Marine Estate Management Authority

HAWKESBURY SHELF MARINE BIOREGION ASSESSMENT

Review of 15 pre-identified sites

Background

The NSW Marine Estate Management Authority (the Authority) was established by the NSW Government in 2013 to advise on policies, priorities and directions for the NSW marine estate.

The NSW marine estate includes marine waters, estuaries and the coast. It extends seaward out to three nautical miles and from the Queensland border in the north to the Victorian border in the south. The full definition and map can be found at www.marine.nsw.gov.au.

Contributors

The Authority acknowledges the key contributions of officers from the following in preparing this report:

- NSW Department of Primary Industries
- Office of Environment and Heritage
- Transport for NSW
- Department of Planning and Environment
- Marine Estate Expert Knowledge Panel

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Hawkesbury Shelf marine bioregion assessment – Review of 15 pre-identified sites

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More information

This paper and more information about the Hawkesbury Shelf marine bioregion assessment are available at www.marine.nsw.gov.au.

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1 Introduction

The Hawkesbury Shelf marine bioregion assessment is a key initiative of the Marine Estate Management Authority (MEMA). The project aims to develop options to enhance and conserve biodiversity in the bioregion, while achieving balanced outcomes and opportunities for stakeholders.

In undertaking this assessment, the NSW Government requested that MEMA specifically include investigation of six existing aquatic reserves and five additional sites as a priority, being areas where the community had requested increased protection through investigation of social, economic and environmental threats. The remaining four aquatic reserves in the bioregion were also considered in the assessment for reasons of completeness.

Collectively, these 15 sites are referred to as 'pre-identified' sites, and are primarily located within the Sydney Metropolitan area (Figure 1).

The assessment included:

- an overview of current management settings of pre-identified sites relevant to biodiversity conservation
- collation of information on environmental, social and environmental benefits at the pre-identified sites from grey and published literature
- community engagement to further identify benefits, threats to benefits, and management opportunities for pre-identified sites. This included interviews with councils whose local government area incorporated pre-identified sites, and an interactive 'web portal'. Detailed community engagement methods and results are provided in 'Summary of Hawkesbury community and stakeholder engagement' (MEMA, 2015a).

1.1 Overview of current management arrangements

Eleven of the pre-identified sites are effectively marine protected areas, declared for a variety of purposes (e.g. fisheries management, education and research) and include protection for all or certain components of biodiversity. Ten are aquatic reserves managed by notifications under the Marine Estate Management Act 2014; and one is a marine extension of a terrestrial National Park managed via a fishing closure under section 8 of the *Fisheries Management Act 1994* (Table 1).

These sites vary in size from 2 to 1444 hectares, and age from 13 to 44 years (Table 1). Bouddi Marine Extension was established in 1971 and the most recent set of six aquatic reserves in 2002. These aquatic reserves (Barrenjoey Head, Narrabeen Head, Cabbage Tree Bay, Bronte-Coogee, Cape Banks and Boat Harbour) were converted from 'Intertidal Protected Areas' (IPAs), established in 1993 in response to extensive harvesting of intertidal invertebrates around Sydney.

The level of protection for biodiversity also varies among these eleven sites (Table 1). Four sites are completely 'no-take' where collecting, destroying or interfering with all forms of marine life is prohibited. These are Bouddi Marine Extension, Cabbage Tree Bay and Shiprock Aquatic Reserves, and the sanctuary zone component of Towra Point Aquatic Reserve.

The remaining sites are 'partial-take' aquatic reserves as they allow for some recreational and commercial fishing. Restrictions are imposed on specific activities, gear types, and extraction of particular species (detailed in section 17, Table 18). Biodiversity protection in

these reserves is focused on marine invertebrates with few restrictions on the harvesting of fin-fish.

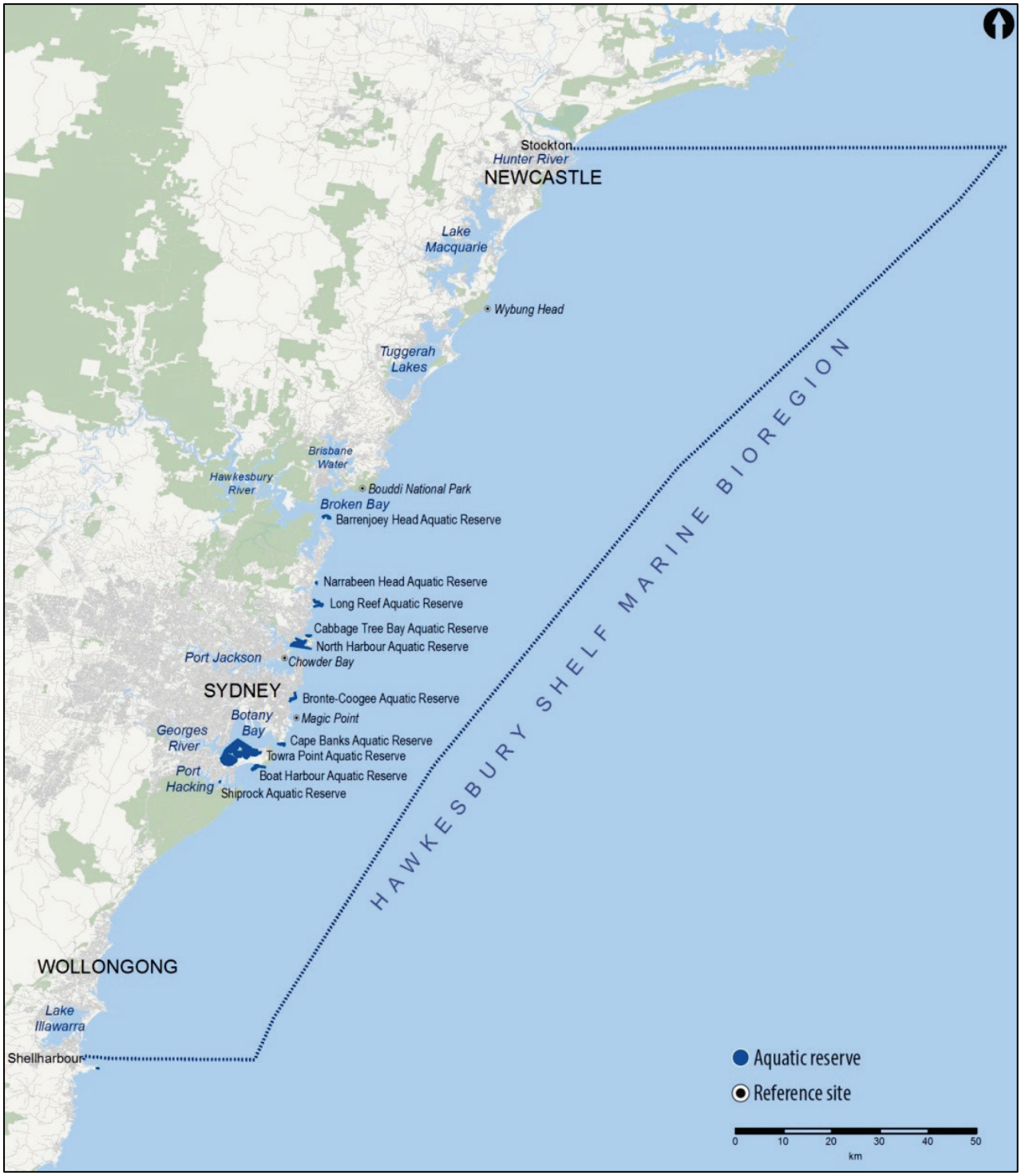

Figure 1. Boundaries of the Hawkesbury Shelf marine bioregion and the locations of the 15 pre-identified sites.

Permits can be issued to take and possess fish or marine vegetation from all aquatic reserves for the following purposes: research, aquaculture, aquarium collecting, aboriginal cultural fishing, and any other purpose approved by the relevant Ministers that is consistent with the objects of the *Marine Estate Management Act 2014* (MEM Act).

Permits are also issued for educational purposes. Recreational fishing competitions are prohibited, without a permit, within Barrenjoey Head, Narrabeen Head, Cabbage Tree Bay, Bronte-Coogee, Cape Banks and Boat Harbour Aquatic Reserves. Recreational fishing competitions can be held in the other aquatic reserves without a permit as long as they are consistent with existing rules. For example, spearfishing competitions are permitted at Long Reef if only fin-fish are taken in accordance with state-wide fishing rules and regulations. The Aquatic Reserve Notification 2015 provides further details (www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/504836/Aquatic-Reserves-Notification-2015-Government-Gazette.pdf).

The other four pre-identified sites (Wybung Head, Chowder Bay, Manly Cove (North Harbour Aquatic Extension) and Magic Point are not reserved (Table 1). Chowder Bay and Manly Cove adjoin the Sydney Harbour IPA in which the collection of invertebrates is prohibited, and Sydney Harbour is closed to commercial fishing. Spearfishing is also prohibited within Chowder Bay. Manly Cove contains critical habitat for little penguins, while Magic Point contains critical habitat for greynurse sharks. Amended fishing rules that prohibit high risk fishing methods including the use of baited hooks were implemented at Magic Point in 2012 aimed at further protecting greynurse sharks.

Marine vegetation is also protected under the *Fisheries Management Act 1994*, and marine reptiles, seabirds, shorebirds and mammals are protected under the *National Parks and Wildlife Act 1974.* A common law right exists to take fish from tidal waters, and as such fish assemblages are not protected unless these common law rights are fettered by regulation.

The NSW Department of Primary Industries (NSW DPI) is responsible for the administration, compliance and management of aquatic reserves, fishing closures, and greynurse shark critical habitat in NSW. This is done in collaboration with local councils, and the NSW Office of Environment and Heritage (OEH) if sites are located adjacent to national parks and reserves. OEH is responsible for management of little penguins, including critical habitat within Sydney Harbour.

Table 1. Current site-specific management and local government area (LGA) of pre-identified sites.

Intertidal Protected Area (IPA), Marine Protected Area (MPA)

Pre-identified site	LGA	Current management	Size of MPA (ha)	Year MPA was declared
1. Bouddi National Park Marine Extension	Gosford City	Commercial & recreational fishing closure (**no-take**)	287	1971
2. Barrenjoey Head Aquatic Reserve	Pittwater	Aquatic reserve (partial-take)	25	2002[a]
3. Narrabeen Head Aquatic Reserve	Pittwater	Aquatic reserve (partial-take)	7	2002[a]
4. Long Reef Aquatic Reserve	Warringah	Aquatic reserve (partial-take)	72	1980
5. Cabbage Tree Bay Aquatic Reserve	Manly	Aquatic reserve (**no-take**)	17	2002[a]
6. North Harbour Aquatic Reserve	Manly, Mosman Municipal	Aquatic reserve (partial-take), IPA	261	1982
7. Bronte-Coogee Aquatic Reserve	Randwick City, Waverley	Aquatic reserve (partial-take), fishing closure for blue groper	42	2002[a]
8. Cape Banks Aquatic Reserve	Randwick City	Aquatic reserve (partial-take)	23	2002[a]
9. Towra Point Aquatic Reserve	Sutherland Shire	Aquatic reserve (partial-take & **no-take zones**)	1444	1987
10. Boat Harbour Aquatic Reserve	Sutherland Shire	Aquatic reserve (partial-take)	66	2002[a]
11. Shiprock Aquatic Reserve	Sutherland Shire	Aquatic reserve (**no-take**)	2	1982
12. Wybung Head	Wyong Shire	No protection		
13. North Harbour Aquatic Extension (Manly Wharf and Cove)	Manly	IPA, commercial fishing closure, Critical habitat – little penguins		
14. Chowder Bay	Mosman Municipal	IPA, commercial fishing closure, spearfishing closure		
15. Magic Point, Malabar	Randwick	Critical habitat – greynurse shark		

a: Gazetted as an Intertidal Protected Area in 1993

2 Bouddi National Park Marine Extension

2.1 Site description

The boundaries and site features of Bouddi National Park Marine Extension are provided in Figure 2 and Table 2.

Table 2. Site features of Bouddi National Park Marine Extension.

Bouddi Marine Extension	Description
LOCATION	Situated immediately north of Broken Bay
LGA	Gosford City
YEAR (declared)	1971 (first established marine protected area in NSW)
SIZE	Incorporates 18.5 km of coastline and 297 ha of ocean floor and overlying offshore waters between Gerrin Point and Third (Bombi) Point, including the Maitland Bombora (Figure 2)
PROTECTION	Bouddi is a 'no-take'area, where all marine organisms are protected by fishing closures, renewable every 5 years
LOCAL AUTHORITIES	Darkinjung Local Aboriginal Land Council, Greater Sydney Local Land Services and Gosford City Council
INFRASTRUCTURE	None

2.1.1 Adjacent features

Bouddi National Park - originally established as a reserve for public recreation in 1935 and declared as a National Park in 1967. In December 2002 the National Park was gazetted to the low-tide water level. This allowed the National Parks and Wildlife Services to manage access and potential threats to the marine environment, particularly the intertidal zone, and encouraged integrated management across terrestrial and aquatic areas (NPWS 2009).

2.1.2 History of declaration

Historically, the establishment of Bouddi National Park is directly attributed to the efforts of local bushwalkers, environmentalists and community conservation groups. This is reflected in the park's transition from a State Park to a National Park and the subsequent expansion to its current size as Bouddi National Park. The Bouddi fishing closure was first declared on 12 November 1971 to give protection to marine species within the marine component of the National Park. The marine extension was effectively the first marine protected area established in NSW.

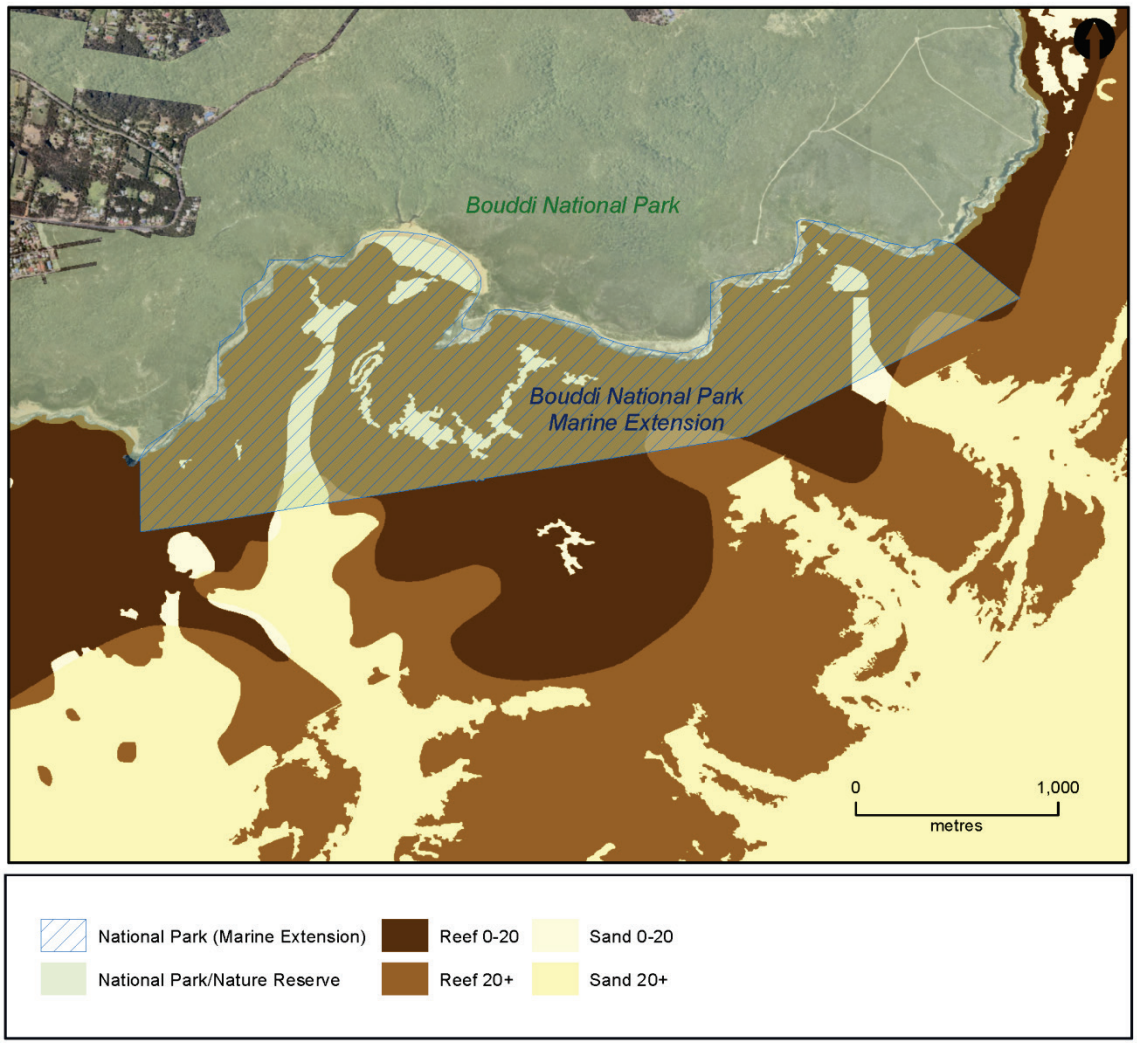

Figure 2. Map of Bouddi National Park Marine Extension showing boundaries and key habitats.

2.2 Environmental benefits

2.2.1 [1]Clean waters

Beach suitability grades[1] are available for Macmasters Beach and Killcare Beach, which are located adjacent to the northern and southern boundaries of the marine extension.

Macmasters Beach and Killcare Beach are rated as 'good' which indicates that the microbial water quality is considered suitable for swimming most of the time but the water may be

[1] Beach suitability grades and supporting information were sourced from 'State of the Beaches 2013-2014' OEH, 2015. Office of Environment and Heritage, State of the Beaches 2014-2015 (Central Coast, Sydney Region) New South Wales. http://www.environment.nsw.gov.au/beach/ar1415/. Swimming sites in NSW are graded as 'very good', 'good', 'fair', 'poor' or 'very poor' in accordance with the National Health and Medical Research Council's 2008 Guidelines for Managing Risks in Recreational Waters. These beach suitability grades provide a long-term assessment of how suitable a beach is for swimming. The grades are determined from the most recent 100 water quality results (two to four years' worth of data depending on the sampling frequency) and a risk assessment of potential pollution sources.

susceptible to pollution from a number of minor sources of faecal contamination. The response to rainfall data indicates that enterococci levels had little response to rainfall, occasionally exceeding the safe swimming limit after 10 mm of rain or more. Macmasters and Killcare beaches have been monitored for enterococci since 2010.

2.2.2 Habitats and assemblages

Bouddi National Park incorporates locally significant coastal landscape features such as Box Head, Maitland Bay, Bombi Point and Mourawaring Point, which form the northern scenic gateway to Broken Bay. The relatively natural catchments (Maitland Bay, Rileys Bay and Tallows Beach) which are rare in the Sydney/Central Coast regions, provides some buffer and protection from land-based threats (e.g. habitat clearing, development and localised pollution sources (NPWS 2009).

The marine extension is influenced by estuarine and oceanic waters as it is located at the entrance to Broken Bay. The site is dominated by rocky shores and shallow rocky reefs, and also contains beaches, shallow soft-sediments, and small areas of soft sediments and rocky reefs within the 20-60 m depth zone (Breen et al. 2005). Bouddi contains 19 of the 20 rocky shore habitats types (e.g. barnacle beds, rockpools, foliose brown algae) identified from surveys of 21 sites within a 75 km stretch of the Hawkesbury Shelf bioregion (Alexander and Gladstone 2013). Habitat types within shallow rocky reefs at this site include urchin-grazed barrens, macroalgae, and sponge-dominated reef (Gladstone 2001, 2007).

Biodiversity within Bouddi Marine Extension includes assemblages characteristic of the habitats described. Scientific studies have identified 102 macroscopic (> 5 mm in size) invertebrate and algal species on rocky shores within Bouddi (Gladstone 2002; Gladstone and Davis 2003) including 50% (66 species) of the molluscs identified in surveys of 21 locations between Newcastle and Broken Bay (Alexander and Gladstone 2013). Twenty-seven species of fish have been recorded in deep-reef habitat, and 69 species of fish and sharks within urchin-grazed barrens habitat (Gladstone 2001, 2007).

2.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Whales, seals and turtles are transitory visitors to Bouddi. In winter, humpback whales (*Megaptera novaeangliae*) and southern right whales (*Eubalaena australis*) may be observed in the area during their annual migration and seals occasionally haul out on beaches and rock platforms to rest (NPWS 2009).
- Threatened birds such as pied oystercatchers, sooty oystercatchers, little tern, osprey and migratory waders utilise the resource-rich estuarine and coastal environments within Bouddi (NPWS 2009).

2.3 Social and economic benefits

2.3.1 Conserving heritage and environment

The Central Coast is the traditional country of the Guringai and Darkinjung Aboriginal peoples. Bouddi is the Aboriginal name for the eastern headland of Maitland Bay and has become synonymous with the park and surrounding area. The origin of the word is uncertain and possible meanings include ‘nose’, ‘the heart’ and ‘water breaking over rocks’ (Strom 1986). Other Aboriginal place names used in the area include Bombi Trig, Gerrin Point,

Kourung, Gourung Point and Mourawaring Head (a variant name for Second Point) (NPWS 2009).

Over 70 Aboriginal sites containing more than 200 objects have been recorded in Bouddi National Park and nearby areas, and other sites are likely to exist. Aboriginal occupation is evident in the form of open middens and camp sites, rock engravings, grinding grooves, rock shelters with art (charcoal and pigment drawings, stencils and paintings) and other archaeological deposits. Figures commonly depicted in the art include humans, marine animals, kangaroos and wallabies. Evidence of Aboriginal usage of estuarine and open coastal environments is reflected in the different species of shellfish found in middens (NPWS 2009).

The Bouddi peninsula is a place of significance in early explorations of the NSW coast. In 1770 Captain James Cook sailed past this location and noted “some pretty high land which projected out in three bluff points, and occasioned my calling it Cape Three Points” (Bulbararing Point with Tudibaring head (First Point), Mourawaring Point (second point), and Bombi Point (third point –the northern head of the Bouddi Marine Extension) (Strom 1986).

The Bouddi Marine Extension contains the remains of the PS Maitland: a paddle steamer wrecked in 1898 and listed on the National Historic Shipwreck Database , and it may also contain other relics and shipwreck remains including those of the Argument, Heath and Narooma (NPWS 2009).

Although occupation of the Bouddi Peninsula by Europeans began in the 1820s early access was via the sea. Eventual settlement, after completion of the railway through Gosford in 1989, primarily occurred around Brisbane Water (Strom 1986).

Bouddi National Park and Marine Extension are listed on the former Register of the National Estate (now a non-statutory archive).

2.3.2 Recreation

Bouddi National Park plays an important role in the provision of nature-based tourism and recreational opportunities at a local and regional level. There is a diverse range of activities undertaken throughout the park including camping, picnicking, sightseeing, bushwalking (e.g. the Bouddi Coastal Walk), bird watching, land-based whale watching, snorkelling, swimming, boating, and other beach activities. The marine extension itself is only accessible via foot or boat. Visitation to the park is seasonal, with visitor numbers swelling during holidays, particularly the summer and Easter holiday periods. It is estimated that the park currently experiences 150-200, 000 visitor days each year (NPWS 2009).

