies (NSW Police, Maritime, Fire, Ambulance) – Ph: 000

6.3 Decommissioning

Whether the structures are removed intact or dismantled at the end of the life of the Sea Dumping Permit 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, structures would be lifted intact by crane to a barge and transported to a waterside location, where the structure would be cleaned, dismantled and disposed of at an appropriate land-based facility;

Option B – If it is not feasible for the structures to be removed intact, then the method of removal of the structures would be subject to a government tender process to ensure the most contemporary methods for removal were employed at the time. Structures would then be transported to a waterside facility where the pieces would be cleaned and disposed of at an appropriate land-based facility; or

Option C – Structures would remain in-situ on the seabed and be allowed to gradually break-down over time.

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. If unacceptable impacts to the environment were detected during monitoring of the OAR 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 structures had been in place. Removal of the structures (Options A or B) would therefore be subject to a separate environmental assessment of their removal.

6.4 Post installation

Within 21 working days from completion of the reef installation, DPI will provide a report to DCCEEW that:

- details the date and time of the placement of the Forster OAR;
- confirmation of the placement site boundaries to two decimal places of a minute (WGS84);
- the estimated maximum depth over the Forster OAR 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); and
- proof of written notification to the Australian Hydrographic Office and NSW Maritime.

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