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Lake Macquarie Artificial Reef Expansion

Statement of Environmental Effects

Department of Primary Industries, Fisheries

30 June 2008

Lake Macquarie Artificial Reef Expansion

Prepared for

Department of Primary Industries, Fisheries

Prepared by

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Executive Summary

This document constitutes a Statement of Environmental Effects (SEE) for the NSW Department of Primary Industries - Fisheries (DPI) that was conducted to assess the potential environmental impact of the proposed extension of an existing artificial reef in Lake Macquarie on the Central Coast of NSW.

The DPI has a program of reef development aimed at increasing fish habitat to provide increased opportunities for recreational fishers. There are currently projects located at Lake Macquarie, St Georges Basin and Botany Bay all at various stages of colonisation by aquatic flora and fauna.

This project comprises the placement of additional 'Reef Balls' within the estuarine environment of Lake Macquarie. These structures are specifically designed for this purpose and are built from a modified concrete aggregate specifically formulated to be attractive to benthic flora and aquatic fauna. The process of placing the reef balls in the lake is specifically designed to create minimum environmental disturbance.

Other sites where similar artificial reefs have been established have displayed positive environmental outcomes to date and monitoring of these sites is ongoing. The existing Lake Macquarie artificial reef site has been subject to a rigorous monitoring program, established to determine the effectiveness of the reef, and identify any environmental impacts; either positive or negative. Since deployment, monitoring of the artificial reef sites indicates that they have been effective in providing new aquatic habitat, with a large diversity and abundance of aquatic vertebrates, invertebrates and alga.

The SEE does not identify any significant negative environmental impacts that may eventuate during or following commissioning of the reef expansion. Indeed, a number of the positive effects that have been observed at the existing Lake Macquarie artificial reef are expected to continue following the expansion of the reef. The SEE indicates that the proposed artificial reef expansion will not require additional mitigation or design changes due to environmental constraints. The reef will however, be subject to a monitoring program, where any adverse effects can be identified. It is not anticipated, however should the need arise, removal of the reef is possible for which a contingency plan is in place.

1.0 Introduction

1.1 Overview

Artificial reefs have been defined as “any material purposely placed in the marine environment to influence physical, biological, or socio-economic processes related to living marine organisms” (Sutton and Bushnell, 2007). Up to 40 countries around the world have constructed artificial reefs (Baine, 2001). Objectives for the deployment of artificial reefs include the enhancement of recreational and commercial fishing, coastal protection and mitigation of habitat loss and damage (Seaman and Jensen, 2000).

The materials used to build artificial reefs vary and have evolved considerably over time. A variety of ‘waste’ material has historically been used in artificial reef construction. These are collectively known as ‘materials of opportunity’, which have included discarded automobile tyres, scuttled ships, concrete pipes, railway cars, and surplus military equipment. However, the use of specially designed prefabricated reef structures is now used in many countries including Japan and Korea, who are considered world leaders in artificial reef technology (Kim, 2001; Sutton and Bushnell, 2007). Primarily made from concrete or steel, ‘design specific’ structures have been demonstrated to be more appropriate in achieving specific fisheries management objectives (Sherman *et al.* 2002).

Artificial reefs are believed to enhance the productivity of designated areas by providing substrate for the settlement and subsequent growth of marine organisms and can play an important role in providing food and refuge for juveniles of commercially and recreationally important species (Pollard and Mathews, 1985). With improved designs and structural integrity, artificial reefs may contribute significantly to environmental and fish habitat enhancement (Branden *et al*, 1994).

There has been considerable debate over the effectiveness of artificial reefs to produce more fish, rather than just attracting existing fish to a new location. This has become known as the ‘attraction-production question’. Attraction is simply defined as the net movement of individuals (e.g. fish) from natural to artificial habitats; whereas a simplified definition of production is the change in biomass over time (Carr and Hixon, 1997). In reality, it is a very complex question and extensive research has failed to provide a definitive answer (Grossman *et al,* 1997; Pickering and Whitmarsh, 1997; Osenberg *et al*, 2002).

The benefit of artificial reefs on fish stocks will likely depend on the management objectives of their use (Lindberg, 1997). Although artificial reefs may have the potential to increase a fishers catch, management strategies have been implemented by all Australian state fisheries agencies to regulate fishing. These regulations can be varied to prevent over-fishing and to ensure that targeted species are not taken before they are sexually mature (Branden *et al*, 1994).

1.2 History of Artificial Reef Use in NSW

There have been at least four detailed reviews of artificial reefs in Australia (Pollard and Mathews, 1985; Kerr, 1992; Branden *et al*, 1994; Coutin, 2001). Collectively these reviews detail the development of Australian artificial reef design, construction, deployment and monitoring from 1965 to 2001. The main purpose of artificial reefs in Australia is for recreational fishers and divers (Branden *et al,* 1994) and historically, materials of opportunity (waste material) have been the main materials used in their construction (Pollard, 1989; Kerr, 1992).

In NSW, the use of artificial reefs began in 1966, with the deployment of a series of artificial reefs in Lake Macquarie using car bodies and tyres (Pollard and Mathews, 1985; Pollard, 1989). Augmentation of these reefs continued in the 1970’s with additional reefs constructed in Batemans Bay, Port Stephens and Port Hacking using car tyres (Coutin, 2001). In addition to these tyre and car body reefs, up to 12 vessels were scuttled beginning in the mid 1970’s to create single-component artificial reefs in NSW coastal waters, beginning with the retired ferry, the ‘Dee Why’, in 1976 (Pollard and Mathews, 1985; Pollard, 1989; Coutin, 2001).

From the mid 1980's, lack of funding and increasingly stringent environmental legislation meant that artificial reef construction in NSW effectively ceased until the introduction of the general recreational fishing fee in 2001, when funds became available for the further investigation of the use of artificial structures as a fisheries enhancement tool.

1.3 Need for an Artificial Reef Program

The Department of Primary Industries – Fisheries (DPI) manages recreational fishing under the *Fisheries Management Act 1994* (FM Act) within both inland and ocean waters of NSW out to 200 nautical miles from the coast. A 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 NSW DPI Artificial Reef Program is consistent with these objectives as it aims to create new, high-quality fishing areas through the deployment of artificial reefs. The artificial reefs provide alternative fishing grounds that may divert fishing effort from natural, existing heavily fished locations. Accordingly, the Department is proposing to deploy additional artificial reefs in a variety of new estuaries. The Program is funded by the Recreational Fishing Trust by funds raised from Recreational Fishing Licence fees.

Since 2005, artificial reefs have been deployed and used for scientific research by the DPI within Lake Macquarie, St Georges Basin and Botany Bay. These were installed as part of the initial pilot stage of the project and have been subject to monitoring since installation to gauge their effectiveness and ecological impacts. So far, they have been considered successful at providing habitat for aquatic life and are therefore being considered for other locations.

1.4 Project Background

The Department has previously deployed artificial reefs as part of its pilot program in Lake Macquarie, Botany Bay, and St Georges Basin. The pilot program has proven successful and the DPI is now looking at deploying additional artificial reefs in two new estuaries (Lake Conjola and Merimbula Lake) and expanding the project within Lake Macquarie.

Lake Macquarie was the first estuary in which the concrete artificial reef modules (known as Reef Balls) were installed in late 2005. This project has been subject to scientific monitoring since installation to ascertain its effectiveness and monitor ecological impacts. So far, the reef in Lake Macquarie has been considered successful at providing habitat for aquatic life and is therefore being considered for expansion.

The DPI selected Lake Macquarie as an ideal location for the first of its artificial reef pilot projects and following community consultation and detailed site inspections, a site was selected as potentially suitable for artificial reef deployment. An environmental assessment was prepared and development application lodged with Lake Macquarie City Council in 2005. The project was approved by Council and deployment of the reef was undertaken in 2005, and has been subject to regular monitoring by the DPI and independent scientific research.

The proposed reef extension will provide an additional artificial reef studies area allowing DPI to build on its understanding of the benefits of artificial reefs.

1.5 Project Objectives

The artificial reef within Lake Macquarie by the NSW DPI, has the following objectives:

- To extend the existing artificial reef and therefore its effectiveness as a fisheries enhancement tool, while limiting and mitigating any possible negative effects;
- Provide additional fishing opportunities for recreational anglers within the lake; and
- Provide additional scope for relevant and valuable monitoring opportunities, to increase the scientific knowledge of artificial reefs and the natural environment.

This Statement of Environmental Effects (SEE) outlines the proposal, the deployment and monitoring methodology and potential environmental impacts. It includes a:

- Detailed description of the site and the project;
- Details of the NSW DPI Artificial Reef Program in NSW and current monitoring results and findings;
- Environmental assessment of the proposal based on the existing environment and currently available information; and
- Outline of the proposed monitoring program and mitigation measures.

2.0 Project Description

2.1 Site Location

Lake Macquarie is located within the Lake Macquarie City Council Local Government Area (LGA) south of Newcastle. The catchment area of the lake covers an area of approximately 700 km^2 and the lake itself has a waterway area of 120 km^2. The catchment supports a wide range of land uses from high density urban development, standard residential to agricultural, industrial, mining and conservation areas. The lake is a declared Recreational Fishing Haven and is a popular holiday destination and excellent boating waterway (Department of Natural Resources, 2008).

The entrance to the estuary is at Swansea and is permanently open. Lake depths range up to a maximum of 11 metres, however generally the lake bed is relatively flat with average depths of 7 metres. Tidal flushing of the lake is restricted by the narrow inlet and it is estimated that only 1% of the lake's volume exchanges with ocean water during each tidal cycle.

The existing reef configuration consists of six separate small reefs off Galgabba Point (refer to Figure 1). They are located along the 5 metre depth contour in a south easterly direction between the two GPS waypoints (WGS84) listed below:

- Northern Mark: 33.05.533 S; 151.36.599 E
- Southern Mark: 33.06.401 S; 151.36.952 E

The existing reefs have been constructed using a total of 180 Reef Ball modules and are separated from each other by approximately 350 to 400 metres. The reefs currently range in size from 10 to 50 Reef Balls and it is proposed to augment these reefs so that each consists of 100 modules. The new modules (up to 420 Reef Balls) will be placed immediately adjacent to the existing reefs. No disturbance of the existing Reef Balls is proposed.