2.3.3 Research and education

Research

Bouddi Marine Extension has been used as a scientific reference site to provide insight into the impact of harvesting on the abundance, size and diversity of marine organisms, by comparing the no-take site to unprotected areas. Fish species richness, total fish density and density of blue groper, luderick, and red morwong were found to be greater in the marine extension than in nearby unprotected areas 28 years after declaration; luderick and red morwong were larger within Bouddi (Gladstone 2001). The limpet, *Cellana tramoserica*, which is subject to harvesting, has also been found to be significantly larger within Bouddi relative to unprotected areas (Alexander and Gladstone 2013).

Education/community engagement

Education and community engagement activities are primarily associated with Bouddi National Park, rather than the marine extension. NPWS provides important face-to-face interpretation and education opportunities through its discovery program involving guided walks, talks and outdoor activities and at the Maitland Bay Information Centre (formerly Maitland Bay Store, listed on the former NSW State Heritage Register).

Visitor information is complemented with programs offered by commercial operators and the broader tourism industry. Central Coast Tourism operates visitor information centres at Gosford, Terrigal and Woy Woy which provide information regarding the park (NPWS 2009).

Research opportunities in the park were enhanced through the opening of the Strom Centre in 2007. The centre is the former property of the late Allen and Beryl Strom who were local conservationists, environmental educators and historians. The property was bequeathed to NPWS on the condition that it 'be developed and used as a centre for the administration and management of Bouddi National Park and for housing educational resources including the deceased collection of papers, photographs and other material relating to Bouddi National Park and its surrounds'. The Strom Centre facilitates research, environmental education and fieldwork which support the management of the park (NPWS 2009).

Several volunteer community groups foster appreciation, understanding and stewardship of biodiversity within Bouddi Marine Extension. These include:

- Kilcare Wagstaffe Trust Inc., "The Trust", which seeks to preserve the natural environment of the Bouddi peninsula, to contribute to the understanding of this environment, and to promote a sense of community and place
- Rumbalara Environmental Education Centre, runs school field excursions to Maitland Bay
- Community Environment Network (e.g. 'Bioblitz' 2013)
- Ocean and Coastal Care Initiatives
- Central Coast Birding Group, Birding NSW
- Bush regeneration group (within the National Park).

2.3.4 Economic benefits

There are no dedicated studies on the economic values of the Bouddi Marine Extension.

3 Barrenjoey Head Aquatic Reserve

3.1 Site description

The boundaries and site features of Barrenjoey Head Aquatic Reserve are provided in Figure 3 and Table 3.

Table 3. Site features of Barrenjoey Head Aquatic Reserve.

Barrenjoey Head	Description
LOCATION	Sydney's northern beaches, at the southern entrance to the Hawkesbury River
LGA	Pittwater
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	25 ha, includes entire rocky shore around Barrenjoey Head
PROTECTION	'partial-take' area; collecting (dead or alive), destroying or interfering with most invertebrates and seaweed is prohibited within the reserve from mean high water to 100 m from mean low water, with the exception of rock lobsters, abalone, sea lettuce (*Ulva lactuca*) and bait weed (*Enteromorpha intestinalis*). Fin-fish may be taken by spear and line.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Pittwater Council
INFRASTRUCTURE	The closest maritime infrastructure is the jetty and boat ramp located at the southern end of Barrenjoey Beach. Small number of moorings located near Barrenjoey Beach. Very large numbers of moorings are located in other parts of Pittwater (http://www.rms.nsw.gov.au/documents/maritime/moorings/mooring-map-pittwater.pdf).

3.1.1 Adjacent features

- Ku-ring-gai Chase National Park
- Lion Island (little penguin colony)

3.1.2 History of declaration

Barrenjoey Head was originally declared as part of the IPA network in July 1993. It and five other IPAs were declared as aquatic reserves on March 31, 2002. These areas were selected based on length, biodiversity, geographic spread, educational values, research, and community consultation.

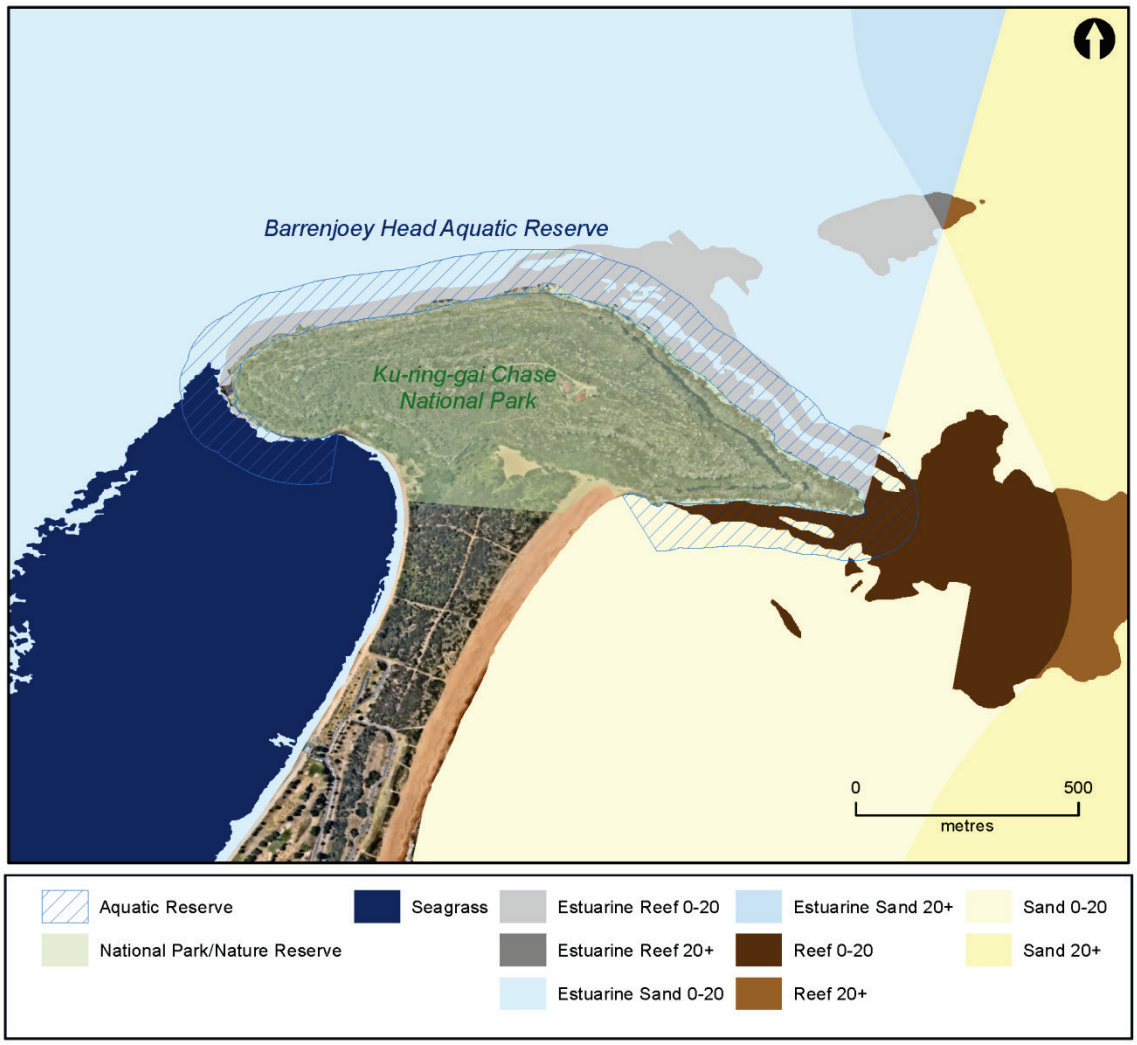

Figure 3. Map of Barrenjoey Head Aquatic Reserve showing boundaries and key habitats.

3.2 Environmental benefits

3.2.1 Clean waters

Beach suitability grades are available for Barrenjoey Beach and Palm Beach which are located adjacent to the boundaries of the aquatic reserve.

Barrenjoey Beach is rated as 'good' which indicates that the water quality is safe for swimming most of the time but can be susceptible to pollution after heavy rain, with several minor sources of faecal contamination, including stormwater. Response to rainfall data indicates that enterococci levels increased slightly with increasing rainfall, regularly exceeding the safe swimming limit after 10 mm or rain or more. The site has been monitored since 1996. Microbial water quality improved significantly in 2000 when the toilet facilities at the beach were connected to the reticulated sewerage system.

Palm Beach is rated as 'very good' which indicates that microbial water quality is considered suitable for swimming almost all of the time, with few potential sources of significant faecal contamination. Response to rainfall data indicates that enterococci levels increased slightly with increasing rainfall, occasionally exceeding the safe swimming limit in response to 20 mm of rainfall or more. The site has been monitored since 1989. Water quality has generally been of a very high standard over the last ten years.

3.2.2 Habitats and assemblages

Barrenjoey Head Aquatic Reserve is dominated by rocky shores and shallow rocky reefs. It also incorporates a small amount of shallow soft-sediments, and seagrass including *Posidonia australis*. The subtidal rocky reef includes urchin-grazed barrens and macroalgal habitat which have both a sheltered and exposed aspect (The Ecology Lab 2006). The estuarine portion of the reserve has been classified as an area with variable conditions, high nutrients and fluvial influences including periodic influx of freshwater (Albani 1978). The reserve is most similar to sites in the main channel or the "Hawkesbury River – Entrance" rather than sites within the Pittwater estuary (Albani 1978).

The combination of estuarine and oceanic influences supports the wide variety of marine life found here including fishes, seaweed and invertebrates (Kingsford and Gillanders 2000; Lincoln Smith 1985, 1988, 1989; The Ecology Lab 2006).

3.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- *Posidonia australis* populations listed as endangered (Creese et al. 2009)
- Syngathids (e.g. seahorses)
- Shorebirds

3.3 Social and economic benefits

3.3.1 Conserving heritage and environment

Barrenjoey is, reputedly, an Aboriginal word for young kangaroo. The site was part of the traditional lands of the Guringai people. The sea was an important source of food, particularly shellfish and fin-fish. The Archaeological Plan prepared for Barrenjoey Head (Banksia Archaeology 2003) does not highlight any significant Aboriginal artefacts. This is thought to be a consequence of extensive modification of the local topography.

A customs house was built in 1843 to combat frequent smuggling activities in the area. New buildings were added in 1862 and survived until they were destroyed by fire in 1976. The first report of any light on the headland was in 1855 when a fire was raised in a basket to assist mariners during stormy weather. Broken Bay and the Pittwater were a safe haven in storms for vessels carrying coal from Newcastle to Sydney.

Barrenjoey Head remained largely undisturbed until 1868, when the first wooden light structures, the Stewart Towers, were erected on the eastern side of the headland. In 1880, construction began on the current light station which remains a significant landmark.

The Long Reef to Barrenjoey coastal rocks are listed on the former Commonwealth Register of the National Estate which is maintained on a non-statutory basis as a publicly available archive and educational resource. This covers an area of approximately 100 hectares, comprising all exposed rocks, cliff faces and rock shelves on the coastal headlands from the northern end of Long Reef Beach to and including, Barrenjoey Head.

3.3.2 Recreation

Barrenjoey Head Aquatic Reserve is not easily accessible due to the surrounding Ku-ring-gai Chase National Park. However, access can be gained by foot or boat, and diving, snorkelling, fishing, and boating are known to occur within the reserve.

3.3.3 Research and education

Research

The reserve has been used as a scientific reference site to investigate the impacts of harvesting (The Ecology Lab 2006), and loss of the habitat-forming crayweed (*Phyllospora comosa*), from the Sydney region (Coleman et al. 2008; Pope 1943)). A study in 2000 which compared reserves previously designated as IPAs to unprotected areas showed no reserve effects for harvested intertidal organisms at Barrenjoey Head (Underwood and Chapman 2000). Barrenjoey Head has also been used as a field site to study ecological patterns and processes related to fishes (Kingsford and Gillanders 2000; Lincoln Smith et al. 1991), and invertebrates (Creese 1980; Lincoln Smith et al. 1991; Underwood and Chapman 1996).

Education/community engagement

No dedicated education programs or volunteer community groups are directly dedicated to the reserve. Barrenjoey Head, however, has recently become a Reef Life Survey site. Reef Life Survey is a global program which allows recreational scuba divers to partner with scientists and managers to collect scientifically robust data on biodiversity (for more information visit http://www.reeflifesurvey.com).

3.3.4 Economic benefits

There are no dedicated studies on the economic values of Barrenjoey Head Aquatic Reserve. However, commercial lobster fishing is known to occur within the area.

4 Narrabeen Head Aquatic Reserve

4.1 Site description

The boundaries and site features of Narrabeen Head Aquatic Reserve are outlined in Figure 4 and Table 4.

Table 4. Site features of Narrabeen Head Aquatic Reserve.

Narrabeen Head	Description
LOCATION	Sydney's northern beaches, near the entrance to Narrabeen Lagoon
LGA	Pittwater
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	7 ha, extends from the southern end of Turimetta Beach to the western extremity of the rock baths at Narrabeen Head
PROTECTION	'Partial-take' MPA; collecting (dead or alive), destroying or interfering with most invertebrates and seaweed is prohibited within the reserve from mean high water to 100 m from mean low water, with the exception of rock lobsters, abalone, sea lettuce (*Ulva lactuca*) and bait weed (*Enteromorpha intestinalis*). Fin-fish may be taken by spear and line.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Pittwater Council
INFRASTRUCTURE	North Narrabeen 50 m rock pool is located on the rocky shore just outside the southern boundary of the reserve, and the clubhouse is set at the back of the platform

4.1.1 Adjacent features

- North Narrabeen Council Reserve
- Greenlink walk - part of the Bicentennial Coastal Walkway, a continuous coastline route between Manly and Palm Beach
- Garigal National Park (2km W)
- North Narrabeen National Surfing Reserve - includes part of Narrabeen Head Aquatic Reserve.
- North Narrabeen Surf Lifesaving Club
- North Narrabeen rock pool

4.1.2 History of declaration

Narrabeen Head was originally declared as part of the IPA network in 1993. It and five other IPAs were declared as aquatic reserves in March 2002. These areas were selected based on length, biodiversity, geographic spread, educational values, and research and community consultation.

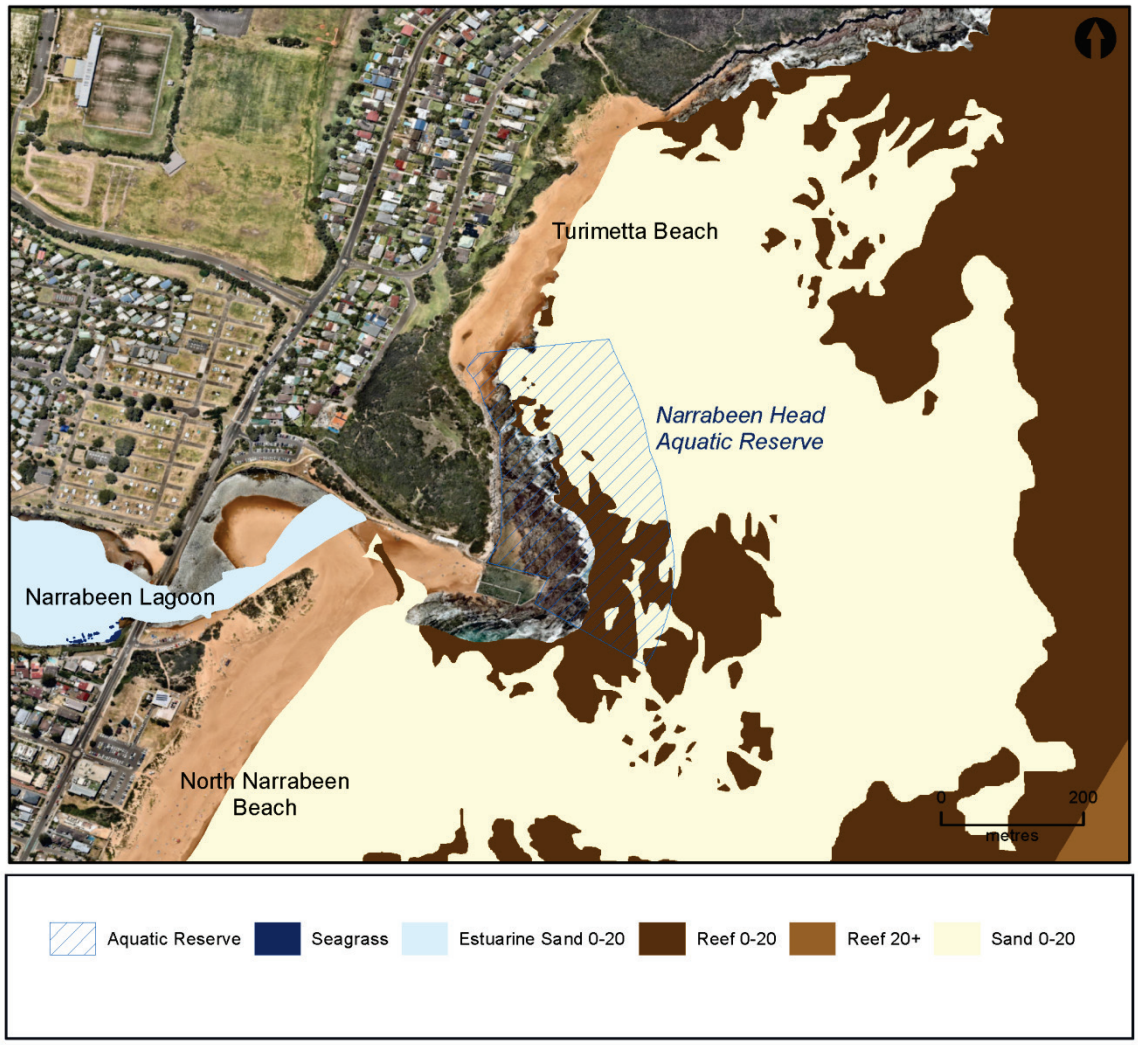

Figure 4. Map of Narrabeen Head Aquatic Reserve showing boundaries and key habitats.

4.2 Environmental benefits

4.2.1 Clean waters

Beach suitability grades are available for Turimetta Beach and North Narrabeen Beach which are located adjacent to the boundaries of the aquatic reserve.

Turimetta Beach is rated as ‘good’ indicating that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution after rain, with several potential sources of faecal contamination including bypasses from Warriewood Wastewater Treatment Plant. Response to rainfall data indicates that enterococci levels increased slightly with rainfall, occasionally exceeding the safe swimming limit in response to 10 mm of rainfall or more. The site has been monitored since 1994. Water quality has generally been of a very high standard over the last ten years.

North Narrabeen Beach is rated as ’good’ indicating that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution after rain, with several potential sources of faecal contamination including discharge from Narrabeen Lagoon. Response to rainfall indicates that enterococci levels increased with increasing rainfall, often exceeding the safe swimming limit in response to 10 mm of rainfall or more.

The site has been monitored since 1989. Water quality has generally been of a very high standard over the last ten years.

4.2.2 Habitats and assemblages

North Narrabeen Head was formed by erosion and weathering of Narrabeen sandstone by coastal processes, predominantly wave action. It is comprised of rocks of the Bald Hill claystone and Newport formations, the uppermost sub-groups of the Narrabeen group. Bald Hill claystone is a distinctive red-brown claystone forming the rock platform and lower section of the cliff. The remainder of the headland is comprised of the Newport formation's shale, siltstones and fine to medium grained sandstones (Coffey & Partners 1987).

Narrabeen Head Aquatic Reserve primarily consists of rocky shores with smaller areas of shallow rocky reef, beach and shallow soft-sediments. The rocky shore comprises of a large area of gently sloping, sandstone platform with boulders and an area of sand build up close to the headland, a few rock pools and large crevices that are immersed during low tide (Goodsell and Underwood 2008). Underwood and Chapman (2000) quantified boulder, crevice, overhang, pool and algae habitat features on the rocky shore.

The reserve contains a diverse array of marine algae, invertebrates and fishes. For example, 34 algae and 38 invertebrate species have been identified on the rocky shore (Underwood and Chapman 2000). Fishes have been studied in the rocky pools (Silberschneider and Booth 2001) and on rocky reefs (Reef Life Survey). Local birds such as oyster catchers, cormorants, sea gulls and sea eagles also forage within the reserve.

4.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Wading birds arrive from New Zealand, Siberia and Japan during the migratory season (November – March) and rest and feed at Narrabeen Head Aquatic Reserve. These include double-banded plover, ruddy turnstone, several species of terns, grey-tailed tattler and red-necked stint.

4.3 Social and economic benefits

4.3.1 Conserving heritage and environment

The Guringai inhabited the local foreshores and headlands of the northern beaches. The area provided an abundance of shellfish and fin-fish as well as bush foods. No heritage sites have been identified, or are likely to be present, at Narrabeen due to the local geology.

From 1987 onwards, the headland was formally linked to adjacent open space areas with the implementation of the Bicentennial Coastal Walkway, which extends from Dee Why to Palm Beach.

North Narrabeen Beach has been a very popular surfing spot since the early 20th Century and is a globally recognised break.

The Long Reef to Barrenjoey coastal rocks are listed on the former Commonwealth Register of the National Estate. It covers approximately 100 ha, comprising all exposed rocks, cliff faces and rock shelves on the coastal headlands from the northern end of Long Reef Beach to and including Barrenjoey Head.

4.3.2 Recreation

The reserve is used for a wide variety of activities including snorkelling, scuba diving, surfing, swimming, sunbathing, picnics, recreational boating, fishing, walking, and dog walking. A recent human usage study found that the reserve was primarily used by shore walkers and swimmers, with recreational fishers and board riders accounting for the remaining users (Wood 2015).

4.3.3 Research and education

Research

Narrabeen Head Aquatic Reserve has been used as a site to investigate the impacts of harvesting and loss of habitats within the Sydney region. A study conducted in 2000 which compared reserves previously designated as IPAs to unprotected areas found no evidence of reserve benefits for harvested intertidal organisms at Narrabeen Head (Underwood and Chapman 2000). The reserve is a Reef Life Survey site and is currently being used in an assessment by university researchers of the effectiveness of aquatic reserves for protecting fishes and subtidal invertebrates in the Sydney region. Narrabeen Head was one of a suite of sites used to assess historical loss of habitat forming cray weed from the Sydney region (Coleman et al. 2008; Pope 1943)). The reserve utilised in studies on the effects of human trampling on algae (Goodsell and Underwood 2008) and diversity of rock pool fishes (Silberschneider and Booth 2001).

A human usage study has been conducted within the reserve (see recreation).

Education/community engagement

Narrabeen Head Aquatic Reserve is highly valued for education and is regularly used as a marine field study site by school groups, particularly kindergarten and primary school children. The reserve is a focal site for programs run by AUSECO (a private environmental education business) and the Pittwater Council's Coastal Environment Centre at Narrabeen Lagoon. The Centre provides environmental education and capacity building with a focus on local biodiversity and ecosystems, coastal management, sustainability and climate change (http://www.pittwater.nsw.gov.au/cec).

Several volunteer community groups foster appreciation, understanding and stewardship of Narrabeen Head Aquatic Reserve including:

- Coastal Environment Centre volunteers
- Friends of Narrabeen Lagoon
- Pittwater Natural Heritage Association

4.3.4 Economic benefits

There are no dedicated studies on the economic values of Narrabeen Head Aquatic Reserve. However, the reserve is an essential component of educational programs, run on a cost-recovery basis, to fund the operation of the Coastal Environment Centre. Private companies Eco-treasures and AUSECO also utilise the reserve.

5 Long Reef Aquatic Reserve

5.1 Site description

The boundaries and site features of Long Reef Aquatic Reserve are outlined in Figure 5 and Table 5.

