Estuarine habitat mapping and geomorphic characterisation of the lower Hawkesbury river and Pittwater estuaries

K. Astles, G. West and R.G. Creese

Industry & Investment NSW
Port Stephens Fisheries Institute
Locked Bag 1, Nelson Bay, NSW, 2315
Australia

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EXECUTIVE SUMMARY

Hawkesbury Nepean Catchment Management Authority (HNCMA) and the Hornsby Shire Council (HSC) have recently set in place management plans for the lower Hawkesbury estuary (LHE) (Hawkesbury-Nepean Catchment Management Authority, 2008, Haines *et al.*, 2008). To implement these plans it is required to better understand the distribution of estuarine habitats and the potential threats to these habitats from human activity within the LHE. Estuarine habitat mapping and geomorphic characterisation of the lower Hawkesbury River and Pittwater estuaries project was designed to provide some of this information. It consisted of mapping the estuarine habitats and undertaking an ecological risk assessment of human activities on those habitats.

Eight different estuarine habitats were mapped throughout the LHE; seagrass, mangroves, saltmarsh, mudflats, sandflats, rocky reef, foreshore habitat and water column. The macrophyte habitats (seagrass, saltmarsh and mangroves) were mapped comprehensively for the whole of the LHE using a combination of aerial photos and ground surveys. Mudflats and sandflats were mapped from aerial photos but there was not sufficient time to include ground surveys. Rocky reef was mapped using side scan sonar images and aerial photos. Due to the long total shore line length of approximately 570 km and the time consuming mapping process, subtidal reef was not completely mapped in the LHE Foreshore Habitat was mapped for a total of 566 km. This habitat was mapped by a combination of aerial photo interpretation and extensive field validation. Water column was mapped as the total water area within the estuary. This layer was also separated into two main classes of depth less than 5 m and depth greater than 5 m. Areas with a depth of greater than 5 m were considered to represent deep subtidal habitat.

Pittwater had the largest area of seagrass beds including extensive beds of the vulnerable *Posidonia australis*. Mangrove Creek had the largest area of mangrove forest and saltmarsh community. The fluvial delta and riverine channel also had large areas of mangroves. Mooney Mooney Creek had the most extensive areas of mudflats and sandflats were most extensive in Pittwater and the marine reach. Rocky reef that was mapped had the largest areas in the fluvial delta, but due to sampling limitations it may be under-estimated in other areas. The dominant foreshore habitat was Natural Soft and was mostly found in the upper reaches of the estuary including Mangrove Creek, riverine channel Berowra Creek, Fluvial Delta and Mooney Mooney Creek. Natural Horizontal Hard foreshore habitat was predominantly found in the lower portion of the LHE including Cowan Creek and Berowra Creek.

A qualitative ecological risk assessment method previously developed by Industry and Investment NSW (I&I NSW) was used to evaluate the risks from human activities on the estuarine habitats in the LHE. The purpose of the risk assessment was to determine which habitats were at intolerable levels of risk from which human activities and then to identify the issues that need to be addressed if these risks are to be reduced. The LHE was divided into sub-catchments and reaches and the risk assessment was done on each of these separately. This enabled specific issues to be identified for each area. The sub-catchments were Pittwater, Cowan, Berowra, Mangrove, Mooney, Mullet and Patonga. The reaches of the Hawkesbury were the marine delta, fluvial tidal delta and riverine channel. Seven human activities were assessed – recreational fishing, aquatic recreation, foreshore development, stormwater/catchment run-off, sewage, dredging and sedimentation and commercial vessels. Risk assessments of commercial fishing in the LHE had been done separately by I&I NSW under the environmental impact assessment process for commercial fisheries in NSW (NSW Fisheries, 2001, 2002). The results of the EIS for these fisheries were incorporated into this project.

The risk assessment identified substantial knowledge gaps with regard to the magnitude, frequency and duration of various components of many of the human activities. These knowledge gaps themselves contribute to the risk to habitats because the level of stress from these human activities

on habitats could be large but there is insufficient information to appropriately manage them. In particular, knowledge gaps were found in the amount of recreational boating (non-fishing) throughout the LHE, nutrient loads at the sub-catchment and reach scales from stormwater, upper catchment run-off and non-point source pollutants, the proportion of contaminated sediments and subtidal erosion and accretion of sediments around habitat edges.

Habitats that had consistently acceptable levels of risk were saltmarsh, wherever it was present, seagrass in Cowan, Berowra, Mooney and Mullet and mangroves in Cowan and Berowra. However, saltmarsh was identified as a priority habitat in all sub-catchments because it has declined over the last ten years. Similarly, seagrass in Cowan and Berowra was also a priority habitat because of its decline. Seagrass in Cowan includes small patches of the vulnerable species *Posidonia australis*. Management of these two priority habitats should consider whether steps could be taken to enhance their distribution and ensure human activities do not increase in the area where these habitats occur.

Recreational fishing and foreshore development posed an intolerable level of risk to habitats such as seagrasses and mudflats throughout the different sub-catchments and reaches. The most important issue arising from these human activities overall is to examine the extent of the interactions (intensity and location) between these human activities and the habitats (e.g., how many and frequently do recreational fishers fish in these habitats). Where the interactions are most intense, investigation of the condition of those habitats is needed to determine the most effective and efficient use of resources for their management.

The top three recommendations arising from this project were:

a) That a spatial map of the human activities assessed be constructed and incorporated into the habitat maps for each sub-catchment and reach. This would enable the location of habitats to be overlaid with the location of their potential threats.

b) That the condition of habitats that had intolerable levels of risk should be quantified and analysed for any signs of degradation. Quantifying both the condition of a habitat and the stressors potentially affecting it is needed to gain a more accurate assessment of the extent of habitat degradation and its possible causes.

c) That priority habitats with acceptable levels of risk (e.g., saltmarsh) be appropriately managed to ensure stressors from human activities do not increase within the areas they occur.

A possible follow-on from this study could be detailed monitoring of habitats close to human activities that posed an intolerable level of risk and, where these activities are not occurring, to monitor rates of change in these contrasting environments. Helicopter imagery for a similar purpose is currently being developed by I&I NSW to map and monitor locations over time to determine impacts on coastal marine habitats.

HOW TO USE THIS REPORT

The maps in this report should be used as a resource for identifying key estuarine habitats throughout the LHE and the location of many of the human activities with respect to these habitats, particularly foreshore activities. It is important to note that the maps are not a complete representation of every habitat patch and human activity occurring in the LHE. However, they are comprehensive enough to include the majority of habitats especially the macrophyte habitats of seagrass, mangroves and saltmarsh.

The risk assessment of this report should be used to identify which habitats within a sub-catchment or reach are at the greatest risk, which human activities contribute to these intolerable risks, the issues that need to be addressed to reduce risks to acceptable levels and the key knowledge gaps to be filled to support the successful implementation of management plans. It is important to note that the risk summary tables be interpreted cautiously where knowledge gaps are large as the risk levels could be worse than is estimated in some cases. A summation of all risks for each habitat for all sub-catchments and reaches combined should not be attempted because of the high proportion of unknown information in a number of sub-catchments. A summation could either under- or over-estimate the risk levels and could therefore be misleading. However, knowledge gaps should not be interpreted as a reason for not acting to address issues for habitats with intolerable levels of risk as the risk assessment was done in a precautionary frame of reference and therefore these estimates are conservative.

PART A

DATA CONSOLIDATION AND MAPPING

1. INTRODUCTION

The estuarine habitat mapping and geomorphic characterisation of the Lower Hawkesbury River & Pittwater Estuaries project has 6 main objectives:

1. Data consolidation.
2. Identification of the values of estuarine habitats & biodiversity.
3. Risk assessment of key threats to estuarine habitats & biodiversity.
4. Prioritisation of on-ground works required to protect estuarine habitats & biodiversity.
5. Management initiatives and recommendations.
6. Integration into planning instruments, documents and strategies.

The focus of part A is on the first of these objectives and it describes the collation, creation and preparation of spatial data to be used in objectives 2 and 3. The main habitat dataset used here was developed during a preceding project which mapped the macrophyte habitats of NSW estuaries (Creese *et al*., 2009). The data collation process, however, not only draws on this and other pre-existing spatial data, but also presents new data to create a more comprehensive coverage of the estuarine habitats in the Lower Hawkesbury Estuary (LHE).

2. METHODS

2.1. Estuarine Geomorphic zones

A key component of the mapping process was the creation of a layer representing the Estuarine Geomorphic zones as described by Roy *et al.* (2001). The mapping of these zones was dependent on two key data sets: detailed bathymetry and well distributed sediment data. The bathymetric data, provided by DECCW, are comprised of a complex set of bathymetric layers with varied spatial extent and resolution (see example in Figure A.1). As the data were still in the phase of processing and clean up, there were some inconsistencies and artefacts within the data that made it difficult to extract the necessary contour information. Similarly, only a very limited dataset was available from URS Australia Pty Ltd for the sediments in the LHE and this did not have sufficient spatial density to create the necessary substrate layers.

Because neither the substrate nor the bathymetry layer was sufficiently complete to allow derivation of the extent of the estuarine geomorphic zones, a layer representing the Estuarine Geomorphic zones could not be derived. A more generalised geomorphic zonation was developed, however, with the guidance of Rob Williams (pers. comm.) (Figure A.2). Ten distinct zones were created in the LHE: Berowra Creek, Broken Bay, Cowan Creek, Mangrove Creek, Mooney Mooney Creek, Mullet Creek, Patonga Creek, Pittwater, Hawkesbury River – Fluvial Delta and Hawkesbury River – Riverine Channel.

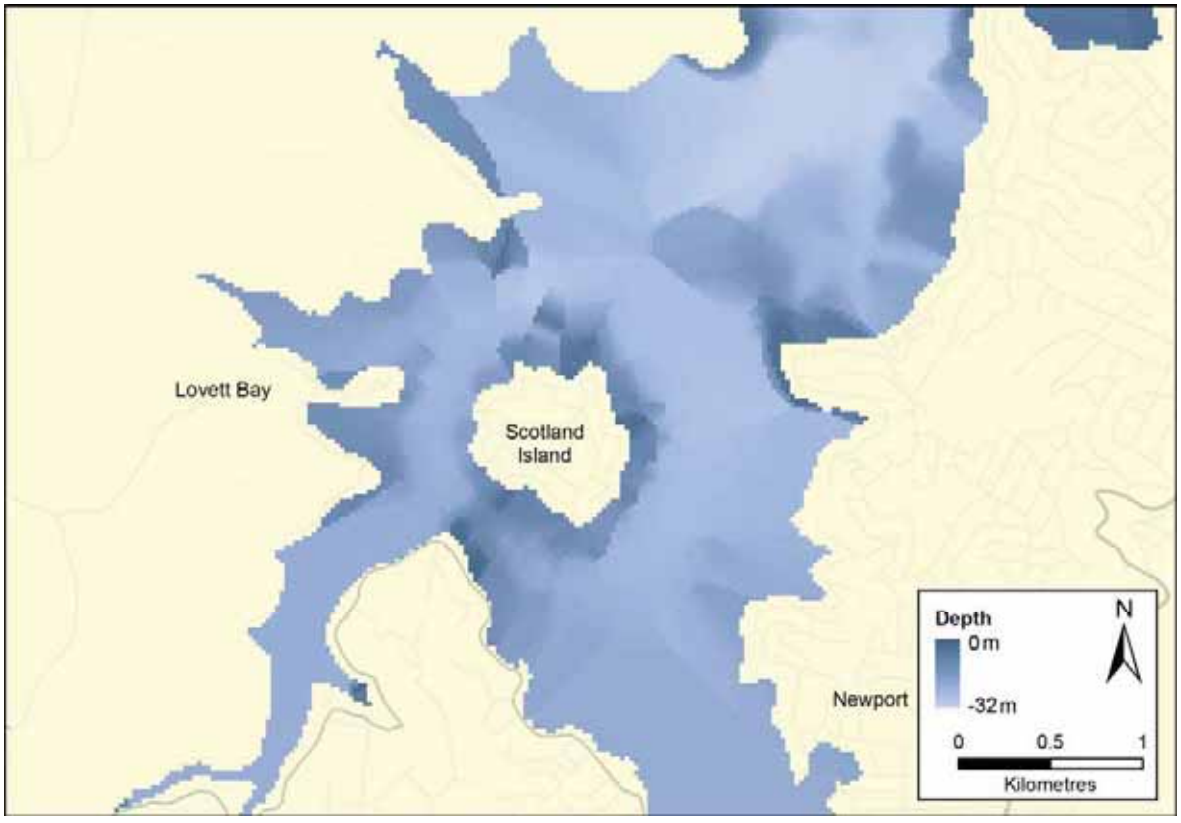

Figure A.1. Detailed gridded bathymetry of Pittwater. This dataset is a composite of several different datasets that vary in spatial extent and resolution.

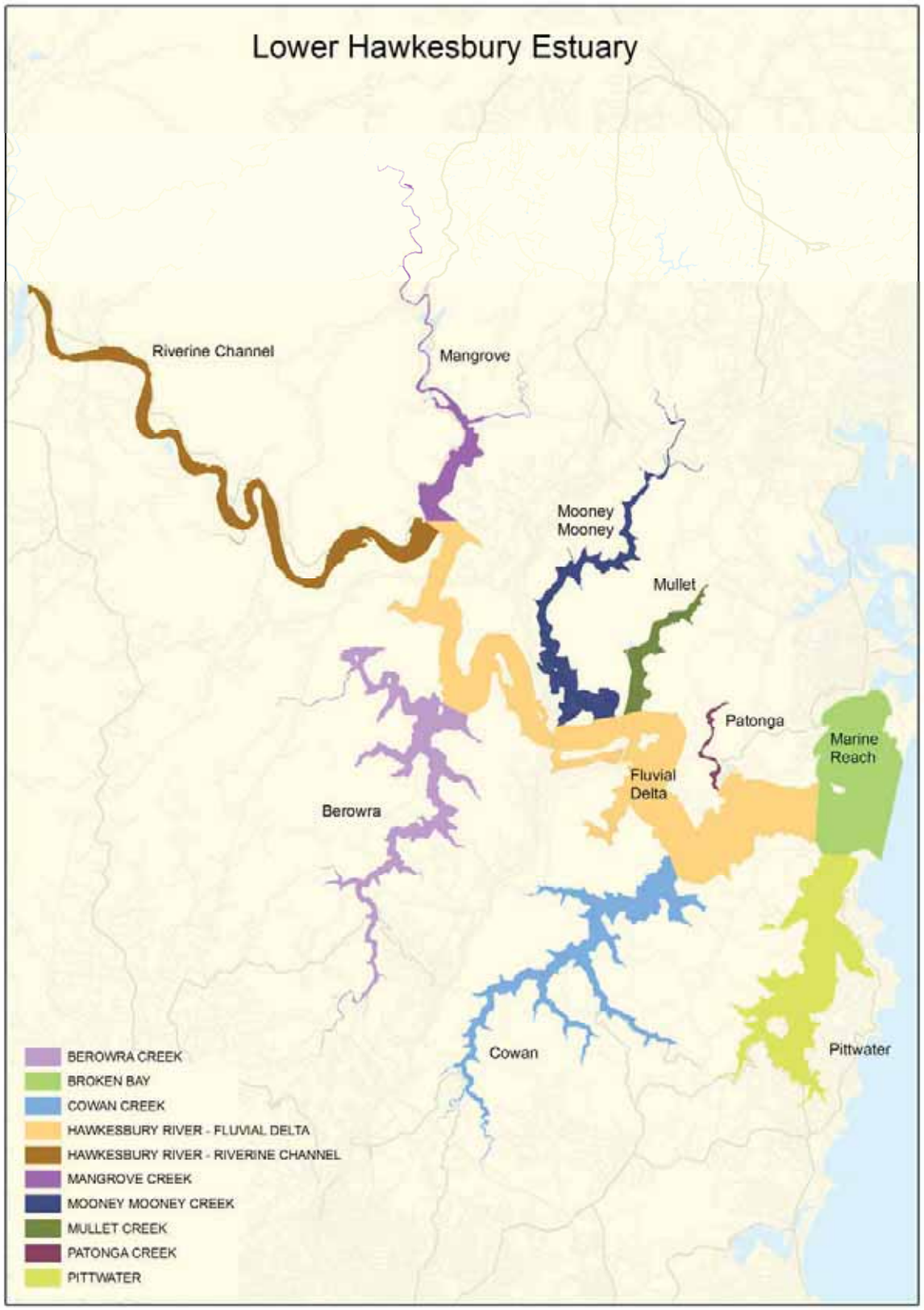

Figure A.2. Estuarine catchments, reaches and general geomorphic zones of the Lower Hawkesbury River.