The site was originally selected due to its lack of natural aquatic habitat (ie rocky reefs or seagrass meadows) and presence of coarse sandy sediments. Sandy sediments are ideal as they provide a stable base for the concrete Reef Balls and limit turbidity issues during deployment and monitoring.

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Lake Macquarie
Artificial Reef Extension
DPI Fisheries

Figure 1 - Artificial Reef Location

2.2 Reef Design

The existing reef and proposed extension is constructed using artificial reef modules known as 'Reef Balls'. Reef Balls are individually cast concrete artificial habitat modules. Additives in the concrete mix increase the strength of the module and lower the pH levels, encouraging the growth of marine plants and settlement of other encrusting organisms (Figure 2).

Figure 2 – Extensive growth on NSW DPI Lake Macquarie artificial reef 23 months after deployment

Figure 3 – Fish life on NSW DPI Lake Macquarie artificial reef

The moulds are produced by a patented system developed by the Reef Ball Development Group in the United States. The Reef Balls are hollow cement hemispheres with numerous smaller holes over the surface allowing the egress of fish and other invertebrates (Figure 3 and Figure 4). Over 500,000 Reef Balls have been deployed worldwide in over 3,200 projects.

Figure 4 – Fish life on NSW DPI Lake Macquarie artificial reef

Research suggests that Reef Balls create substantial fish, invertebrate and marine plant habitat, with Reef Balls shown to reach 80% or more of the natural species diversity and population densities of nearby natural reef systems within just a few years (Reef Ball Foundation). Encrusting algae and invertebrates ensure the reefs eventually reach a stage where they are unrecognisable from their original form. As well as being more aesthetically pleasing, this additional growth also attracts more fish, and creates a more natural ecosystem.

The artificial reef extension in Lake Macquarie is proposed to consist of 420 new Reef Balls of varying sizes (Table 1). The six existing reefs have been constructed using a total of 180 Mini-bay Balls. Three of the reefs consist of 10 modules each whilst the other three reefs consist of 50 modules each. These sites will be extended so that they all consist of 100 modules each. A sketch plan of the reef layout is shown in Figure .

Table 1 – Dimensions of Reef Ball sizes proposed for the Lake Macquarie artificial reef

	Width	Height	Footprint	Spaced Footprint	Weight
	(m)	(m)	(m^2)	(m^2)	kg
Pallet Ball	1.22	0.88	1.17	4.93	682 - 1000
Bay Ball	0.91	0.61	0.65	3.65	170 – 341
Mini-bay Ball	0.76	0.53	0.45	3.1	68 – 91

NSW DPI experience has indicated that the ideal spacing between each Reef Ball is approximately 1 metre. The existing number of Reef Balls and proposed extension is listed in Table 2. As a result of the extension, the approximate footprint of each reef will be 357 m^2. Therefore, all six reefs will cover a total of 2,142 m^2 of the lake bed.

Table 2 – Proposed reef extension details

Existing Reef Size	Additional Reef Ball Modules		
(No. modules)	Mini-bay Balls	Bay Balls	Pallet Balls
10	40	25	25
50	26	12	12
(x 3) = Total 180	198	111	111

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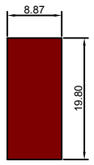
NOTES:
There is approximately a 1m gap between reef balls.
From the centre point of a mini bay ball it is a minimum distance of 1.835m between it and the nearest bay balls centre point. There is a minimum of 1.99m between the mini bay balls and the closest centre point of a pallet ball. There is a 2.065m gap between the bay balls and pallet balls centre points. There is a 2.065m gap between every row to allow for the spacing of the pallet balls in the rows and the gap between the bay balls and the pallet balls.

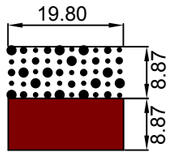
Individual reefs are separated by approximateliy 350m (not shown to scale).

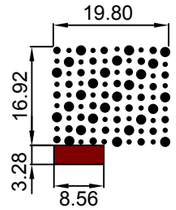
LEGEND
- Pallet Ball - 1.22m (Diameter)
- Bay Ball - 0.91m (Diameter)
- Mini Bay Ball - 0.76m (Diameter)

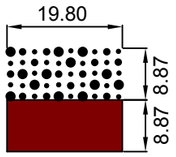
Approximate existing reef extent (10 mini-bay balls).

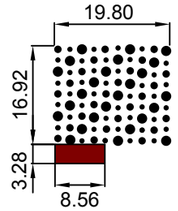


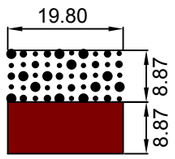
Approximate existing reef extent (50 mini-bay balls).

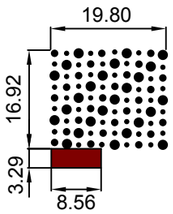












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Lake Macquarie
Artificial Reef Extension
DPI Fisheries

Figure 5 - Artificial Reef Layout

2.3 Deployment

The reef ball modules will be delivered to Lake Macquarie by truck from their construction site in Sydney, NSW. The reef ball modules will be loaded onto a barge for transportation to the artificial reef site at a predetermined and pre-approved loading site (eg boat ramp). Deployment will occur outside of peak usage times (such as weekends, school and public holidays) for the lake.

The modules will then be individually deployed at the proposed location from the barge using a crane and a team of three commercially certified divers as shown in Figure 6. This will ensure the correct placement of each individual module, limiting unnecessary turbidity issues and enabling a high level of control over the deployment process.

Pending approval of the proposal from all consenting authorities and the meeting of all statutory obligations, deployment of the artificial reef is anticipated to take approximately 10 days.

Figure 6 – Installation of Reef Balls by barge in St Georges Basin

2.4 Proposed Monitoring Program

The existing reef and extension will continue to be monitored quarterly using the current monitoring methodology. The monitoring will be conducted using both diver census and baited underwater video (BUV). As well as monitoring fish recruitment and environmental effects such as sedimentation, DPI will be building on the existing research, including monitoring of diurnal (daily and seasonal) variation in fish populations on artificial reefs as well as catch monitoring in association with local anglers and fishing clubs.

Further detail on the monitoring program is provided in Chapter 6.2.

3.0 Current NSW DPI Artificial Reef Program

3.1 Existing Reefs

The DPI has deployed a series of small design-specific artificial reefs using Reef Balls (Figure 6) in three NSW estuaries to increase fish habitat and improve recreational fishing opportunities (Table 3). These reefs were part of a pilot study with long term monitoring to determine best practice procedures for artificial reef construction, deployment, placement, and monitoring while assessing the structures effectiveness as a recreational fisheries enhancement tool. The effects of the artificial reefs have been monitored in detail both pre and post deployment using a combination of baited underwater video (BUVs) and diver surveys. Monitoring has shown the reefs to be effective in providing habitat for estuarine species, including those targeted by recreational fishers.

Table 3 – Existing NSW DPI Artificial Reefs

Location	Deployment Date	Monitoring Start	Monitoring Completion	No. and Size of Reef
Lake Macquarie	December 2005	September 2005	December 2007	3 x 50 ball reefs 3 x 10 ball reefs
Botany Bay	June 2006	March 2006	June 2008	6 x 30 ball reefs
St Georges Basin	February 2007	November 2007	February 2009	6 x 30 ball reefs

This pilot study has provided DPI with a highly successful model and proven design for the deployment of artificial reefs in barren areas of NSW coastal estuaries. DPI has gained an excellent understanding of artificial reef design and management (see further detail on Reef Balls below). The main benefit of using design-specific individual modules of this nature is that the reef ball modules can be moved and located elsewhere or removed completely from the water if required.

Figure 7 – Typical Reef Ball module showing hollowed construction (image courtesy of the Reef Ball Foundation)

3.2 Reef Performance

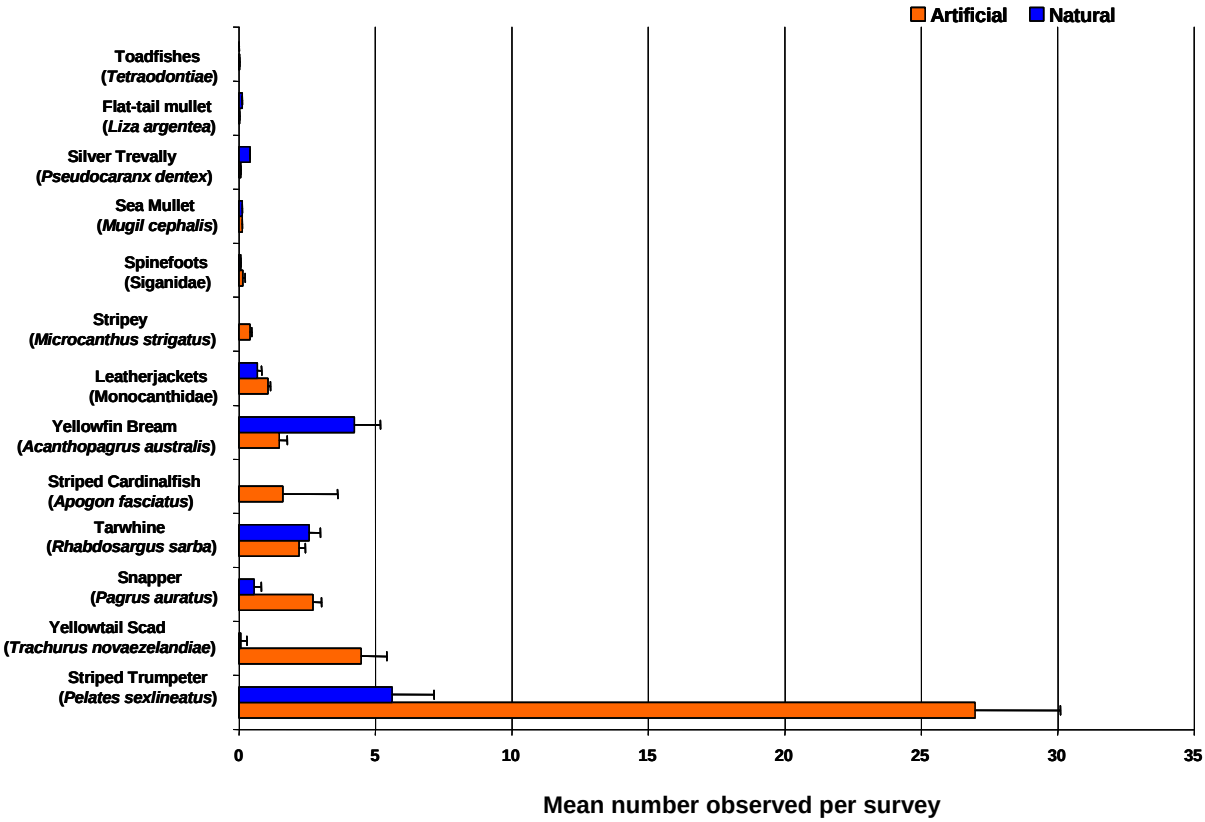
DPI has monitored the existing artificial reefs in Lake Macquarie before and after deployment. Results from the two years of post deployment monitoring from Lake Macquarie have illustrated the high diversity of fish species found on the artificial reefs. Up to 42 species of fish have so far been identified (Table 4). The species found include resident, reasonably sedentary species such as striped cardinalfish, gloomy octopus, striped catfish and moray eels, but the artificial reefs also attract more transient species such as highfin amberjack, yellowtail kingfish, silver trevally, yellowfin bream and snapper.