Table 5. Site features of Long Reef Aquatic Reserve.

Long Reef	Description
LOCATION	Sydney's northern beaches
LGA	Warringah
YEAR (declared)	1980
SIZE	~72 ha in size, and extends from Collaroy rock baths south to Long Reef Surf Lifesaving Club (Figure 5)
PROTECTION	Partial-take MPA; invertebrates and seaweed cannot be taken (dead or alive) from mean high water to 100m from spring low water and fin-fish may be collected by spear and line. Collections for scientific and educational purposes require a permit
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Warringah Council
INFRASTRUCTURE	Fisherman's Beach has a boat ramp but there are no other types of maritime infrastructure within or near the reserve

5.1.1 Adjacent features

- Dee Why Lagoon Wildlife Refuge – listed as a designated wildlife refuge under JAMBA (Japan Australia Migratory Birds Agreement) and CAMBA (China Australia Migratory Birds Agreement)
- Long Reef Wildlife Protection Area
- Greenlink walk – part of the Bicentennial Coastal Walkway, a continuous coastline route between Manly and Palm Beach (hosts Sculptures by the Sea; Sculptures by the Sea - Art installation 30-50,000 people
- Long Reef Golf Course (good stormwater management plan)
- Long Reef Surf Lifesaving Club
- Residential

5.1.2 History of declaration

In 1974 a scientific team from the Australian Museum, including Bennett, Pope and Coleman, began a campaign to protect Long Reef platform from harvesting to preserve it for educational and scientific purposes. Isobel Bennett (1909-2008; one of Australia's pioneering marine biologists) claimed that Long Reef was a 'living museum, which provided probably more microhabitats for marine animals to breed than any similar area on the coast' (Anon, 1974a in (Pollard 1997)). Concerns were also expressed with regard to disturbance of migratory waders and other birds which fed and roosted on and around the rock platform. After discussions between Warringah Council, Department of Lands and what was then NSW Fisheries, amendments to the *Fisheries and Oyster Farms Act* in 1979 allowed for the

declaration of areas like Long Reef as aquatic reserves. Long Reef itself was declared on the 30 May 1980 (Pollard 1997).

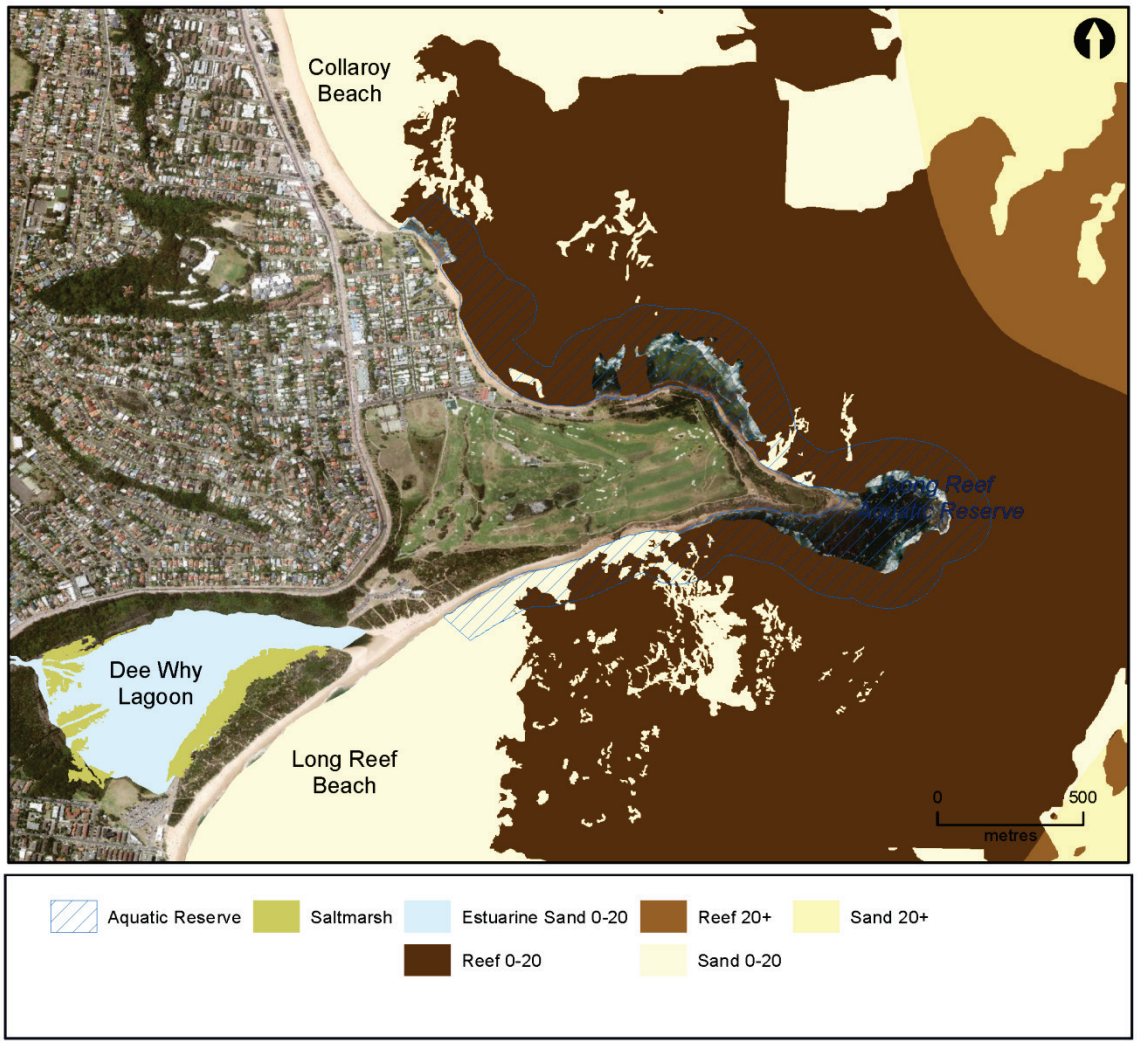

Figure 5. Map of Long Reef Aquatic Reserve showing boundaries and key habitats.

5.2 Environmental benefits

5.2.1 Clean waters

Beach suitability grades are available for Collaroy Beach and Long Reef Beach which are located adjacent and partially within the boundaries of the aquatic reserve.

Collaroy Beach is rated as 'good' indicating that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution from several potential sources of faecal contamination including stormwater. Response to rainfall data indicates that enterococci levels generally increased with increasing rainfall, often exceeding the safe swimming limit in response to 10 mm of rainfall or more. The site has been monitored since 1989.

Long Reef Beach is rated as 'good' indicating that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution from several potential sources of faecal contamination, including discharge from Dee Why Lagoon. Response to rainfall data indicates that enterococci levels generally increased with

increasing rainfall, regularly exceeding the safe swimming limit in response to 20 mm of rainfall or more. The site has been monitored since 1989.

5.2.2 Habitats and assemblages

The geology of Long Reef Headland is unusual among those found in the vicinity of Sydney in that instead of being composed of Hawkesbury Sandstone, which weathers into steep rocky headlands, it is a mixture of shales and conglomerates which have formed broad, flat platforms below a sloping sand dune. The oldest exposed rocks at Long Reef were formed in the Triassic period, over 230 million years ago. These are known as the Bald Hill Claystone deposits. At the prominent eastern headland, sandstone is interbedded with this claystone.

During the Tertiary Period, 12 – 63 million years ago, dykes of molten volcanic rock intruded into joints or weakened areas of this claystone (Pollard 1997). At the small beach south of the headland lateritic (red crusted) ironstone can be found. This rock, known as limonite, was formed during the Miocene Epoch, 12 – 26 million years ago, when iron particles moved out from the weathered claystone to the overlying soil (Pollard 1997).

Long Reef Aquatic Reserve primarily contains rocky shores and shallow rocky reefs, with smaller areas of beach and shallow soft-sediments. In two places the platform retreats and the waves reach the sand producing steep, narrow reflective beaches; 'Little Makaha' on the northern side and a smaller gap on the southern side which lead to the reef break called 'Butterbox'.

Long Reef rocky shore is rare in that it covers almost all four points of the compass and as such incorporates a wide range of exposed and sheltered habitats (Breen et al. 2005; Colman and Mitchell 2011). The rocky shore also includes one of the most extensive intertidal rock platforms in NSW, and small and large boulder fields which are uncommon on the open coast of the Hawkesbury Shelf bioregion (Colman and Mitchell 2011; Pope 1943).

The wide variety and different exposures of habitats at Long Reef support a rich biodiversity including algae, invertebrates, fishes and birds (Colman and Mitchell 2011; Pope 1943). Recent scientific studies identified 91 macroscopic invertebrate (> 5 mm in size) and algal species on the rocky platform at Long Reef (this did not include cryptic or in-sediment fauna) (Gladstone 2002) and mollusc diversity is considered relatively high for a lower latitude reef (Smith 2009).

A diversity of temperate fishes are found in the intertidal pools and subtidal areas of the reef, some of which are harvested commercially and recreationally (Pope 1943). Vagrant tropical fishes and invertebrates regularly settle at Long Reef during the summer months, with 37 species of fishes recorded (Booth et al. 2007; Colman and Mitchell 2011).

5.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Black rockcod (*Epinephelus daemelii*)
- Weedy seadragons (*Phyllopteryx taeniolatus*)
- Many species of seabirds and local and migratory waders occur on the Long Reef rock platform, roosting at the tied island at the extreme eastern end at high tide and foraging amongst the intertidal reef during low tide. The number of bird species

recorded at Long Reef over several years is 136 (Colman and Mitchell 2011), with 49 bird species counted in the area listed as threatened or international migratory birds (Warringah Council 2011). Birds at Long Reef have been monitored by volunteers from Reef Care and Long Reef Waders since December 2007 and this monitoring contributes knowledge to the national Shorebird 2020 program.

- The protected little penguin (*Eudyptula minor*) is occasionally seen at Long Reef. Adjacent sand dunes, at the point of Long Reef, were a nesting area for little penguins prior to World War II (Colman and Mitchell 2011).
- The critically endangered greynurse shark (*Carcharias taurus*) is known to aggregate in a gutter just outside the reserve in approximately 16m of water (Otway and Parker 2000).

5.3 Social and economic benefits

5.3.1 Conserving heritage and environment

The Guringai people originally inhabited the area but development has reduced Aboriginal cultural sites to two middens on the north east and southern side of the headland. Aboriginal stories have also been incorporated into public art at the Long Reef look-out at the eastern end of the headland.

Fisherman's Beach has been used by fishers since the 18th century. One of a number of huts built by fishermen in the 1870s remains at the eastern end of Fisherman's Beach on the northern side of Long Reef headland. It is owned by Warringah Council and rented to the Long Reef Fishing Club and is designated as a local heritage item. Several ship wrecks have also occurred at and adjacent to Long Reef.

Long Reef was listed on the former Commonwealth Register of the National Estate (RNE) due to its unique geology.

5.3.2 Recreation

Swimming, scuba diving, walking, surfing, fishing, stand up paddleboards, and jet skiing occurs at Long Reef. A recent human usage study found that the reserve was primarily used by shore walkers and swimmers, with recreational fishers, boats, divers and board riders accounting for the remaining users (Wood 2015).

5.3.3 Research and Education

Research

Long Reef has been a scientific research site for universities and the Australian Museum for over 70 years, contributing to some of the earliest published accounts of marine biodiversity in NSW (Dakin et al. 1948; Hindwood 1942; Pope 1943). Long Reef was used in studies by Professor William John Dakin (1883-1950) and Dr Isobel Bennett (1909-2008), and features in the classic text '*Australian Seashores: a guide to the temperate shores for the beach-lover, the naturalist, the shore-fisherman and the student'* first published in 1952 (Dakin 1952). Since declaration as a reserve, Long Reef continues to be a drawcard for local and international researchers (e.g. Bishop et al. 2009; Booth et al. 2007; Gladstone 2002; James and Underwood 1994; McGuinness 1984; McGuinness and Underwood 1986) and has recently inspired the book *'Exploring tidal waters on Australia's temperate coast'* (Colman and Mitchell 2011).

Long Reef is also regularly used as a university teaching resource due to early biological work on ecological zonation and its unique geological features. For example, during the 1980s the rock platform was intensively studied by students from the University of Technology Sydney, who produced reports on intertidal ecology and effects of human usage on the rock platform and its biota (Pollard 1997).

The reserve has also been used as a site to investigate the loss of habitat-forming crayweed from the Sydney region (Coleman et al. 2008; Pope 1943) and to investigate the impact of harvesting on the abundance and diversity of subtidal organism (USyd, unpublished data).

Trace fossils and fossil tracks, trails and burrows are also relatively common at Long Reef. The more important fossils found are amphibian vertebrate bones and a fossil crustacean about 250 mm in length (Colman and Mitchell 2011). Ancient water ripple marks and mud cracks are also preserved in the rocks (Colman and Mitchell 2011).

A human usage study has recently been conducted within the reserve (see recreation).

Education/community engagement

Long Reef Aquatic Reserve is an important site for marine education and stewardship in the Sydney region. School groups and the general community regularly visit the reserve to learn about marine life. The ground floor of the Warringah Surf Rescue Radio building at Fisherman's Beach has been used as an informal community education and training room for many years. During the summer months Fishcare Volunteers open the room's marine exhibits to the public for viewing and conduct guided educational 'reef walks' for the community on the rock platforms. The Coastal Environment Centre (Pittwater Council), and AUSECO (private company) also use the platform to teach school students about marine biodiversity and the role of marine reserves.

Several volunteer community groups foster appreciation, understanding and stewardship of Long Reefs biodiversity. These include but are not limited to:

- Reefcare (http://reefcarelongreef.org.au) formed in 1997, now consists of a large number of community volunteers who meet each month to regenerate and conserve remnant areas of grasslands, sand dunes and marine migratory bird habitats adjacent to Long Reef Aquatic Reserve. They also maintain the education room which contains preserved and dried specimens and perform monthly monitoring of Hormosira and associated infauna at Long Reef.
- Friends of Long Reef – advocating the need for and benefits of declaring part of Long Reef Aquatic Reserve as a 'no-take' sanctuary zone.
- Fishcare Volunteer Program (http://reefcarelongreef.org.au/fishcare-volunteers) is managed by NSW DPI. Volunteers conduct free guided reef walks for the wider community.
- Phil Colman (pioneer of Long Reef protection) runs tours of Long Reef for a range of stakeholders including commercial groups.
- 'Friends of Dee Why Lagoon' (adjacent to aquatic reserve).

5.3.4 Economic benefits

There are no dedicated studies on the economic values of Long Reef Aquatic Reserve.

6 Cabbage Tree Bay Aquatic Reserve

6.1 Site description

The boundaries and site features of Cabbage Tree Bay Aquatic Reserve are outlined in Figure 6 and Table 6.

Table 6. Site features of Cabbage Tree Bay Aquatic Reserve

Cabbage Tree Bay	Description
LOCATION	Southern end of Manly Beach, on the northern headland of Sydney Harbour
LGA	Manly
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	17 ha in size and extends from the southern end of Manly beach to the northern end of Shelly Beach Headland, encompassing all of Cabbage Tree Bay (Figure 6).
PROTECTION	'no-take' MPA; all collecting (dead or alive), destroying or interfering with all forms of marine life is prohibited from the mean high water mark, to a point 100 metres from the mean low water mark.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Manly Council
INFRASTRUCTURE	boat ramp, boat shed on rocky shore, ocean swimming pool

6.1.1 Adjacent features

- Coastal walkway
- Shelly Beach Council Reserve
- Sydney Harbour National Park
- Manly National Surfing Reserve includes the Cabbage Tree Bay Aquatic Reserve
- North Steyne Surf Lifesaving Club
- Shelly Beach IPA

6.1.2 History of declaration

Shelly Beach was originally declared as part of the IPA network in July 1993. Cabbage Tree Bay and five other IPAs were declared as aquatic reserves on March 31, 2002. These areas were selected based on length, biodiversity, geographic spread, educational values, research, and community consultation. The Little Bluey site to the south of Cabbage Tree Bay was not included in the reserve as several submissions noted that this area was historically important for recreational rock fishing. Part of this section remains as Shelly Beach IPA where the collection of rocky shore species is prohibited but finfish may be harvested.

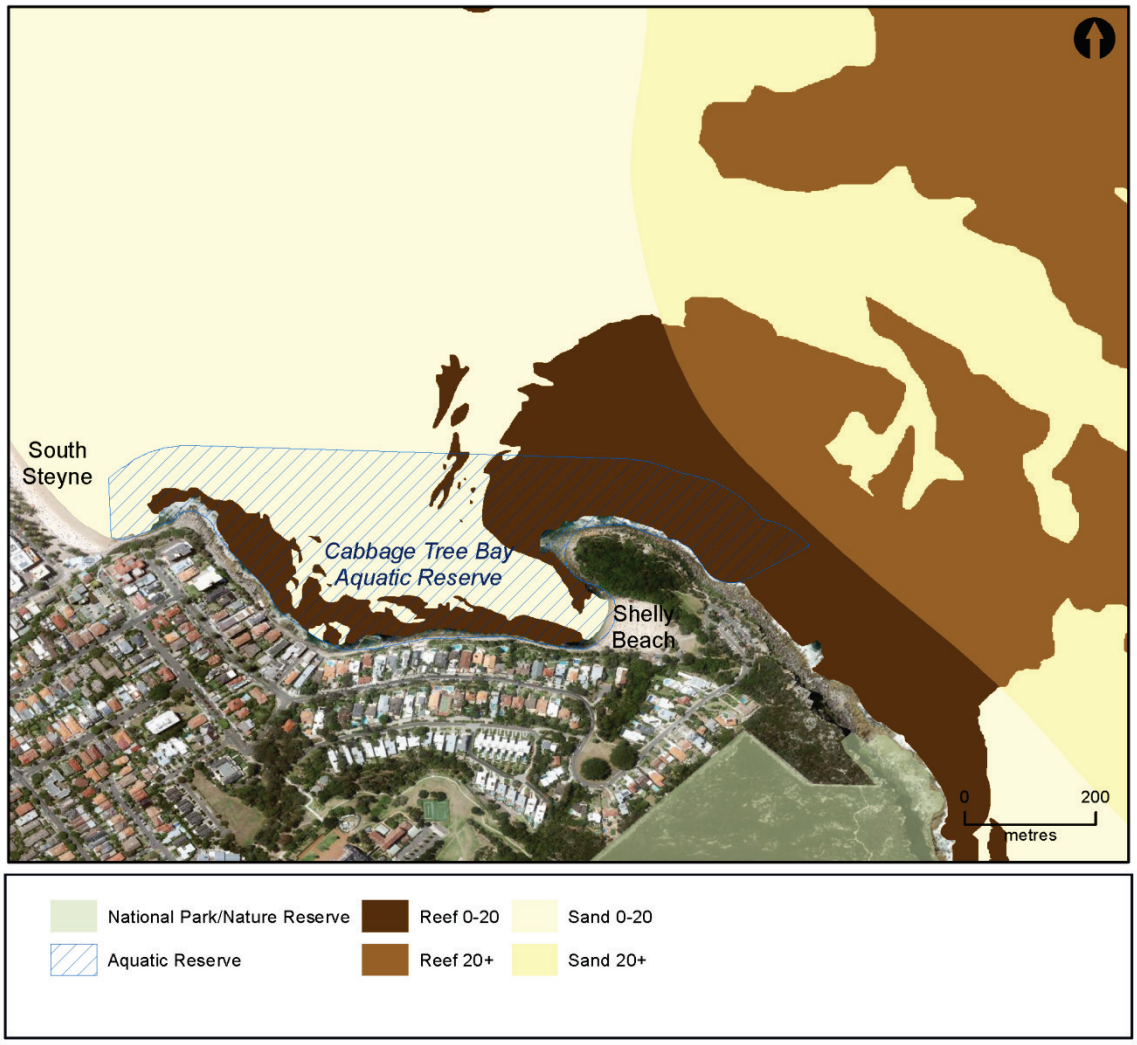

Figure 6. Map of Cabbage Tree Bay Aquatic Reserve showing boundaries and key habitats.

6.2 Environmental benefits

6.2.1 Clean waters

The Beach Suitability Grade for Shelly Beach is 'very good' indicating that microbial water quality is considered suitable for swimming almost all of the time, with few potential sources of significant faecal contamination. Response to rainfall data indicates that enterococci levels generally increased with increasing rainfall, often exceeding the safe swimming limit in response to 10 mm of rain or more.

The site has been monitored since 1989. Microbial water quality improved in 2000–2001 when sewage overflows to the bay were diverted to North Head Wastewater Treatment Plant.

6.2.2 Habitats and assemblages

Cabbage Tree Bay is a small west-facing embayment with north and west facing beaches. Shelly Beach is the only west-facing beach on the east coast of Australia providing protection from dominant southerly swells. The reserve primarily contains rocky shore, shallow rocky reefs and shallow soft-sediments with smaller areas of beach and seagrass also present.

Over 50 large invertebrate species have been documented on the rocky shores, and more than 160 species of marine fish have been recorded within Cabbage Tree Bay (The Ecology Lab 2006). This includes common temperate fishes, tropical vagrant fish, and iconic species such as blue groper, cuttlefish, wobbegongs, and port Jackson sharks. Anecdotal and scientific evidence indicates that many harvested species are relatively abundant and large in size within the reserve when compared to unprotected areas (e.g. dusky flathead, yellow-fin bream, snapper) (University of Sydney, unpublished data).

Blue groper (*Achoerodus viridis*; protected species) are abundant within the reserve and regularly interact with divers and snorkelers. Juvenile dusky whaler sharks regularly use the bay as a nursery area during the warmer months. Observing these sharks on a regular basis within the reserve is considered to be a unique experience for the bioregion.

6.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Turtles - very occasional visitors to the reserve
- Black rockcod – a resident black rockcod is regularly observed within the reserve
- Sygnathids, including the weedy seadragon
- Eastern water dragons
- Little penguins are sometimes observed feeding within the reserve

6.3 Social and economic benefits

6.3.1 Conserving heritage and environment

Cabbage Tree Bay is part of the traditional lands of the Guringai (or Ku-ring-gai) people. Early references to the Guringai comment on fishing, shellfish harvesting, and crab and lobster netting. Fishing was an important activity with flathead, mackerel, whiting, john dory, rockcod, jewfish, mullet and snapper being the most popular species. Fish were caught using canoes constructed from bark, and handlines were made from fibres tied to fishhooks made from shell or bone (Manly Council 2000). Despite extensive modification of the surrounding land, including the shoreline at Fairy Bower, there is evidence of occupation of Aboriginal people in the area. In particular a shell midden has been recorded near the Fairy Bower car park.

When Sydney was first colonised, the ocean beach at Manly, including North Steyne, was originally known as Cabbage Tree Beach, while Fairy Bower and Shelly Beaches were part of Cabbage Tree Bay. The Bay was named after the cabbage tree palms which grew around the beach and along the adjoining creek, the edible hearts of which were used for pig food, the trunks for building, and the leaves for thatch and hats (Manly Council 2000). The sheltered location of Shelly Beach and its unspoilt setting made it a popular destination for picnicking during the nineteenth century. The promenade was constructed at the end of the 19 century providing easier access to Cabbage Tree Bay. In 1929 a pool was built on the Fairy Bower rock platform by local residents (Manly Council 2000).

Cabbage Tree Bay is part of the *Manly-Freshwater National Surfing Reserve*. This area is the site of the first legal bathing (1902), first surf club (1903), first body surfing and surf boat

boat (1907), Duke Kahanamoku's famous surfing demonstration (1915) and the first world surfing championships (1964) (http://www.surfingreserves.org/manly.php).