2.2. Estuarine macrophytes

The distribution of estuarine macrophytes in the LHE has been mapped several times in the past either completely as in West *et al.* (1985) or West and Williams (2001 unpublished) and partially by Williams and Watford (1997), Williams and Watford (1999) and Williams and Thiebaud (2007). The most recent complete mapping was as part of the Seabed Mapping Project (SMP) (Creese *et al.*, 2009).

The macrophyte mapping in this study is an extract from the SMP dataset. The SMP maps were captured from digital aerial imagery in accordance with the standards established for the Comprehensive Coastal Assessment (CCA) (Williams *et al.*, 2007). An outline of the methods are listed below:

- Ortho-rectification of aerial images.
- Onscreen digitising of estuarine macrophyte boundaries at a scale of 1:1500.
- Field validation of initial digitised polygons and boundaries.
- Updating of maps with field data.
- Attribution of all data.
- Checking (and correcting if necessary) the resulting topology.
- Integration of the final layers into I&I NSW's Estuarine Habitat Database.

The habitats mapped are listed in Table A.1. The estuarine macrophytes for the LHE were extracted out of the SMP database and areas were calculated for each subcatchment/reach.

Table A.1. Habitat attributes used in the mapping of NSW estuarine macrophytes (from Creese *et al.*, 2009).

Habitat	Macrophyte
Mangrove	Mangrove
	Mangrove/Saltmarsh
Seagrass	*Halophila*
	Halophila/*Ruppia*
	Posidonia
	Posidonia/*Halophila*
	Posidonia/*Halophila*/*Ruppia*
	Posidonia/*Ruppia*
	Posidonia/*Zostera*
	Posidonia/*Zostera*/*Halophila*
	Ruppia
	Zostera
	Zostera/*Halophila*
	Zostera/*Halophila*/*Ruppia*
	Zostera/*Ruppia*
Saltmarsh	Saltmarsh

2.3. Foreshore habitats

Foreshore habitat mapping, including the mapping of artificial and natural surfaces, had been initiated in the LHE as part of the SMP. The mapping in the SMP covered the foreshore of Patonga, Cowan Creek, Pittwater and Broken Bay (Figure A.3). The mapping in this project is a continuation of the methods developed in the SMP (Creese *et al.*, 2009). The process involves overlaying the Lands Digital Topographic Database coastline onto ortho-rectified digital images and cutting the coast into segments that represent the different foreshore classes listed in Table A.2. The foreshore classes were then validated by field examination or cross referenced to Google Earth imagery if field validation could not be achieved. Examples of the hard surface foreshore classes found in the LHE are in Figure A.4.

Table A.2. Simplified representation of the Intertidal foreshore categories) based on Creese *et al.,* 2009).

Substratum/Habitat	Definition
Artificial rock wall (km)	Typically vertical to 45°, consolidated/structured sandstone blocks, mixed rock, concrete, etc, or unconsolidated rock fill.
Natural Horizontal hard	Flat or sloped solid rock > 15 m long & 2 m wide. Can have deep crevices and rockpools.
Natural Vertical hard	Solid vertical rock > 15 m long & 2 m wide; can have deep crevices.
Natural soft	Natural mangrove foreshore, with muddy sediments. Muddy sediments, no large stands of mangroves, but may have or 1 – 2 small trees. Sandy sediments with no obvious vegetation, very few rocks.
Mixed natural hard	Solid rock and rocks ranging from small pebbles to large boulders. Rocks ranging from small pebbles to large boulders with no solid rock.
Mixed natural hard + natural soft	Sand/mud interspersed with rock.
Riverine veg	Dense brackish riverine riparian vegetation other than mangroves.
Artificial rock wall + natural soft	
Artificial rock wall + natural rock	
Artificial rock wall + natural hard & soft	
Artificial rock wall + mangroves	

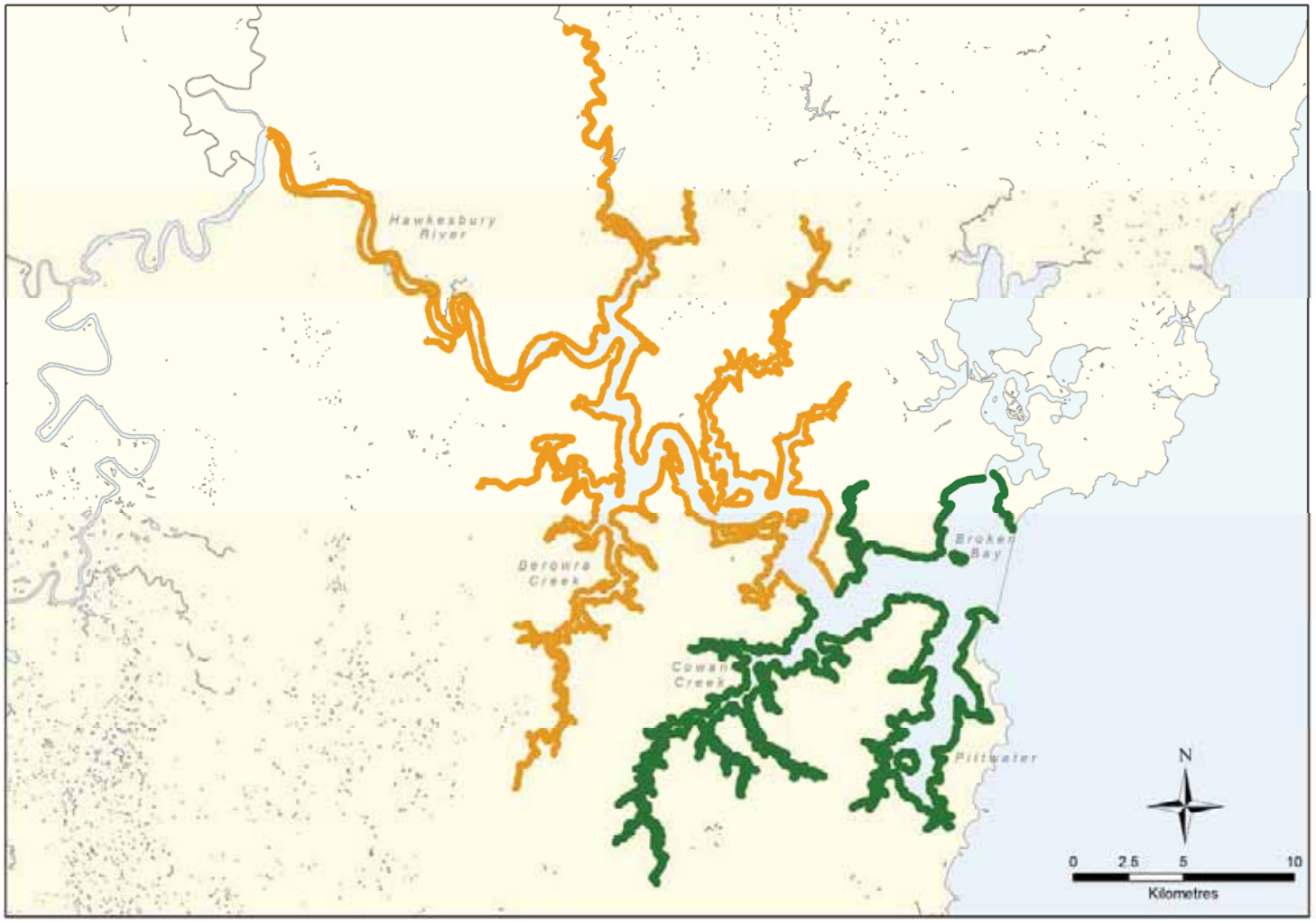

Figure A.3. Extent of shoreline mapped in the Lower Hawkesbury Estuary. Green indicates foreshore mapped during the Seabed Mapping Project and orange is the foreshore mapped during this project.

Figure A.4. Examples of hard surface foreshore habitat in the Lower Hawkesbury Estuary. Natural vertical rock platform (A), natural horizontal rock platform (B), artificial rock walls (C&D).

2.4. Subtidal rocky reef

The mapping of subtidal reefs in the LHE is also a continuation of the SMP pilot. The SMP mapped reef in Pittwater and portions of Cowan creek. The near shore subtidal rocky reef was mapped via two methods; onscreen digitising and Side Imaging Sonar (SIS). Both methods are described in detail in the SMP (Creese *et al.*, 2009) but summarised below.

The first method involves the mapping of reef using onscreen digitising. Reef features are mapped using ortho-rectified imagery at an onscreen scale of 1:1500. Mapped reef areas were validated in the field using a bathyscope and an underwater video system. Mapping using this process is limited by image quality and water clarity and was restricted to the near-shore subtidal reef in Pittwater.

The second method, SIS, was used to add to the mapping already done in Cowan Creek for the SMP, as well as to map, as comprehensively as possible, the reef in the rest of the LHE. The SIS method involves the use of a Humminbird 1197c series Side Imaging Sonar unit connected to a 16 channel GPS to scan the near-shore subtidal reef in depths greater than 5 m. Scans were collected by travelling along the shore with the port side of the boat towards the shallow edge of the shoreline to allow the starboard side of the sonar beam to scan the deeper edge for reef. The boat was travelling at a speed of 4 – 5 knots and the scan width was up to 60 m. The recorded sonar files were downloaded on a PC and recoded to XTF format files. The final converted files were then imported into SonarWizMAP v4 (Chesapeake Technology Inc.). The sidescan data were then

exported to ArcGIS as geo-referenced TIF images. The reef boundaries were then digitised in ArcGIS 9.3 at a scale of 1:1500. All reef polygons were validated in the field using an underwater video system and reef structure was recorded as either: Bedrock, Bedrock/Boulder, Boulder, Cobble, Cobble/Boulder or Ledge. The areas for total reef and reef type were calculated for each subcatchment/reach.

The total recorded area and length of shoreline scanned using SIS were mapped from the geo-referenced TIF images in ArcGIS 9.3. The full extent of these images was mapped via onscreen digitising at a scale of 1:5000 then clipped using ArcTool box with the sub-catchment LHE shapefile to discard unmapped terrestrial areas. The total area and shoreline were calculated for all subcatchments.

2.5. Jetties / marinas

Jetties and marinas are mapped to a very limited extent in the NSW Lands DCDB and the DTDB databases. A review of these databases indicated that the coverage was inconsistent and missing many of the jetties now present within the LHE. Therefore, a new layer was created using digital imagery already within the I&I NSW image library, along with digital imagery provided by the HNCMA. All jetties were manually entered via onscreen digitising in Arcview 9.3 at various scales. The final mapped layer was validated by exporting as a KML file and viewing in Google Earth. Jetties which were not visible in either the digital imagery of Google Earth were added via field mapping.

Marinas were identified using the digital imagery and NSW Maritime Boat Maps. All jetties found to be within a known marina were selected and attributed as part of a given marina. Numbers were reported for each catchment and reach.

2.6. Sand / mud flats

Sand flats and mud flats were mapped within the LHE using high resolution digital imagery provided by HNCMA and by images already in the I&I NSW spatial image catalogue. The mapping of these features was limited by water clarity and tide at the time of image capture. The features mapped, therefore, may not be truly representative of their full extent. Mud flats were mapped as any exposed mud area within the imagery. Sand flats were mapped as any exposed, potentially exposed or shallow sub tidal sand area visible in the imagery. All features were mapped at a scale of 1:5000 using onscreen digitising techniques. Limited field validation was carried out. The areal extent of sand flats and mud flats was calculated for each catchment/reach.

2.7. Water depth

Water depth within the LHE is highly variable and ranges from areas of shallow flats to depths of approximately 30 m. Depth data were provided by DECCW to assist in the creation of a depth classification to divide the estuarine water area into categories of 0 – 5 m and greater than 5 m. Because of the limitation of this dataset (see section 2.1), detailed contour maps could not be produced. Rather, the less detailed NSW Maritime Bathymetric layer was used. While the accuracy of this layer is unknown, it does provide a consistent coverage for the whole LHE thereby allowing the creation of a data layer relatively quickly.

The NSW maritime Bathymetry layer was clipped to isolate the LHE water area and the contour polygons were then dissolved into two depth categories: 0 – 5 m and >5 m. This polygon layer was then merged with the LHE estuary water area. Any discrepancies that resulted from misalignment between the layers were either dissolved to ensure comparative areas or clipped if the polygons

were outside the LHE water area. The resulting layer was then cut into the subcatchment/reaches and the total areas calculated.

2.8. Riverside settlement

Riverside settlement including Recreational parks, Housing/Riverside settlement and unsewered housing blocks were mapped in the LHE using data provided by Hornsby Shire Council, Pittwater Council, Gosford City Council and the NSW Lands Digital Cadastral Database (DTDB). Polygons were selected based on zoning information, proximity to estuary shore and the DTDB feature codes. Areas of each land use type were extracted and reported for each subcatchment/reach.

2.9. Oyster leases

Oyster leases within the LHE were extracted from the I&I NSW Oyster Lease database. The total area of leases for each subcatchment/reach were calculated.

2.10. Navigation aids, moorings and boat ramps

Navigation aids, moorings and boat ramp locations for the LHE subcatchments and reaches were extracted from the 2008 NSW Maritime Moorings and Navigation Aids layer. The resulting subset was spatially associated with each LHE subsection and the number of navigation aids, moorings and boat ramps were then counted for each subcatchment and reach. The number within 10 m of any estuarine habitat type was then determined.

2.11. No wash zones

No Wash Zones were mapped within the LHE using the NSW Maritime Boat Maps numbered 9A and 9B. The No Wash Zones were manually digitised onscreen by cutting the LHE water area layer. The No Wash Zones polygons were extracted from the LHE water layer and the areas calculated.

2.12. Risk assessment data extraction

Data for input into the risk assessment framework (see Part B) involved the extraction of features that were within 10 m of estuarine habitats. Summaries were generated by selecting the features within a 10 m buffer of the estuarine habitats. The data were reported in two ways – either as total number of features (e.g., total number of jetties within 10 m of seagrass) or as total area (e.g., total area of parkland that is within 10 m of seagrass). Summary tables of the extracted data are included in Appendix 1.

3. RESULTS

3.1. Estuarine macrophytes

The total area of seagrass mapped in the LHE was estimated to be 280.72 ha (Table A.3). Seagrass was found in eight of the ten zones with the majority found in the Pittwater subcatchment (185.51 ha). No seagrass was found in Mangrove Creek or Hawkesbury River – Riverine Channel. Mangroves were found in eight of the ten zones in the LHE totalling an area of approximately 1000.52 ha. The majority of the mangrove was found in Hawkesbury River – Riverine Channel (250.31 ha), Hawkesbury River – Fluvial Delta (200.31 ha), Mangrove Creek (195 ha) and Berowra Creek (190 ha). Saltmarsh was also found in eight of the nine sections totalling 290.44 ha. The largest areas were found in Mangrove Creek (126.45 ha) and Hawkesbury River – Riverine Channel (107.15 ha). No mangroves or saltmarsh were mapped in Broken Bay. Figure A.5 is an example of the estuarine macrophytes mapped in Cowan Creek.