Table 4 – List of species recorded on Lake Macquarie NSW DPI Artificial Reefs

Species	Diver Survey	BRUV
Striped Cardinalfish (*Apogon fasciatus*)	✓	✓
Striped Trumpeter (*Pelates sexlineatus*)	✓	✓
Yellowtail Scad (*Trachurus novaezelandiae*)	✓	✓
Snapper (*Pagrus auratus*)	✓	✓
Tarwhine (*Rhabdosargus sarba*)	✓	✓
Yellowfin Bream (*Acanthopagrus australis*)	✓	✓
Striped catfish (*Piotosus lineatus*)	✓	
Fanbelly Leatherjacket (*Monacanthus chinensis*)	✓	✓
Stripey (*Microcanthus strigatus*)	✓	✓
Silver Biddies (*Gerreidae*)	✓	✓
Trumpeter Whiting (*Sillago maculate*)	✓	✓
Yellowfin Leatherjacket (*Meuschenia trachylepsis*)	✓	✓
Silver Trevally (*Pseudocaranx dentex*)	✓	✓
Diamondfish (*Monodactylus argentus*)	✓	
Moray Eels (*Muraendiae*)	✓	
Eastern Fortescue (*Centrapogon australis*)	✓	
Silver Sweep (*Scorpis lineolate*)	✓	✓
Toadfishes (*Tetraodontiae*)	✓	✓
Sixspine Leatherjacket (*Meuschenia freycinenti*)	✓	✓
Spinefoots (*Siganidae*)	✓	
Gobies (*Gobidae*)	✓	
Whiting (*Silganidae*)	✓	✓
Luderick (*Girella tricuspidate*)	✓	✓
Gloomy Octopus (*Octopus tetricus*)	✓	✓
Estuary Catfish (*Cnidoglanis macrocephalus*)	✓	
Three-bar Porcupinefish (*Dicotylichth punctulatus*)	✓	✓
Longfin Bannerfish (*Heniochus acuminatus*)	✓	
Mado (*Atypichthys strigatus*)	✓	✓
Giant Trevally (*Caranx ignobilis*)	✓	✓
Pineapplefish (*Cleidopus gloriamaris*)	✓	
Ocellate Butterflyfish (*Parachaetodon ocellatus*)	✓	
Maori Wrasse (*Opthalmolepis lineolatus*)	✓	
Magpie Morwong (*Cheilodactylus vestitus*)	✓	
Bluestriped Goatfish (*Upeneichthys lineatus*)	✓	✓
Bartail Goatfish (*Upeneus tragula*)	✓	✓
Ocean Jacket (*Nelusetta ayraudi*)	✓	✓
Longsnout Flounder (*Ammoteretis rostratus*)	✓	✓
Highfin Amberjack (*Seriola dumerili*)	✓	✓
Blackspot Goatfish (*Parupeneus spilurus*)		✓
Stout Longtom (*Tylosurus gavialoides*)		✓
Stingrays (*Dasyatidae*)		✓
Batfishes (*Ephippidae*)		✓

A large difference in the species composition between artificial and natural reefs in Lake Macquarie has been observed (Figure 8). Artificial reefs attract higher numbers of striped trumpeter, yellowtail scad, snapper, cardinalfish and stripeys. Natural reefs seem to attract higher densities of yellowfin bream and silver trevally. The yellowfin bream data, however, is confounded by one natural reef site that has an unusually high population of yellowfin bream. The differences in composition may be attributable to at least two factors: i) the difference in structural complexity between Reef Balls and natural reef; or ii) artificial reefs are undergoing the process of succession to a natural reef state.

Figure 8 – Comparison of densities and species observed using BUVs on NSW DPI Artificial Reefs and natural reefs within Lake Macquarie



3.3 Independent Assessment of Reef Performance

The University of Newcastle has been conducted an independent assessment of diversity, abundance and catch rates for the Lake Macquarie artificial reefs. This study is compared the populations of fish on the NSW DPI artificial reefs to the natural reefs located in Lake Macquarie. This data was collected 8 months subsequent to deployment. The preliminary data in this section is extracted from a draft version of the scientific manuscript *Artificial reefs: Do they provide similar CPUE to anglers when compared to natural reefs in a recreational fishing haven, Lake Macquarie NSW*? (Stephen Clair *unpublished data*)

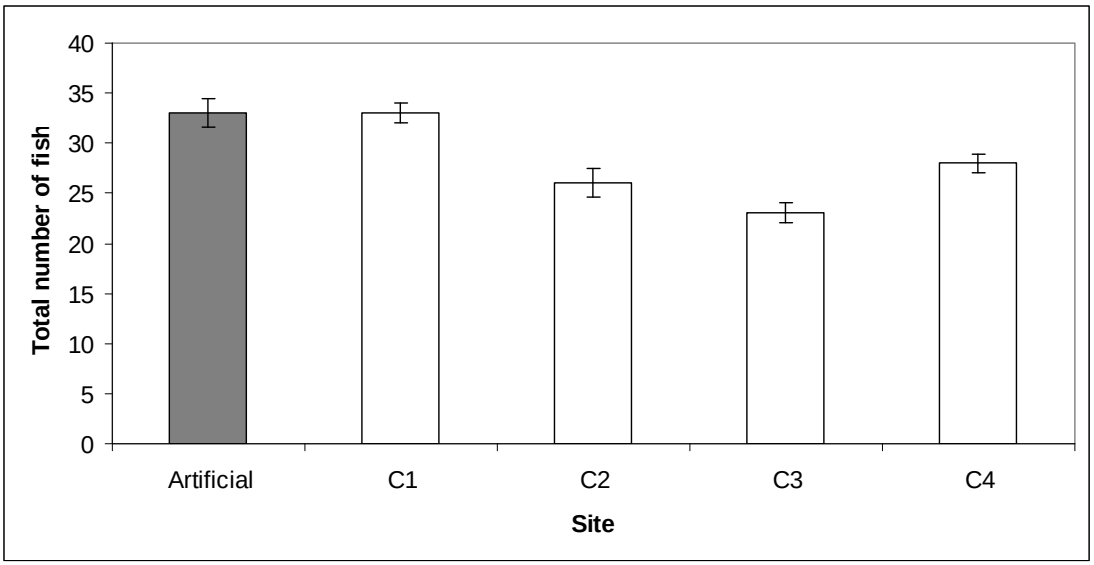
3.3.1 Methodology

The six artificial reefs in Lake Macquarie were considered as one unit. This artificial reef treatment was compared to four control (natural) reef sites, carefully chosen to replicate the treatment site in terms of area and depth. Reefs were sampled by line fishing for one hour per day, with sampling order randomised to avoid confounding effects of time of day, tides etc. All fishing gear was standardised, with fishing conducted from a boat drifting over the site.

3.3.2 Results

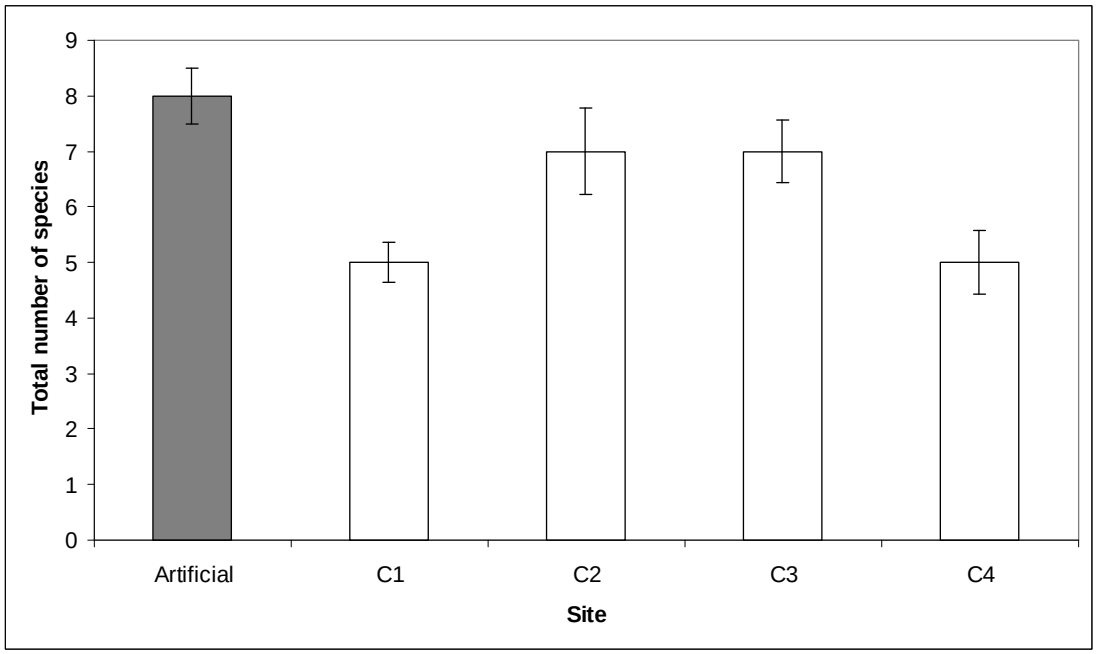
Preliminary results of the independent survey indicated that the total abundance of fish caught at Lake Macquarie differed at artificial and control reef sites. The artificial reef and control site 1 both produced 33 fish, with control site 3 producing only 23 fish for the same 7 day sampling period (Figure 9).