Commercial fishers used Cabbage Tree Bay until the 1950s. The remains of a lookout tower, which was once used to spot schools of fish can still be found on the far side of Shelly Beach.

6.3.2 Recreation

Cabbage Tree Bay is an extremely popular site for aquatic sport recreation such as scuba diving, snorkelling, swimming, boating, kayaking, surfing, and stand up paddle boarding, as well as picnicking, walking and sunbathing (Figure 8). The abundance of marine life has also made this area increasingly popular for underwater photography. Public events and festivals are often associated with the Bay (e.g. Manly Cole Classic Ocean Swim, Ocean Care Day, Day at the Bay). The reserve is highly accessible as it is located in Manly (a population tourist destination) which has supporting transport services (e.g. bus, ferry). Shelly Beach was rated as NSW's best beach and 4th in Australia (Manly Council 2000).

Cabbage Tree Bay provides protection from dominant southerly swells and a safe refuge for recreational boaters in strong southerly seas and winds. The bay provides protection in almost all sea and wind conditions which is a key consideration in boating safety.

Activities and social values associated with the reserve were evaluated in a usage study conducted by the previous Department of Environment and Climate Change NSW in 2008 (Figure 8 & 9). The popularity of Cabbage Tree Bay was found to be due to its clean protected waters, marine life, naturalness of the surroundings, and public facilities (Figure 8). A recent study of human usage found that the reserve had the highest density of total users and divers and snorkellers when compared to seven other sites in the Sydney region (Wood 2015). The total users were primarily made up of shore walkers and swimmers.

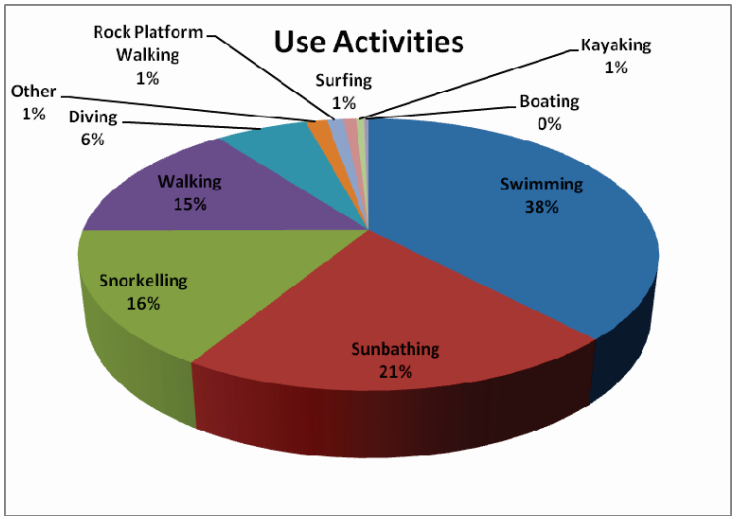

Figure 7. Recreational activities (%) within Cabbage Tree Bay (DECC 2008)

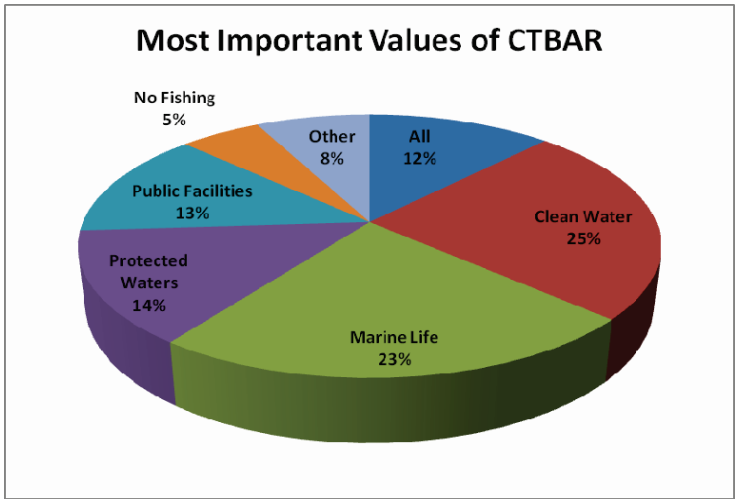

Figure 8. Social values (%) relating to Cabbage Tree Bay (DECC 2008)

6.3.3 Research and Education

Research

Cabbage Tree Bay has been used to learn about the impact of harvesting on abundance, size and diversity of marine organisms by comparing the aquatic reserve to unprotected areas (Curley 2007; The Ecology Lab 2006; Thierry 2010). A study in 2000 which compared reserves previously designated as IPAs to unprotected areas showed no reserve effects for harvested intertidal organisms at Shelly Beach IPA (Underwood and Chapman 2000).

Baseline monitoring of subtidal biodiversity and habitats within Cabbage Tree Bay was completed 1-3 years after the reserve was declared (Curley 2007; The Ecology Lab 2006) but is yet to be repeated. A study has recently been conducted using Reef Life Surveys and results are indicative of reserve benefits, however, this research has not been published.

Cabbage Tree Bay is also used by researchers to study the general ecology of marine organisms. For example, the arrival of tropical fish recruits in relation to water temperature has been monitored at Cabbage Tree Bay for over 10 years (Booth et al. 2007); acoustic tags have been used to track the movements of blue groper and wobbegong sharks and captive bred wobbegongs have been released into the bay to examine survival rates (Lee 2014; Lee et al. 2014a; Lee et al. 2015).

Human usage studies have also been conducted within the reserve (see recreation).

Education/community engagement

Cabbage Tree Bay Aquatic Reserve is increasingly used by educational, volunteer and recreational groups which are focused on enjoyment and conservation of marine life. These include: Manly Environment Centre (Manly Council), Ecotreasures (walking and snorkelling tours for school groups, international visitors), Manly Sea Life Sanctuary, Eco Divers, dive shops, Bold and the Beautiful swim group, and School and University students. Manly Environment Centre runs an annual festival called ‘Day at the Bay’ which celebrates the protection of marine life at Cabbage Tree Bay. There is a strong sense of stewardship within the local community who report illegal fishing activities, clean up marine debris and assist with rescues of sick or injured marine life within the bay.

Several volunteer community groups foster appreciation, understanding and stewardship of local biodiversity. These include but are not limited to:

- 'Friends of Cabbage Tree Bay' (FOCTB) was established by Manly Council in partnership with DPI NSW. The purpose of the group is to: educate visitors about the biodiversity of Cabbage Tree Bay and the importance of preserving and protecting this biodiversity, increase public awareness of conservation issues within the reserve, and provide visitor information services which encourages appreciation of the reserves values. In 2014, FOCTB volunteers were awarded the Community Actions and Partnerships Award by Keep Australia Beautiful NSW.
- Eco Divers – a marine conservation group based on the Northern Beaches which undertakes clean ups, animal rescue, research, public education, underwater photography.
- Reef Life Survey
- Bold and the Beautiful Swim Squad Manly – an informal swim group who swim 7 days a week from Manly to Shelly Beach and back. The group regularly posts comments and pictures about marine biodiversity within the bay.

6.3.4 Economic benefits

There are no dedicated studies on the economic values of Cabbage Tree Bay Aquatic Reserve. However, direct economic benefits are derived via dive schools, educational tour companies, and hire of aquatic recreational equipment. Five scuba diving companies, one company that teaches surf safety, and one surf school are licensed to operate within the Bay.

Multiple cafes and restaurants also operate within the vicinity. The Sydney Beaches Valuation Project, which included Manly Ocean Beach, provides relevant insight into the economic value of this area (Anning 2012; SCCG 2013).

7 North Harbour Aquatic Reserve

7.1 Site description

The boundaries and site features of North Harbour Aquatic Reserve are outlined in Figure 9 and Table 7.

Table 7. Site description summary of North Harbour Aquatic Reserve

North Harbour	Description
LOCATION	Sydney Harbour
LGA	Mosman, Manly
YEAR (declared)	1982
SIZE	261 hectares between North Head and Dobroyd Head
PROTECTION	Partial-take MPA; line fishing for finfish is currently the only form of fishing permitted in the reserve, all other fishing and collection methods are prohibited. The collection of intertidal invertebrates is also prohibited within the entirety of Sydney Harbour IPA. Commercial fishing has been banned in the Harbour since 2006 due to concerns over elevated levels of dioxin contamination.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Manly Council, Mosman Municipal Council
INFRASTRUCTURE	Seawalls, boat ramps, jetties and pontoons. Moorings located just outside the reserve in Little Manly Cove. Additional moorings located in North Harbour – east side of Manly Cove and near Forty Baskets Beach (http://www.rms.nsw.gov.au/documents/maritime/moorings/mooring-map-sydney.pdf).

7.1.1 Adjacent features

- Sydney Harbour National Park
- The Spit to Manly walk runs adjacent to much of the aquatic reserve

7.1.2 History of declaration

In 1979, *The Fisheries and Oysters Farms Act 1935*, was amended to include provisions specifically dealing with the creation and management of aquatic reserves. North Harbour was one of forty sites in NSW listed for consideration as an aquatic reserve under a government initiative to preserve a representative section of the NSW aquatic ecosystems for future generations.

North Harbour Aquatic Reserve was declared in 1982. The site was considered to be ideal for an aquatic reserve due to its proximity to the largest urban population centre in NSW and hence accessibility for recreational, educational, scientific and conservation purposes. Biodiversity surveys also indicated that the site was representative of intertidal and subtidal rocky reef habitats in central NSW and supported relatively rich flora and fauna.

Line-fishing for finfish is the only form of fishing permitted in the reserve, all other fishing and collection methods are prohibited.

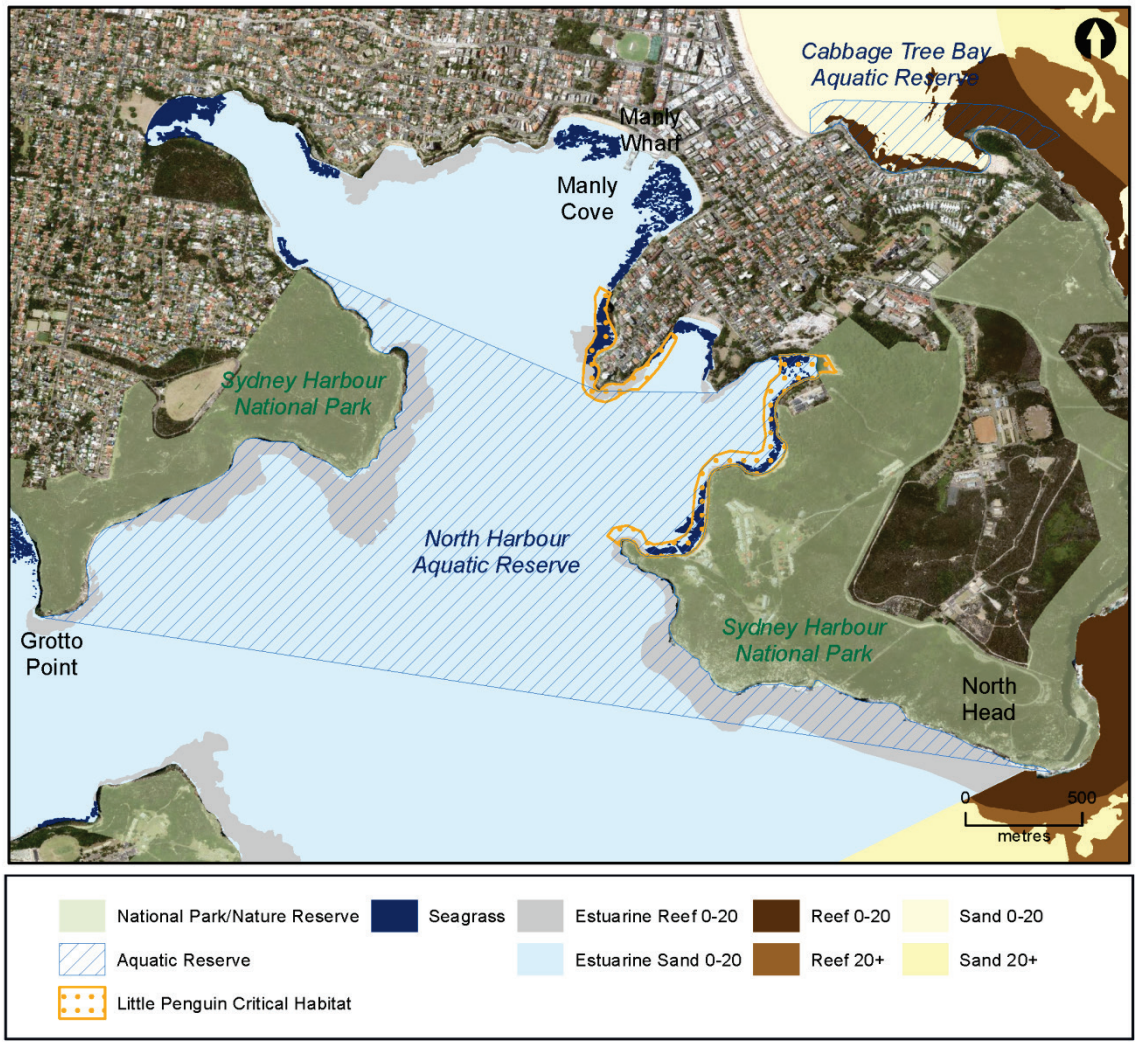

Figure 9. Map of North Harbour Aquatic Reserve showing boundaries, key habitats, and location of little penguin critical habitat.

7.2 Environmental benefits

7.2.1 Clean waters

Beach suitability grades are available for Little Manly Cove and Forty Baskets Pool located adjacent to the boundaries of the aquatic reserve.

Little Manly Cove is a rated as ‘good’ indicating that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution from a number of minor sources of faecal contamination. Rresponse to rainfall data indicates that enterococci levels generally increased with increasing rainfall, often exceeding the safe swimming limit in response to 10 mm of rainfall or more. The site has been monitored since 1994.

Forty Baskets Pool is rated as ‘good’ indicating that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution from a number of potential sources of minor faecal contamination. Response to rainfall data indicates that enterococci levels increased with increasing rainfall, frequently exceeding the safe swimming limit in response to 20 mm of rainfall or more.

The site has been monitored since 1994. Microbial water quality has improved slightly since 2000–2001 owing to licensing of discharges from the sewerage system (and associated works such as the Northside Storage Tunnel) and improved management of stormwater.

7.2.2 Habitats and assemblages

North Harbour Aquatic Reserve primarily incorporates rocky shore, shallow rocky reefs and shallow soft sediments, but also contains beaches and seagrasses including *Posidonia australis*.

Most of the western shoreline, and smaller areas of the eastern shoreline, is rocky shore and subtidal reef. These reef areas are dominated by the macroalgal species *Ecklonia radiata* and *Sargassum* species (Creese et al. 2009; Department of Planning 2005; Mulhearn 2001; West et al. 2004). More detailed mapping along the western shoreline shows that a strip of urchin-grazed barrens habitat exists between areas of mixed barrens and macroalgae, and at Dobroyd Head a section of the reef is dominated by sessile invertebrates (Creese et al. 2009).

Biodiversity has not been well studied but is likely to be typical of assemblages associated with the habitat types described. Reef life surveys have been conducted within this site but results have not been published to date.

7.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Little Penguins - Sydney Harbour is home to the only mainland breeding colony of little penguins in NSW, which is listed as an endangered population under the *Threatened Species Conservation Act 1995*. The colony currently contains 65 breeding pairs (averaged over five years) which nest in rock falls and rocky shorelines around Manly Point and in Sydney Harbour National Park, North Harbour. Some of these sites have been declared as critical habitat to provide greater protection and stricter controls over activities that are considered key threats (e.g. predation by dogs, cats and foxes, loss of breeding habitat, disturbance at nesting sites) (NSW NPWS 2002).
- The seagrass species *Posidonia australis*, *Zostera* spp. and *Halophila* spp. - found along the eastern side of the reserve (Creese et al. 2009).
- Three previously unknown occurrences of the saltmarsh plant *Wilsonia backhousei*, listed as vulnerable under the NSW Threatened Species Conservation Act 1995, have been located here (Kelleway et al. 2007).
- Sygnathids, including pipefish, big-bellied and white's seahorse
- Humpback and southern right whales intermittently enter the Harbour from late April to November during their annual migrations. Mothers with calves have often been sighted. Dolphins and seals are also occasional visitors to the Harbour.

7.3 Social and economic benefits

7.3.1 Conserving heritage and environment

The area surrounding the reserve has a rich history, beginning with extensive Aboriginal occupation, which is evidenced through the many middens that are still present. The entire North Harbour area was used extensively by the Aboriginals, known locally as the Gayemal clan of the Guringai tribe, who spent much of their time on the foreshores of Sydney Harbour (AHO, 2008). At that time, North Harbour was known as *Kunn-na, Kunna* or *Cannae* (Living Harbour 2008). More recently, Metropolitan Local Aboriginal Land Council has recognised Bob Waterer as a traditional owner of Guringai country.

The oldest Aboriginal site known in the Manly LGA is dated to about 4100 years before present. There are 5 recorded Aboriginal sites within the area: open middens, midden with shelter and rock engraving.

The reserve is rich in many plant and animal species that were used by the Guringai for food and material. Early references to the Guringai comment on fishing or shellfish harvesting, and crab and lobster netting. Fishing was an important activity with flathead, mackerel, whiting, John Dory, rockcod, jewfish, mullet and snapper being the most popular species. Fish were caught using canoes constructed from bark, and handlines were made from fibres tied to fishhooks made from shell or bone (Manly Council 2000).

A "First Fleet" survey party camped at Grotto Point on 28th January1788. Captain Arthur Phillip described the local Aboriginal people as "manly natives" and the area within the Harbour was subsequently named Manly. Following the formation of the new Colony of Sydney in 1788 scattered settlement began in the Manly Cove and North Harbour areas.

The area was used as Australia's first Quarantine Station. In the period up to 1984, this station was the main line of defence for the colony against diseases such as measles, scarlet fever, influenza and small pox.

Some of the colony's earliest collections of marine specimens were made at Spring Cove, now within the aquatic reserve. These include those gathered by Dr James Stuart, a superintendent at the North Head Quarantine Station during the 1830s. His collections and drawings can still be seen at the Australian Museum in Sydney.

The 'Centurion' shipwreck is the most intact shipwreck remaining in North (Sydney) Harbour Aquatic Reserve. A 63m timber clipper rigged as a Barque with square sails on two masts, it was built in Aberdeen Scotland in 1869 and sank on the 6 January 1887 while being towed out to the heads carrying 400 tonnes of coal. The wreck lies in 18 metres of water opposite Cannae Point. It is protected under the *NSW Heritage Act 1977*.

In 1991 the significance of the area was recognised when North Head was placed on the now former Register of the National Estate.

Forty Baskets Beach was named for a catch of forty baskets of fish sent to a contingent of returned Sudan troops at the North Head Quarantine Station in 1885.

7.3.2 Recreation

North Harbour Aquatic Reserve is of high recreational significance to the local community. It is enjoyed by a range of users for its protected and clean waters, foreshore access, public facilities, surrounding parkland and bushland and the diverse marine habitats and species living within the aquatic reserve. It is very popular for scuba divers, snorkellers and swimmers, boat users, kayakers and for those undertaking general leisure activities. A large number of recreational boats anchor in Spring Cove (Widmer and Underwood 2004).

A recent human usage study found that a site within the reserve was primarily used by shore walkers and swimmers, with recreational fishers, boats, and board riders accounting for the remaining users (Wood 2015).

7.3.3 Research and education

Research

The reserve has been infrequently used by researchers relative to other aquatic reserve. Studies have primarily focused on fishes and large invertebrates (Assaf 2001; Thierry 2010).

Education/community engagement

Several volunteer community groups foster appreciation, understanding and stewardship of local biodiversity. These include but are not limited to:

- Manly Environment Centre volunteers
- Reef Life Survey

7.3.4 Economic benefits

There are no dedicated studies on the economic benefits of the reserve.

8 Bronte-Coogee Aquatic Reserve

8.1 Site description

The boundaries and site features of Bronte-Coogee are provided in Figure 10 and Table 8.

Table 8. Site description summary of Bronte-Coogee Aquatic Reserve

Bronte-Coogee	Description
LOCATION	Sydney's eastern beaches
LGA	Waverly, Randwick City
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	43 ha in size and covers about 4 km of coastline from the southern extremity of Bronte Beach to the rock baths at the northern end of Coogee beach.
PROTECTION	Partial-take MPA; collecting (dead or alive), destroying or interfering with most invertebrates and seaweed is prohibited within the reserve from mean high water to 100m from mean low water, with the exception of rock lobsters, abalone, sea lettuce (*Ulva lactuca*) and bait weed (*Enteromorpha intestinalis*). Fin-fish may be taken by spear and line. There is a smaller fisheries closure which encompasses Clovelly Bay and Gordons Bay in which spearfishing or the collection of blue groper by any method is prohibited.
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council, Randwick City Council, Waverley Council
INFRASTRUCTURE	Clovelly rock pool, concrete ramp into water at Gordons Bay, underwater dive trail at Gordons Bay

8.1.1 Adjacent features

- Coastal walkway (voted number one on trip advisor)
- Council parklands.
- Residential.
- Sydney Harbour NP 15km to north, Botany Bay NP 15km to south.
- Bronte, Clovelly and Coogee Surf Lifesaving Clubs.

8.1.2 History of declaration

Gordons Bay has been closed to spearfishing since January 1992 due to concerns about its impact on local fish populations and potential dangers to other water users (Land Systems EBC Pty Ltd., 1994). Bronte-Coogee was declared as an IPA in July 1993 to protect intertidal communities because of the diversity of habitats (platform, crevices, rock-pools and boulders) and the extensive length of rocky shore found at the site. The Bronte-Coogee Aquatic Reserve was declared on 31 March 2002 and included the northward extension of the spearfishing closure and full protection of the blue groper within this zone. Protection of

the blue groper was of particular interest to the local community who swim and snorkel with this iconic fish.