Table A.3. Area (ha) of estuarine macrophytes in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Seagrass	Mangrove	Saltmarsh
Pittwater	185.51	17.48	2.68
Cowan	14.13	19.41	3.02
Berowra	3.93	190.29	13.56
Mangrove	0.00	195.54	126.45
Mooney Mooney	0.06	73.21	8.09
Mullet	7.87	6.24	0.94
Patonga	36.84	48.02	9.43
Marine Reach	3.50	0.00	0.00
Hawkesbury River – Fluvial Delta	28.88	200.03	19.12
Hawkesbury River – Riverine Channel	0.00	250.31	107.15
Total	280.72	1000.52	290.44

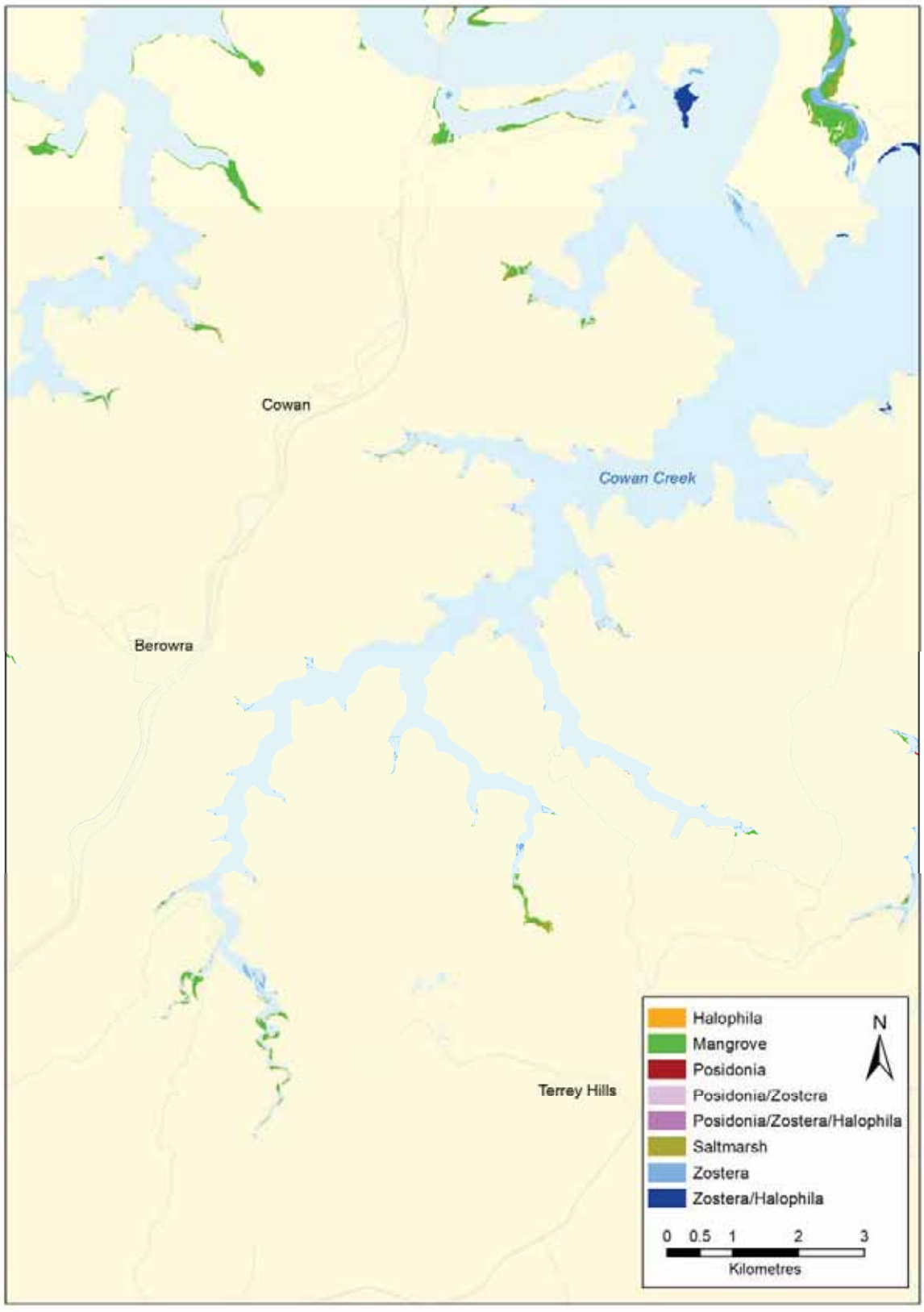

Figure A.5. Estuarine macrophytes of Cowan Creek.

3.2. Foreshore habitat

A total of 566 km of foreshore was mapped in the LHE. A summary of the foreshore classes can be found in Table A.4, and Figure A.6 is an example of the mapped foreshore classes.

The largest component of the mapped foreshore is 'Natural Soft' (238.83 km) mostly occurring in the upper reaches of the estuary including: Mangrove Creek (60.1 km), Hawkesbury River – Riverine Channel (51.736 km), Berowra creek (43.196 km), Hawkesbury River – Fluvial Delta (26.994 km) and Mooney Mooney Creek (26.337 km). A total of 176.948 km of 'Natural Horizontal Hard' and 19.663 km of 'Natural Vertical Hard' habitat were mapped. These two habitats were predominantly found in the lower portions of the LHE including Cowan Creek and Berowra Creek. Artificial rock wall was found in all sections other than Broken Bay.

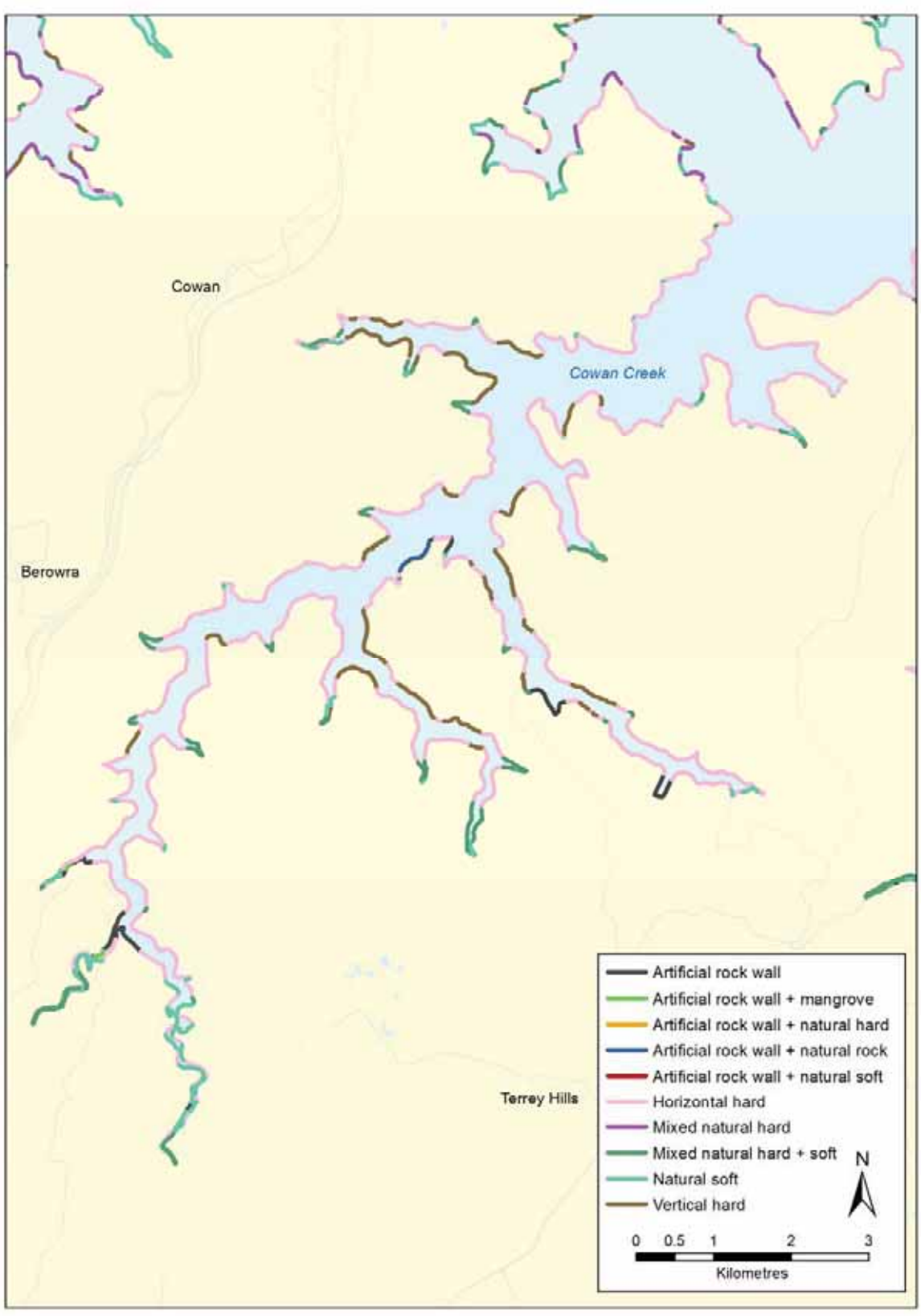

Figure A.6. Foreshore habitats of Cowan Creek.

Table A.4. Length (km) of intertidal foreshore habitats mapped for each Lower Hawkesbury Estuary section.

Subcatchment/Reach	Pittwater	Cowan	Berowra	Mangrove	Mooney Mooney	Mullet	Patonga	Marine Reach	Hawkesbury River – Fluvial Delta	Hawkesbury River – Riverine Channel	Total
Artificial rock wall	19.203	4.012	3.628	0.186	0.256	0.49	0.118	0	3.194	1.02	32.107
Riverine veg	0	0	0.008	0.098	0.005	0	0	0	0	0.049	0.16
Natural Horizontal hard	14.754	63.225	26.664	0.35	17.726	10.152	1.91	7.796	32.381	1.99	176.948
Natural Vert hard	0.085	12.076	4.428	0	0.103	0.04	0	0.593	1.532	0.806	19.663
Natural soft	11.001	9.12	43.196	60.102	26.337	1.682	4.947	3.721	26.994	51.736	238.836
Mixed natural hard	0.12	0	18.318	0	7.821	2.133	2.389	0	11.464	9.072	51.317
Mixed natural hard + soft	3.665	8.678	2.941	0.2	5.933	1.664	0.263	0.459	5.233	0.111	29.147
Artificial rock wall soft	2.512	0	0	0.646	1.071	0.056	0.022	0	1.303	0.355	5.965
Artificial rock wall + natural rock	1.937	0.391	0.297	0	0.098	0	0.187	0	0.857	0.049	3.816
Artificial rock wall + natural hard & soft	1.065	0	1.053	0	0	0.137	0	0	2.483	0	4.738
Artificial rock wall + mangroves	0.348	0.208	0	0.128	0.41	0.13	0	0	1.583	0.221	3.028

3.3. Subtidal rocky reef

The nearshore rocky reef layer for the LHE was derived from SIS (see example in Figure A.7), except for Pittwater (see section 2.4). A total of 80.4 ha of rocky reef habitat was mapped. The area surveyed and reef habitat mapped for each subcatchment/reach is listed in Table A.5. The majority of the reef was found in the Fluvial Delta (27.73 ha) and Broken Bay (24.06 ha). Patonga Creek, Mullet Creek and Mangrove Creek were not surveyed for sub tidal reef as the water was too shallow to scan. The dominant reef types were Bedrock/Boulder (38.76 ha), Boulder (25.14 ha) and Bedrock (10.37 ha). Figure A.8 shows the total area in which SIS surveys were conducted and Figure A.9 shows the total reef mapped using both methods.

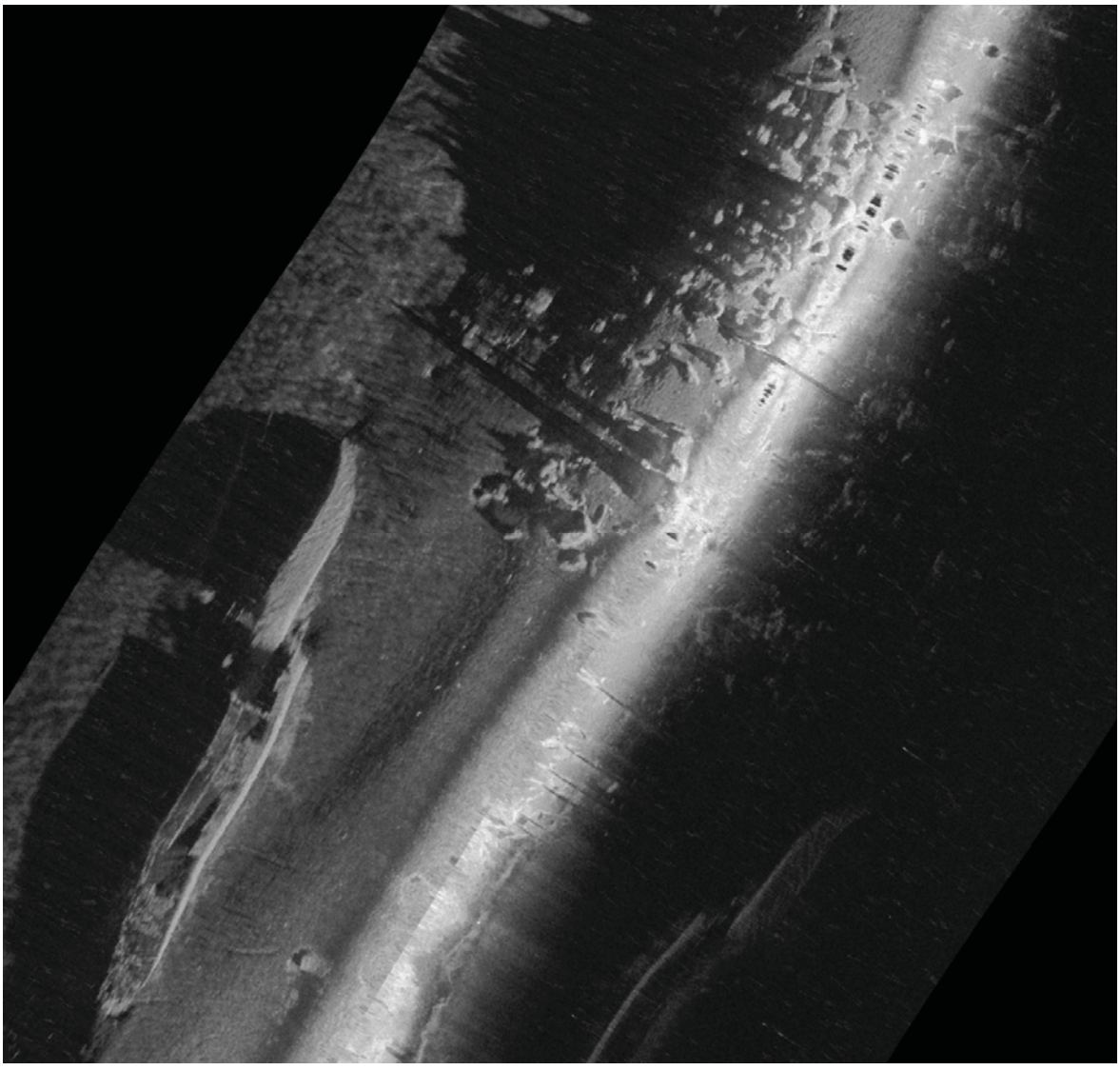

Figure A.7. Side scan imagine sonar (SIS) image showing an example of a boulder dominated reef alongside a ship wreck in the LHE.

Table A.5. Summary of subtidal reef mapping in the LHE including: estimated length of shore sampled, area (ha) covered by the Side Imaging Sonar (SIS) and total amount of reef (km) found.

Estuary	Bedrock	Bedrock/Boulder	Boulder	Cobble	Cobble / Boulder	Ledge	Total Reef	Total SIS	Total Shoreline (km)
Berowra			0.25			0.23	0.48	34.13	2.25
Marine Reach	2.50	13.50	8.06				24.06	94.38	3.37
Cowan	1.45	0.15	3.85			1.56	7.00	228.63	28.53
Mooney Mooney	0.06	0.07			0.09	0.02	0.23	7.11	1.74
Pittwater	0.14	2.80	6.86	0.89	0.36		11.05	8.85	0.70
Hawkesbury River – Fluvial Delta	6.20	15.46	3.29	1.53	1.21	0.04	27.73	296.17	28.84
Hawkesbury River – Riverine Channel	0.02	6.79	2.83				9.63	70.39	9.9
Total	10.37	38.76	25.14	2.42	1.66	1.85	80.20	739.66	75.33

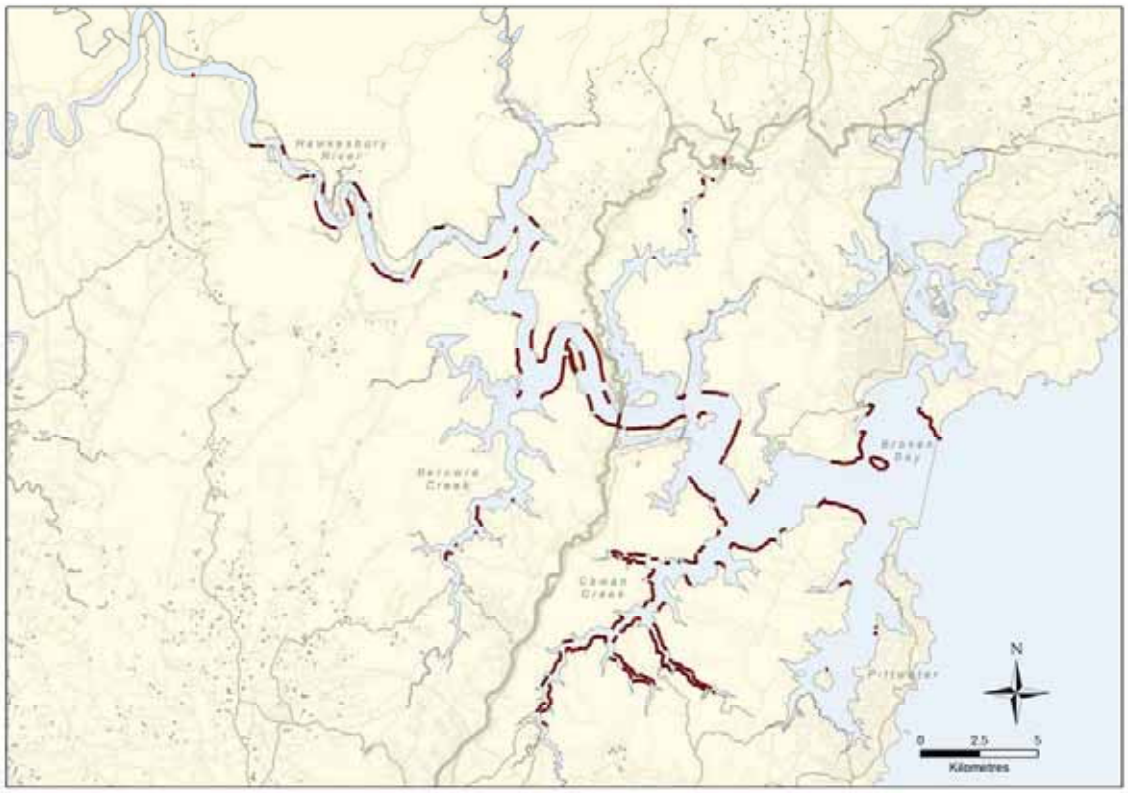

Figure A.8. Areas in the Lower Hawkesbury Estuary where Side Imaging Sonar was conducted.