Figure 9 – Total abundance of fish caught at Lake Macquarie on artificial reefs and control sites



The total diversity found on reefs in Lake Macquarie was observed to be highest on the artificial reefs with 8 species recorded. Control sites recorded between 5 and 7 species for the same sampling period (Figure 10).

Figure 10 – Total number of species recorded during sampling at Lake Macquarie artificial reefs and control sites



Total Catch Per Unit Effort (CPUE) was comparable amongst all sites with an average of around 4 fish per hour at artificial and control reefs (Figure 11). Catch per unit effort of legal sized fish, however, was highest at the artificial reef sites with an average of one legal sized fish caught per hour, with control sites having a CPUE of 0.25-0.6 (Figure 12).

Figure 11 – Total CPUE for Lake Macquarie, comparing artificial reef and control sites

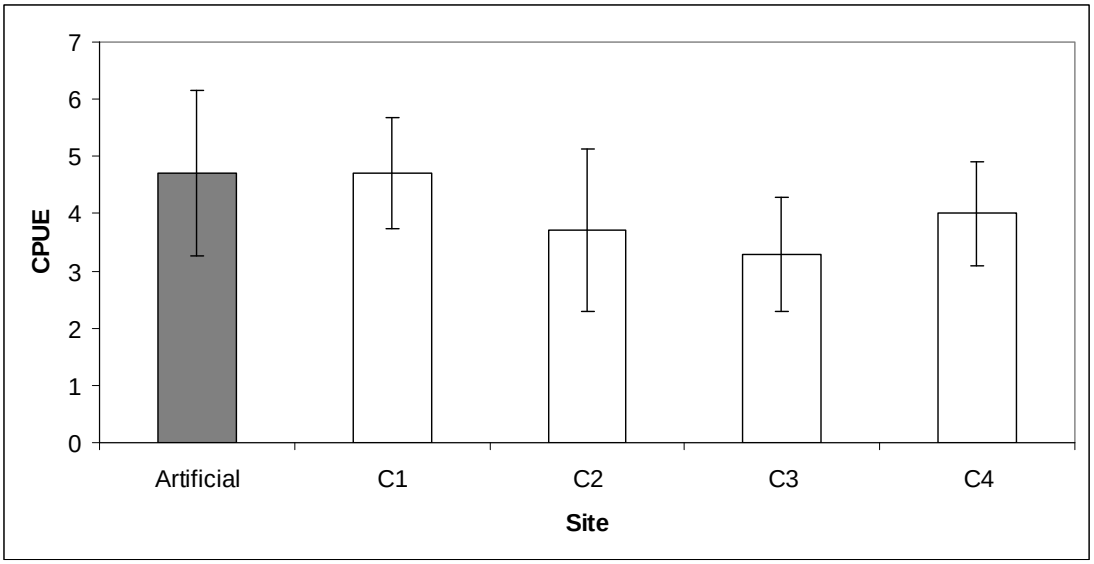
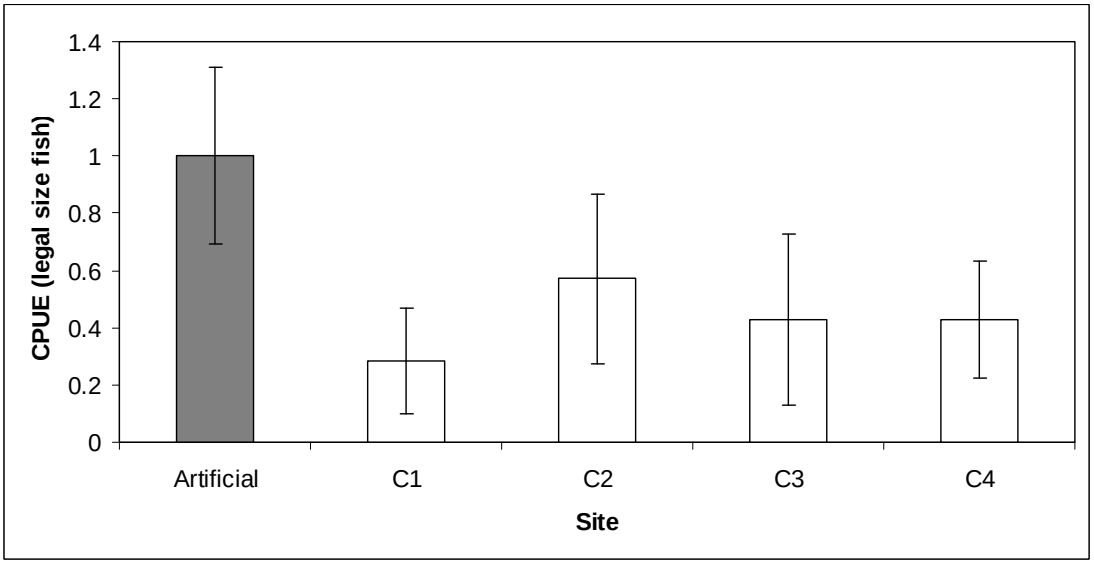


Figure 12 – CPUE of legal sized fish at Lake Macquarie artificial and control reef sites



Monitoring has indicated that the artificial reefs program has met its objectives and has been a success. By placing artificial reefs in previously barren areas, new diverse habitat for fish and invertebrates has been created. There has been succession of algae on the artificial reefs with extensive marine plant growth on the surface of the Reef Balls, suggesting that the materials used in construction are appropriate for the conditions. Colonisation of the reefs was almost instant, with fish observed inhabiting the reef balls within 2 days. Initially, just a few individuals were present, however the population of fish recorded has been increasing the longer monitoring has continued. Not only do the reefs support a large number of fish, but also high species diversity.

The reef has also been a success in terms of enhancing recreational fishing opportunities. After just 8 months, the abundance, diversity, and catch rates of recreational species are as good as or better than control sites at Lake Macquarie. This independent data strengthens NSW DPI information that the reefs are successful and are making a measurable positive contribution to the environment of Lake Macquarie.

4.0 Statutory Approvals

4.1 Commonwealth Legislation

4.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Department of the Environment, Water Heritage and the Arts (DEWHA). The EPBC Act applies to all states and territories and is focused on the protection of matters of National Environmental Significance which are defined as:

- World Heritage properties
- National Heritage places
- Wetlands of international importance
- Threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)

The DEWHA Protected Matters database was searched on 6 February 2008. A point search on the site coordinates, plus a 10 kilometre buffer, was conducted. Within this area, the database indicates that the following matters of NES are potentially present:

- 48 Threatened species
- 46 Migratory species

Other matters protected by the EPBC Act in the area include:

- Commonwealth Lands – 5
- Register of the National Estate – 4
- Listed Marine Species – 62
- Whales and other Cetaceans – 13
- State and Territory Reserves – 2
- Regional Forest Agreements – 1

Of the threatened species listed, the Green Turtle (*Chelonia mydas*) is known to occur within Lake Macquarie and was assessed as having a moderate likelihood of occurring at the proposed reef site based on available habitat. *Chelonia mydas* is listed as Vulnerable under both Commonwealth and State legislation and is therefore considered to be a matter of National Environmental Significance.

It is noted that a Bilateral Agreement under the EPBC Act between the Commonwealth and the State of NSW is in place with respect to the approval of proposals and their environmental impacts to matters of National Environmental Significance. The Bilateral Agreement recognises NSW's environmental planning system and legislative requirements with respect to the assessment of environmental impacts to matters of National Environmental Significance. With respect to determining the significance of impacts to threatened species, the bilateral agreements allows for assessments to be undertaken in accordance with Part 6 of the NSW *Threatened Species Conservation Act 1995* or Part 7A of the NSW *Fisheries Management Act 1994*.

Therefore an assessment to determine the significance of potential impacts to the *Chelonia mydas* is provided in Appendix A.

4.2 NSW Legislation

4.2.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) establishes the framework under which environmental planning instruments (state environmental planning policies, regional environmental plans and local environmental plans) are prepared. These instruments guide and control development within the state of NSW and provide the basis for determining whether development is acceptable in a given location given the objectives for the area and the social, economic, and environmental impacts of the proposal.

The EP&A Act contains three pathways under which development can be assessed and approved:

- Part 3A – major infrastructure or developments of state significance
- Part 4 – any development that requires consent under an environmental planning instrument and is not subject to assessment under Part 3A or Part 5
- Part 5 – where a proposal does not require development consent and is being carried out by a public authority, an environmental assessment must be prepared and approved prior to the activity being carried out.

The proposed development, whilst being carried out by a public authority (the NSW DPI), requires development consent under the Lake Macquarie Local Environmental Plan 2004, and is therefore subject to Part 4 of the EP&A Act. The proposal therefore requires the submission of a development application to Lake Macquarie City Council, accompanied by a SEE, for their consideration prior to granting of consent. A modification to the existing consent was considered and it was determined that a new development application was required due to the relative increase in size of the proposal.