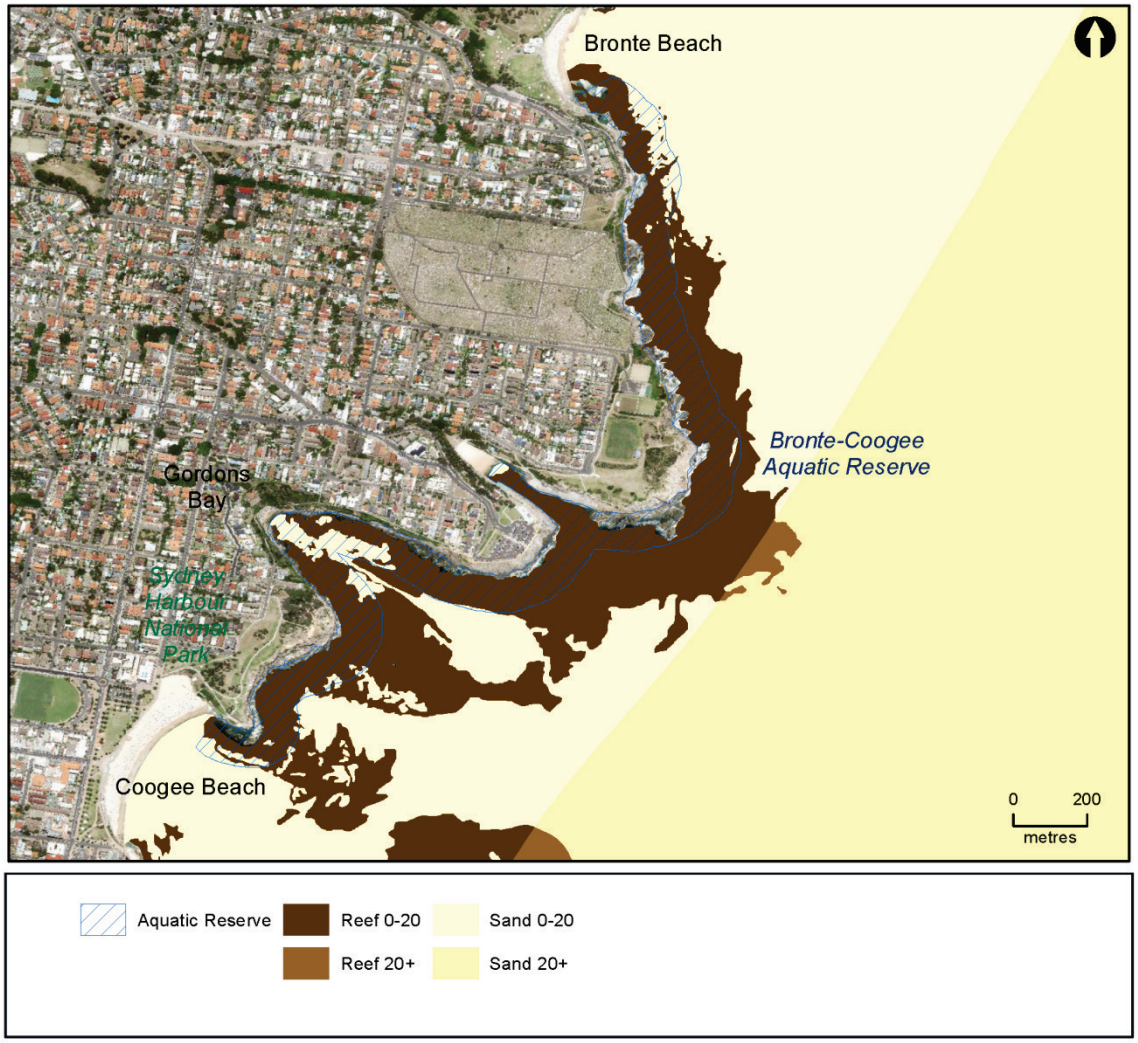

Figure 10. Map of Bronte-Coogee Aquatic Reserve showing boundaries and key habitats.

8.2 Environmental benefits

8.2.1 Clean waters

The beach suitability grade for Clovelly Beach is 'very good' indicating that microbial water quality is suitable for swimming most of the time, with few potential sources of faecal contamination. Response to rainfall data indicates that enterococci levels increased slightly with increasing rainfall, often exceeding the safe swimming limit after 20 mm of rainfall or more. The site has been monitored since 1989.

Gordons Bay is rated as 'good' indicating that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution from several potential sources of faecal contamination, including stormwater. Response to rainfall data indicates that enterococci levels increased slightly with increasing rainfall, often exceeding the safe swimming limit after 5 mm of rainfall or more. The site has been monitored since March 2013.

8.2.2 Habitats and assemblages

Bronte-Coogee Aquatic Reserve primarily contains rocky shore and shallow rocky reef, but also contains beach and shallow soft sediment habitat. Rocky reefs have been documented to contain urchin-grazed barrens, fringe, kelp forests, and sponge habitat.

Approximately 125 algae and invertebrate species have been recorded on the rocky shores of the reserve (Underwood and Chapman 2000). Recent scientific studies identified 110 and 99 macroscopic (> 5 mm in size) invertebrate and algal species on the rocky platform at Bronte and Clovelly respectively (this did not include cryptic or in-sediment fauna) (Gladstone 2002; Gladstone and Davis 2003). Recreationally important fish species are also common including: red morwong, luderick, rock blackfish, yellow-fin bream, and leatherjackets (Curley et al. 2013).

Blue groper (*Achoerodus viridis*; protected species) are abundant within the reserve and regularly interact with divers and snorkelers.

8.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Sygnathids including the weedy seadragon

8.3 Social and economic benefits

8.3.1 Conserving heritage and environment

This site is part of the traditional lands of the Dharawal people. Aboriginal people made use of the abundant fresh water available at Bondi, Tamarama and Bronte and they fished and collected seafood from these waters and shores. Extensive modification of the topography has resulted in limited archaeological work being undertaken in the area.

The Clovelly Bay enclosure (including Clovelly baths, the concrete promenades, beach and facilities) is classified by the National Trust of Australia (NSW) and is included in its register. In its statement of significance, the National Trust stated that: “Clovelly Bay Enclosure is significant for the following reasons: it is unique along the New South Wales coast as it is the only swimming area that has been developed from a naturally occurring coastal feature and as such it is also the largest coastal swimming pool; it also includes one of four formed and enclosed concrete pools in the Sydney Region; it is evidence of human endeavour modifying the coastline for the provision of a recreational facility; it has associations with local swimming clubs; and its members; and it has high aesthetic value (Sydney Harbourside & Ocean Pools Survey, National Trust, July 1994).

Clovelly Bay enclosure, including the baths and Shark Point are also included in Randwick Council’s heritage register (Randwick Local Environmental Plan 1998). Waverley Council commenced construction of the Bronte Baths in 1887. Before the Baths there was an existing swimming spot in this location, known as ‘the bogey hole’.

The reserve also has a strong fishing heritage, and is utilised by Gordons Bay & Coogee Bay Fishing Clubs.

8.3.2 Recreation

Bronte-Coogee Aquatic Reserve is highly accessible, has a high level of supporting transport services and facilities, and forms part of the Coastal Walkway. As such it is a popular site for

aquatic sport recreation such as scuba diving, snorkelling, fishing, swimming, boating, stand up paddle boards, and picknicking, walking and sunbathing. Clovelly and Gordons Bay are particularly popular due to their relatively sheltered conditions and in-water infrastructure (i.e. dive ramp, underwater dive trail, pool ladders), and Gordons Bay is frequently used by commercial dive businesses to train scuba divers. The coastal walking track along the cliffs atop the aquatic reserve provides a popular place to observe migrating humpback and southern right whales, dolphins, and seabirds.

8.3.3 Research and education

8.3.4 Research

Bronte-Coogee has been used to learn about the impact of harvesting on abundance, size and diversity of marine organisms, by comparing the aquatic reserve to unprotected areas (Curley et al. 2013; Thierry 2010; Underwood and Chapman 2000). A study in 2000 which compared reserves previously designated as IPAs to unprotected areas showed no reserve effects for harvested intertidal organisms at Bronte-Coogee (Underwood and Chapman 2000). In contrast, data on the Gordons Bay component of Bronte-Coogee found that densities of Red Morwong and Bream were higher within the reserve than at unprotected areas where spearfishing occurs (Curley et al. 2013). A recent study of the effect of aquatic reserves using Reef Life Survey data has also been conducted, however, these data have not been peer reviewed.

General ecological studies have been conducted within the reserve on fishes and invertebrates, e.g. Hulafish (Smith and Suthers 1999) and mado (Gaston and Suthers 2004). Acoustic tags were used to track the movements of blue groper within the reserve, and indicated that the size of reserve is adequate to encompass typical movement patterns of this species (Lee et al. 2014b).

8.3.5 Education/community engagement

Bronte-Coogee Aquatic Reserve is utilised for the ‘Marine & Coastal Adventure Program’ co-ordinated by Randwick City Council. The entire program has ~1000 participants per annum and includes snorkelling within Clovelly and Gordons Bay.

Several volunteer community groups foster appreciation, understanding and stewardship of the reserves biodiversity. These include but are not limited to:

- Bondi marine centre volunteers
- Gordon’s Bay scuba diving club - cares for and maintains the underwater nature trail
- Reef Life Survey
- Gordons Bay Reserve Bush Regeneration Group (adjacent)

8.3.6 Economic benefits

There are no dedicated studies on the economic values of Bronte-Coogee Aquatic Reserve.

9 Cape Banks Aquatic Reserve

9.1 Site description

The boundaries and site features of Cape Banks Aquatic Reserve are provided in Figure 11 and Table 9.

Table 9. Site description summary of Cape Banks Aquatic Reserve

Cape Banks	Description
LOCATION	Northern headland of Botany Bay
LGA	Sutherland Shire
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	~23 ha in size, and extends along the whole foreshore from the bridge at Cape Banks to the Endeavour Light at Henry Head.
PROTECTION	Partial-take MPA; collecting (dead or alive), destroying or interfering with most invertebrates and seaweed is prohibited within the reserve from mean high water to 100m from mean low water, with the exception of rock lobsters, abalone, sea lettuce (*Ulva lactuca*) and bait weed (*Enteromorpha intestinalis*). Fin-fish may be taken by spear and line. Recreational fishing competitions and collections for scientific and educational purposes require a permit.
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council, Randwick City Council
INFRASTRUCTURE	None

9.1.1 Adjacent features

- Kamay Botany Bay National Park
- NSW Golf Club (Course adjacent to Cape Banks est. 1928)

9.1.2 History of declaration

Cape Banks was originally declared as part of the IPA network in 1993. Cape Banks and five other IPAs were replaced with Aquatic Reserves in March 2002. These areas were selected based on length, biodiversity, geographic spread, educational values, and research and community consultation.

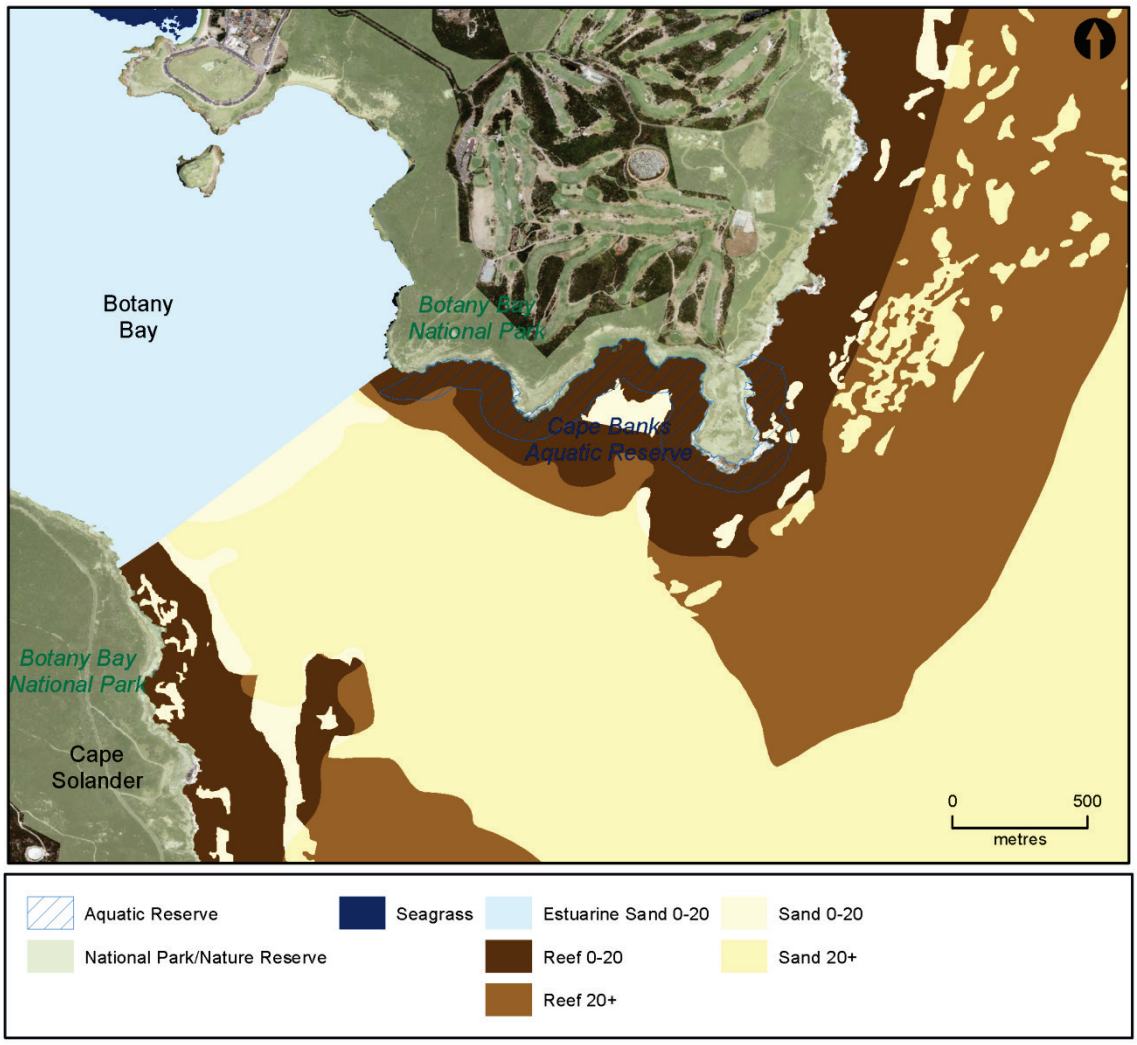

Figure 11. Map of Cape Banks Aquatic Reserve showing boundaries and key habitats.

9.2 Environmental benefits

9.2.1 Clean waters

A beach suitability grade is available for Congwong Bay located near the western boundary of the aquatic reserve.

Congwong Bay is rated as ‘very good’ which indicates that microbial water quality is considered suitable for swimming almost all of the time, with few significant sources of faecal contamination. The response to rainfall graph indicates that enterococci levels increased with increasing rainfall, often exceeding the safe swimming limit in response to 10 mm of rainfall or more. The site has been monitored since 1994.

9.2.2 Habitats and assemblages

Cape Banks Aquatic Reserve primarily contains rocky shore and shallow rocky reef but also incorporates a small amount of shallow soft-sediment habitat. The rocky shore has a boulder field, which are relatively uncommon in NSW, and provides habitat for a number of species that are rare elsewhere (McGuinness and Underwood 1986, Chapman 2002, Cruz Motta et al. 2003, Chapman 2005).

Biodiversity has been widely studies within the reserve. 79 species of fin-fish including tropical species have been recorded at Cape Banks in annual fish surveys conducted since 1987 (Kingsford, unpublished data). Nineteen species of algae and 45 species of invertebrates have been recorded in association with Cunjevoi habitat within the reserve (Monteiro et al. 2002b).

The boulder field at Cape Banks has been shown to be a relatively stable habitat with a distinctive set of communities related to microhabitats such as the boulders' upper surface (sessile species, predominately algae), under surface (encrusting worms, sponges, ascidians, bryozoans, bivalves, barnacles, cnidarians, and echinoderms), crevices (gastropods and crabs), substratum below (encrusting and foliose algae, encrusting worms, ascidians, bryozoans, bivalves, barnacles, cnidarians), and sediment (various burrowing species) (McGuinness 1984, McGuinness and Underwood 1986, McGuinness 1987, McGuinness 1988, McGuinness 1988, Chapman 2005).

9.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Weedy seadragons have been recorded at sites directly adjacent to the reserve (Sanchez-Camara and Booth 2004). Current data shows that weedy seadragons are relatively abundant at these sites compared with other Sydney locations (Dragons of Sydney – Citizen Science Program, unpublished data).
- A range of shorebirds can be observed within the reserve. Historically, a sizable colony of little penguins existed at Cape Banks. The colony no longer exists, however, penguins still visit the site regularly to forage (NPWS 2000).

9.3 Social and economic benefits

9.3.1 Conserving heritage and environment

Cape Banks is part of the traditional lands of the Goorawal people. The reserve is rich in plant and animal species that were used by the Goorawal, and middens have been found at Cape Banks, Congwong and Little Congwong Bays. Engravings of a whale and its calf, a shark and several unidentified motifs have been identified on the La Perouse peninsula.

Botany Bay is the site of first contact between Aboriginal people and the crew of James Cook's *Endeavour* in 1770. Cook and Banks saw abundant evidence of Aboriginal people around the shores of the bay when they arrived in 1770. This included huts, bark canoes, fishing equipment and scarred trees.

In 1937 a coal hauler called the *Minmi* was wrecked on Cape Banks. The wrecked iron hull of the *Minmi* can still be seen on the rocks to the west of the Cape.

The Cape Banks area is listed under the former Commonwealth's Register of the National Estate (Natural). The site is significant due to the fine exposures of large-scale cross stratification of the Hawkesbury sandstone.

9.3.2 Recreation

Due to limited shore access, Cape Banks Aquatic Reserve has very few recreational or commercial activities. Anecdotal information suggests the reserve is primarily used for

fishing, however, Cape Banks had a lower mean numbers of fishers (< 5 per km of shoreline), compared to other sites in Sydney (Kingsford et al. 1991).

9.3.3 Research and education

Research

Cape Banks has been the focus of extensive, internationally recognised scientific research for over 40 years. This site has been used for research by the University of Sydney and has been the centre of study for over 25 Ph.D/M.Sc. research theses, 35 Honours theses and 200 scientific papers. The site is also used for invertebrate collection by the School of Biological Sciences at the University of Sydney, and for on-going research projects on echinoderms (e.g. sea urchins).

Surveys of fish assemblages have been conducted annually at Cape Banks since 1987 (Holbrook et al. 1994), constituting the longest temporal data set on reef fish assemblages in the Sydney region (Kingsford, unpublished data).

A study in 2000 which compared reserves previously designated as IPAs to unprotected areas showed no reserve effects for intertidal organisms at Cape Banks (Underwood and Chapman 2000). In contrast, removal of cunjevoi at Cape Banks by fishers has been shown to result in marked changes to the assemblages in low-shore areas (Fairweather 1991, Monteiro et al. 2002b).

Cape Banks is currently being utilised as a site to test the rehabilitation of crayweed (*Phyllospora comosa*) using transplantation methods. Crayweed is a habitat-forming seaweed which was once common in the Sydney region, but has been lost presumably due to sewage effluent impacts (Coleman et al. 2008).

Education/community engagement

Cape Banks has primarily been used for educational purposes by universities, particularly the University of Sydney. There are no community groups which directly foster appreciation, understanding and stewardship of biodiversity at Cape Banks. However, Reef Life Survey has two dedicated survey sites just west of the reserve at Henrys Head (approx. 200m from reserve boundary) and Browns Rock (approx. 400m from reserve boundary). Dragons of Sydney – Citizen Science Program (Weedy seadragons) also has sites directly adjacent to the reserve.

9.3.4 Economic benefits

There are no dedicated studies on the economic values of Cape Banks Aquatic Reserve.

10 Towra Point Aquatic Reserve

10.1 Site description

The boundaries and site feature of Towra Point Aquatic Reserve are provided in Figure 12 and Table 10.

Table 10. Site description summary of Towra Point Aquatic Reserve

Towra Point	Description
LOCATION	Kurnell Peninsula within Botany Bay
LGA	Sutherland Shire
YEAR (declared)	1987
SIZE	~1444 ha, extends from Shell Point on the western side of the Bay to Bonna Point in the east.
PROTECTION	Towra AR is divided into two zone types, a refuge zone (889 ha) and a 'no-take' sanctuary zone (555 ha). Collecting invertebrates or marine vegetation, whether alive or dead, is prohibited within the entire reserve; while fin-fish may be taken by line or net within the refuge zone only. Botany Bay became a recreational fishing haven in 2002.
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council Sutherland Shire Council
INFRASTRUCTURE	Moorings are located at the northern end of Woolooware Bay and Sandringham. A small number are also located at Kurnell. Five courtesy moorings are located in Towra Point Reserve.

10.1.1 Adjacent features

- Towra Point Nature Reserve – listed under the former Commonwealth's Register of the National Estate (Natural).
- Dog off Leash Area (Bonna Point)
- Towra Point Wetlands, including neighbouring wetland areas at Shell Point (Woodlands Bay) are a component of the Georges River-Botany Bay estuary. Also listed under the Ramsar Convention on Wetlands of International Importance and is also part of the JAMBA (Japan Australia Migratory Birds Agreement) and CAMBA (China Australia Migratory Birds Agreement).
- Industrial and urban development including recreational clubs and sporting facilities

10.1.2 History of declaration

In 1982, areas of Towra Point were consolidated to form Towra Point Nature Reserve (managed by OEH). The reserve supports the largest wetland of its type in the greater Sydney region and was primarily established for nature conservation especially of wetlands and migratory birds. The establishment of an aquatic reserve was designed to protect the highly significant marine habitats that surround the nature reserve (e.g. seagrasses) by placing restrictions on fishing and prohibiting bait gathering.

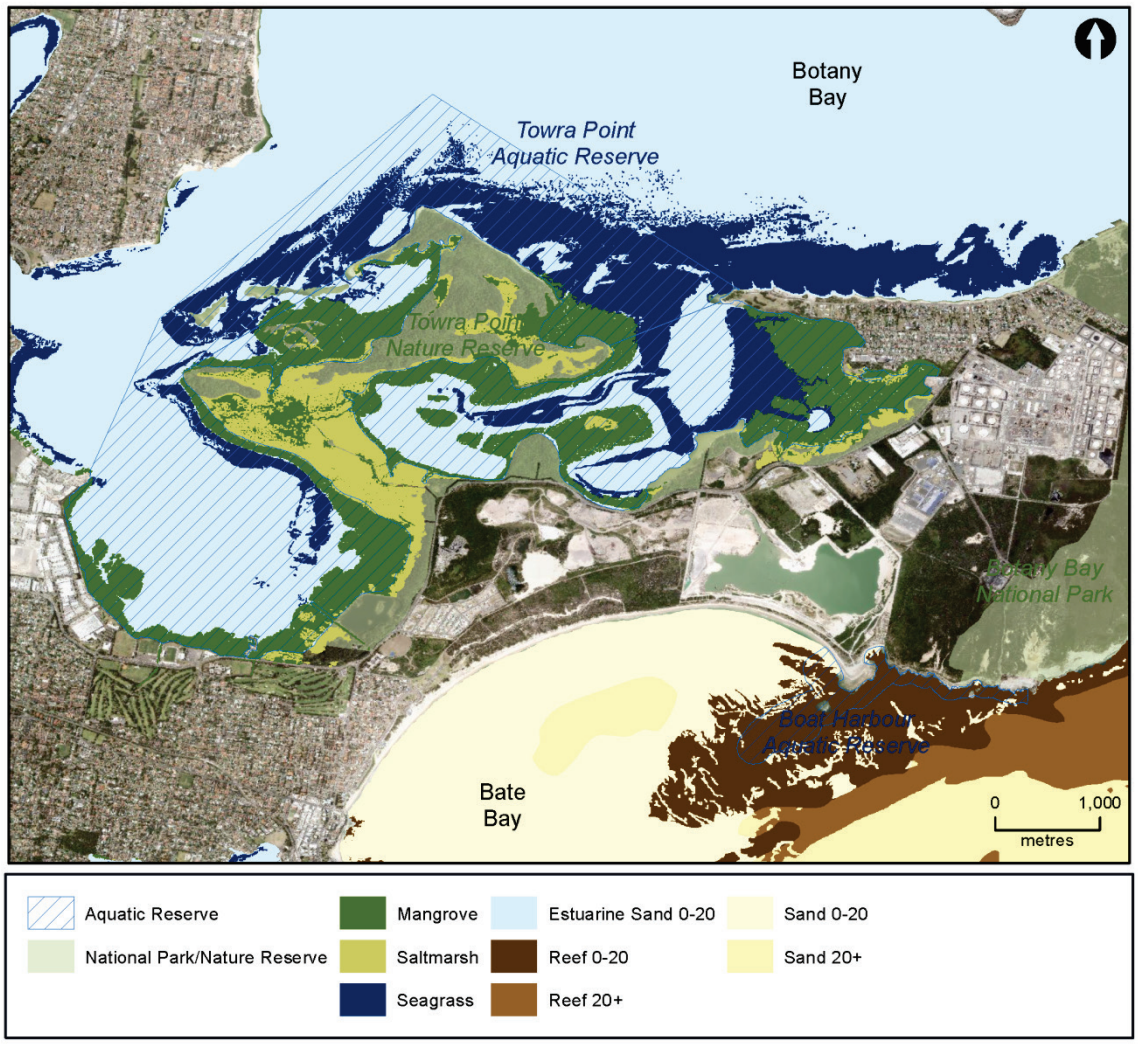

Figure 12. Map of Towra Point Aquatic Reserve showing boundaries and key habitats.