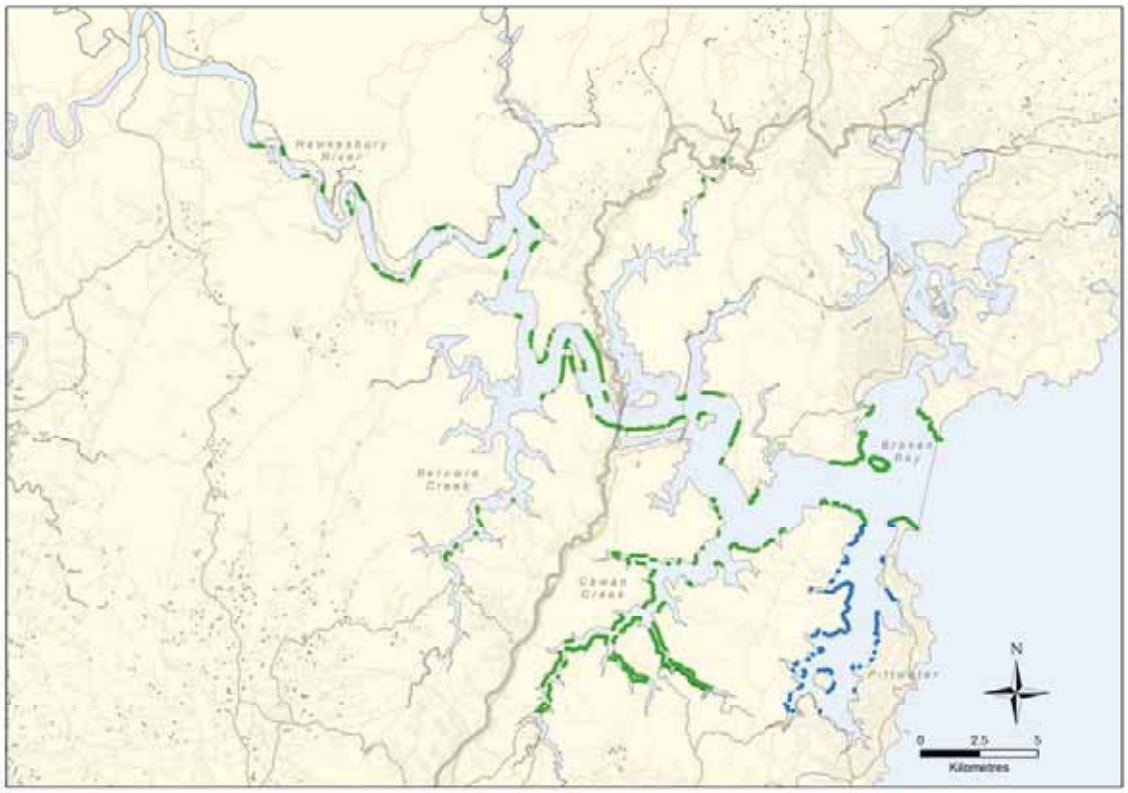

Figure A.9. Areas of subtidal near-shore reef mapped in the Lower Hawkesbury Estuary. Blue indicates areas mapped via onscreen digitising, green is reef mapped via Side Imaging Sonar.

3.4. Jetties and marinas

The total number of jetties mapped in the LHE was 1371 (Table A.6). Almost half of these were found in Pittwater (677). A total of 318 were found in the Fluvial Delta and 167 in Berowra. No jetties were mapped in the Marine Reach. The total number of marinas mapped was 16 with nine of these occurring in Pittwater (Figure A.10).

Table A.6. Marinas and wharves/jetties mapped in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Marinas (No.)	Wharves/jetties (No.)
Pittwater	9	677
Cowan	3	49
Berowra	2	167
Mangrove	0	34
Mooney Mooney	0	48
Mullet	0	2
Patonga	0	15
Marine Reach	0	0
Hawkesbury River – Fluvial Delta	2	318
Hawkesbury River – Riverine Channel	0	61
Total	16	1371

3.5. Sand/mud flats

Sand and mud flats were mapped for the whole LHE where imagery allowed. A total of 633.78 ha of mud flats was mapped (Table A.7). The majority of these occurred in Mooney Mooney Creek (270.6 km), Fluvial Delta (120.671 ha), and Berowra Creek (149.81 ha). No mud flats were mapped in Pittwater (Figure A.11), Cowan Creek or Broken Bay. Sand flats were mapped in 6 sections in the LHE totalling 336.18 ha, the majority being found in Broken Bay (92.104 ha), Pittwater (88.154 ha) Cowan (77.189 ha) and Berowra Creek (64.956 ha). No Sand flats were mapped in Mangrove Creek, Mooney Mooney Creek, Mullet Creek or Riverine Channel.

Table A.7. Total area of mud/sand flats mapped in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Mud flats (ha)	Sand flats (ha)
Pittwater	0	88.154
Cowan	0	77.189
Berowra	149.81	64.956
Mangrove	46.661	0
Mooney Mooney	270.654	0
Mullet	27.278	0
Patonga	4.039	4.777
Marine Reach	0	92.104
Hawkesbury River – Fluvial Delta	120.671	9.007
Hawkesbury River – Riverine Channel	14.676	0
Total	633.789	336.187

3.6. Water depth

The total water area of the LHE is approximately 13,357 km^2. Shallow water accounts for 7355.7 km^2 of the total water area and deep subtidal accounts for the remaining 6001.9 km^2 (Table A.8). Figure A.11 shows the distribution of water depth in Pittwater.

Table A.8. Water depth in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Shallow <5 m	Deep subtidal >5 m
Pittwater	597.96	1241.186
Cowan	297.36	1038.1
Berowra	1263.051	36.516
Mangrove	449.056	10.456
Mooney Mooney	798.5	1.112
Mullet	293.455	3.554
Patonga	60.491	0
Marine Reach	263.976	1450.452
Hawkesbury River – Fluvial Delta	2657.931	1691.755
Hawkesbury River – Riverine Channel	673.906	528.848
Total	7355.686	6001.979

3.7. Riverside settlement

Recreational parks were located in seven of the ten estuarine sections in the LHE, with a total shore frontage of 29.434 ha. The majority, some 15.725 km is found in Pittwater. No Recreational parks were identified in Mangrove Creek, Mooney Mooney Creek or Mullet Creek. A total of 57.268 km of shore frontage is Housing/Riverside settlement. There are 1982 unsewered housing blocks with most of these in the Fluvial Delta or Pittwater. An example of riverside housing for Pittwater is shown in Figure A.11.

Table A.9. Recreational parks and Riverside settlement in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Recreational parks (km)	Housing/Riverside settlement (km)	Unsewered Housing Blocks (No.)
Pittwater	15.725	23.725	407
Cowan	1.429	1.026	29
Berowra	0.053	5.428	229
Mangrove	0	3.847	131
Mooney Mooney	0	3.775	269
Mullet	0	0.739	24
Patonga	0.39	1.366	113
Marine Reach	3.739	0	0
Hawkesbury River – Fluvial Delta	6.02	12.718	584
Hawkesbury River – Riverine Channel	2.078	4.644	196
Total	29.434	57.268	1982

3.8. Oyster leases

Oyster leases are found in six of the LHE sections: Berowra Creek, Mangrove Creek, Mooney Mooney Creek, Mullet Creek, Patonga and the Fluvial Delta. A total of 311 oyster leases was identified totalling 417.751 ha (Table A.10). The majority of the leases are found in Mooney Mooney Creek (105) and Fluvial Delta (104). Whilst Berowra Creek has 57 leases the area occupied is 82.005 ha, similar to that in the Fluvial Delta which has 104 leases. Pittwater, Cowan Creek and Broken Bay and The Riverine Channel have no oyster leases.

Table A.10. Oyster leases in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Oyster Lease (No.)	Oyster Lease (ha)
Pittwater	0	0
Cowan	0	0
Berowra	57	82.005
Mangrove	3	2.889
Mooney Mooney	105	149.464
Mullet	30	76.247
Patonga	12	13.479
Marine Reach	0	0
Hawkesbury River – Fluvial Delta	104	93.668
Hawkesbury River – Riverine Channel	0	0
Total	311	417.751

3.9. Navigation aids, moorings and boat ramps

There are a total of 20 boat ramps, 4447 moorings and 246 in-stream navigation aids in the LHE (Table A.11). The majority of the boat ramps occur in Pittwater (5), Fluvial Delta (5) and the Riverine Channel (5). Of the 4447 moorings mapped, 3174 occur in Pittwater and 659 in the Fluvial Delta. The Fluvial Delta has the largest number of navigation aids with 83, followed by Pittwater with 61 and Cowan Creek with 24 (Figure A.10).

Table A.11. Boat ramps, Moorings and navigation aids in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Boat ramps (No.)	Moorings (No.)	Navigation aids (No.)
Pittwater	5	3174	61
Cowan	2	201	36
Berowra	1	223	15
Mangrove	1	24	5
Mooney Mooney	0	50	9
Mullet	0	0	0
Patonga	1	57	0
Marine Reach	0	1	16
Hawkesbury River – Fluvial Delta	5	659	83
Hawkesbury River – Riverine Channel	5	58	24
Total	20	4447	249

3.10. No wash zones

A total of 9 No Wash Zones (NWZ) were mapped. There is one NWZ that occurs at the boundary between the Fluvial Delta and Riverine Channel. The Zone was split to allow for the calculation of the water area per section that fell within a NWZ. The total area of NWZ is 27.797 km^2, Pittwater has the largest single NWZ with an area of 10.094 km^2. The Fluvial Delta has 4 NWZ and Cowan Creek has three (Figure A.11). Pittwater and Berowra Creek each have one.

Table A.12. No Wash Zones in the Lower Hawkesbury Estuary.

Subcatchment/Reach	Count	Water Area (km^2)
Pittwater	1	10.094
Cowan	3	4.451
Berowra	1	6.393
Mangrove	0	0
Mooney Mooney	0	0
Mullet	0	0
Patonga	0	0
Marine Reach	0	0
Hawkesbury River – Fluvial Delta	4*	6.472
Hawkesbury River – Riverine Channel	1*	0.386
Total	10	27.797

** One No wash Zone crossed over the boundary between the Fluvial Delta and the Riverine Channel. It was split to allow the calculation of area in each section.*

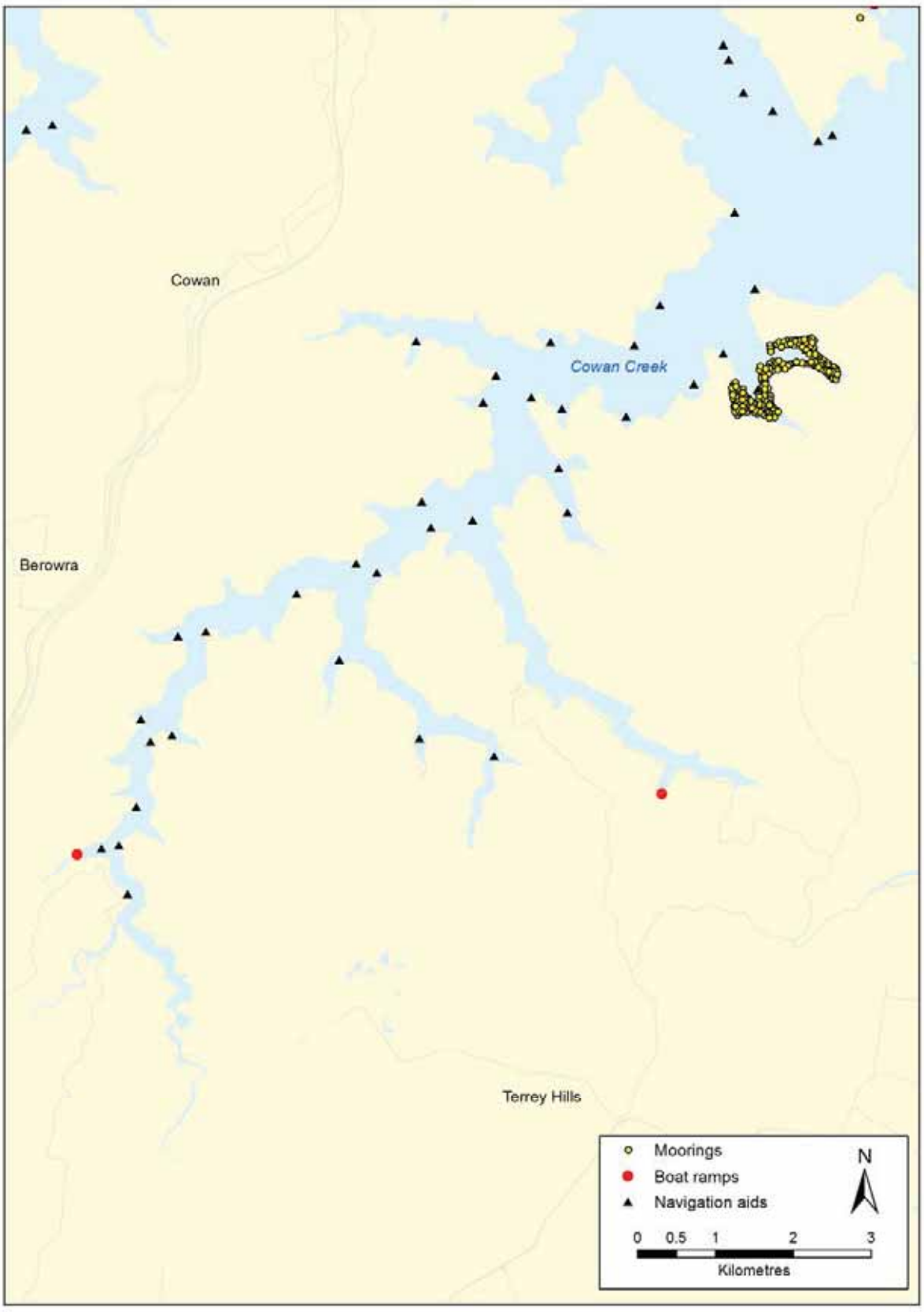

Figure A.10. Boat ramps, moorings and navigation aids in Cowan Creek.

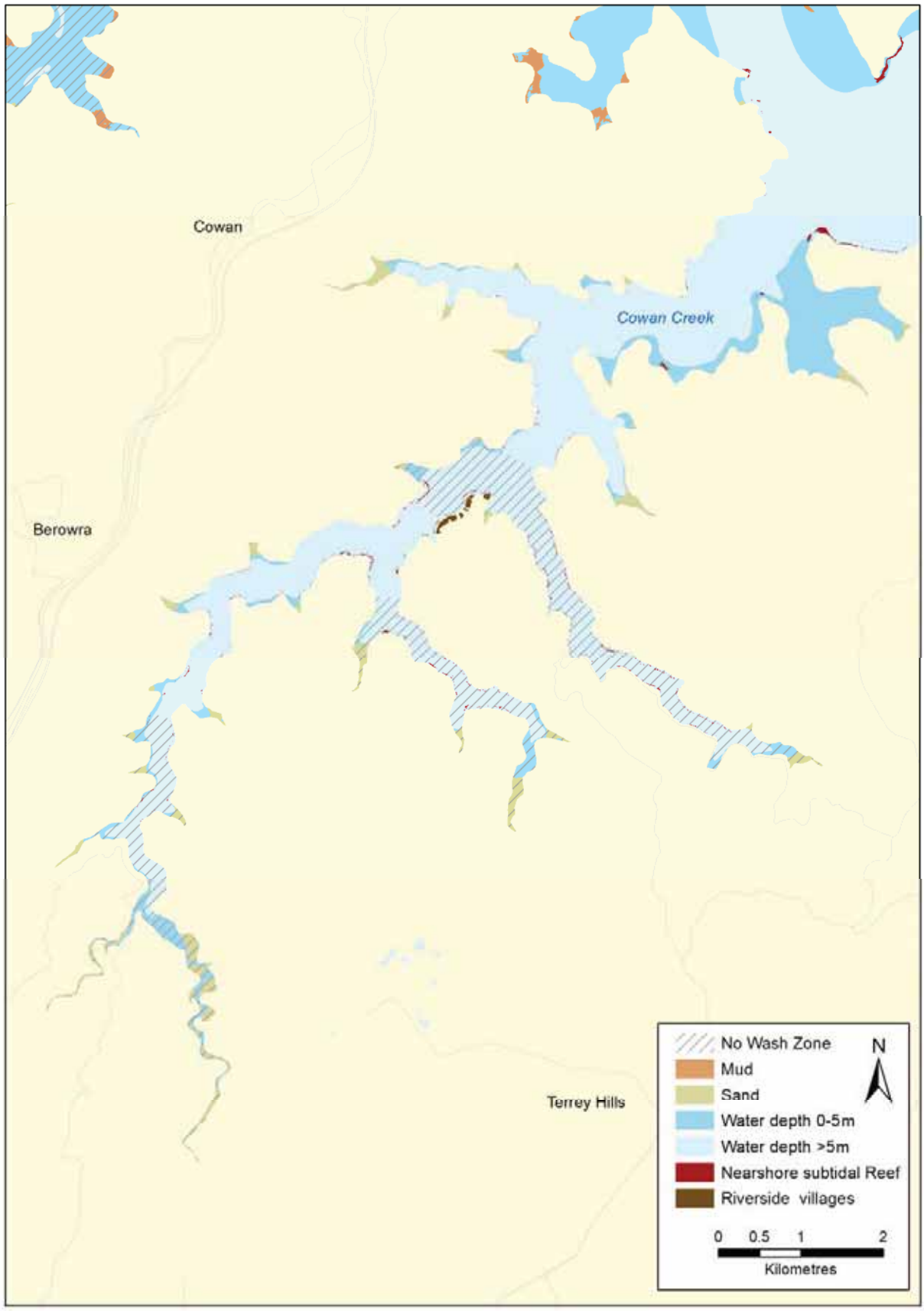

Figure A.11. Subtidal sand flats, No Wash Zones, water depth, Riverside housing and Subtidal Reef in Cowan Creek.