The purpose of this SEE is to assess the environmental impacts of the proposal in accordance with Section 79C of the EP&A Act which requires the consent authority to consider:

- Any statutory requirements and planning instruments
- The likely impacts of the development on both the natural and built environments and social and economic impacts in the locality
- The suitability of the site for development
- Any public or other submissions
- The public interest

4.2.2 Fisheries Management Act 1994

The objectives of the *Fisheries Management Act 1994* (FM Act) are to:

- Conserve fish stocks and key fish habitats
- Conserve threatened species populations and ecological communities of fish and marine vegetation
- Promote ecologically sustainable development – including the conservation of biological diversity
- Promote viable commercial fishing and aquaculture industries
- Promote quality recreational fishing opportunities
- Appropriate share fisheries resources between the users of those resources
- And provide social and economic benefits for the wider community of NSW.

The Recreational Fishing Licence Fee program is implemented under the provisions of the FM Act, with funds raised going to the Recreational Fishing Trust. The purpose of the Trust under the FM Act is to invest in projects that enhance or manage recreational fishing, involve research into fish and their ecosystems, or ensure compliance with fishing regulatory controls. The Artificial Reefs Program is funded by the Trust with both the dual objective of enhancing recreational fishing opportunities and assisting in the conservation of fish stocks and natural habitats.

The FM Act also serves to protect threatened species and acts in conjunction with the threatened species provisions of the EP&A Act. Aquatic species or communities listed under the Schedules 4 or 5 of FM Act.

4.2.3 Water Management Act 2000

Under the *Water Management Act 2000*, permits are required for 'controlled activities' which are defined under the Act as:

a) the erection of a building or the carrying out of a work (within the meaning of the EP&A Act), or
b) the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or
c) the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or
d) the carrying out of any other activity that affects the quantity or flow of water in a water source.

Carrying out of a controlled activity without a permit issued under Clause 90 of the Act is an offence. However, Clause 39A of the Water Management (General) Regulation 2004 exempts public authorities and local councils from obtaining a controlled activity permit in relation to all controlled activities they carry out in, on or under waterfront land.

Department of Primary Industries (Fisheries) is a public authority under the definitions of the Act and therefore is exempt from obtaining a controlled activity approval for the proposal. Furthermore, the proposal is consistent with guidelines published by the Department of Water and Energy for In-stream works. The proposal:

- Does not impact on the riparian corridor;
- Will not alter the existing hydraulic, hydrologic, and geomorphic functions of the waterway; and
- Will be monitored to ensure no scour, bed degradation, or adverse ecological impacts occur.

4.2.4 Crown Lands Act 1989

Under the *Crown Lands Act 1989* it is an offence to "erect a structure", "interfere with any substance", or "deposit of leave on public land any matter of a prescribed class" without a licence or lease granted under the Act. Lake Macquarie is defined as 'public land' and therefore the Minister for Crown Lands may issue a licence or lease under the Act following consideration of an environmental assessment.

The NSW DPI will consult with the Department of Lands and obtain the necessary licences prior to the extension of the artificial reef.

4.3 Environmental Planning Instruments

4.3.1 Lake Macquarie Local Environmental Plan 2004

The Lake Macquarie Local Environmental Plan 2004 (LEP) provides guidelines in accordance with the EP&A Act for the orderly development and management of land use within the Lake Macquarie Local

Government Area. The proposed artificial reef site is shown as "Lake and Waterways" on the Lake Macquarie LEP maps. The LEP has the following objectives for land zoned as Zone 11:

a) recognise the importance of Lake Macquarie and its waterways as an environmental asset, not only to Lake Macquarie City, but to the Hunter and Central Coast Regions, and

b) ensure that development of the Lake and its waterways occurs in a manner that is consistent with the principles of ecologically sustainable development, and

c) ensure development does not adversely affect the ecology, scenic values or navigability of the Lake or its waterways, and

d) ensure that aquatic and terrestrial habitats and their interface are protected and enhanced and are not adversely affected by the recreational use of the Lake or its waterways, and

e) provide for sustainable and viable economic use of the Lake and its waterways, and

f) provide for sustainable water cycle management.

Under the zoning provisions of the LEP, the proposal requires development consent from Lake Macquarie City Council. Overall, the proposal is considered consistent with the objectives of the LEP for the LGA as a whole and for the waterway zone. In particular, the extension of the reef will particularly assist in the protection / enhancement of natural aquatic habitats and assist to improve the sustainability of recreational fishing within the lake.

4.3.2 State Environmental Planning Policy No. 71 (Coastal Protection)

State Environmental Planning Policy No. 71 (Coastal Protection) (SEPP 71) applies to the Coastal Zone of NSW and aims to protect and manage the natural, cultural, recreational, and economic attributes of the NSW coast.

SEPP 71 requires that a consent authority (in this instance, Lake Macquarie City Council) consider sixteen matters when determining a development application for development on land within the Coastal Zone. These have been considered as part of this environmental assessment and include the following matters of particular relevance to the proposal:

- the aims of SEPP 71
- the suitability of development given its type, location and design and its relationship with the surrounding area,
- measures to conserve fish (within the meaning of Part 7A of the Fisheries Management Act 1994) and marine vegetation (within the meaning of that Part), and their habitats
- measures to reduce the potential for conflict between land-based and water-based coastal activities,
- measures to protect the cultural places, values, customs, beliefs and traditional knowledge of Aboriginals,
- likely impacts of development on the water quality of coastal water bodies,

Under the SEPP, the proposal is considered to be "significant coastal development" which is defined as being development within 100 metres below mean high water mark of the sea, a bay, or an estuary. Consequently, a copy of the development application must be forwarded to the Director-General within 2 days of the development application being lodged with Council. Council must not determine the development application within 28 days after a copy of the application is received by the Director General, during which time the Director-General may specify additional matters to be taken into consideration by council in its assessment.

4.3.3 State Environmental Planning Policy (Infrastructure) 2007

The aim of the SEPP (Infrastructure) is to facilitate effective delivery of infrastructure through:

- Improving regulatory certainty and efficiency through a consistent planning regime for infrastructure
- Providing flexibility in the location of infrastructure
- Allowing for efficient development, redevelopment or disposal of surplus government owned land
- Identifying the environmental assessment category into which different types of infrastructure falls
- Identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure development
- Providing for consultation with relevant public authorities about certain development during the assessment process or prior to development occurring.

DPI understands that under SEPP (Infrastructure) 2007, waterway or foreshore management activities may be permitted without consent if carried out by a public authority and if the development conforms to one of the three definitions below:

a) riparian corridor and bank management, including erosion control, bank stabilisation, resnagging, weed management, revegetation and the creation of foreshore access ways, and
b) instream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes, and
c) coastal management and beach nourishment, including erosion control, dune or foreshore stabilisation works, headland management, weed management, revegetation activities and foreshore access ways.

However, the proposed artificial reef is not adequately described by these definitions. The intention of the proposed artificial reefs is to provide a fisheries enhancement tool and not an aquatic habitat rehabilitation tool. Therefore, this approach will not be pursued and it is considered that development consent is required.

4.3.4 Hunter Regional Environmental Plan 1989

The Hunter REP includes the following relevant objectives with respect to natural resources and recreation:

- protect natural areas of geological, ecological or scenic interest such as important forests, bushlands, wetlands, rivers, estuaries, lakes, beach and dune systems, headlands, mountain ridges and escarpments
- strictly control any reduction in the extent of important natural areas, especially important habitats such as natural wetlands
- ensure adequate provision of a wide range of recreation and leisure opportunities including a wide range of open space types in accordance with developing needs and capability of the land concerned
- encourage compatible recreation and nature conservation and other land and water uses wherever appropriate throughout the region, and in particular improve public access to natural areas, including foreshores and waterways

The proposal is consistent with these objectives and in particular will assist in enhancing / protecting natural aquatic habitats and providing additional opportunities for recreation use on Lake Macquarie.

5.0 Environmental Assessment

5.1 Land Use

Lake Macquarie is a popular holiday and recreational area. Current activities on the waterway include fishing, sailing, water skiing, canoeing and swimming.

The lake bed is Crown Land and administered by the Department of Lands. Consultation with the Department of Lands will be conducted prior to the deployment of the additional Reef Balls.

The extension of the existing artificial reef is unlikely to have a significant impact on land use in the area. The reef is intended to enhance recreational fishing opportunities within the waterway and the proposed site has to date proven successful in achieving the program objectives and demonstrated its environmental suitability.

The site around the reef is likely to be utilised by recreational fishing boats. These boats will tend to be anchored, drifting or travelling at low speed. The balls themselves are at depths that will not limit other activities from taking place in the area and will not pose a danger to boats and other water craft.

5.2 Topography, Geology, and Soils

The artificial reef site is underlain by medium to coarse sand sediments and, with the exception of algae and seagrasses colonising the existing Reef Balls, contains no existing seagrass habitat. The water depth above the reef site is approximately 5 metres. These site characteristics are ideal, as they enable the placement of the reef ball modules on a stable base, while limiting turbidity, enabling successful diver and video monitoring of the site.

Prior to the existing reef being placed, it was considered that local changes in flow patterns and velocity had a small potential to contribute to minor bed scour, or increased deposition of sediments in the immediate vicinity of the Reef Balls. This risk was considered low given the coarse sandy nature of the bottom sediments and low flow velocities. During the ongoing monitoring since deployment, no significant scouring or sediment deposition has been observed around the currently deployed modules. It is therefore unlikely that the installation of the additional modules will result in any bed scour or sediment deposition in the area.

An increased use of the area by recreational anglers may result in damage and erosion of the lake bed due to an increase in the number of boats anchoring in that location. It should be noted however that not all boats are expected to use anchors, but may drift or trawl over the site.

Changes to the bed in the vicinity of the reef balls will be monitored and if detrimental impacts are noted, measures to manage boats in the area will be considered in consultation with NSW Maritime.

5.3 Water Quality

A review of long-term water quality data within Lake Macquarie (Eyre, 2005) indicated that there has been an overall long-term decrease in nutrient concentrations within the lake as a result of land management activities in the catchment. There have also been improvements to water clarity and dissolved oxygen. Generally, water quality within the middle of the lake was “Good” with very low nutrient levels, good light penetration, excellent dissolved oxygen, and low algae levels. The water quality of the central lake margins were classed as “Marginal” with depressed light penetration, excellent dissolved oxygen, small periodic increases in nutrients, periodically elevated algae, elevated bacteria, and increase in seagrass areas.