10.2 Environmental benefits

10.2.1 Clean waters

A beach suitability grade is available for Silver Beach which is located adjacent to the eastern boundary of the aquatic reserve.

Silver Beach is rated as ‘good’ which indicates that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution from a number of potential sources of faecal contamination including stormwater. The response to rainfall graph indicates that enterococci levels generally increased with increasing rainfall, often exceeding the safe swimming limit after 10 mm of rainfall or more. The site has been monitored since 1994. Microbial water quality has varied among years owing to variations in rainfall.

10.2.2 Habitats and assemblages

Towra Point Aquatic Reserve primarily contains saltmarsh, mangroves, seagrasses (including *Posidonia australis*), mudflats, and shallow soft-sediments and also incorporates a small amount of beach habitat.

The reserve protects one of the largest and most diverse wetland complexes remaining in the Sydney region. Towra Point Nature Reserve, located adjacent to the aquatic reserve is a Wetland of International Importance and was declared a Ramsar Site under the Ramsar Convention in 1984. Much of the remaining important seagrasses, mangroves and migratory wading bird habitats in Botany Bay are found within this area.

More than 200 fish species have been recorded in the aquatic reserve and it provides nursery habitat supporting commercial and recreational fish stocks in the coastal Sydney region. For example, common silver biddy (*Gerres ovatus*), yellow bream (*Acanthospagrus australis*) and flat-tail mullet (*Liza argentea*) are found in large numbers at Towra Point and use the mangrove habitats during the juvenile stage of their life cycle. Saltmarsh within the reserve is a particularly important habitat for crab species.

10.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Towra Point is one of the most important migratory bird sites in NSW and an important breeding area for the endangered little tern (*Sterna albifrons*). The most significant nesting site for little terns (endangered) in the Hawkesbury Shelf bioregion was previously located on the northern side of Botany Bay but was relocated to Towra Spit Island in 1993/94 to make way for a third runway at Sydney Airport (NPWS 2000b). This area is within the Towra Point Aquatic Reserve.
- Historical data indicates the presence of sygnathids and black rockcod within the reserve, however, recent records are not available (DECCW 2010).

10.3 Social and economic benefits

10.3.1 Conserving heritage and environment

Middens, rock shelters, engravings, burial sites and other items of indigenous heritage have been found within Towra Point Nature Reserve.

In 1770, Captain James Cook first sailed the Endeavour into Botany Bay and initiated contact with Aboriginal people inhabiting the bay. Cook and his crew explored Towra Point, mapped the lagoon adjacent to Towra Beach and took botanical and zoological specimens from the area. Later, the First Fleet repeated these explorations in 1788.

Oyster farming was pioneered in the Towra Point area in the late 1870's. Evidence of early oyster farms within the reserve includes buildings, tar pits, oyster racks and wharves.

A commercial fishing industry in Botany Bay began in 1790, and by the 1850s fishermen had built shacks on the shores of Boat Harbour and Weeney, Woolooware and Quibray Bays. Salted catches were sent across the Bay to the Sydney market. Fishermen set their nets from the beach at Bonna Point to catch mullet. Recreational fishermen formed a fishing club that had its headquarters at Bonna Point. *Gracilaria* (agar producing seaweed) was also harvested from Botany Bay, including Bonna Point during the Second World War.

Source and further information (http://www.ssec.org.au/).

10.3.2 Recreation

The primary recreational uses of Towra Point include swimming, fishing, boating and kite surfing. There have been no formal studies of recreational use for the reserve.

10.3.3 Research and education

Research and Education/community engagement

Each year since 1991 the Botany Bay Field Studies Centre has taken students from years 11 and 12 to Towra Point to complete a field study of a fragile ecosystem. Students gain an insight into and experience of the biophysical nature of a wetland and are given information about the ecology of the area, particularly its importance for migratory birds and as a nesting site for little tern (http://www.ssec.org.au/). National Parks provides guided tours and runs school excursions within the reserve to teach students to study an ecosystem at risk. The University of Western Sydney has also used the site for undergraduate field trips for over 20 years, visiting mangrove and saltmarsh habitat and collecting data on molluscs.

Several volunteer community groups foster appreciation, understanding and stewardship of Towra Point Aquatic Reserve. These include but are not limited to:

- Friends of Towra Point Nature Reserve
- Sutherland Shire Environment Centre volunteers

10.3.4 Economic benefits

There are no dedicated studies on the economic values of Towra Point Aquatic Reserve.

11 Boat Harbour Aquatic Reserve

11.1 Site description

The boundaries and site features of Boat Harbour Aquatic Reserve are provided in Figure 13 and Table 11.

Table 11. Site description summary of Boat Harbour Aquatic Reserve

Boat Harbour	Description
LOCATION	Open coast just south of Botany Bay
LGA	Sutherland Shire
YEAR (declared)	2002, gazetted as an IPA in 1993
SIZE	~ 72 ha in size and includes the southern part of the Kurnell peninsula, incorporating the whole of Pimweli Rocks incorporating the whole of Merries Reef and extending east to three green 'Water Board' vents at Potter Point.
PROTECTION	Partial-take MPA; collecting (dead or alive), destroying or interfering with most invertebrates and seaweed is prohibited within the reserve from mean high water to 100m from mean low water, with the exception of rock lobsters, abalone, sea lettuce (*Ulva lactuca*) and bait weed (*Enteromorpha intestinalis*). Fin-fish may be taken by spear and line.
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council, Sutherland Shire Council
INFRASTRUCTURE	None

11.1.1 Adjacent features

- Botany Bay National Park
- Cronulla Beach Reserve
- Cronulla Beach
- Boat Harbour village / community
- 4WD Park
- Kurnell oil refinery
- Cronulla National Surfing Reserve
- North Cronulla Surf Lifesaving Club

11.1.2 History of declaration

Boat Harbour was originally declared as part of the IPA network in July 1993. Boat Harbour and five other IPAs were replaced with aquatic reserves on March 31, 2002. These areas were selected based on length, biodiversity, geographic spread, educational values, research, and community consultation.

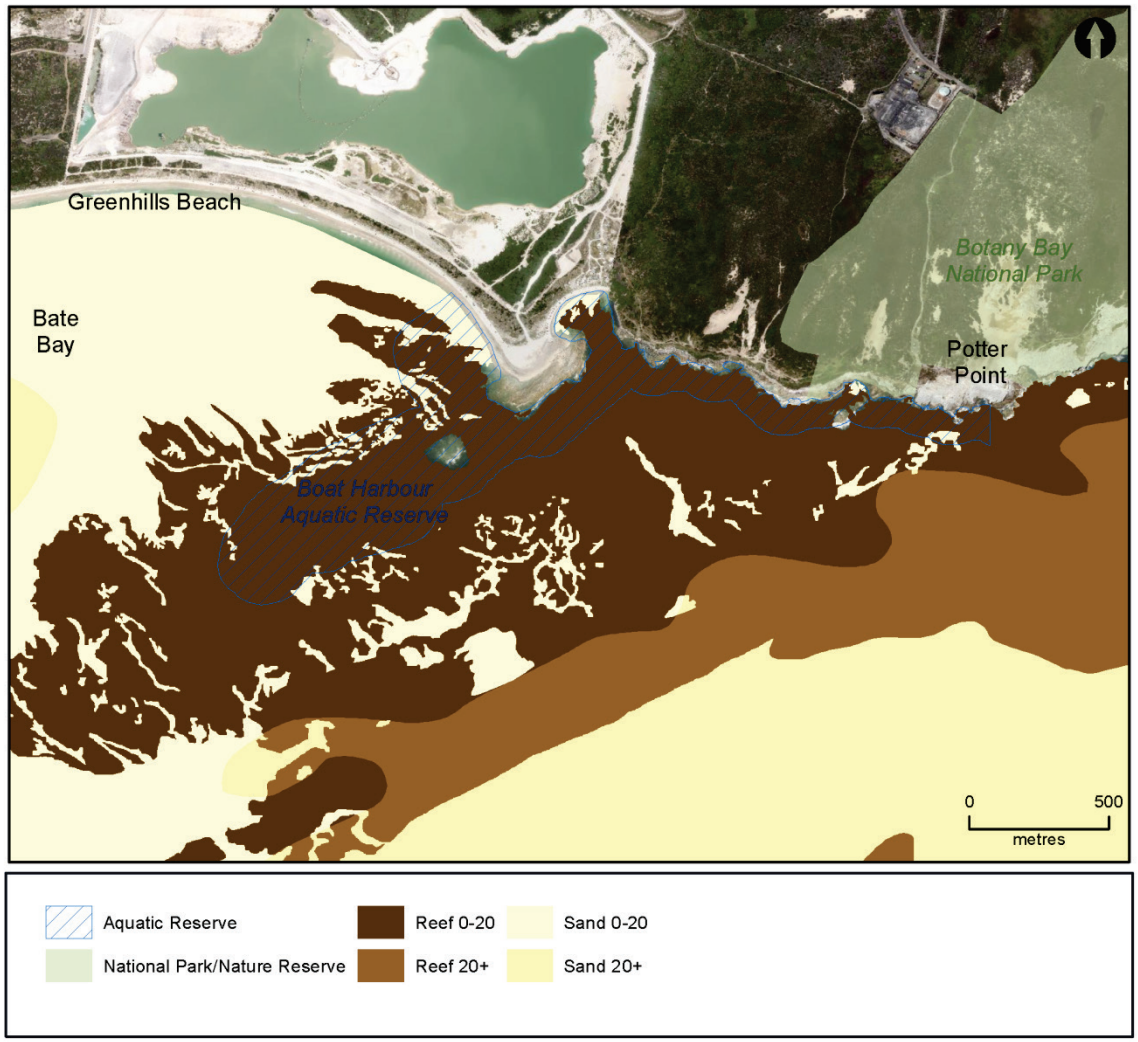

Figure 13. Map of Boat Harbour Aquatic Reserve showing boundaries and key habitats.

11.2 Environmental benefits

11.2.1 Clean waters

Boat Harbour is a narrow, 150 metre long private beach at the northern end of Bate Bay. It is the beach closest to the Cronulla WWTP outfall at Potter Point. The beach suitability grade for Boat Harbour is 'poor' which indicates that microbial water quality is influenced by faecal pollution, with on-site sewer systems behind the beach a potential source of contamination. The response to rainfall graph indicates that enterococci levels had little response to rainfall, occasionally exceeding the safe swimming limit across most rainfall categories. The site has been monitored since 1989. Microbial water quality improved in 2001–2002 following the upgrade of the Cronulla WWTP in April 2001. The creek at the northern end of the beach has been identified as the source of ongoing low levels of contamination in Boat Harbour. Further investigations have been unable to identify if the source of contaminants is human or non-human.

11.2.2 Habitats and assemblages

Boat Harbour Aquatic Reserve primarily includes rocky shore and shallow rocky reef including large offshore emergent reef 'The Merries Reef'. Small areas of beach and shallow soft-sediments also occur within the reserve.

Little information is available on biodiversity within the reserve.

11.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- The rocky shore within Boat Harbour is a key site for shorebirds, which aggregate here prior to migration. The endangered little tern (*Sterna albifrons* subspecies *sinensis*) nest in NSW during spring on habitats on the open coast including sand spits, sand islands and beaches, and feed in nearby waters. The species is now much less widespread; on the open coast sightings of little terns have been recorded from around the Hunter River, Lake Macquarie, Tuggerah Lakes, the Entrance, Long Reef (Breen et al. 2005) and Boat Harbour.

11.3 Social and economic benefits

11.3.1 Conserving heritage and environment

There is little information on the aboriginal heritage associated with Boat Harbour, however, middens have been identified at the site.

Shellgrit gathering for the pet-bird and poultry industries which began at the turn of the century, occurred at Boat Harbour. A commercial fishing industry in Botany Bay commenced in 1790 operating mainly from the northern side. By the 1850s fishermen had built many shacks on the shores of Boat Harbour and Weeney, Woolooware and Quibray Bays, and sent their salted catch across the Bay to the Sydney market.

Source and further information (http://www.ssec.org.au/).

11.3.2 Recreation

There is little information on recreat within Boat Harbour Aquatic Reserve. Recreational fishing is occasionally observed, and the site is adjacent to a commercially operated 4WD park, which allows for beach access to 4WDs.

11.3.3 Research and education

Research

Boat Harbour has been infrequently used as a research site. A study in 2000 which compared reserves previously designated as IPAs to unprotected areas showed no reserve effects for harvested intertidal organisms at Boat Harbour (Underwood and Chapman 2000). Boat Harbour has recently been included as a Reef Life Survey site, and in analyses of marine protected area effects conducted by The University of Sydney.

Education/community engagement

Boat Harbour is not utilised for regular educational activities. No local community volunteer groups which foster appreciation, understanding and stewardship of biodiversity could be identified, with the exception of Reef Life Survey volunteers.

11.3.4 Economic benefits

There are no dedicated studies on the economic values of Boat Harbour Aquatic Reserve.

12 Shiprock Aquatic Reserve

12.1 Site description

The boundaries and site features of Shiprock Aquatic Reserve are provided in Figure 14 and Table 12.

Table 12. Site description summary of Shiprock Aquatic Reserve

Shiprock	Description
LOCATION	Western headland of Burraneer Bay, off Little Turriel Point in Port Hacking
LGA	Sutherland Shire
YEAR (declared)	1982
SIZE	200 m of shoreline (~2ha in size)
PROTECTION	No-take area, collection and disturbance of all marine life is prohibited
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council, Sutherland Shire Council
INFRASTRUCTURE	Boat ramp, stairs to dive site, moorings located in nearby Dolans Bay and Burraneer Bay (http://www.rms.nsw.gov.au/documents/maritime/moorings/mooring-map-botany-bay-georges-river.pdf)

12.1.1 Adjacent features

- Residential
- Royal National Park (2 km S)

12.1.2 History of declaration

The Underwater Research Group of NSW began diving Shiprock in early 1965 and subsequently put in a submission to have Shiprock protected due to the unique nature of biodiversity relative to the size of the area. ‘Never before had we encountered anything like this concentration and variety of animals in which almost every phylum was represented. Species hitherto regarded as rare or uncommon were found in great numbers and all available living space was crowded with masses of invertebrates (Lawler 1972)’.

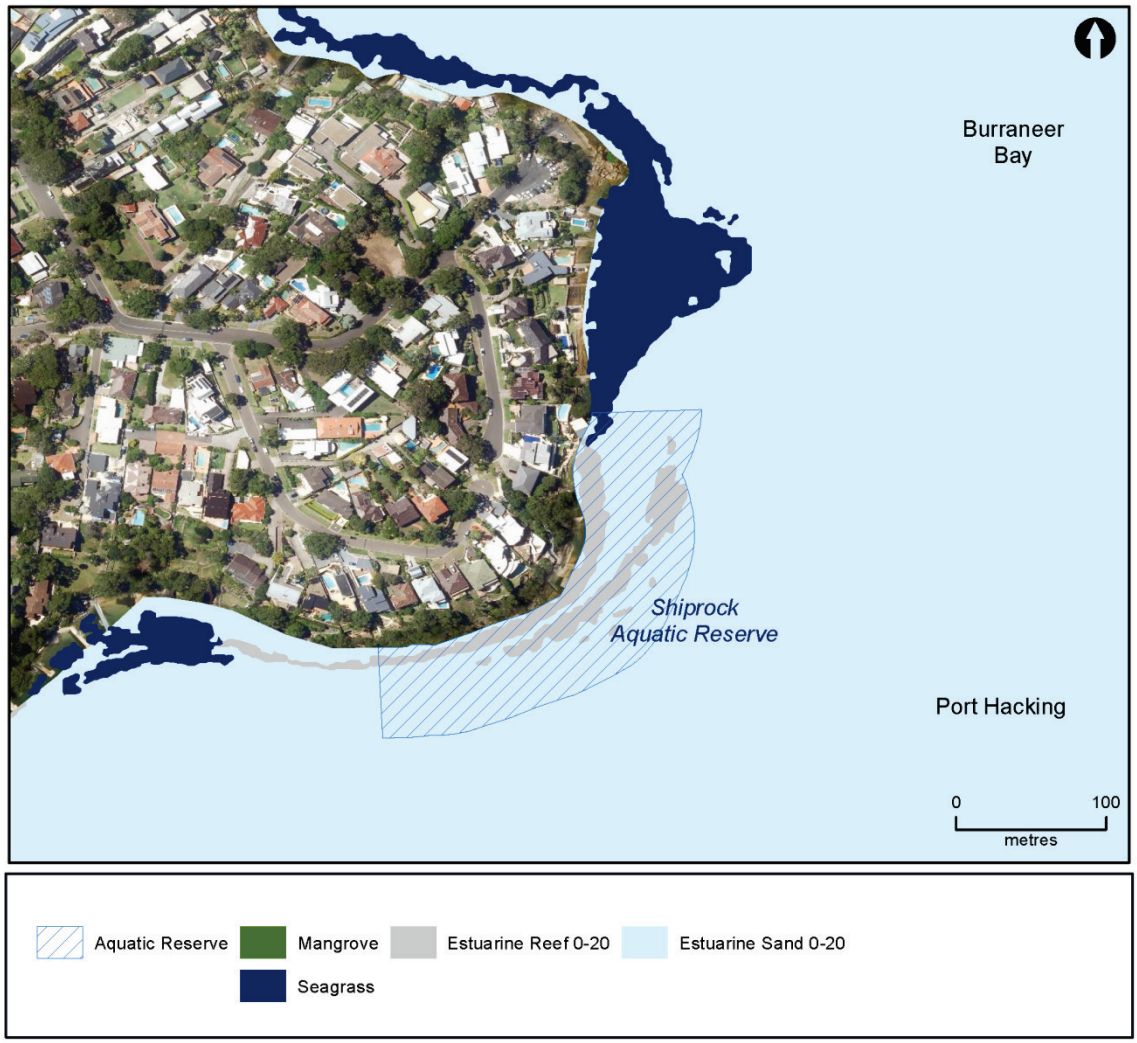

Figure 14. Map of Shiprock Aquatic Reserve showing boundaries and key habitats.

12.2 Environmental benefits

12.2.1 Clean waters

The closest area to Shiprock with a beach suitability grade is Lilli Pilli Baths, a tidal swimming area on the western side of Lilli Pilli Point. The baths are rated as ‘good’ which indicates that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution after heavy rain because of several potential sources of faecal contamination. The response to rainfall graph indicates that enterococci levels increased with increasing rainfall, often exceeding the safe swimming limit after 5 mm of rainfall or more. The site has been monitored since 1999.

12.2.2 Habitats and assemblages

Shiprock Aquatic Reserve contains rocky shore, shallow rocky reef and small amounts of shallow soft sediments and seagrasses. A combination of strong currents, clean oceanic water and complex submarine rocky areas has resulted in a diverse environment inhabited by a wide variety of marine plants, invertebrates and fish. Over 130 species of fish have been recorded in this small area and inhabit the underwater caves, crevices and bommies along with various species of algae and invertebrates such as worms, snails, crustaceans,

soft corals and sponges. During the summer, expatriate tropical species can be observed at Shiprock.

12.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Sygnathids including ghost pipefish, pot-bellied seahorses and weedy seadragons
- Black rockcod

12.3 Social and economic benefits

12.3.1 Conserving heritage and environment

Shiprock gets its name from the prominent ship-like rock which adorns the shore. The reserve is listed under the former Commonwealth's Register of the National Estate (Natural) due to its diverse fauna, expatriate tropical fishes and value as a dive and underwater photography site.

Further, heritage information could not be sourced for Shiprock Aquatic Reserve or directly adjacent areas.

12.3.2 Recreation

Due to its diversity of marine life the reserve provides one of the most popular scuba diving sites in the Sydney area. Access and facilities at Shiprock have been improved within the last 4 years. Other recreational activities are rare within the Reserve.

12.3.3 Research and education

Research

Research has been infrequently conducted at Shiprock. The site, however, has recently been used as a scientific reference site for Reef Life Survey studies on the impact of harvesting.

Education/community engagement

No education programs are regularly conducted within Shiprock Aquatic reserve.

Local volunteer community groups foster appreciation, understanding and stewardship of Shiprock's biodiversity including:

- Underwater Research Group
- Reef Life Survey

12.3.4 Economic benefits

There are no dedicated studies on the economic value of the reserve.

13 Wybung Head

13.1 Site description

A map and site features of Wybung Head are provided in Figure 15 and Table 13.

Table 13. Site description summary of Wybung Head.

Wybung Head	Description
LOCATION	Munmorah State Recreation Area, Central Coast
LGA	Wyong Shire
PROTECTION	Unprotected area
LOCAL AUTHORITIES	Darkinjung Local Aboriginal Land Council, Wyong Shire Council
INFRASTRUCTURE	None

13.1.1 Adjacent features

- Munmorah State Recreation Area

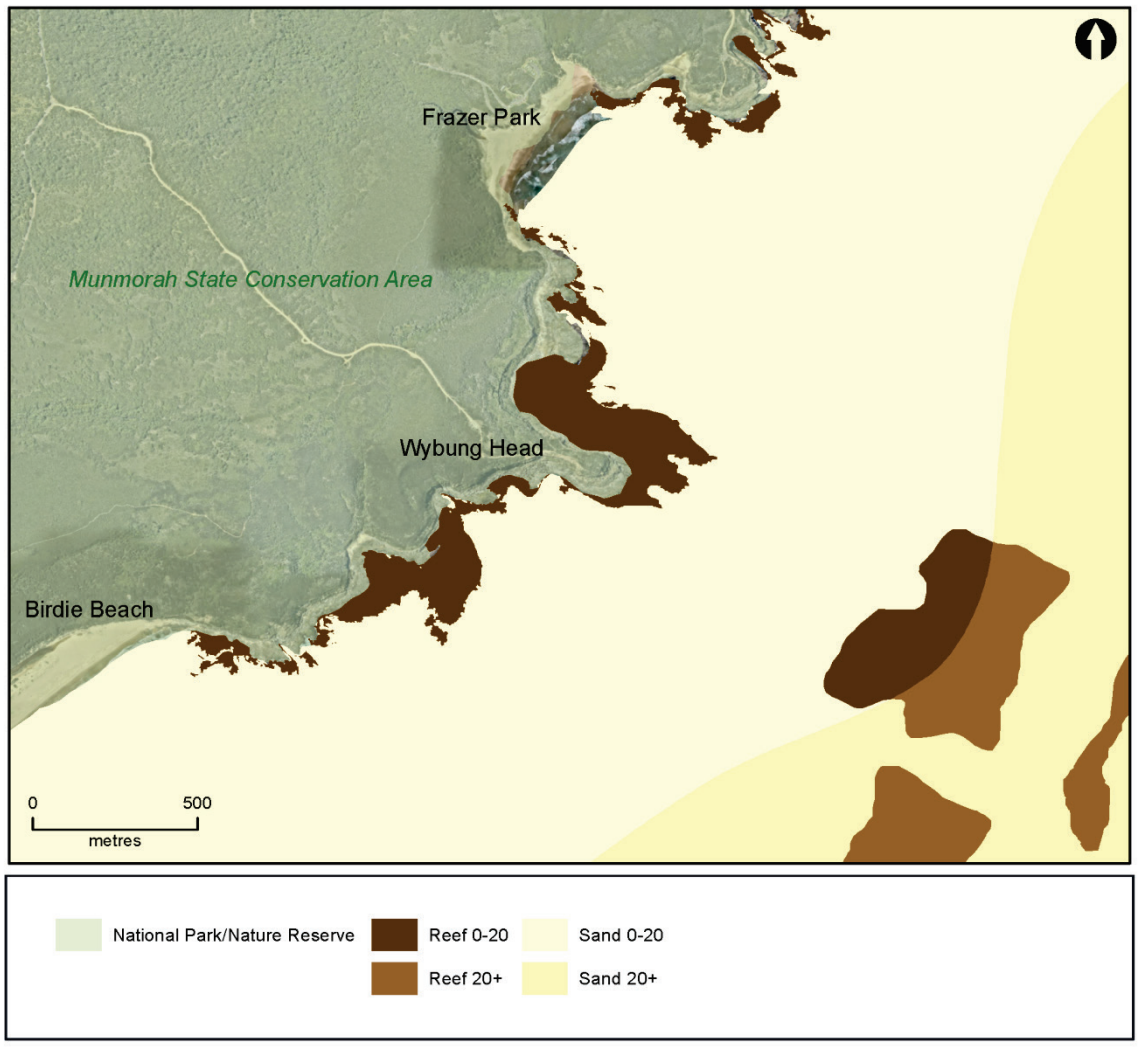

Figure 15. Map of Wybung Head showing key habitats.