PART B

QUALITATIVE ECOLOGICAL RISK ASSESSMENT OF HUMAN DISTURBANCES ON ESTUARINE HABITATS

K.L. Astles

4. INTRODUCTION

This part of the report is the qualitative ecological risk assessment of the estuarine habitats in the lower Hawkesbury estuary (LHE). It aims to provide information to help prioritise natural estuarine resource issues within the Hawkesbury Nepean region and guide rehabilitation efforts to where it is most essential. This information will assist Hornsby Shire Council (HSC) in implementing the Lower Hawkesbury Estuary Management Plan (Haines *et al*., 2008) and the Hawkesbury Nepean Catchment Management Authority (HNCMA) to implement the Catchment Action Plan (Hawkesbury Nepean Catchment Management Authority, 2008). It will also assist other councils and natural resources managers with jurisdictions in the area to identify issues for habitat management.

4.1. Ecological value of estuarine habitats

The risk assessment focused on the ecological value of estuarine habitats. Ecological value was defined as the contribution a habitat makes to allow assemblages of organisms and ecological and biogeophysical processes to function within their natural ranges (Farber *et al.*, 2002). Therefore, value was defined from the perspective of the natural or non-human components of the environment and excluded human-orientated values such as economic worth and social amenity. These latter values, whilst important, were not considered because their determination was beyond the resources and timeframe of this project.

The major ecological values of estuarine habitats are summarised in Table B.1. The relative contribution of each estuarine habitat to these ecological values is dependent on the habitat characteristics. These habitats, either directly or indirectly, are collectively required to enable an estuary to function within its natural ranges. Hence, all habitats within the LHE were considered to have equal ecological importance.

Table B.1. A list of some of the main ecological values of estuarine habitats.

Ecological Value	Description
Refuge	Refuge for organisms from effects of other processes such as predation or tidal flows.
Nursery	Suitable sites for growth of larvae and juveniles of organisms.
Settlement/spawning site	Suitable sites for laying eggs, larval metamorphosis, development.
Food supply	Direct provision of food for plankton to vertebrate organisms.
Water quality improvement	Cycling of nutrients and other biogeochemical processes.
Contribution to trophic network	Direct and indirect provision of food throughout a complex network of ecological relationships.
Substratum stability	Root and rhizome structures stabilise sediments in the substratum.
Connection with other habitats	Provision of sources and sinks of organisms at different stages in life cycle, provision of patches of habitat between habitat types, circulation and provision of nutrients among habitats.
Water flow modification	Physical structure of habitat alters tidal and catchment flows at larvae and small spatial scales.
Self maintenance	Ability to reproduce itself, growth, distribution and spatial expansion or contraction.

The relative importance of one habitat type over another in terms of its contribution to the overall natural functioning of the estuary could not be determined (Roberts *et al.*, 2003). Estimating relative value requires assigning a level of importance to the functionality a habitat has for its range of organisms compared to those in other habitats. Estuarine ecosystems are ecologically very complex and the linkages and roles between habitats, processes and assemblages of organisms are still being unravelled especially for Australian estuaries (e.g., Gillanders, 2007; Scanes *et al*., 2007). Consequently, there is little scientific basis on which to assign relative importance to one habitat compared to another.

5. METHODS

5.1. Qualitative ecological risk assessment

A qualitative ecological risk assessment method has been developed by I&I NSW (formerly Department of Primary Industries) and used in the environmental impact statements for all commercial fisheries in NSW (Astles, 2008; Astles *et al.*, 2006; Astles *et al.*, 2009). It is consistent with the AS/NZS 4360. The method included the risk assessment of marine habitats. This method has been adapted to be used here to assess the risk to estuarine habitats in the LHE.

Risk assessment is one main component of an overall process called risk analysis (Figure B.1). Risk assessment consists of four stages – risk context, risk identification, risk characterization and issues arising. 'Risk context' defines the undesirable event and the spatial and temporal extent of that event. The undesirable event is the consequence that stakeholders (e.g., HSC, HNCMA) want to avoid or mitigate. 'Risk identification' categorises the habitats and generates a list of the sources of risk, i.e., potential threats to the habitats from human activities. 'Risk characterization' estimates the likelihood that the sources of risk (i.e., threats) identified in the previous stage will cause the undesirable event defined in the risk context. This forms the main part of the risk assessment component and has a series of steps, explained in detail below. 'Risk characterisation' assigns a level of risk to each estuarine habitat type. 'Issues arising' are things that resource managers need to address in order to reduce the risk to these habitats suffering the unwanted consequences from a pre-determined range of human activities. These issues are then fed into the risk management component of risk analysis.

Therefore, there are two main outputs of the qualitative ecological risk assessment for each estuarine habitat – a level of risk for each of the human activities that could affect each habitat and the issues that contribute to a habitat being at risk. These issues then form the basis of management action to reduce the risks to these habitats.

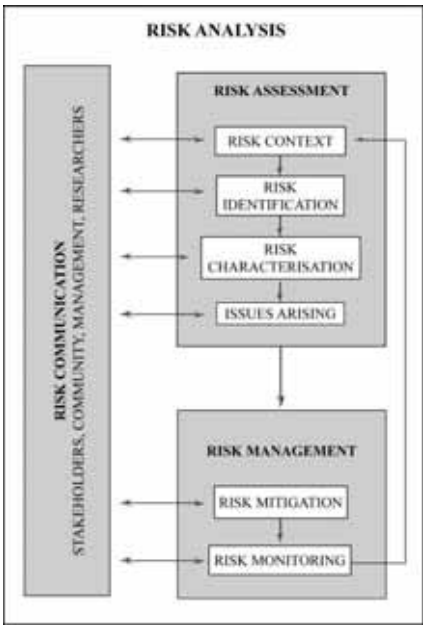

Figure B.1. Framework for qualitative ecological risk analysis of estuarine habitats.

5.2. Determining the level of risk for estuarine habitats in the Hawkesbury

The level of risk for a habitat is based on two primary factors – the overall level of threat to a habitat from a human activity and the ability of a habitat to withstand this overall threat, known as its vulnerability. Thus, overall threat is based on human activities and vulnerability is determined by the biological characteristics of habitats and cannot be changed by human intervention. These two primary factors are combined in a risk matrix from which one of three risk levels are determined – intolerable, tolerable and acceptable risk (Figure B.2). These three levels were based on those used in the HSC Lower Hawkesbury estuary management plan (Haines *et al*., 2008). The risk matrix is designed so that, as managers addresses issues that are effective in reducing the overall threat to a habitat, the level of risk will also be reduced. In this way management action can be directly linked to the level of risk to a habitat with the aim of moving habitats with intolerable levels of risk to tolerable or acceptable levels.

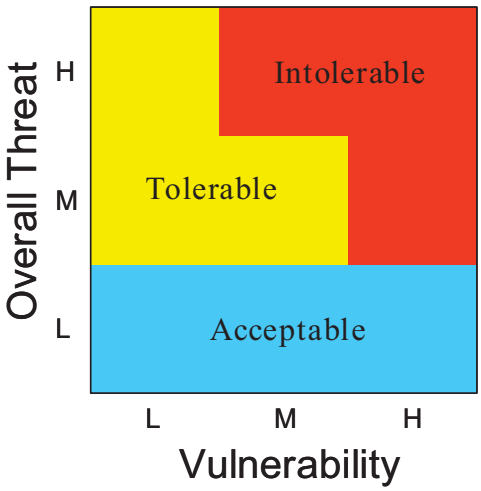

Figure B.2. Risk matrix for determining the level of risk (intolerable, tolerable and acceptable) for each habitat. L – low, M – medium, H – high.

Habitats with high vulnerability are likely to be more affected by a potential threat than those with low to medium vulnerability. Therefore, it was considered that even a medium overall threat level to a habitat with high vulnerability could be severely degraded. This was reflected in the risk matrix in which a greater proportion of the intolerable risk level was allocated to habitats with high vulnerability. Such an allocation directs management to put a high priority on those actions which reduce threats to a low level to better protect these more vulnerable habitats.

The vulnerability of a habitat is a combination of its resistance, the ability to withstand a disturbance, and its resilience, the ability to recover from a disturbance (Underwood, 1989; Minchinton, 2007). Resistance and resilience are based on a habitat's biological, ecological or geomorphological characteristics (Minchinton, 2007). These characteristics can be either susceptible or not susceptible to making a habitat vulnerable to human disturbances. Thus a susceptible characteristic makes a habitat either less able to withstand a physical disturbance or less able to recover from a disturbance within the timeframe set by the risk context. A set of decision rules (Tables B.8-14) for each characteristic determines whether it is susceptible or not. The number of susceptible characteristics sets the level of resistance or resilience as high, medium or low. Vulnerability is then determined by plotting the resistance and resilience levels on a vulnerability matrix (Figure B.3).

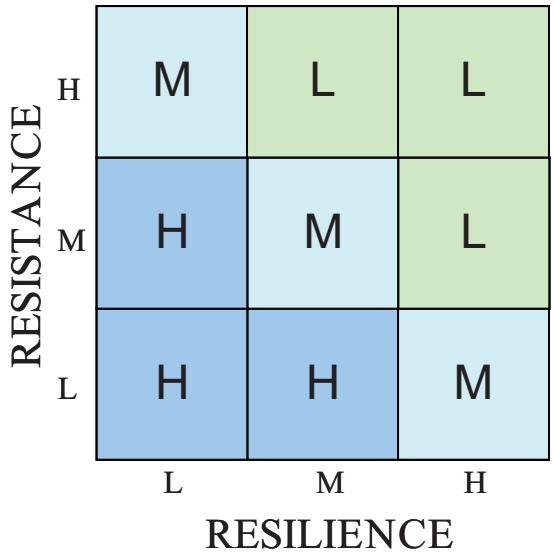

Figure B.3. Vulnerability matrix used to determine the level of vulnerability of a habitat. L – low, M – moderate, H – high.

The overall threat to a habitat from a human activity was determined by examining the relationship between the pressure, its stressors and the potential outcomes (Scanes *et al.*, 2007) (Figure B.4). Pressures are the human activities that are known to occur within the estuary, such as aquatic recreation. Stressors are the factors of an activity that potentially result in a change in some aspect of a habitat. For example, stressors from aquatic recreation could include anchoring, trampling and gross pollutants (i.e., rubbish disposal). Potential outcomes are the changes that could occur in a habitat as a result of its interaction with the stressors. For example, an outcome from trampling could be compaction of sediment on a mudflat or partial physical damage to mangrove roots in a mangrove forest (Ross, 2006). For the purposes of the risk assessment an outcome was limited to a habitat being either susceptible or not susceptible to a stressor causing a change to some aspect of its biological, ecological, geomorphic or physicochemical properties. The susceptibility of a habitat being affected by a stressor was determined by the level of potential interaction with the stressor and the size of the stressor (e.g., magnitude, frequency, duration). The level of potential interaction was based on the total aerial cover of a habitat within a sub-catchment or reach. The greater the aerial extent the more likely it will encounter a stressor.

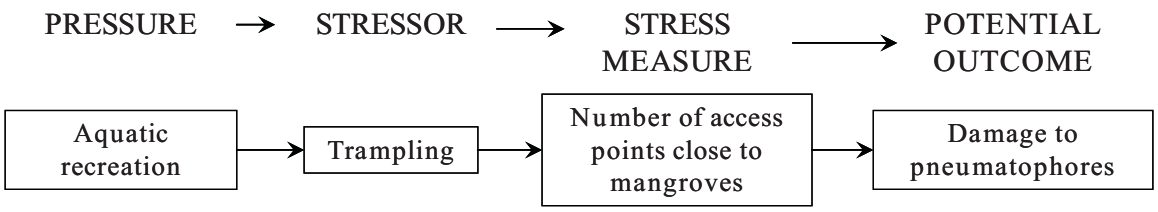

Figure B.4. Relationship between pressure, stressor, stress measure and potential outcome and an example for aquatic recreation.

Each stressor had a measure of its magnitude, duration, frequency and/or distribution depending on the level of data and information available within the timeframe of the risk context. Some of these measures were indirect because of a lack of specific data. For example, the number of recreational foreshore parks within 10 m of a habitat was an indirect measure of the stressor for trampling. A more direct measure of this stressor would have been the number of people walking through a habitat over a specified period of time. But information at this level of detail is rarely available across a sub-catchment or whole estuary, so indirect measures must be used. Decision rules were set for each measure of a stressor to determine whether a habitat was susceptible or not susceptible (Tables B.8-14). The overall threat level was determined by summing the number of stressors that each habitat was susceptible to for each human activity.

5.3. Sub-catchment and habitat characteristics

In order to separate differences among the sub-catchments and river reaches a set of standard characteristics for each area was identified. These characteristics included water surface area, percentage of urbanised/industrial land, which of the human activities occur in the area, presence of threatened estuarine species or communities and presence of non-native invasive species. The percentage of urbanized land area, presence of vulnerable/endangered species or ecological communities (as per state or federal legislation) and presence of non-native invasive species were used to give a priority rating to the sub-catchment (Table B.2). The priority rating is to be used to alert management agencies to the level of importance of addressing the issues that arise in the risk assessment for a particular sub-catchment or reach. The higher the priority the more important it is for issues to be addressed. Thus management agencies with several sub-catchments and reaches within their jurisdiction can more easily determine where their efforts are most needed.

Table B.2. Catchment priority rating criteria and levels.

Characteristic questions	Priority rating	Criteria based on answers to characteristic questions
i) Are vulnerable / endangered ecological communities present?	C1	Yes for i), ii), iii)
ii) Are non-native invasive species present?	C2	Yes for i) & ii) or iii)
iii) Is the percentage of urbanised/industrial ≥20%?	C3	Yes for i) or iii)

A further way differences among sub-catchments and reaches were distinguished was by a broad characterization of the estuarine habitats present in each area. These characterizations included the area of each habitat, percentage of water surface area of each habitat and whether it is known that the habitat has declined in the past ten years (as per Williams and Thiebaud, 2007). The latter characteristic was used to give a priority rating to each habitat. This priority rating is used to alert management agencies to the level of importance in addressing issues for particular habitats within a sub-catchment or reach.

5.4. Assumptions and limitations

5.4.1. Press, pulse and ramp disturbances and responses

Two factors that need to be taken into account when assessing the risks to habitats is the way human activities act as disturbances and the way habitats respond to these disturbances. Human activities in estuaries may act as disturbances in two main ways – short term (pulse) in which the human activity occurs for a discrete period and then stops, continuous (press) in which the activity does not stop (Underwood, 1989) or ramp in which a disturbance steadily increases over time and may or may not stop (Lake, 2000). Any one human activity may produce both short term or continuous disturbances. For example, a stormwater outlet may produce a continuous disturbance during periods of consistent rain events but a short term disturbance from a storm event during a dry period. Similarly habitats may have a short term response or a continuous one to these disturbances. For example, a propeller from an outboard motor may destroy part of a seagrass bed where it passes through but the seagrass is able to regrow. This is a short term response. However, an alternative response to this same disturbance may be that the space in the seagrass bed created by the propeller is colonised by other species, such as non-native invasive species, which may prevent the original seagrass species from regrowing, thus changing the species composition of the habitat (Glasby and Underwood, 1996; Underwood, 1989). This is a long term response.