The deployment of the Reef Balls has the potential to increase localised water turbidity during placement on the lake bed. This potential impact has been limited to the extent practicable by appropriate site selection and methods of deployment.

The bed of the site consists of medium to coarse sand sediments and the balls will be slowly placed on the bed using a crane operated barge. Each ball will be guided into place by commercially certified divers and in order to operate effectively, they will need to minimise impact of the balls on the lake bed to maintain suitable visibility.

Use of the reefs for recreational fishing activities has the potential to introduce water pollutants such as oils and fuels from boat engines. Litter may also be produced by reef users, however it is not expected that the reefs themselves will contribute to any increase in such water pollutants. Furthermore, such pollution is an offence under the *Protection of the Environment Operations Act, 1994*.

5.4 Hydrodynamics

Lake Macquarie is a relatively enclosed body of water and has a limited tidal range of approximately 0.2m. Tidal current velocities are low throughout the lake except in the entrance channel (Australian Water and Coastal Studies et al, 1995).

Wind blowing across the lake surface generates surface currents, which in turn set in motion water below the surface resulting in three-dimensional current circulation patterns. These currents assist in maintaining water quality in the lake by increasing tidal exchange and vertical mixing. Studies by Manly Hydraulics Laboratory indicated that wind induced circulations in Lake Macquarie exceed tidal currents (Australian Water and Coastal Studies et al, 1995).

Numerical modelling by Australian Water and Coastal Studies (1995) found that:

- away from shoreline boundaries, the near surface current flowed in the direction of the wind with a weaker return current in the bottom part of the Lake;
- the strongest currents were produced by the strongest winds from the south and south-west;
- winds from all directions produce currents in the shallow areas near the western end of the Lake entrance and in the entrance itself, which could be expected to increased tidal exchange; and
- depending on the wind direction, the surface flow converged at different locations on the shoreline, producing regions where flotsam such as dead seagrass would tend to accumulate during periods of sustained winds from a particular direction.

Given the low hydraulic profile and flow through nature of the proposed reef balls and depth, limited impacts on circulation flows within the lake are predicted. Some disturbance to flows may occur, but given the weak nature of bottom currents within the lake and depth of the proposal, such disturbance is unlikely to have negative impacts on overall lake flows.

5.5 Biodiversity

5.5.1 Aquatic Habitat

The site for the existing artificial reef was selected based on depth, substrate, and lack of existing habitat (ie rocky reefs, seagrass meadows). Therefore, the substrate of the reef site will not impact on areas generally considered to provide important aquatic breeding, feeding or foraging functions.

The artificial reef extension is intended to provide additional artificial habitats for aquatic life within Lake Macquarie. Previous studies overseas conducted on artificial reef systems indicate that biodiversity can be greatly increased through the use of Reef Balls. This has been supported by the research conducted to date on the NSW DPI Artificial Reef Program within Lake Macquarie and elsewhere in NSW.

The Reef Balls will provide a platform for the growth of aquatic alga and plants, as well as provide suitable habitat for fish seeking food and shelter. The reef extension will potentially provide an excellent breeding ground and should attract a large range of herbivorous and carnivorous fish to the area.

By providing additional aquatic habitat within Lake Macquarie, it is predicted that the productivity of the area both in an ecological and fishery sense, will increase.

5.5.2 Seagrasses

Seagrasses are angiosperms that live submerged in estuarine and coastal waters. A seagrass mapping study of Lake Macquarie (Australian Water and Coastal Studies et al, 1995) found that four species of seagrasses occur in Lake Macquarie:

- *Halophila ovalis*;
- *Posidonia australis*;
- *Ruppia* sp.; and
- *Zostera capricornia*.

There is evidence that areas of seagrass meadow have been increasing within Lake Macquarie as a result of improved water quality and catchment management practices (Eyre, 2005). Seagrass beds are important to the ecology of Lake Macquarie in the following ways (Australian Water and Coastal Studies et al, 1995):

- Seagrass beds stabilise shorelines by binding the sediments with their rhizomes and in areas of the Lake where dense beds of the long leaved form of *Zostera capricorni* exist, their leaves absorb wave energy.
- Prevents the full force of waves impacting upon the shore and causing erosion.
- Some water birds, namely black swans, feed on the rhizomes and algal epiphytes of *Zostera capricorni*.
- Many species benefit from organic matter released by the slow bacterial and fungal breakdown of seagrass detritus.
- Herbivorous fish feed on the algal epiphytes of seagrasses.
- Seagrasses provide a habitat for a variety of coelenterates, molluscs, crustaceans, polychete worms and larval, juvenile and adult fish of many species.

As seagrass provides food and shelter for marine life, seaweed and kelp forest formation is seen as an integral part of environmentally sustainable coastal development. Artificial reefs have the potential to increase seagrass communities. Studies conducted by Choi et al (2002) indicate that seagrass species may colonise the artificial reef in as little as 15 months.

There are currently no seagrass beds within the proposed reef extension areas. The reefs will therefore not destroy existing seagrass habitat. Following deployment of the reef balls, monitoring will enable identification of any colonisation that may be occurring and identify which species are present.

5.5.3 Threatened Species

Database searches revealed a number of threatened species under the TSC Act, FM Act, and EPBC Act are known or predicted to occur within 10km of the subject site.

Terrestrial flora will not be impacted as a result of the proposal and therefore no assessment of such species has been conducted.

Whilst the list of threatened species either recorded or predicted to occur in the area is extensive, most are not expected to occur at the site due to its aquatic nature. Aquatic species that have a moderate chance of occurring at the site include the Green Turtle (*Chelonia mydas*). Whilst other turtle species and aquatic mammals are recorded or considered as having potential to occur in the area, there are a relatively large number of recorded sightings of Chelonia mydas within Lake Macquarie. An assessment of potential impacts to this species was therefore prepared and is presented in Appendix A.

The proposal will not impact on any habitat that is known to be important to threatened species, nor will it directly kill injure or maim any individuals. This combined with the low likelihood of threatened species occurring at the site and the methodology of deployment (crane and commercially certified divers) results is a low risk of any impacts to:

- Threatened species
- Endangered ecological communities
- Endangered populations

Therefore an assessment of significance under the EP&A Act or EPBC Act is not required.

5.6 Climate

Lake Macquarie is located within the temperate east coast climate of New South Wales, therefore the climate of the region is characterised as having warm summers and cool winters.

The Bureau of Meteorology's weather monitoring station at Norah Head (Station No. 061366) is the closest weather monitoring station to the proposal site with long term averages. The station was operating between 1989 and 2008.

Based on the summary climate statistics published for Norah Head by the Bureau of Meteorology the area is characterised by maximum annual average temperatures of 25.1° in February and minimum annual averages of 9.3° in July. Rainfall is highest in February with average recordings of 142mm and lowest in August with average recordings of 70.7mm. The average annual rainfall at Norah Head is 1229.6mm. On average wind speeds are highest in the afternoon with November typically recording higher 3pm wind speeds with an average of 23.5km/hr. Morning winds tend to be predominantly southerlies through to northerlies with little wind from the sea, with afternoon winds being predominantly southerlies and north easterlies.

5.7 Air Quality

A database search of the online National Pollutant Inventory (NPI) database revealed that predominant sources of pollutants within the Lake Macquarie LGA include:

- Electricity generation
- Motor vehicles
- Domestic/commercial aerosols and solvents
- Architectural surface coatings
- Recreational boating
- Lawn mowing

According to the NPI database, the top pollutants by total emissions (kg/year) within the Lake Macquarie LGA included the following air pollutants:

- Sulphur dioxide

- Oxides of nitrogen
- Carbon monoxide
- Volatile organic compounds
- Particulate matter
- Hydrochloric acid
- Ethanol
- Sulphuric Acid
- Xylenes (individual or mixed isomers)
- Fluoride compounds

The general air quality and greenhouse gas emissions within the LGA are considered to be reasonable (Lake Macquarie City Council, 2007).

Minor impacts to air quality may result in the immediate vicinity of the reefs as a result of recreational boat engines. The proposal is not expected to significantly increase regional boat usage and therefore will not substantially increase the contribution of this activity to regional air quality.

5.8 Noise and Vibration

There are currently no major noise or vibration sources in the area. Some residential areas are distantly located to the east and are unlikely to be disturbed intermittently by recreational power boats, particularly on weekends and Public Holidays.

Increased boating in the area may potentially increase boat noise emissions in the immediate vicinity. However, boat speeds will be typically low while fishing and this increase in the frequency of noise sources will not impact on any sensitive noise receptors.

5.9 Social-Economic Environment

5.9.1 Waterway Navigation

The reefs have the potential to increase boat traffic in the immediate reef vicinity. If the reef extension results in the site becoming increasingly popular, some potential adverse impacts include:

- Boating accidents / collisions
- Boating noise
- Over-fishing of the reef

However, it is likely that the attraction of the reef will result in a threshold level of use, above which the users are likely to seek less competition and better amenity at alternative fishing sites. The use of the site can be monitored and controls implemented if required such as implementation of speed zones or the provision of moorings combined with the prohibition of anchor use to limit numbers.

It is noted that the Reef Balls are located at a depth of 5 metres which is sufficient to avoid causing damage to the hulls or keels of boats. The Reef Balls range in height from 0.53 to 0.88 metres, therefore providing a minimum of at least 4 metres of clearance over the reef. This clearance is in excess of the depth required by the typical recreational vessels likely to be using the area.

5.9.2 Regional Tourism

Lake Macquarie is a declared Recreational Fishing Haven, and the area is a popular tourist destination. Recreational fishing is a major activity in the area and the artificial reef will be intended to augment this activity on the lake.

It is estimated that direct expenditure on fishing related items in NSW is in excess of $550 million dollars (Department of Primary Industries, 2008). Enhancing recreational fishing opportunities within Lake Macquarie has the potential to increase local expenditure on fishing related activities and indirectly through other tourism and hospitality services.