13.2 Environmental benefits

13.2.1 Clean waters

Beach suitability grades are available for Frazer Beach and Birdie Beach which are located adjacent to Wybung Head.

Frazer Beach and Birdie beach are rated as ‘very good’ which indicates that the microbial water quality is considered suitable for swimming almost all of the time, with few potential sources of faecal contamination. The response to rainfall graph indicates that enterococci levels had little response to rainfall and remained below the safe swimming limit across all rainfall categories. The site has been monitored since 2002 and microbial water quality has been of a very high standard.

13.2.2 Habitats and assemblages

Wybung Head is dominated by rocky shore and shallow rocky reefs with smaller areas of shallow soft-sediment. There are few studies on marine biodiversity at Wybung Head. However, 27 fish species of fishes have been recorded in deep rocky reef habitat (Gladstone 2007).

13.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Greynurse sharks have been observed in this area, but there is little information to support the frequency of occurrence.

13.3 Social and economic benefits

13.3.1 Conserving heritage and environment

Wybung is a local Aboriginal word meaning ‘Dangerous Sea’. There is a paucity of publicly available information on heritage specific to the Headland.

Wybung rock platform was one of 25 platforms in the Hawkesbury Shelf bioregion recommended for protection by Short (1995) based on representativeness, uniqueness, and naturalness (condition) (Breen et al. 2005).

13.3.2 Recreation

Wybung Head is accessible by foot and boat. The headland is used for bushwalking and general sight-seeing including whale watching. A camping ground is located south of the Head and associated beaches are utilised for swimming, surfing, fishing and camping. The difficulty of shore access, unpatrolled beach and exposed coastline limit recreational activities (e.g. snorkelling, scuba diving) at Wybung Head itself, and there are few points of boat access on the adjacent coastline.

Wybung Head is a population spot for recreational fishing, including local club competitions. However, it is also recognised as a ‘black spot’ for fishing deaths in NSW.

13.3.3 Research and education

Research

Few research studies have been conducted in the marine component of Wybung Head, with the exception of Gladstone (2007) who has used the site as a scientific reference area for fish in large-scale biodiversity surveys.

Education/community engagement

The marine component of Wybung Head is not regularly used for educational purposes.

No local community volunteer groups are known to be associated with the site.

13.3.4 Economic benefits

There is little information on economic benefits related to Wybung Head. However, this stretch of coast is an important catch area for commercial lobster fishers.

14 North Harbour Aquatic Extension (Manly Wharf & Manly Cove)

14.1 Site description

A map and site features of North Harbour Aquatic Extension are outlined in Figure 16 and Table 14.

Table 14. Site description summary of North Harbour Aquatic Extension

North Harbour Aquatic Extension	Description
LOCATION	Northern side of Sydney Harbour. Major tourist destination and commuter hub between the northern beaches and Sydney City
LGA	Manly
PROTECTION	Subtidal marine environment is unprotected, intertidal habitats are protected as part of Sydney Harbour IPA. Temporal fisheries restrictions have also been implemented within little penguin Critical Habitats. Patrolling fisheries officers maximise compliance with fishing rules and provide advice to fishers. A commercial fishing closure is currently in place for the entirety of Sydney Harbour.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Manly Council
INFRASTRUCTURE	manly wharf, netted swimming enclosure, boat moorings located in the east side of Manly Cove and from Forty Baskets Beach to Jilling Cove (http://www.rms.nsw.gov.au/documents/maritime/moorings/mooring-map-sydney.pdf)

14.1.1 Adjacent features

- Sydney Harbour National Park
- The Spit to Manly walk
- Commercial and residential areas
- Manly Sea Life Sanctuary
- Manly Ferry Terminal

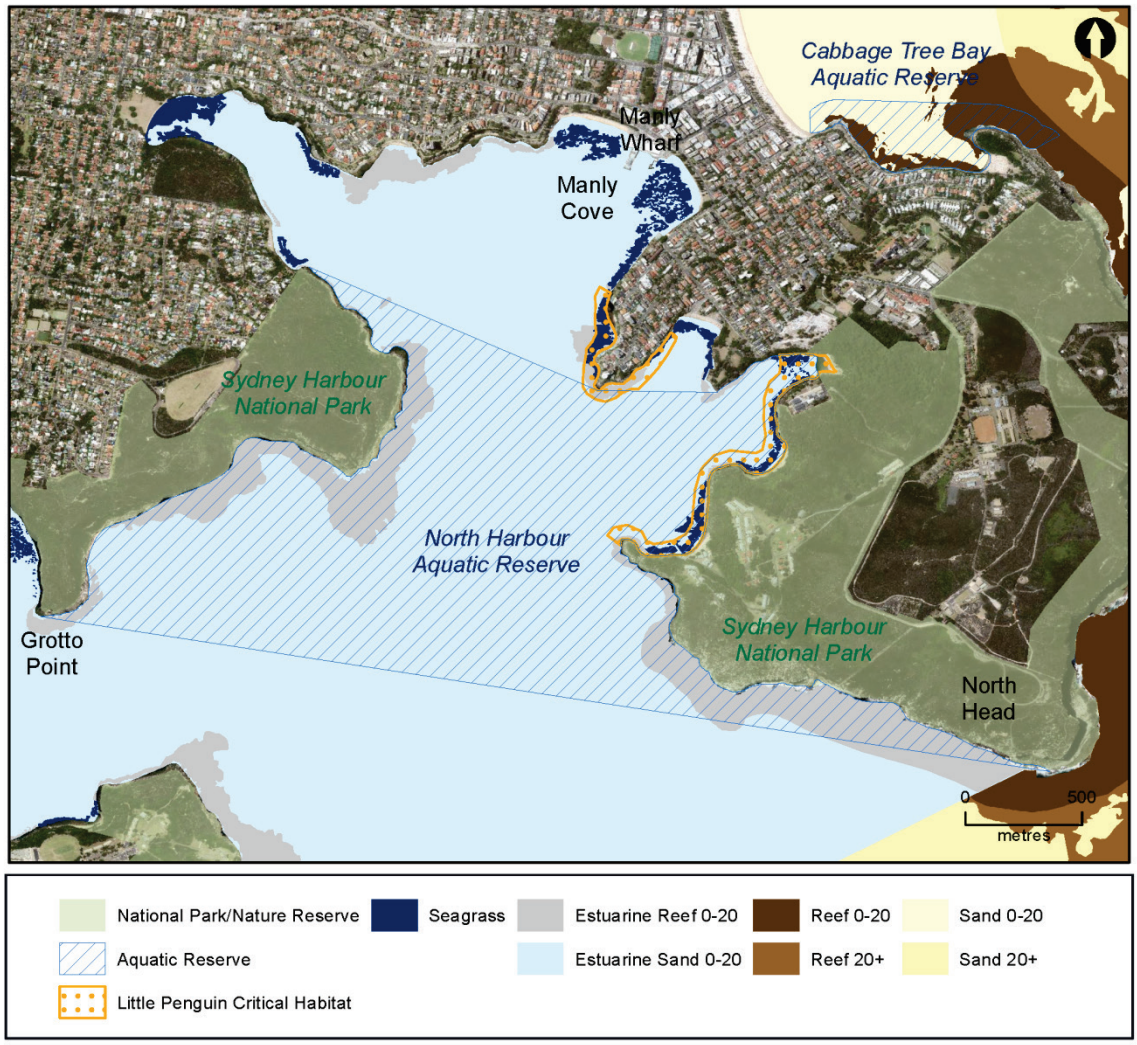

Figure 16. Map of North Harbour Aquatic Extension showing key habitats and critical habitat for little penguins.

14.2 Environmental benefits

14.2.1 Clean waters

Manly Cove is a netted swimming enclosure near the centre of the 250 metre long beach that stretches to the west of the Manly Ferry Terminal. The beach is backed by a walking track and park. The beach suitability grade of 'good' indicates that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution from a number of minor sources of faecal contamination. The response to rainfall graph indicates that enterococci levels generally increased with increasing rainfall, regularly exceeding the safe swimming limit in response to 20 mm of rainfall or more. The site has been monitored since 1994. Microbial water quality has generally improved since 2000–2001 owing to licensing of discharges from the sewerage system and improved management of stormwater.

14.2.2 Habitats and assemblages

North Harbour Aquatic Extension contains large areas of rocky shores, shallow rocky reef and shallow soft-sediments. Beach and seagrass (including *Posidonia australis*) habitats

also occur in this area. The biodiversity associated with these habitats has not been formally assessed.

14.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Sydney Harbour is home to the only mainland breeding colony of little penguins in NSW, which is listed as an endangered population under the *Threatened Species Conservation Act 1995*. The colony currently contains 65 breeding pairs (averaged over five years) which nest in rock falls and rocky shorelines around Manly Point and in Sydney Harbour National Park, North Harbour. Penguins are known to nest under Manly Wharf. Some of these sites have been declared as critical habitat to provide greater protection and stricter controls over activities that are considered key threats (e.g. predation by dogs, cats and foxes, loss of breeding habitat, disturbance at nesting sites) (NSW NPWS 2002).
- Sygnathids, including pipefish, big-bellied and white's seahorse
- *Posidonia australis* (Creese et al. 2009)

14.3 Social and economic benefits

14.3.1 Conserving heritage and environment

Over 100 years of seaside recreation in the Manly area began in 1853 when Sydney's first seaside resort was built at Manly, complete with the first Manly Wharf. Other aspects of heritage are similar to that described for North Harbour Aquatic Reserve.

For Aboriginal Heritage see 'North Harbour Aquatic Reserve'.

14.3.2 Recreation

The Manly Cove area is highly accessible and is heavily utilised for swimming, snorkelling, walking, picnicking, scuba diving, boating, fishing, and kayaking. Manly Cove and Little Manly are two of the top recommended spots for snorkelling and scuba diving in Sydney Harbour (SIMS 2014).

14.3.3 Research and education

Research

Research has focused on seahorses which inhabit the nets at Manly Cove (Harasti et al. 2010). Extensive loss of seagrass at Manly Cove has been quantified by surveys and potential recovery of seagrass after replacement of block and chain moorings with seagrass friendly moorings has been monitored (Gladstone 2010, 2013).

Education/community engagement

Several volunteer community groups foster appreciation, understanding and stewardship of North Harbour's biodiversity. These include but are not limited to:

- Penguin Wardens
- Manly Sea Life Sanctuary

- Manly Environment Centre volunteers
- Eco Divers
- Two Hands Project

14.3.4 Economic benefits

There are no dedicated studies of the economic value of Manly Cove.

15 Chowder Bay

15.1 Site description

A map and site features of Chowder Bay are outlined in Figure 17 and Table 15.

Table 15. Site description summary of Chowder Bay

Chowder Bay	Description
LOCATION	Southern side of Middle Head peninsula in Sydney Harbour
LGA	Mosman
PROTECTION	Spearfishing is prohibited within the bay and rocky shore organisms are protected by the Sydney Harbour IPA. A commercial fishing closure is currently in place for the entirety of Sydney Harbour.
LOCAL AUTHORITIES	Metropolitan Local Aboriginal Land Council, Mosman Municipal Council
INFRASTRUCTURE	Jetties, netted swimming enclosure. A small number of moorings are located in adjacent Taylors Bay and a large number of moorings on the south side of the harbour (e.g. Rose Bay and Watsons Bay).

15.1.1 Adjacent features

- Sydney Harbour National Park
- Clifton Gardens Park - heavily used for picknicking, general recreation, and as a dogs off-leash area (includes beach)
- Urban development
- Infrastructure related to the Sydney Institute of Marine Science (SIMS) – educational discovery centre, aquarium, boat and lab facilities
- NSW Fisheries office
- Restaurants, Cafes, other local businesses
- Naval Wharf

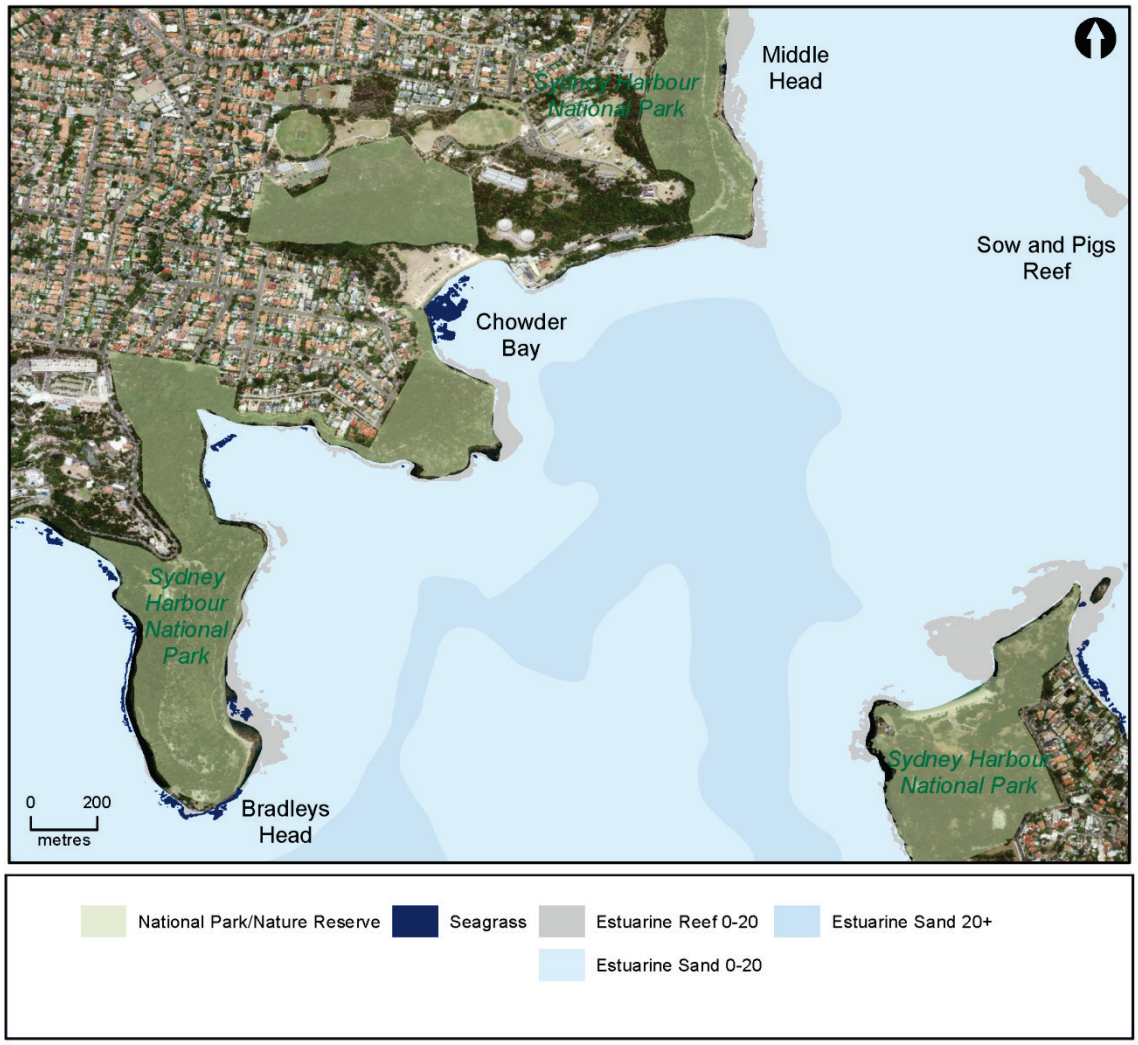

Figure 17. Map of Chowder Bay showing key habitats.

15.2 Environmental benefits

15.2.1 Clean waters

Clifton Gardens is a large netted swimming area at the western end of a 250 metre long beach in Chowder Bay. It has a beach suitability grade of 'good' which indicates that microbial water quality is suitable for swimming most of the time but the water may be susceptible to pollution from several minor sources of faecal contamination. The response to rainfall graph indicates that enterococci levels increased with increasing rainfall, often exceeding the safe swimming limit in response to 5 mm of rainfall or more, and frequently after 20 mm or more. The site has been monitored since 1994. Microbial water quality has generally improved since 2000–2001 due to licensing of discharges from the sewerage system (and associated works such as the Northside Storage Tunnel) and improved management of stormwater.

15.2.2 Habitats and assemblages

Chowder Bay contains rocky shore, shallow rocky reefs, soft sediments, beach, and seagrass habitats. In-water infrastructure (e.g. jetties, swimming nets) also provide artificial habitat for a range of organisms such as sea horses.

Biodiversity associated with these habitats has not been widely published, however Reef Life Survey volunteers have completed many surveys of fishes and large invertebrates at the site. The only two specimens of the recently discovered Sydney scorpionfish (*Scorpaenopsis insperatus*) were collected at Chowder Bay (Motomura 2004).

15.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Sygnathids, including pipefish, big-bellied and white's seahorse

15.3 Social and economic benefits

15.3.1 Conserving heritage and environment

Chowder Bay was once an important area for the Borogegal clan, and the area was known as Koree. No other Aboriginal heritage information could be sourced that is specific to the site (see 'North Harbour Aquatic Reserve).

Historic buildings and facilities at Chowder Bay were established as a submarine miners depot, and then used as barracks and mess buildings for the Australian military. Infrastructure was restored by Sydney Harbour Federation Trust and the area is now occupied by the Sydney Institute of Marine Science and other businesses.

In terms of European History - Chowder Bay was most likely given its name from the Whalers that would make chowder from the seafood from the Bay. Clifton Gardens was the site of a pleasure ground which was opened in 1863. In 1871 a hotel was opened on the site and in the 1880's the grounds expanded to include a bathing enclosure, dancing pavilion and a skating rink.

In the 1890's, a base was built at Chowder Bay for the Submarine Mining Corps. In 1922, after changes in technology that made these types of mines ineffective, the Corps was disbanded. Chowder Bay then became a depot and barracks for Army engineers. In the 1970's it was the site of the Army Maritime School until the school closed in 1997.

Source and further information (http://www.harbourtrust.gov.au/)

15.3.2 Recreation

Chowder Bay is a popular recreational space due to the accessibility of the foreshore and beach and the security provided by the netted swimming enclosure. Marine-based recreational activities include swimming, snorkelling, diving, use of unpowered water crafts, and recreational fishing (SIMS 2014).

Chowder Bay is one of the top recommended spots for snorkelling and scuba diving in Sydney Harbour (SIMS 2014) and is frequented by underwater photographers, particularly for macro-photography. The Bay is one of the most popular fishing locations within Sydney Harbour with activity being highest on the weekends and during the warmer months (SIMS 2014). It is also one of the most intensively used sites in the Harbour for boat anchoring, particularly during the weekends (SIMS 2014).

A human use study using high resolution remote camera photography was initiated in March 2015. Results to date indicate that Chowder Bay is dominated by Jetty activity (both fishing and non-fishing), yacht mooring and beach goers (Flynn et al. 2015).

15.3.3 Research and education

Research

The Sydney Institute of Marine Science is based at Chowder Bay. As such this area is increasingly used for scientific research which involves collection of organisms and in-water experiments.

Education/community engagement

Mosman Council co-ordinates ‘Underwater Mosman’ (a website which provides information on marine life found at Chowder Bay), and ‘Summerama’ (a coastal activities program). The Sydney Institute of Marine Science regularly utilises the site for outreach programs and events (e.g. Harbour Hike, student programs, Discovery Centre). Lands Edge, which is based at Chowder Bay, provides curriculum-based field studies programs, outdoor education and recreational activities for both primary and secondary students with a distinctive focus on coastal environments.

Several volunteer community groups foster appreciation, understanding and stewardship of Chowder Bay’s biodiversity. These include but are not limited to:

- Reef Life Survey
- Eco Divers

15.3.4 Economic benefits

There are no formal studies on the economic value of Chowder Bay, however, cafes, restaurants, and the commercial education company ‘Lands Edge’ operate within the Bay.

16 Magic Point

16.1 Site description

A map and site features of Magic Point are outlined in Figure 18 and Table 16.