Without specifically designed ecological experiments to unravel how disturbances act on habitats and how habitats respond to these disturbances there will always be uncertainty in determining the level of threat a particular human activity poses to a habitat. Consequently, the decision rules used to determine threat levels were set in a precautionary manner, i.e., toward over-estimating the level of threat.

5.4.2. Cumulative and interactive disturbances

Multiple disturbances within an estuary may have cumulative effects. Cumulative effects may be additive, antagonistic or synergistic (Crain *et al.*, 2008). Additive effects occur when each disturbance produces its own effect but does not interact with the effects of other disturbances, such as sediment contamination from pollutants and increased turbidity from dredging. Antagonistic effects occur when the consequences of one disturbance act against the consequences of another disturbance, such as increased water flow eroding accumulated sediments from catchment run-off. Synergistic effects occur when the consequences of two or more disturbances interact to produce a combined different consequence than either of the disturbances acting on their own. For example, different salinities interact with increased nutrients to change the magnitude and type of effect on habitats and benthic organisms.

Without specifically designed ecological experiments to unravel how the effects of multiple human activities occurring in the LHE may be interacting with each other there will be uncertainty in determining their impacts on the habitats. The risk assessment assessed each human activity as though it was occurring independently of other disturbances. Where there is specific evidence of how multiple disturbances may be interacting this can be incorporated into the risk assessment at a later point.

5.5. Habitats

The following eight habitats were assessed:

a) Seagrass
b) Mangroves
c) Saltmarsh
d) Intertidal mudflats
e) Rocky reefs – subtidal, intertidal
f) Sandflats – subtidal, intertidal
g) Deep subtidal soft sediments (>5 m)
h) Water column

Not all of these habitats were mapped to the same level of detail due to the timeframe of the project (see Part A). Digital images of all habitats that were mapped (see example in Figure B.5), including the metadata, are presented on a DVD accompanying this report.

Note on assessing the risk to the water column

The water column as a habitat can be affected by biophysical (e.g., changes in flow or velocity due to presence of a seawall) or biogeochemical (e.g., increased nutrients from unsewered housing blocks) disturbances. The risk assessment method used for this project is primarily geared toward assessing the risks from biophysical disturbances. Risks to the water column from biogeochemical disturbances would be better assessed using a tool specifically designed for these types of disturbances. The NSW Department of Environment, Climate Change and Water (DECCW) have recently released such a tool called Coastal Eutrophication Risk Assessment Tool (CERAT). The tool is designed to predict the relationship between land use in catchments and its impact in estuaries and contains catchment and estuary models for every estuary in NSW. CERAT will be provided free of charge to councils and CMAs. More information about the tool is available at www.environment.nsw.gov.au/research/cerat.htm or the OzCoasts website.

The risk assessment on the water column in this report, therefore, was limited to the physical disturbances that could affect it, such as re-suspension of sediments, and an indication of the potential threat from water borne pollutants, such as sewage effluent from unsewered housing blocks. Due to the limited data available on the concentrations and loadings of water borne pollutants at the sub-catchment and reach scale, the risk assessment could only give a general indication of where potential problems might occur at these spatial scales which need to be investigated in more depth using a specific risk assessment tool designed for the water column (e.g., CERAT).

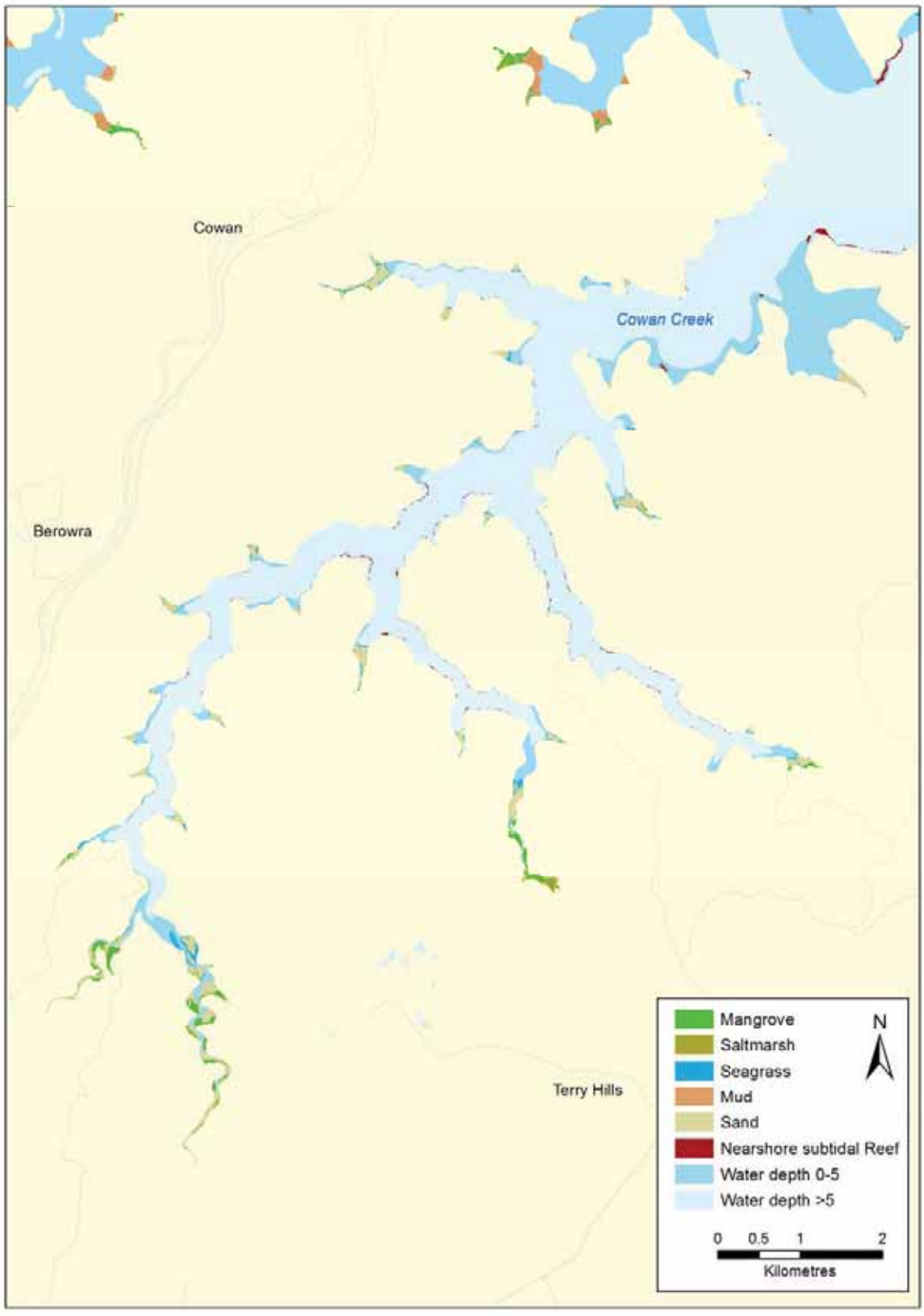

Figure B.5. An example of the estuarine habitats mapped in Cowan Creek.

5.6. Human activities

Eight human activities of potential concern that occur in the estuary were identified:

1. Recreational fishing – line fishing from shore or boat, bait collection, cleaning fish, hand held nets used in prawning. It does not include activities associated with boating as this was included under aquatic recreation.
2. Aquatic recreational activities – boating including launching and retrieving boats, waste disposal, foreshore picnicking and walking, swimming, aquatic competitions such as water ski races, moorings.
3. Commercial fishing – oyster farming, estuary general and estuary prawn trawl fisheries
4. Foreshore development – housing, commercial and private buildings, jetties, marinas, wharves, permanent moorings and seawalls
5. Sewage treatment – sewage treatment outfalls, effluent from boats, effluent from non-sewered residential developments
6. Stormwater and catchment run-off – discharges from stormwater pipes, run-off from residential, commercial, rural land use
7. Dredging and sedimentation – removal and/or movement of seabed material from the estuary by mechanical means to create navigational channels for boats (commercial and recreational), sedimentation as a result of human activities including contamination of sediments, erosion and accretion due to human activities
8. Commercial vessels – public and private ferries, water taxis, commercial cruise vessels.

These human activities were considered the sources of risk to the estuarine habitats in the risk assessment.

5.6.1. Commercial fishing

This is the only activity from the above list that has been subjected to comprehensive environmental impact assessments in recent years. In 2001 and 2002, I&I NSW (formerly NSW Fisheries) did an Environmental Impact Statements (EIS) for the Estuary General and Estuary Prawn Trawl fisheries in NSW as required under Commonwealth and state legislation. As part of meeting these requirements I&I NSW undertook a risk assessment of the impacts of these commercial fisheries on estuarine habitats. The results of the EIS for these two fisheries on the habitat component have been extracted (NSW Fisheries, 2001, 2002), updated and documented for this report (see Section 3.3.2.3a).

The NSW Oyster Industry recently undertook a sustainability assessment which included an assessment of the effects of oyster farming on estuarine habitats (NSW Oyster Industry, 2006). The results of the oyster industry's study have been extracted from their sustainability report, updated and documented for this report (see Section 3.3.2.3b).

5.7. Spatial scales – sub-catchments and reaches

A risk assessment of each estuarine habitat done on the whole of the LHE would not provide sufficient differentiation between levels of risk and hence would not adequately prioritise habitats for management purposes. Therefore, the estuary was divided into its component sub-catchments and main channel reaches and a risk assessment done for all habitat types and human activities occurring within each sub-catchment or reach (Figure B.6). This sub-division also provides natural resource managers with a means of identifying management units within their areas of responsibility. The sub-catchments and main river reaches were:

a) Pittwater
b) Cowan Creek
c) Berowra Creek
d) Mangrove Creek
c) Mooney Mooney Creek
d) Mullet Creek
e) Patonga Creek
f) Marine reach – Lion Island to western head of Pittwater
g) Fluvial delta – western head of Pittwater to Spencer
h) Riverine channel – Spencer to Wiseman's Ferry

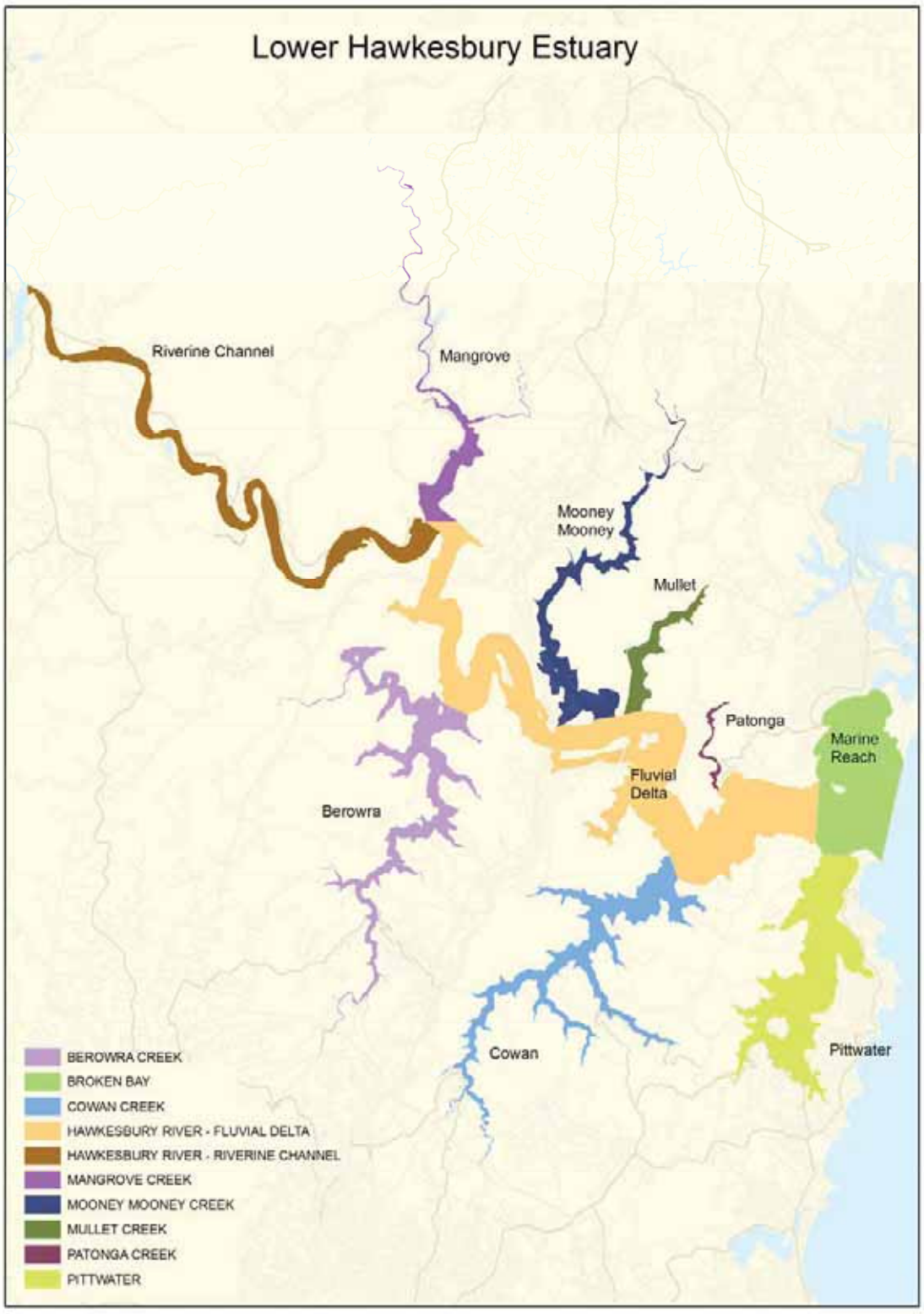

Figure B.6. Map of the lower Hawkesbury estuary showing the sub-catchments and reach divisions used in the risk assessment.

5.8. Data and information sources

The following reports were used as sources of information for specific areas within the LHE (listed alphabetically) (see reference list for full details):

- Aerial survey of lower Hawkesbury River
- Analysis of changes to aquatic habitats and adjacent land-use in the downstream portion of the Hawkesbury Nepean river over the past sixty years
- Berowra Creek Estuary Management Study and management plan
- Berowra Creek Estuary Management Plan Review
- Berowra Creek estuary process study – aquatic ecological investigations
- Berowra Creek estuary process study – review and interpretation of existing data
- Berowra Creek estuary process study – sediment characteristics and processes
- Brooklyn estuary management plan
- Brooklyn estuary management study
- Brooklyn estuary process study
- Commercial and recreational fishing survey for Berowra Creek estuary
- Final report sediment and antifoul monitoring program, Hawkesbury River
- Hawkesbury-Nepean River Environmental Monitoring Program: Final Technical Report
- Lower Hawkesbury Estuary Management Plan
- Mapping the habitats of NSW estuaries
- Pittwater estuary management study
- Pittwater estuary process study
- Sustainable aquaculture strategy
- The Hawkesbury-Nepean Catchment Action Plan

Additional data were provided by a range of experts in relevant fields and current research programmes being undertaken by various government departments. These are referenced throughout the document.

6. RESULTS

6.1. Risk context

The risk context was determined to be the likelihood that estuarine habitats in the LHE will be irreparably degraded by human activities in the next twenty years. Degraded was defined as a change in a habitat physically and/or biogeochemically that impairs its biological and/or ecological processes such that it can no longer maintain its natural functions. Human activities were considered to be a disturbance when they have occurred at a sufficient magnitude and frequency (press and pulse) to cause an effect on any component of a habitat.

6.2. Risk identification

The sources of risk to estuarine habitats were the pressures of the eight human activities and their stressors. A description of the stressors for each human activity and their potential outcomes on the estuarine habitats is given below (Table B.3). These are based on the scientific literature and are not exhaustive. It should be noted that just because a stressor exists does not mean that it is having an effect on a habitat. The magnitude, duration, frequency and/or distribution of a stressor will determine whether it will have an effect (Underwood, 1989). This is addressed in the risk characterization stage. The potential outcomes listed in Table B.3 are only an indication of what could occur if the stressor was of sufficient intensity.

Many of the stressors are similar among different pressures such as trampling from aquatic recreation and recreational fishing or release of pollutants into sediments for foreshore development and catchment run-off (Table B.3). However, the magnitude, frequency, duration and nature of these similar stressors will be different depending on their source. The relationship between a stressor and its source is important when making decisions about appropriate management action in response to these stressors.