5.9.3 Heritage

The reef area is devoid of any former marine structures and consists of a sandy lake bed. Whilst subsurface artefacts are unlikely to occur, no excavation of the lake bed is proposed and the proposal will therefore not impact on any potential subsurface archaeological deposits (if present).

6.0 Environmental Management

6.1 Summary of Mitigations Measures

There are generally only minor negative environmental impacts predicted as a result of the proposal. Therefore, the primary mechanism for the management of any predicted or unexpected environmental impacts is to implement a monitoring program. The program has the dual purpose of ensuring that negative environmental effects are not occurring and to further scientific knowledge regarding the effect of artificial reefs in NSW estuaries.

6.2 Monitoring Program

Quarterly monitoring program of the Lake Macquarie artificial reef will be done using the existing methodology to include the reef extension. The purpose of the monitoring will be to assess the impacts and effectiveness of the reef. The monitoring objectives are to:

- determine the number, size, and species composition of fish assemblages on artificial reefs;
- document the algal and encrusting invertebrate succession on the artificial reefs; and
- determine the condition of the lake bed surrounding the artificial reef, especially in regards to sediment erosion and deposition.

6.2.1 Sampling

Monitoring will be carried out using baited underwater video (BUV) with diver surveys supplementing this technique. The use of video as a sampling device has the following advantages:

- allows for non-invasive qualitative and quantitative observations;
- provides remote recording beyond physiological limitations of divers over long periods of time;
- can record a large amount of data quickly;
- removes observer bias and error;
- provides a visual record;
- allows for low-light recording (to study the fish assemblage in low visibility conditions); and
- provides the possibility of accurate metric measurement.

The camera is mounted on a stand and includes a bait holder. Video sequences will be analysed with a real-time counter, and the abundance of each observed species will be recorded. The maximum number of individuals of each species will be recorded as the actual value of relative abundance for each replicate.

6.2.2 Diver Surveys

Diver censuses are an important artificial reef supplementary monitoring technique. Diver surveys provide an estimate of fish abundances and diversities for species that are more cryptic and not recorded by the BUV. Divers will record species present, abundances and age classes, while also taking photographs of the Reef Ball surface to monitor algal succession.

6.2.3 Site Condition

It is proposed that a diver-conducted photographic survey will be undertaken quarterly to assess gross changes in the condition of the immediate area (i.e. scouring, deposition, anchor damage or waste).

6.2.4 Additional Monitoring and Research Opportunities

The deployment of the proposed artificial reefs also provides an opportunity for organisations external to the NSW DPI, such as post-graduate university grant studies, to conduct further research on the ecological implications and environmental impacts of artificial reefs in estuaries. The NSW DPI and the Recreational Fishing Saltwater Trust will encourage separate funding applications for such studies.

6.3 Decommissioning

Experience on the three existing artificial reefs within Lake Macquarie, St Georges Basin and Botany Bay indicate that there is a very low likelihood of the reefs resulting in adverse environmental impact. Generally the artificial reefs have been highly successful and provide a net environmental benefit. Provided this continues at the Lake Macquarie site, the intention of the project is for the Reef Balls to remain on the lake bed indefinitely.

Whilst unlikely to be required, decommissioning of the reefs will be undertaken if the results of the monitoring indicated that adverse ecological or environmental impacts are occurring following the expansion of the reef. Some examples of impacts that if identified, may require removal of the Reef Balls are:

- Catch rates at unsustainable levels or adverse impacts on biodiversity
- Extensive damage to lake bed or seagrass communities from increased boating activity
- Contribution of the reef to exotic species colonisation or spread
- Excessive deposition of sediment or initiation of bed scouring
- Widespread and negative community feedback

Impacts of decommissioning would be similar to deployment and may include an increase in short term turbidity. Species that had taken residence at the reef would be required to find alternative suitable natural habitats and any juvenile species would be vulnerable to predation until suitable cover was located.

The need for rehabilitation or post-removal monitoring would be decided based on the adverse impacts that had lead to the decision for decommissioning. The Reef Balls are not intrusive into the lake bed and therefore, it is likely that once the Reef Balls had been removed, a ‘do nothing’ approach would allow the site to return to its pre-existing, natural state within a relatively short period of time.

7.0 Discussion

The proposal to extend an artificial reef within Lake Macquarie will impact an area of less than 0.0006% of the waterway. The site has been selected based on appropriate depths, impact on other lake users, the lack of existing habitat and bed materials to ensure that:

- No existing critical habitat is damaged
- Minimise the risk of turbidity issues during deployment and monitoring
- Minimise risk of erosion and scour
- Minimise conflict with other waterway users
- Maximise the opportunities for study and research into artificial reef systems

No impacts to threatened species or endangered ecological communities or populations are predicted.

Overall, the proposal will result in a net environmental and social benefit, with only minor risks of negative impacts occurring. Through the monitoring program, any negative impacts that do occur can be detected and mitigations measures implemented through regulation of the use of the site or removal of the Reef Balls if necessary. However, the likelihood of these potential negative impacts occurring is low.

The extension of an artificial reef within Lake Macquarie by the NSW DPI, will provide additional fishing opportunities for recreational anglers by providing an alternative to existing sites within the lake. It is expected that by providing additional habitat for aquatic species that the artificial reefs will reduce pressure on natural reefs within the lakes and assist to ensure the long-term sustainability of the area as a Recreational Fishing Haven. The reefs will also provide valuable monitoring opportunities, to increase the scientific knowledge of artificial reefs and the natural environment.

8.0 References

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Appendix A Threatened Species Assessment

Appendix A Threatened Species Assessment

Table 5: Threatened Species (TSC Act and EPBC Act)

Scientific Name	Common Name	Conservation Status		Habitat Requirement	Likelihood
		TSC Act	EPBC Act		
Birds					
Apus pacificus	Fork-tailed Swift		Mi	Ma	Low
Ardea alba	Great Egret, White Egret		Mi	We, Ma	Low
Ardea ibis	Cattle Egret		Mi	We, Ma	Low
Burhinus grallarius	Bush Stone-curlew	E		T	NE
Calidris tenuirostris	Great Knot	V	Mi	Ma	Low
Calonectris leucomelas	Streaked Shearwater		Mi	Ma	Low
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		T	NE
Charadrius leschenaultii	Greater Sand-plover	V	Mi	Ma	Low
Charadrius mongolus	Lesser Sand-plover	V	Mi	Ma	Low
Diomedea amsterdamensis	Amsterdam Albatross		E, M	Ma	Low
Diomedea antipodensis	Antipodean Albatross	V	V, Mi	Ma	Low
Diomedea dabbenena	Tristan Albatross		E, Mi	Ma	Low
Diomedea exulans	Wandering Albatross	E	V, Mi	Ma	Low
Diomedea gibsoni	Gibson's Albatross	V	V, Mi	Ma	Low
Gallinago hardwickii	Latham's Snipe, Japanese Snipe		Mi	We	Low
Haematopus fuliginosus	Sooty Oystercatcher	V		Ma	Low
Haematopus longirostris	Pied Oystercatcher	V		Ma	Low
Haliaeetus leucogaster	White-bellied Sea-Eagle		Mi	T	NE
Hirundapus caudacutus	White-throated Needletail		Mi	T	NE
Ixobrychus flavicollis	Black Bittern	V		Ma	Low
Lathamus discolor	Swift Parrot	E	E	T	NE
Macronectes giganteus	Southern Giant-Petrel	E	E	Ma	Low
Macronectes halli	Northern Giant-Petrel		V	Ma	Low
Merops ornatus	Rainbow Bee-eater		Mi	T	NE
Monarcha melanopsis	Black-faced Monarch		Mi	T	NE
Myiagra cyanoleuca	Satin Flycatcher		Mi	T	NE
Ninox connivens	Barking Owl	V		T	NE
Ninox strenua	Powerful Owl	V		T	NE
Numenius madagascariensis	Eastern Curlew		Mi	We	
Pandion haliaetus	Osprey	V	Mi	Ma	Low
Pluvialis fulva	Pacific Golden Plover		Mi	We	
Pterodroma leucoptera leucoptera	Gould's Petrel	E	E, Mi	Ma	Low
Pterodroma neglecta neglecta	Kermadec Petrel (western)	V	V	Ma	Low

Scientific Name	Common Name	Conservation Status		Habitat Requirement	Likeli-hood
		TSC Act	EPBC Act		
Ptilinopus regina	Rose-crowned Fruit-Dove	V		T	NE
Puffinus carneipes	Flesh-footed Shearwater	V	Mi	Ma	Low
Puffinus pacificus	Wedge-tailed Shearwater		Mi	Ma	Low
Rhipidura rufifrons	Rufous Fantail		Mi	T	
Rostratula australis	Australian Painted Snipe	E	V, Mi	Ma	Low
Sterna albifrons	Little Tern	E	Mi	Ma	Low
Thalassarche bulleri	Buller's Albatross		V, Mi	Ma	Low
Thalassarche cauta	Shy Albatross	V	V, Mi	Ma	Low
Thalassarche chlororhynchos	Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross		Mi	Ma	Low
Thalassarche impavida	Campbell Albatross		V, Mi	Ma	Low
Thalassarche melanophris	Black-browed Albatross	V	V, Mi	Ma	Low
Thalassarche salvini	Salvin's Albatross		V, Mi	Ma	Low
Thalassarche steadi	White-capped Albatross		V, Mi	Ma	Low
Tyto novaehollandiae	Masked Owl	V		T	NE
Xanthomyza phrygia	Regent Honeyeater	E	E, Mi	T	NE
Xenus cinereus	Terek Sandpiper	V	Mi	Ma	Low
Cetaceans					
Balaenoptera edeni	Bryde's Whale		Mi	Ma	Low
Balaenoptera musculus	Blue Whale	E	E, Mi	Ma	Low
Caperea marginata	Pygmy Right Whale		Mi	Ma	Low
Eubalaena australis	Southern Right Whale	V	E, Mi	Ma	Low
Lagenorhynchus obscurus	Dusky Dolphin		Mi	Ma	Low
Megaptera novaeangliae	Humpback Whale	V	V, Mi	Ma	Low
Orcinus orca	Killer Whale, Orca		Mi	Ma	Low
Frogs					
Crinia tinnula	Wallum Froglet	V		We	NE
Heleioporus australiacus	Giant burrowing frog	V	V	T	NE
Litoria aurea	Green and Golden Bell Frog	E	V	We	NE
Litoria littlejohni	Littlejohn's Tree Frog, Heath Frog	V	V	F	NE
Mixophyes iteratus	Southern Barred Frog, Giant Barred Frog	E	E	T	NE
Mammals					
Aepyprymnus rufescens	Rufous Bettong	V		T	NE
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	V	T	NE
Dasyurus maculatus	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll	V	E	T	NE
Dugong dugon	Dugong	E	Mi	Ma	Low
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V			NE