Table 16. Site description summary of Magic Point

Magic Point	Description
LOCATION	Eastern suburbs of Sydney. The headland which encompasses Magic Point and Boora Point begins at the Southern end of Maroubra beach and extends around into Long Bay
LGA	Randwick
PROTECTION	Greynurse Shark Critical Habitat.
LOCAL AUTHORITIES	La Perouse Local Aboriginal Land Council, Randwick City Council
INFRASTRUCTURE	None
OTHER	Magic Point, has been identified as an important aggregation site for greynurse sharks

16.1.1 Adjacent features

- Maroubra Beach
- Malabar Headland National Park
- Anzac Rifle Range
- Long Bay IPA (south of Magic Point)

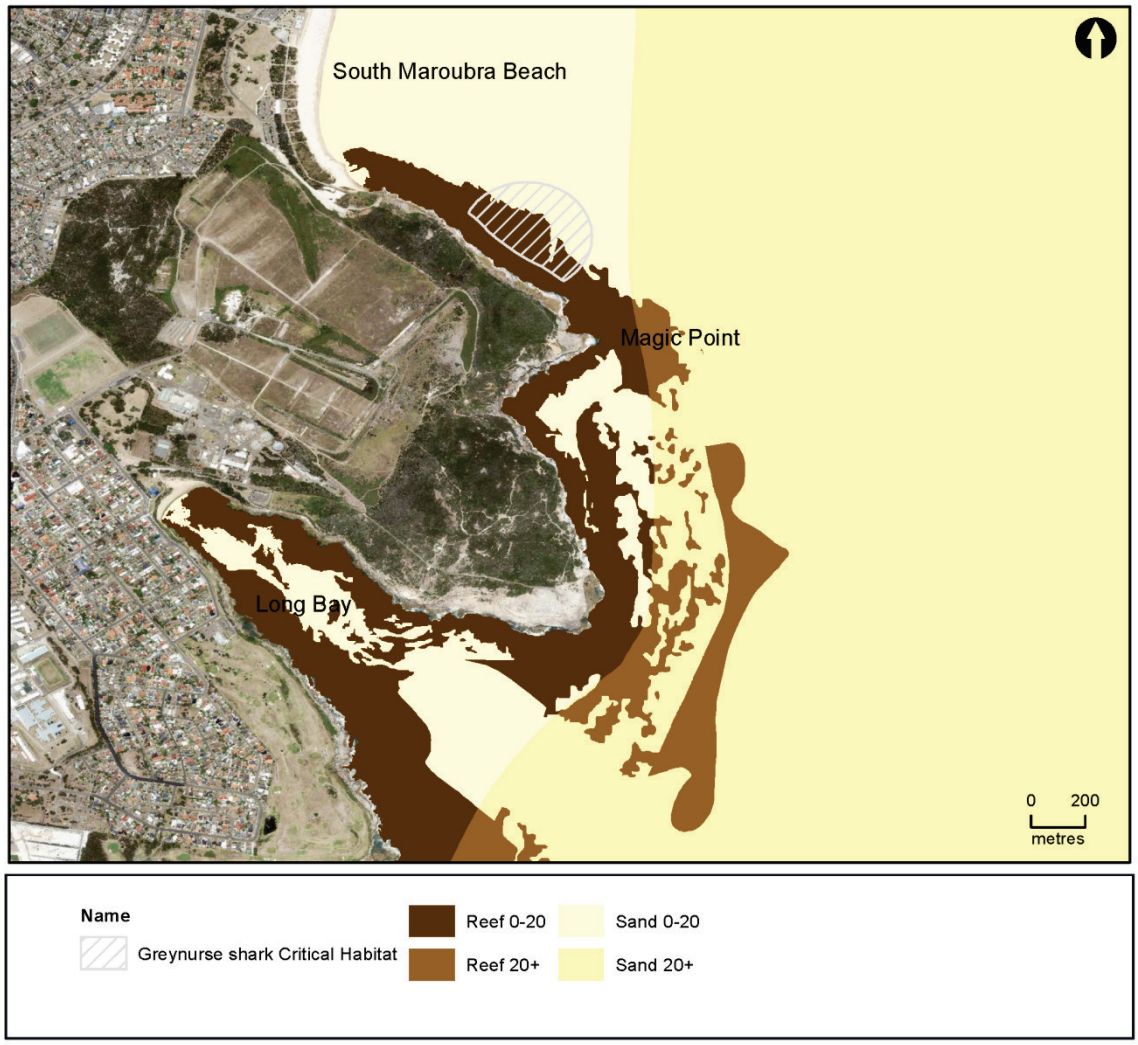

Figure 18. Map of Magic Point showing key habitats and critical habitat for greynurse sharks.

16.2 Environmental benefits

16.2.1 Clean waters

South Maroubra Beach adjacent to Magic Point has a beach suitability grade of 'good'. This indicates that microbial water quality is suitable for swimming most of the time, but the water may be susceptible to pollution following rainfall. The response to rainfall graph indicates that enterococci levels increased slightly with increasing rainfall, occasionally exceeding the safe swimming limit in response to 5 mm or more of rainfall. The site has been monitored since December 2012.

16.2.2 Habitats and assemblages

Magic Point is dominated by rocky shores and shallow rocky reefs. The latter includes urchin-grazed barrens and macroalgal habitat types. Fifty one species of finfish have been recorded in diversity surveys of barrens and kelp habitat at Magic Point at 3-19 m depth (Curley 1998).

16.2.3 Threatened and protected species

A range of threatened and protected species are likely to utilise the habitats at this site and adjacent areas including marine mammals, shorebirds, fishes and sharks. Although site-specific data are not available for all species the following have been reported in the literature or by the community:

- Surveys have identified Magic Point, as an important aggregation site for greynurse shark within the Hawkesbury Shelf marine bioregion. Sharks were observed here for over 50% of surveys in numbers representing 3.5% of the observed population in NSW (NSW Fisheries 2002). In December 2002, NSW Fisheries declared critical habitat for greynurse sharks at Magic Point. The shape of the critical habitat was amended in 2012 and centred over the main aggregation site and extended 200 m seaward to improve protection and reduce complexity of rules. To reduce impacts on shore-based recreational fishers, waters within 50 m of the shore were excluded from the critical habitat, noting that shore-based recreational line fishing was permitted under the original 2002 rules. Commercial line fishing restrictions apply within 500 m of the aggregation site prohibiting all line fishing methods other than spinning and trolling with fly or artificial lure, and restricted leadlining. Recreational line fishing restrictions apply within the Magic Point critical habitat prohibiting all recreational line fishing methods other than the use of soft plastics, artificial fly or lures.

  The national Code of Conduct for Diving with greynurse sharks applies in all NSW waters including greynurse shark critical habitat and aggregation sites, and penalties apply for interfering with threatened species of fish including greynurse shark.

- Weedy seadragons

16.3 Social and economic benefits

16.3.1 Conserving heritage and environment

There was a paucity of site-specific information on heritage for this site. For heritage information in the local vicinity see ‘Cape Banks Aquatic Reserve’.

16.3.2 Recreation

Magic Point is used for walking, swimming, fishing and scuba diving. The latter are primarily taken out by commercial dive charters, licensed to operate within the greynurse shark critical habitat. The site is a popular and relatively safe rock fishing locality in close proximity to a major urban centre.

A quantification of use study using high resolution remote camera photography was initiated in March 2015. Results to date indicate that activity at Magic Point is dominated by beach goers and rock walkers. Use of the site by commercial dive boat operators is sporadic but consisted of large group sizes (Flynn et al. 2015).

16.3.3 Research and education

Research

Magic Point has been used to study patterns of diversity and abundance of fish assemblages within the Hawkesbury Shelf bioregion (Curley 1998), and is now a Reef Life Survey site. Research has also focused on the effect of recreational scuba divers on the behaviour and physiology of greynurse sharks (Barker et al. 2011a; Barker et al. 2011b). ‘Spot a shark’, a non-profit dive community research project has also been established in conjunction with Macquarie University. The group utilizes a computer-based software

program to identify sharks from individual markings and track movements between dive sites.

Maroubra was used as an unprotected area in a study in 2000 which compared reserves previously designated as IPAs to unprotected areas (Underwood and Chapman 2000).

Education/community engagement

The presence of greynurse sharks has been the primary focus of education and stewardship activities associated with Magic Point. For example, SeaLife Sanctuary in association with the NSW Fishing Trust performs rescues of sharks entangled with fishing gear at Magic Point. Randwick Council also conducts rock pool rambles at South Maroubra as part of the Marine & Coastal Adventure Program.

Several volunteer community groups foster appreciation, understanding and stewardship of marine biodiversity, particularly greynurse sharks at Magic Point. These include but are not limited to:

- Underwater Research Group
- Spot a Shark –research and rescues of injured sharks
- Grey Nurse Shark Watch (Reef Check Australia)
- Reef Life Survey
- Dragons of Sydney – Citizen Science Program (Weedy seadragons)

16.3.4 Economic benefits

There are no dedicated studies on the economic values of Magic Point. The greynurse shark aggregation site, however, provides direct economic benefits for commercial dive operators licensed to operate within the area.

17 Overview of benefits

17.1 Environmental benefits

All pre-identified sites offer relatively clean water with beaches within or adjacent to sites having 'good' or 'very good' beach suitability grades (OEH 2015). An exception to this is Boat Harbour Aquatic Reserve, which is the only coastal beach in the Sydney region to receive a beach suitability grade of 'poor' (Table 17). This is potentially due to contamination from on-site sewer systems located behind the beach.

A diverse range of habitats are represented in the pre-identified sites but saltmarsh, mangroves, mudflats, deep soft sediments and deep rocky reefs only occur in one of the reserves (Table 17).

Eleven of the pre-identified sites are effectively marine protected areas. Ten are aquatic reserves and one is a marine extension of a terrestrial National Park. These sites vary in size from ~2-1444 hectares, and age from 13-44 years (Table 18). Bouddi Marine Extension was established in 1971 and the most recent set of six aquatic reserves in 2002.

The level of protection for biodiversity also varies among these eleven sites (Table 18). Four sites are completely 'no-take' where collecting, destroying or interfering with all forms of marine life is prohibited. These are Bouddi Marine Extension, Cabbage Tree Bay and Shiprock Aquatic Reserves, and the sanctuary zone component of Towra Point Aquatic Reserve. The remaining sites are 'partial-take' aquatic reserves, and allow for some fishing. Restrictions are imposed on specific activities, gear types, and extraction of particular species. Biodiversity protection in these reserves is focused on marine invertebrates with few restrictions on the harvesting of fin-fish.

The other four pre-identified sites are not reserved, and are located at Wybung Head, Chowder Bay, Manly Cove (North Harbour Extension) and Magic Point. Chowder Bay and Manly Cove adjoin the Sydney Harbour IPA in which the collection of invertebrates is prohibited, and Sydney Harbour is also closed to commercial fishing. Spearfishing is also prohibited within Chowder Bay. Manly Cove contains critical habitat for little penguins, while Magic Point contains critical habitat for greynurse sharks.

On-ground research and scientific evidence on the benefits of protected area effects are limited to three of the pre-identified sites: Bouddi National Park Marine Extension, Cabbage Tree Bay Aquatic Reserve and Bronte-Coogee Aquatic Reserve. Scientific studies found that species diversity and/or abundance and size of some fish and invertebrate species within these sites were greater than in similar unprotected areas.

There is no conclusive evidence of protected area effects for the remaining eight aquatic reserves. Recent analyses using Reef Life Survey data (The University of Sydney and Sydney Institute of Marine Science, unpublished), suggest positive effects for some 'no-take' aquatic reserves (e.g. Shiprock), and minimal effects for 'partial-take' reserves.

Few studies have examined the effect of protection on invertebrate communities which are the focus of harvesting restrictions in 'partial-take' aquatic reserves. The most comprehensive scientific study, published in 2000, found no consistent differences in intertidal communities between reserves originally declared as IPAs and unprotected reference areas (Barrenjoey Head, Narrabeen Head, Cabbage Tree Bay, Bronte-Coogee, Cape Banks and Boat Harbour; Underwood and Chapman 2000). Ineffective compliance within the reserves was proposed as a contributing factor.

17.2 Consistency with CAR principles

The system of aquatic reserves and Bouddi National Park Marine Extension were declared at different times for a variety of purposes including protection for all or certain components of biodiversity (e.g. intertidal invertebrates, fisheries management, education and research, and management of user conflict).

For example, six of the current aquatic reserves in the bioregion were originally established as IPAs in 1993 using temporary fishing closures under fisheries management legislation and were gazetted in response to extensive harvesting of intertidal invertebrates around Sydney.

Consequently, retrospective application of Comprehensiveness, Adequacy and Representativeness (CAR) principles demonstrates that a very small proportion of key habitat types found within the bioregion are represented because the system pre-dated, and was not established with the objective of complying with CAR principles. In particular, rocky reefs, beaches and sub-tidal sandy habitats have low levels of representation.

An analysis of the existing system of marine protected areas in the bioregion against CAR principles has been undertaken. The analysis concludes that, overall, the current system of aquatic reserves and national parks in the Hawkesbury Shelf bioregion does not meet the CAR planning principles. In particular the current system does not meet the:

- Comprehensive principle - as it does not include examples of the full range of different ecosystems and habitats in the bioregion, with only around 1 per cent of the bioregion in ten aquatic reserves and Bouddi National Park marine extension
- Representative principle - as it does not include examples of coastal lakes, deep rocky reefs, deep sandy seabed, and only small areas of habitats such as shallow rocky reefs, rocky shores estuarine reefs, and some seagrass species
- Adequate principle - due to the small size of reserves (individually and in total area), the small number of no-take reserves, the boundaries of the reserves which often cut across continuous features, and the compliance challenges caused by complex rules and resourcing.

17.3 Social and economic benefits

The pre-identified sites provide opportunities for a range of social and economic benefits associated with conserving environment and heritage including participation, enjoyment, cultural heritage and use, and a range of direct and indirect economic values including ecotourism. A summary of the identified benefits is presented in Table 19. Formal studies of social benefits have not generally been conducted at the site-scale. Exceptions include a recent human usage study of four aquatic reserves and four unprotected sites within the Sydney region which found that non-extractive activities accounted for 99% of use (Wood 2015).

Aquatic reserves that are highly accessible and relatively safe for water activities, for example Cabbage Tree Bay and Bronte-Coogee Aquatic Reserves, provide high quality diving and snorkelling relative to more remote areas (e.g. Boat Harbour and Barrenjoey Head) and have high nature tourism values. Similarly, Magic Point is heavily used by dive operators due to the presence of greynurse sharks, and Shiprock Aquatic Reserve is also an important site for dive operators due to its biodiversity values.

Long Reef, Narrabeen and Cabbage Tree Bay Aquatic Reserves and Manly Cove are focal sites for school and community education programs run by council environment centres and private companies. Several conservation-focused community groups foster stewardship of

these sites (e.g. Friends of Cabbage Tree Bay, Eco Divers, Reefcare Long Reef and Manly Penguin Wardens).

Pre-identified sites have been the focus of internationally recognised scientific research (e.g. Cape Banks Aquatic Reserve and Magic Point). Aquatic reserves and Bouddi National Park Marine Extension have been used as scientific reference sites to provide insight into the impact of harvesting on abundance, size and diversity of marine organisms, by way of comparisons with unprotected areas. These research and education opportunities are not available in the absence of marine protected areas, and hence are a key social and economic benefit.

There was little quantitative information available on the economic benefits at the scale of individual sites. Available information for NSW, however, provides some insight into the likely economic benefits associated with different recreational activities (Vanderkooi 2015).

Table 17. Clean waters and key habitat types present at pre-identified sites.

Clean waters: green indicates a beach suitability grade of 'good' or 'very good', red indicates a 'poor' grade (OEH 2015). Habitat types: darker-shaded boxes indicate the most common habitat types within the site. Abbreviations: AR (Aquatic Reserve), ME (Marine Extension).

	PRE-IDENTIFIED MARINE PROTECTED AREAS LISTED FROM NORTH TO SOUTH IN THE BIOREGION											OTHER PRE-IDENTIFIED SITES			
	BOUDDI NATIONAL PARK ME	BARRENJOEY HEAD AR	NARRABEEN HEAD AR	LONG REEF AR	CABBAGE TREE BAY AR	NORTH HARBOUR AR	BRONTE-COOGEE AR	CAPE BANKS AR	TOWRA POINT AR	BOAT HARBOUR AR	SHIPROCK AR	WYBUNG HEAD	NORTH HARBOUR AQUATIC EXTENSION	CHOWDER BAY	MAGIC POINT
Clean Waters															
Saltmarsh															
Mangroves															
Other Seagrasses															
Posidonia seagrass															
Mudflats															
Beaches															
Rocky shores															
Shallow soft sediments															
Deep soft sediments															
Shallow rocky reefs															
Deep rocky reefs															

Table 18. Current level of biodiversity protection within the pre-identified sites.

Abbreviations: AR (Aquatic Reserve), ME (Marine Extension), PTA (Partial-take Area). Key: dark green = species protected; light green = protected in part of the reserve or seasonal closure.

	PRE-IDENTIFIED MARINE PROTECTED AREAS LISTED FROM NORTH TO SOUTH IN THE BIOREGION												OTHER PRE-IDENTIFIED SITES			
	BOUDDI NATIONAL PARK ME	BARRENJOEY HEAD AR	NARRABEEN HEAD AR	LONG REEF AR	CABBAGE TREE BAY AR	NORTH HARBOUR AR	BRONTE-COOGEE AR	CAPE BANKS AR	TOWRA POINT AR (SANCTUARY ZONE)	TOWRA Point AR (REFUGE ZONE)	BOAT HARBOUR AR	SHIPROCK AR	WYBUNG HEAD	NORTH HARBOUR AQUATIC EXTENSION	CHOWDER BAY	MAGIC POINT
Protection level	No-take	PTA	PTA	PTA	No-take	PTA	PTA	PTA	No-take	PTA	PTA	No-take				
Biodiversity protection																
Intertidal invertebrates																
Subtidal invertebrates																
(Abalone & Rock lobster)																
Marine vegetation																
(Bait weed & sea lettuce)																
Management control/activity																
Fin-fish by line (fisheries closure)																
Fin-fish by spear (fisheries closure)																
Eastern blue groper by line (fisheries closure)																
Critical habitat (fishing restrictions)																
Presence of threatened and protected species																
Posidonia australis seagrass																
Sygnathids																
Greynurse shark																
Black rockcod																
Shorebirds																
Little penguins																
Size of MPA (ha)	287	25	7	72	17	261	42	23	555	889	66	2				
Year MPA was declared	1971	2002[a]	2002[a]	1980	2002[a]	1982	2002[a]	2002[a]	1987	1987	2002[a]	1982				

Table 19. Social & economic activities documented within the pre-identified sites.

Abbreviations: AR (Aquatic Reserve), ME (Marine Extension).

	PRE-IDENTIFIED MARINE PROTECTED AREAS LISTED FROM NORTH TO SOUTH IN THE BIOREGION												OTHER PRE-IDENTIFIED SITES			
	BOUDDI NATIONAL PARK ME	BARRENJOEY HEAD AR	NARRABEEN HEAD AR	LONG REEF AR	CABBAGE TREE BAY AR	NORTH HARBOUR AR	BRONTE-COOGEE AR	CAPE BANKS AR	TOWRA Point AR (REFUGE ZONE)	TOWRA POINT AR (SANCTUARY ZONE)	BOAT HARBOUR AR	SHIPROCK AR	WYBUNG HEAD	NORTH HARBOUR AQUATIC EXTENSION	CHOWDER BAY	MAGIC POINT
Research & education	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recreation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Recreational boating	■	■	■	■	partial	■	■	■	■	■	■	■	■	■	■	■
Recreational fishing		■	■	■		■	■	■	line only		■		■	■	■	■
Commercial fishing		■	■				■	■			■		■			■
Conserving heritage & environment	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cruise shipping																
Ports & shipping						■								■		
Boating - commercial & charter (e.g. diving, fishing boats)	■	■	■	■	■	■	■		■		■		■	■	■	■
Water transport services (ferries, water taxis etc.)						■								■	■	
Maritime related activities (e.g. infrastructure, ramps, marinas)			■	■	■	■	■		■			■		■	■	■
Tourism & accommodation	■				■		■									
Coastal urban settlement				■	■	■	■	■	■	■	■	■		■	■	■
Retail & trade			■	■	■	■	■		■			■		■	■	

18 Overview of perceived key threats to environmental benefits

There is a paucity of site-specific data on threats to environmental benefits for the pre-identified sites. A summary of perceived threats common across the pre-identified sites is provided here from the outcomes of community engagement (council meetings and webportal). Detailed community engagement methods and results are reported in 'Summary of Hawkesbury community and stakeholder engagement' (MEMA, 2015a).

18.1 Illegal fishing and hand gathering

Lack of compliance with marine protected area and general saltwater fishing regulations was perceived by the community as one of the most imminent threats to the effectiveness of aquatic reserves and Bouddi National Park Marine Extension for conserving biodiversity and optimising social and economic benefits. This included illegal fishing and collecting, use of illegal fishing gear, harvesting of under-size and protected organisms, and exceeding bag-limits. This view is supported by data from the DPI Fisheries Compliance Operations Branch (2010-2015), and human usage studies at selected sites such as Cabbage Tree Bay (DECC 2008). As aquatic reserves are relatively small in size, even minimal poaching activity can have negative impacts on environmental, social and economic benefits.

Several factors were perceived by the community to contribute to compliance effectiveness including:

- Ineffective communication of aquatic reserve objectives, locations, regulations and boundaries at a local and regional scale.
- Inadequate signage and delineation of boundaries within aquatic reserves e.g. boat-based fishing is problematic due to lack of visible boundaries and requirement for boat-based enforcement.
- Lack of simple and consistent fishing and collecting restrictions across the marine protected area system. For example, 'partial-take' areas (rather than 'no-take') cause particular confusion as they allow harvesting of some species or by some methods, and are conducive to illegal activity such as collecting protected invertebrates for bait within aquatic reserves where line fishing for fin-fish is legal.
- Variation in restricted activities within different parts of some aquatic reserves. For example, Bronte-Coogee and Towra Point Aquatic Reserves contain complex and confusing regulatory provisions, including overlapping fisheries management regulations.
- The remote location and associated reduced levels of public visitation at some aquatic reserves (e.g. Barrenjoey Head, Boat Harbour) and Bouddi Marine Extension can result in reduced levels of community reporting.
- Lack of resources for compliance operations including surveillance technology.

18.2 Legal fishing and hand gathering

Legal fishing and hand gathering was perceived by the community as a threat to environmental benefits at the pre-identified sites. This was particularly the case for eight of the ten aquatic reserves where some fishing and collecting is still permitted. Perceived threats related to:

- Direct removal of organisms and potential flow on effects
- Contribution to marine debris which may impact biodiversity (entanglement, ingestion) and aesthetic values.
- Apparent conflict with the primary objective of aquatic reserves to protect biodiversity, and contribution to lack of simple messaging about the management role of these areas.
- Potential hazards for other in-water recreational users (e.g. swimming and snorkelling versus line-fishing in Clovelly Pool, Bronte-Coogee Aquatic Reserve).
- Conflict with other recreational activities such as snorkelling and scuba diving with the objective of viewing natural biodiversity.

18.3 Recreation, tourism and education

While activities associated with visitation are viewed as a primary community benefit of pre-identified sites, several activities are also perceived as potential threats to biodiversity and the quality of experiences by the community at specific sites.

- Snorkelling, diving, swimming may contribute to wildlife disturbance and habitat damage in some sites where these activities are intense (e.g. Cabbage Tree Bay Aquatic Reserve).
- Educational tours, may contribute to wildlife disturbance and trampling of intertidal habitats at sites frequently visited by large groups (e.g. Long Reef Aquatic Reserve).
- Dogs, particularly when off lead, were viewed as a potential threat to shorebirds and the experience of other users at several sites (e.g. Towra Point, Long Reef, and Boat Harbour Aquatic Reserves).
- Four wheel driving was reported to occur on the beach and rock-platform within Boat Harbour aquatic reserve potentially disturbing shorebirds and damaging habitats.
- Boat anchoring was recognised as a potential threat to habitat for those areas which contained sensitive habitats (e.g. seagrass beds).
- Vessel strike from boating was perceived as a potential threat to little penguins
- Boating is a potential safety hazard to swimmer and divers where the latter activity is intense (e.g. Cabbage Tree Bay Aquatic Reserve).
- All forms of passive recreation contribute to marine debris which may impact biodiversity (entanglement, ingestion) and aesthetic values.

18.4 Land-based impacts

Land-based activities were considered to be a threat to biodiversity, habitats and water quality for pre-identified sites located adjacent to urbanized areas via input of nutrients, organic matter, sediment, toxic pollutants, litter, microplastics and altered runoff and modification of supporting terrestrial habitats. Of particular concern was:

- Current and future urban development within or adjacent to protected areas (e.g. Towra Point, Greenfield development)
- Stormwater runoff
- Point source discharges including sewage treatment plants and sewage overflows (e.g. North Harbour).
- Illegal reclamation
- Lack of sediment controls for development sites
- Lack of compliance activity

18.5 Shark meshing of adjacent beaches

Shark meshing at beaches adjacent to pre-identified sites was identified as a potential threat to marine life, particularly for those which encompass or occur in the vicinity of known greynurse shark habitats (Magic Point, Long Reef).

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