The potential outcomes of the stressors have some similarities across habitats such as erosion, sediment destabilization and damage to plant material. How these potential outcomes manifest themselves will be different for each habitat type. Importantly, all the potential outcomes could in some way make a habitat unsuitable for biota to occupy it or lead to substantial changes in the habitat's diversity and functioning. For example, trampling on mudflats has been shown to decrease sediment porosity and redox potential and alter particle size composition (Contessa and Bird, 2004). This creates unfavourable conditions for burrowing shrimp, which has implications for its recolonisation of this habitat, in turn affecting the biophysical properties of mudflats (Brown and Wilson, 1997; Contessa and Bird, 2004). The consequences of potential outcomes on habitats is important when making decisions about what to measure to assess the effectiveness of management actions.

Table B.3. A summary of some of the stressors of each human activity (pressures) and the potential outcomes of these stressors on estuarine habitats.

Pressure	Stressors	Potential outcomes
Recreational fishing	• Entanglement by fishing gear; • Bait pumping/collection; • Trampling of vegetation; • Gross pollutants; • Transport of non-native invasive species. *References:* Brown & Wilson, 1997; Wynberg & Branch, 1997; Contessa & Bird, 2004; Lewin *et al*., 2006; O'Toole *et al.*, 2009	*Seagrass*: damage to seagrass blades or rhizomes, non-native invasive species. *Saltmarsh*: compaction of sediment, damage to plants, lower ground level, increased retention of tidal water. *Mangroves*: damaged pneumatophors, compaction of sediment. *Mudflats*: compaction of sediment, change in sediment composition, decreased bioturbation. *Sandflats*: compaction of sediment, change in sediment composition, decreased bioturbation. *Rocky reef*: damage to sessile biota. *Deep subtidal*: accumulation of rubbish *Water column*: floating rubbish.
Aquatic recreation	• Trampling of vegetation; • Anchoring; • Gross pollutants; • Boat operations in shallow water; • Boat wash downs; • Effluent discharges; • Boat wash; • Boat maintenance; • Propeller scaring; • Antifouling contaminants; • Moorings. *References*: Bell *et al.*, 2002; Dafforn *et al.*, 2009; Hastings *et al.*, 1995; Ross, 2006; Scholer, 1974; van der Valk & Attiwill, 1983; West *et al.*, 2007.	*Seagrass*: damage or removal of seagrass blades and rhizomes, erosion, sediment destabilization, decreased conditions for growth from increased turbidity, transfer of non-native invasive species. *Saltmarsh*: compaction of sediment, damage to plants, lower ground level, increased retention of tidal water. *Mangroves*: damaged pneumatophors, compaction of sediment, erosion, sediment destabilization. *Mudflats*: compaction of sediment, change in sediment composition, erosion. *Sandflats*: compaction of sediment, change in sediment composition, erosion. *Rocky reef*: damage to sessile biota. *Deep subtidal*: accumulation of rubbish, resuspension of sediments. *Water column*: floating rubbish, resuspension of sediments, algal blooms, increase turbidity, transfer of non-native invasive species, oil/fuel pollution.

Table B.3 cont'd

Pressure	Stressors	Potential outcomes
Foreshore development	• Change of hardness and slope of shore; • Antifouling contaminants; • Increased access to shoreline; • Change of flow and tidal regimes; • Pollutant deposition and accumulation; • Clearance of natural vegetation; • Inappropriate seawalls. *References*: Adam, 2008; Blockley, 2007; Davis & Froend, 1999; Finlayson & Rea, 1999; Glasby *et al.*, 2007; Laegdsgaard, 2006; Pressey & Middleton, 1982; Saintilan & Williams, 1999, 2000.	*Seagrass*: erosion, sediment destabilization, decreased conditions for growth from increased turbidity, sediment contamination, smothering. *Saltmarsh*: compaction of sediment, damage to plants, lower ground level, increased retention of tidal water, sediment contamination. *Mangroves*: damaged pneumatophors and mature plants, erosion, sediment destabilization, sediment contamination. *Mudflats*: change in sediment composition, erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Sandflats*: change in sediment composition, erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Rocky reef*: damage to sessile biota. *Deep subtidal*: accumulation of pollutants, resuspension of sediments, changed accretion rates, changed sediment transport, infilling. *Water column*: resuspension of sediments, increase turbidity, changed tidal exchange & hydrodynamics.
Stormwater/catchment runoff	• Increased nutrients; • Changed flow regime; • Increased freshwater input; • Increased sedimentation; • Pollutants. *References:* Baynton *et al.*, 1996; Harris, 2001; Hauxwell & Valiela, 2004; Scanes *et al.*, 2007.	*Seagrass*: decreased conditions for growth, sediment contamination, smothering. *Saltmarsh*: sediment contamination. *Mangroves*: sediment contamination. *Mudflats*: erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Sandflats*: change in sediment composition, erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Rocky reef*: mortality of sessile biota. *Deep subtidal*: accumulation of pollutants, resuspension of sediments, changed accretion rates, changed sediment transport, infilling. *Water column*: resuspension of sediments, increase turbidity, changed hydrodynamics.

Table B.3 cont'd

Pressure	Stressors	Potential outcomes
Sewage	• Increased nutrients; • Freshwater input; • Increased sedimentation; • Pollutants. *References:* Burkholder *et al.*, 2007; Harris, 2004; Hauxwell & Valiela, 2004; Orth *et al.*, 2006; Scanes *et al.*, 2007.	*Seagrass*: decreased conditions for growth, sediment contamination, smothering. *Saltmarsh*: sediment contamination. *Mangroves*: sediment contamination. *Mudflats*: erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Sandflats*: change in sediment composition, erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Rocky reef*: mortality of sessile biota. *Deep subtidal*: accumulation of pollutants, resuspension of sediments, changed accretion rates, changed sediment transport, infilling. *Water column*: resuspension of sediments, increase turbidity, changed hydrodynamics.
Dredging & sedimentation	• Mechanical removal & dumping of sediment; • Erosion & accretion of sediment; • Changed bathymetry & water flow. *References:* Ellison, 1999; Jones, 1986; Orth *et al*., 2006; Smith & Rule, 2001.	*Seagrass*: erosion, destabilization of sediment. *Saltmarsh*: nil. *Mangroves*: erosion, change in accretion rates of sediment. *Mudflats*: erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Sandflats*: change in sediment composition, erosion, changed accretion rates, changed sediment transport, infilling, sediment contamination. *Rocky reef*: nil. *Deep subtidal*: resuspension of sediments, changed accretion rates, changed sediment transport, infilling. *Water column*: increased turbidity, changed flushing patterns and tidal flows.
Commercial vessels (i.e., vessels operated as a business or public service e.g., ferries)	• Boat wash; • Contamination of sediments from anti-fouling; • Boat maintenance. *References:* Bishop, 2004; Dafforn *et al.*, 2008, 2009a,b; Glasby, 2001.	*Seagrass*: erosion, destabilization of sediment. *Saltmarsh*: nil. *Mangroves*: erosion. *Mudflats*: erosion, sediment contamination. *Sandflats*: erosion, sediment contamination. *Rocky reef*: nil. *Deep subtidal*: resuspension of sediments. *Water column*: increased turbidity.

6.3. Risk characterisation

6.3.1. Habitat vulnerability

The resistance of estuarine habitats (the ability of a habitat to withstand stressors) to the effects of human activities was based on three physical aspects – structure, form and attachment (e.g., Inglis, 1995; Chapman and Underwood, 1995; Butler, 1995).

i) Structure: The degree the structure is altered depends on its hardness.
Hard – minimal to no change in shape when physical contact made
Flexible – can change shape but returns to original condition after contact removed
Soft – changes shape under contact and does not return to original condition after contact removed

ii) Form – The degree to how easily physical contact can be made is related to its form
Vertical/erect – extends up from surface of substratum vertically or at an angle
Flat – laying on surface of substratum without vertical parts*
Sub-surface – laying beneath surface of substratum*
*(*Sub-surface and flat forms of a habitat will be susceptible if a human activity acts at or below the surface of the substratum either physically or biologically)*

iii) Attachment – The degree a habitat can be displaced
Permanent – fixed in place by geological means
Sessile – attached to substratum by biological means (plant and animal)
Loose – unattached to substratum

The resilience of estuarine habitats (the ability of habitats to recover from an interaction with stressors) (Skilletter, 1995) was determined by either biological characteristics (for biological habitats) (e.g., Saintilan *et al*., 2009; Hogarth, 2007) or geomorphic characteristics (for geological habitats) (e.g., Minchinton, 2007; Inglis, 1995).

a) Biological characteristics

i) Regrowth/regeneration: The rate at which an organism can regrow damaged parts
Fast – within 1 week
Moderate – within 1 month
Slow – greater than a month

ii) Recolonisation: ability to occupy new patches or space
Dispersal range – wide (anywhere within the estuary), narrow (within 100m of parent habitat)

iii) Reproduction: ability to replace itself
Propagule output – large (>50), small (<50)
Cycle – seasonal, aseasonal

b) Geomorphic characteristics

i) Replenishment/rebuilding: The rate at which its processes can rebuild its physical or biochemical structure
Accretion of sediment: fast (< 1 month), slow (> 1 month)
Reformation of structure: fast (< 1 year), slow (> 1 year)

Decision criteria were set to determine whether a characteristic makes a habitat susceptible or not susceptible to the stressors of a human activity (Table B.4). The total number of susceptible characteristics determined the level of resistance or resilience (Table B.5). The results of the vulnerability analysis of estuarine habitats is given in Table B.6 and summarized in Table B.7.

Vulnerability of water column habitat

There were two vulnerability ratings determined for the water column. A moderate vulnerability rating was used when assessing physical disturbances to the water column, such as water movement from boats or commercial vessels. Its resistance was low (mixing of water in wake of physical disturbance) but its resilience was high (usually recovers quickly from short term mixing). A high vulnerability rating was used when assessing biogeochemical disturbances to the water column, such as sewage effluent from unsewered housing blocks. Its resistance and resilience were both low because contaminants will alter the biochemical composition of the water in the short term and the water does not recover its normal biochemical composition quickly. This is based on the assumption of no additional interactions, such as the hydrodynamics of the sub-catchment or reach, which may modify these effects (positively or negatively). As noted earlier, a more specific risk assessment tool (e.g., CERAT) for the water column should be used to assess the risk to its biochemical properties.

Table B.4. Decision criteria used to determine the resistance and resilience levels for estuarine habitats.

Category	Characteristic	Susceptible	Not susceptible
Resistance:			
Physical	Structure	Hard	Flexible, soft
	Form	Sub-surface, flat	Erect
	Attachment	Permanent	Sessile, loose
Resilience:			
Biological	Regrowth/regeneration	Fast, moderate	Slow
	Recolonisation	Wide dispersal	Narrow dispersal
	Reproduction:		
	Propagules	Large number	Small number
	Life cycle	Aseasonal	Seasonal
Geomorphic	Accretion rate	Within 1 month	> 1 month
	Reformation rate	Within 1 year	> 1 year

Table B.5. Resistance and resilience levels based on the number of susceptible characteristics.

Resistance	Number susceptible characteristics	Resilience Biological	Number susceptible characteristics	Resilience Geomorphic	Number susceptible characteristics
Low	3	Low	≥4	Low	1
Medium	2	Medium	3	High	0
High	1	High	1 – 2		

Table B.6. Results of the vulnerability analysis of estuarine habitats. S – susceptible, N – not susceptible, *P* – physical, *B* – biochemical, L – low, M – medium, H – high. See Table B.4 for the calculation of resistance and resilience levels.

Characteristic	**Seagrass**		**Saltmarsh**		**Mangroves**		**Mudflats**		**Rocky reefs**		**Sandflats**		**Deep subtidal**		**Water column**	***P***	***B***
Physical:																	
Structure	Flexible	S	Soft, flexible	S	Flexible	S	Soft	S	Hard	N	Soft	S	Soft	S	Soft	S	S
Form	Erect & subsurface	S	Erect	S	Erect	S	Subsurface	N	Erect	S	Sub-surface	N	Sub-surface	N	NA	-	-
Attachment	Sessile	S	Sessile	S	Sessile	S	Loose	S	Loose	S	Loose	S	Loose	S	NA	-	-
Resistance		**L**		**L**		**L**		**M**		**M**		**M**		**M**		**L**	**L**
Biological:																	
Regrowth/ regeneration	*Posidonia* – Slow *Zostera* – Moderate Other – Fast, seasonal	S N N	Slow	S	Fast	N											
Recolonisation	Narrow	S	Narrow	S	Wide	N											
Reproduction:																	
Propagules	Small	S	Small	S	Large	N											
Life cycle	Seasonal	S	Unknown	S	Seasonal	S											
Geomorphic:																	
Accretion rate							1 month	N	> 1 month	S	< month	N	< month	N	NA	-	-
Reformation rate							1 year	N	> 1 year	S	< year	N	< year	N	< year	N	-
															> year	-	S
Resilience		**L**		**L**		**H**		**L**		**L**		**H**		**H**		**H**	**L**
Vulnerability		**H**		**H**		**M**		**H**		**H**		**L**		**L**		**M**	**H**

Table B.7. Summary of levels of resistance, resilience and vulnerability levels for estuarine habitats. See Figure B.3 for derivation of vulnerability levels

Habitat	Resistance	Resilience	Vulnerability
Seagrass	Low	Low	High
Saltmarsh	Low	Low	High
Mangroves	Low	High	Moderate
Mudflats	Medium	Low	High
Rocky reef	Medium	Low	High
Sandflats	Medium	High	Low
Deep subtidal	Medium	High	Low
Water column – Physical	Low	High	Moderate
Water column – Biochemical	Low	Low	High

6.3.2. Overall threat analysis, risk levels and issues arising for sub-catchments and reaches in the LHE

6.3.2.1. Stressor measures, decision criteria and uncertainty

Tables B.8-14 contain the measures of the stressors used for each human activity and the decision criteria to determine whether a habitat was susceptible or not susceptible to the stressor. The measures chosen were based on consultation with experts in the field and the availability of data and information. A more detailed description of each measure and its justification is given in Appendix 2. The measures sought to capture the magnitude, duration, frequency and distribution of the stressors, however, not all these variables were able to be identified for every stressor. Furthermore, some measures covered a number of stressors because information for more specific measures was not available. For example, the measure for trampling and gross pollutants was the number of boats under 7 metres length active in the area being assessed. This represented the number of people who could potentially be accessing estuarine habitats who could trample it and dispose of rubbish. It doesn't represent an accurate measure of the number of people actually trampling on estuarine habitats. In a qualitative ecological risk assessment such measures can only give an indication of the level of a threat, not an exact numerical value of that threat. If the results of the risk assessment placed a habitat at an intolerable level then one of the issues arising would be to quantify more accurately the variables of the measure of the stressor.

The decision criteria were also based on consultation with experts. The criteria were set conservatively so that they would tend to over estimate the risk for estuarine habitats. This was done for two reasons. First, many of the measures used to estimate the magnitude, duration, frequency and/or distribution of the stressors were qualitative and indirect. Therefore, there was uncertainty in how accurate these measures were in describing the level of impact of the stressors on the estuarine habitats. Second, knowledge of the recovery of degraded habitats from different human activities was also uncertain (see section 2.4.1). In addition, our knowledge of how different human activities interact with each other and the nature of any combined effects (see section 2.4.2) was also unknown. Therefore, a bias towards over-estimation of the level of risk for estuarine habitats was considered appropriate within a precautionary framework for this context. In this way, uncertainty was incorporated into the decision criteria.

In a qualitative risk assessment it is difficult to quantify levels of uncertainty. However, it is important to take into account the level of information available to access the risk to a habitat from potential stressors of human activities. This was done by counting the number of stressor measures where there was no information on each habitat type or human activity for each sub-catchment and

reach. The number was expressed as a percentage of the total number of stressor measures used for a human activity in each sub-catchment or reach. The total number of stressor measures varied among sub-catchments and reaches when a particular stressor was not present (e.g., not all sub-catchments had sewage treatment plants (STP), therefore the stressor measure for STP was not applicable in these sub-catchments, reducing the total number of stressor measures for this activity). The percentage of stressor measures where information was unknown was presented with the risk levels in each risk summary table. The percentage of unknowns shows how much information was available to assess the level of risk for each activity. The level of risk and the percentage of unknowns were not linked because it could not be determined to what extent the lack of information might influence the overall threat rating and hence the risk level. However, if the percentage of unknown stressor measures was greater than 55 percent the risk level was assessed to be undetermined. Setting this level to be greater than 50 percent put emphasis on those stressors where knowledge gaps are the greatest.

Table B.8. Stressor measures and decision criteria for **recreational fishing** used in the threat analysis for each sub-catchment and reach in the LHE. Sh – shallow (<5m), D – deep (>5m), T – total, shallow and deep, Hab – habitat. See Table B.3 for a list of the stressors. See Appendix 2.1 for rationale of measures used.