Scientific Name	Common Name	Conservation Status		Habitat Requirement	Likeli-hood
		TSC Act	EPBC Act		
Miniopterus australis	Little Bentwing-bat	V		T	NE
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V		T	NE
Mormopterus norfolkensis	Eastern Freetail-bat	V		T	NE
Petaurus norfolcensis	Squirrel Glider	V		T	NE
Petrogale penicillata	Brush-tailed Rock-wallaby		V	T	NE
Phascolarctos cinereus	Koala	V		T	NE
Potorous tridactylus tridactylus	Long-nosed Potoroo (SE mainland)		V	T	NE
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	T	NE
Reptiles					
Caretta caretta	Loggerhead Turtle	E	E, Mi	Ma	Low
Chelonia mydas	**Green Turtle**	**V**	**V, Mi**	**Ma**	**Moderate**
Dermochelys coriacea	Leathery Turtle, Leatherback Turtle, Luth	V	V, Mi	Ma	Low
Hoplocephalus bungaroides	Broad-headed Snake	E	V	T	
Sharks					
Carcharias taurus (east coast population)	Grey Nurse Shark (east coast population)	E	CE	Ma	Low
Carcharodon carcharias	Great White Shark	V	V, Mi	Ma	Low
Pristis zijsron	Green Sawfish, Dindagubba, Narrowsnout Sawfish	E	V	Ma	Low
Rhincodon typus	Whale Shark		V, Mi	Ma	Low

Notes

CE:	Critically Endangered	T:	Terrestrial	NE: Not expected
E:	Endangered	Ma:	Marine	
V:	Vulnerable	We:	Wetland	
Mi:	Listed Migratory	F:	Freshwater streams/rivers	
Ma:	Listed Marine			

Table 6: Threatened Species (Fisheries Management Act 1994)

Scientific Name	Common Name	Habitat	Likelihood
Endangered Species			
Austrocordulia leonardi	Sydney Hawk dragonfly	Only recorded in deep shady river pools. Site does not include preferred habitat and is outside predicted range	Not expected
Carcharias taurus	Grey nurse shark	Shallow coastal waters, deep gutters around rocky outcrops and reefs.	Low
Craterocephalus fluviatilis	Murray hardyhead	Freshwater – lower reaches of Murray River system	Not expected
Maccullochella ikei	Eastern freshwater cod	Freshwater – Clarence and Richmond Rivers	Not expected
**Maccullochella macquariensis*	Trout cod	Freshwater – lower reaches of Murray – Darling system	Not expected
Nannoperca oxleyana	Oxleyan pygmy perch	Coastal and swampy drainages, streams in Northern NSW to SE Qld. (Freshwater)	Not expected
Notopala sublineata	River snail	Free-flowing rivers of the Murray Darling System	Not expected
Pristis zijsron	Green sawfish	Shallow bays, estuaries and lagoons. Last records: 1972 in Northern NSW, 1926 Sydney.	Low
Thunnus maccoyii	Southern bluefin tuna	Occurs in oceanic waters	Low
Endangered Populations			
Mogurnda adspersa	Western population of the purple spotted gudgeon	Western population occur within the Murray-Darling system	Not expected
Ambassis agassizii	Western population of the olive perchelt	Occurs in the Darling drainage system upstream of Burke	Not expected
Endangered Ecological Communities			
Aquatic ecological community in the natural drainage system of the lower Murray River catchment			Not expected
Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River			Not expected
Species Presumed Extinct			
Vanvoorstia bennettiana	Bennetts Seaweed	Red algae only previously recorded in Port Jackson.	Low
Vulnerable			
Archaeophya adamsi	Adams emerald dragonfly	Small freshwater streams in Hawkesbury and Sydney regions	Not expected
Bidyanus bidyanus	Silver perch	Fast flowing freshwater. Natural population near Torrumbarry Weir in Murray River.	Not expected
Branchinella buchananensis	Buchanans fairy shrimp	Temporary saline lakes, north west NSW.	Not expected
Carcharodon carcharias	Great white shark	Temperate and sub-tropical ocean. Inshore waters near islands, and seal colonies	Low
Epinephelus	Black cod	Temperate and sub-tropical waters.	Low

Scientific Name	Common Name	Habitat	Likelihood
daemelii		Rocky reefs, caves or deep (10 – 40 m) ledges	
Macquaria australasica	Macquarie perch	Cool freshwater, upper reaches of Murray-Darling system	Not expected
Nannoperca australis	Southern pygmy perch	Small, slow flowing freshwater with vegetation cover. Murray and Murrumbidgee Rivers.	Not expected
Marine vegetation			
Nereia lophocladia	Marine brown alga	Occurs near Muttonbird Island, Coffs Harbour.	Not expected

Assessment of Significance - Chelonia mydas (Green Turtle)

The Green Turtle is a large sea-turtle that grows up to 1 metre in length. It has a heart shaped shell, is olive green, brown and black, and the scales on the side of its face and limbs have distinctive pale edges.

The Green Turtle is widely distributed in tropical and sub-tropical seas. Usually found in tropical waters around Australia but also occurs in coastal waters of NSW, where it is generally seen on the north or central coast. It is an ocean-dwelling species and spends most of its life at sea. It is carnivorous when young but as adults feed only on marine plant material. Green Turtles nest on beaches and eggs are laid in holes dug into the sand throughout their range.

Threats to the Green Turtle include:

- Collision with boats and other marine traffic
- Accidental entanglement in shark nets, traps, longlines and other fishing gear
- Marine debris, particularly plastic, which is mistaken for jellyfish and can cause asphyxiation, abrasion, infection and blockages of the turtle's digestive system when swallowed.
- Predation of nest sites by feral pigs and foxes
- Disturbance to nest sites.

The following assessment of significance has been prepared in accordance with guidelines issued by the Department of Environment and Climate Change – Threatened Species Assessment Guidelines- the assessment of significance (August 2007).

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Green turtles are known to occur in Lake Macquarie, however information on their habits and patterns is relatively limited.

During deployment of the artificial reefs, direct impacts to Green Turtles is unlikely given the use of a single barge and divers to slowly place each Reef Ball module on the lake bed. The reef site does not contain any seagrass beds and therefore no reduction in local food resources for mature turtles is expected.

The reefs may result in an increased localisation of boat traffic associated with recreational fishing around the reefs. Whilst collision with boats and marine traffic and accidental entanglement in fishing gear is noted as a threat to the Green Turtle, the proposal is not expected to increase this risk occurring over current levels given that:

- Boat traffic using the site will generally be slow moving, drifting, or anchored therefore minimising the risk of collision.
- Observations of the current reef site have not noted particular concentrations of litter or discarded fishing gear.

Therefore the proposal is not likely to place the species at risk of extinction through any as there will be:

- No impacts to breeding or nesting grounds;
- No impacts to foraging resources; and
- Low risk of causing death or injury to individuals.

(b) in the case of an endangered population whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable – no endangered populations listed are likely to occur in the study area or be impacted by the proposal.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

1) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction
2) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable – no endangered or critically ecological communities listed are likely to occur in the study area or be impacted by the proposal.

(d) in relation to the habitat of a threatened species, population or ecological community:

1) the extent to which habitat is likely to be removed or modified as a result of the action proposed
2) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
3) the importance of the habitat to be removed, modified, fragmented, or isolated to the long-term survival of the species, population, or ecological community in the locality

The proposed activity will not result in the removal of existing habitat for threatened species. The proposal will result in minor modifications to the lake bed through the placement of the concrete Reef Modules. There are no seagrasses present and therefore this area is therefore likely to provide only low importance habitat to the Green Turtle. Any turtles in the area will be able to continue to use th site in a similar manner following the installation of the reef.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitats will be directly or indirectly affected in an adverse manner as a result of the proposal.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There are a total of 10 priority actions identified under the NSW DEC threat abatement plans and recovery strategies to assist with the recovery of the Green Turtle. The proposal is consistent with these actions.

There is also a national Recovery Plan for Marine Turtles in Australia (Environment Australia, 2003). The overall objective of this plan is:

To reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild.

The proposal is unlikely to have a detrimental impact on Green Turtles or hinder their recovery in the wild. Therefore, the proposal is consistent with the objectives of this recovery plan.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Key threatening processes under the relevant acts that relate to the proposal and which affect Green Turtles include:

- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris (EPBC Act)
- Entanglement in, or ingestion of anthropogenic debris in marine and estuarine environments (TSC Act)
- Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams (FM Act)

Marine debris can consist of pollution such as discarded fishing gear and plastic packaging materials. Turtles can be injured or killed by marine debris through ingestion of plastics, or entanglement in lines/nets resulting in infection, disease and death.

The Reef Ball modules are designed to provide habitat for marine life and as such will not directly cause injury or fatalities to aquatic organisms. Recreational fishing around the site has the potential to contribute to localised concentrations of anthropogenic debris and therefore contribute to these key threatening processes. However, monitoring of the existing reef sites has not noted any observable increase or local concentration of marine debris or discarded fishing gear as a result of the artificial reefs. It is therefore considered that the proposal is unlikely to increase the impact of marine debris.

As discussed in Section 5.4, the Reef Balls will cause minimal disturbance to natural flows and as such will not contribute to the key threatening process listed above.