Human activity: Recreational fishing

Stress Measure	Decision criteria	
	Susceptible	**Not Susceptible**
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/Sh ha; >6/D ha; >20/T ha & Hab: >0.2	Boat hr: <50/Sh ha; <6/D ha; <20/T ha & Hab: >0.2
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/km & Hab: >0.2	Shore hr: <200/km & Hab: <0.2
3. Is bait collected in this habitat?	Yes	No
4. Is recreational fishing known to be a vector for non-native invasive species?	Yes	No

Table B.9. Stressor measures and decision criteria for **aquatic recreation** used in the threat analysis for each sub-catchment and reach in the LHE. Hab – habitat. See Table B.3 for a list of the stressors. See Appendix 2.2 for rationale of measures used.

Human activity: Aquatic recreation

Stress Measure	Decision criteria	
	Susceptible	**Not Susceptible**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2
3. Proportion of habitat within no wash zones	< 0.1	> 0.1
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2
5. Number of marinas within 10m of a habitat	> 0	0
6. Is aquatic recreation known to be a vector for non-native invasive species in this habitat?	Yes	No

Table B.10. Stressor measures and decision criteria for **foreshore development** used in the threat analysis for each sub-catchment and reach in the LHE. See Table B.3 for a list of the stressors. See Appendix 2.3 for rationale of measures used.

Human activity: Foreshore development

Stress Measure	**Decision criteria**	
	Susceptible	**Not Susceptible**
1. Proportion of artificial rock wall within 10m of a habitat	> 0.1	≤ 0.1
2. Proportion of habitat shore length within 10m of an artificial wall	> 0.02	≤ 0.02
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1
7a. Proportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2
8. Is foreshore development known to be a vector for non-native invasive species in this habitat?	Yes	No

Table B.11. Stressor measures and decision criteria for **stormwater and catchment runoff** used in the threat analysis for each sub-catchment and reach in the LHE. See Table B.3 for a list of the stressors. See Appendix 2.4 for rationale of measures used.

Human activity: Stormwater and catchment runoff

Stress Measure	**Decision criteria**	
	Susceptible	**Not Susceptible**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2
2. Flushing time of bay days	> 2	< 2
3. Effective TN load mg/m^2/day	≥3	<3
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ha	< 5t/ha
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2
6. Is stormwater and catchment runoff to be a vector for non-native invasive species in this habitat?	Yes	No

Table B.12. Stressor measures and decision criteria for **sewage treatment** used in the threat analysis for each sub-catchment and reach in the LHE. See Table B.3 for a list of the stressors. See Appendix 2.5 for rationale of measures used.

Human activity: Sewage treatment

Stress Measure	Decision criteria	
	Susceptible	**Not Susceptible**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02
2. Number of STP in bay	>0	0
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary
4. Total N loads from STP to water surface area	≥3	<3
5. Total N loads from non-point source pollutants (e.g., vessels > 6m) to water surface area	≥3	<3
6. Is sewage treatment known to be a vector for non-native invasive species in this habitat?	Yes	No

Note: The stressor measures for sewage treatment related directly to the water column habitat. Whilst there are effects from sewage treatment on other habitats, such as seagrass, via changes to the water column it was decided to assess the direct threats to the water column only as the primary focus of potential disturbance for this stressor.

Table B.13. Stressor measures and decision criteria for **dredging** used in the threat analysis for each sub-catchment and reach in the LHE. See Table B.3 for a list of the stressors. See Appendix 2.6 for rationale of measures used.

Human activity: Dredging

Stress Measure	Decision criteria	
	Susceptible	**Not Susceptible**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2
2. Sedimentation rate from human activities	≥3.0mm/yr	<3.0mm/yr
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2
5. Is dredging known to be a vector for non-native invasive species in this habitat?	Yes	No

Table B.14. Stressor measures and decision criteria for **commercial vessels** used in the threat analysis for each sub-catchment and reach in the LHE. See Table B.3 for a list of the stressors. See Appendix 2.7 for rationale of measures used.

Human activity: Commercial vessels

Stress Measure	Decision criteria	
	Susceptible	**Not Susceptible**
1. Number of ferry vessels operating (car or passenger)	≥1	<1
2. Frequency of ferry services per day (car or passenger)	≥8	<8
3. Frequency of water taxis per day	≥8	<8
4. Frequency of commercial cruise ships operating per day	≥4	<4
5. Number of habitats within 10m of routes of ferry services	≥2	<2
6. Number of habitats within 10m of routes of water taxi services	≥2	<2
7. Number of habitats within 10m of routes of commercial cruise ships	≥2	<2
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr
9. Is commercial vessels known to be a vector for non-native invasive species in this habitat?	Yes	No

6.3.2.2. Whole estuary

(A) OVERALL RISKS

It was not possible to do an overall assessment of the risks to habitats for the whole of the LHE. However, Table B.15 summarises all the risk levels for each habitat for all human activities combined for each sub-catchment and reach. The large percentage of unknown information in each sub-catchment or reach means these risk levels have a substantial level of uncertainty. As explained in section 3.3.2.1, the percentage of unknowns shows how much information was available to assess the level of risk for each activity. The following examples illustrate how to combine the level of risk and the percentage of unknown information when interpreting Table B.15 or any other risk summary table that follows. Seagrass habitat in Pittwater has an intolerable level of risk from at least four human activities. This level of risk is based on information with a low percentage of unknowns (i.e., few knowledge gaps) and is unlikely to change. The intolerable level of risk to seagrass is likely to be real and therefore needs to be addressed. By contrast, intertidal mudflat habitat in Mangrove Creek has an intolerable level of risk for at least two human activities. This level of risk is based on information with a higher percentage of unknowns and could change, either by increasing or decreasing the number of intolerable risks for this habitat, if the knowledge gaps were filled. The intolerable level of risk to intertidal mudflats is potentially worse than estimated and needs to be investigated further.

As a result of the large percentage of unknowns, it was not considered appropriate to combine all sub-catchments and reaches into a single risk level for each habitat for the whole LHE as this could under-estimate the level of risk for some habitats (e.g., deep subtidal) and over-estimate the risk for others (e.g., mudflats) and hence be misleading to management agencies. Instead Table B.15 should be read in terms of an example of the overall picture that can be conveyed of the risk to estuarine habitats if the substantial knowledge gaps can be filled in the future.

Table B.15. Summary of all risk levels combined for all human activities.

This table should be read with caution and with attention to the substantial level of unknown information for each habitat in each sub-catchment and reach (see text for details). IT – intolerable, T – tolerable, A – acceptable, % Unk – percentage of stressor measures across all human activities that were unknown, NP – not present, NA – not applicable.

	Pittwater				Cowan				Berowra			
Habitats	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**
Seagrass	4	0	1	28.57	1	0	2	36.59	0	0	4	31.82
Mangroves	0	2	2	28.57	0	0	3	36.59	0	0	4	31.82
Intertidal mudflats	1	0	4	28.57	1	0	2	36.59	1	0	3	31.82
Saltmarsh	0	0	5	28.57	0	0	3	36.59	0	0	4	31.82
Rocky reef	2	0	3	28.57	1	0	2	36.59	1	0	3	31.82
Sandflats	0	3	2	28.57	0	1	2	36.59	0	1	3	31.82
Deep subtidal	0	3	2	28.57	0	3	0	36.59	0	0	4	31.82
Water Column - P	0	0	2	21.43	0	0	1	21.95	0	0	1	20.45
Water Column - B	1	0	1	2.38	0	0	2	2.44	0	0	2	6.82

	Patonga				Mullet				Mooney				Mangrove			
Habitats	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**
Seagrass	2	0	2	33.33	0	0	4	30.56	0	0	3	35.90	0	0	0	17.95
Mangroves	0	2	2	33.33	0	0	4	30.56	0	1	2	35.90	0	1	2	46.15
Intertidal mudflats	3	0	1	33.33	2	0	2	30.56	2	0	1	35.90	2	0	1	46.15
Saltmarsh	0	0	4	33.33	0	0	4	30.56	0	0	3	35.90	0	0	3	46.15
Rocky reef	0	0	0	11.11	0	0	0	11.11	1	0	2	35.90	0	0	0	17.95
Sandflats	0	2	2	33.33	0	0	0	11.11	0	0	0	23.08	0	0	0	17.95
Deep subtidal	0	0	0	11.11	0	0	4	30.56	0	0	3	35.90	0	0	3	46.15
Water Column - P	0	0	2	11.11	0	0	2	11.11	0	0	1	23.08	0	0	1	17.95
Water Column - B	0	0	1	13.89	0	0	1	16.67	0	0	1	10.26	0	0	1	20.51

	Marine reach				Fluvial delta				Riverine channel			
Habitats	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**	**IT**	**T**	**A**	**% Unk**
Seagrass	NP	NP	NP	NA	1	0	2	34.88	NP	NP	NP	NA
Mangroves	NP	NP	NP	NA	0	3	0	34.88	0	2	2	42.50
Intertidal mudflats	NP	NP	NP	NA	3	0	0	34.88	1	0	3	42.50
Saltmarsh	NP	NP	NP	NA	0	0	3	34.88	0	0	4	42.50
Rocky reef	1	0	2	47.22	1	0	2	34.88	1	0	3	42.50
Sandflats	0	1	2	47.22	0	1	2	34.88	NP	NP	NP	NA
Deep subtidal	0	1	2	47.22	0	2	1	34.88	0	1	3	42.50
Water Column - P	0	0	1	25.00	0	0	1	20.93	0	0	2	20.00
Water Column - B	0	0	1	19.44	0	0	1	13.95	0	0	1	20.00

(B) OVERALL ISSUES

Clearly, the most pressing issue overall arising from the risk assessment is the lack of information on some key human activities. Little assessment could be made of the risk to the water column and deep subtidal habitats because data on stressors to water quality (e.g., nutrient levels from catchment run-off, stormwater outlets) and the proportion of contaminated sediments were unavailable at the sub-catchment and reach scales of the assessment. The superficial information used for aquatic boating activity (non-fishing) under-estimated the risk to all estuarine habitats from aquatic recreation. Therefore, these knowledge gaps should be filled if a more robust qualitative risk assessment is required.

Habitats that had consistently acceptable levels of risk were saltmarsh wherever it was present, seagrass in Cowan, Berowra, Mooney and Mullet and mangroves in Cowan and Berowra. This suggests that these habitats are reasonably well protected from the threat of some human activities based on the current level of information available. However, it is important to note that saltmarsh was identified as a priority habitat in all sub-catchments because it has declined significantly over the last ten years (Williams and Thiebaud, 2007). Similarly, seagrass in Cowan and Berowra was also a priority habitat because of its decline. The seagrass in Cowan includes small patches of the

vulnerable species *Posidonia australis*, which may warrant further investigation and possible protection.

Whilst saltmarsh, seagrass and mangroves in these sub-catchments had acceptable levels of risk it cannot be concluded that they are completely protected from the potential impacts of human activities because there are still significant knowledge gaps concerning a number of human activities. As some of these gaps are filled, some of the measures of the stressors may need to be revised to provide a more direct measure of the potential threat from some of the human activities. For example, the number of people that walk through a mangrove or saltmarsh from an adjacent public access point (e.g., recreational park) over a given period would be a more direct measure of the potential threat from foreshore development than its distance from a park. Such information would also provide a more cost-effective means of determining relevant management action (e.g., where a fence between a park and saltmarsh is needed and where it is not).

The categories 'Recreational fishing' and 'foreshore development', which tended to have fewer knowledge gaps, often posed an intolerable level of risk to habitats such as seagrasses and mudflats throughout the different sub-catchments or reaches. Further examination of the extent of these interactions (intensity and location) and the condition of habitats where the interactions are most intense is the most important issue arising from these human activities overall.

6.3.2.3. Risk levels, key knowledge gaps and key issues for sub-catchments and reaches

The results from the 'risk characterization' and 'issues arising' stages of the risk assessment given below have been designed to be self contained so that the different management bodies (e.g., local councils) within the LHE need focus only on the results that are relevant to their specific jurisdictions, including areas where their jurisdictions overlap with others (e.g., reaches of the Hawkesbury river), rather than having to read all the results for every area. The results include the risk levels for each habitat from each human activity, the issues arising for those habitats with intolerable levels of risk only, a summary of the key knowledge gaps and a summary of the key issues needing to be addressed. The latter section will help individual management agencies identify priority actions for their sub-catchments and reaches.

Although many of the issues and knowledge gaps are similar throughout, the differences of each sub-catchment and reach make each set of results distinctive. Therefore, despite the repetition of some of the results, each area should be read carefully and the reader should not assume the results are exactly the same from one sub-catchment to another. The recommendations apply to all sub-catchments and reaches. Risk levels for each habitat, for all human activities combined is presented for the whole LHE at the end of the section but in a cautionary manner.

NOTE: Disproportionate representation of some human activities in the results

Some human activities emerged more frequently than others as contributing to the intolerable levels of risk to some estuarine habitats, e.g., recreational fishing. This occurred because these human activities had more information available to use in the risk assessment than others. Substantial knowledge gaps in some activities (e.g., catchment run-off, recreational non-fishing boating activity) resulted in the risk from these activities to habitats being unable to be fully determined. Consequently, human activities with little information are under-represented in the results and those with more information possibly over-represented. Therefore, although recreational fishing occurs frequently as contributing to the intolerable risk to habitats it is not necessarily the most important human activity contributing to the risk. Only when adequate information is available for the under-represented human activities can the relative importance of the contributions of all human activities to the levels of risk be fully determined. However, the human activities that do contribute to intolerable levels of risk should not be dismissed and require action to address the issues identified, irrespective of other human activities.

(A) PITTWATER

Catchment and habitat characteristics

Table B.16. Summary of the catchment and habitat characteristics for Pittwater. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action (see Section 2.3).

Characteristic				
Surface water area (ha)	1836.09			
Total length foreshore (km)	56.19			
Habitat	**Area (ha)**	**% of water surface area**	**Decline in last 10 years ?**	**Habitat priority**
Seagrass	185.51	10.10	Y	⚑
Mangroves	17.48	0.95	N	
Mudflats	10.01	0.54	U	
Saltmarsh	2.68	0.15	Y	⚑
Rocky reef	11.03	0.60	N	
Sandflats	78.15	4.25	Y	⚑
Deep subtidal	1241.186	67.60	U	
Water column	Not calculated		N	
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	P			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	YES			
iii) % sub-catchment urbanised/industrial ≥ 20%	YES			
Catchment priority:	**C1**	(see Table B.2)		

Table B.17. Summary of intolerable and tolerable risk levels for Pittwater.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Seagrass	Recreational fishing
		Foreshore development
		Stormwater & catchment run-off
		Commercial vessels
	Mudflats	Recreational fishing
	Rocky reef	Recreational fishing
	Water column	Stormwater & catchment run-off
Tolerable	Mangroves	Recreational fishing
		Stormwater & catchment run-off
	Sandflats	Recreational fishing
		Foreshore development
		Stormwater & catchment run-off
	Deep subtidal	Aquatic recreation
		Foreshore development
		Commercial vessels

Table B.18. Summary of all risk levels for all estuarine habitats in Pittwater for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/catch't			Sewage			Dredging/Sedimentation			Commercial vessels			**# Activities for each habitat with**		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	H	IT	H	L	A	H	M	IT	H	M	IT	H			H	U	UD	H	M	IT	4	0	1
Mangroves	M	M	T	M	M	M	M	L	A	M	M	T	M			M	U	UD	M	L	A	0	2	2
Intertidal mudflats	H	H	IT	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	L	A	1	0	4
Saltmarsh	H	L	A	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	L	A	0	0	5
Rocky reef	H	H	IT	H	L	A	H	M	IT	H	L	A	H			H	U	UD	H	L	A	2	0	3
Sandflats	L	H	T	L	L	A	L	M	T	L	M	T	L			L	U	UD	L	L	A	0	3	2
Deep subtidal	L	L	A	L	M	T	L	M	T	L	L	A	L			L	U	UD	L	M	T	0	3	2
Water Column - P	M	-	-	M	-	-	M	L	A	M	-		M			M	U	UD	M	L	A	0	0	2
Water Column - B	H	-	-	H	-	-	H	-		H	M	IT	H	L	A	H	-		H	-		1	0	1
# Habitats with:																								
INTOLERABLE			3			0			2			2			0			UD			1			
TOLERABLE			2			1			2			2			0			UD			1			
ACCEPTABLE			2			5			4			4			1			UD			6			
% Unknowns			0			33.3			0			16.7			0			80			55.5			

Issues arising for habitats with intolerable risk levels for Pittwater

Habitat: Seagrass Number of human activities contributing to risk: 4

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and seagrass habitat from both boat and shore-based fishing. Annual recreational fishing from boats exceeded 50 hours per hectare of shallow water area (< 5 m) in Pittwater and the estimated proportion of seagrass habitat in these shallow areas was 30%. Annual recreational fishing from the shoreline exceeded 200 hours per kilometre of shoreline in Pittwater and the estimated proportion of seagrass habitat along the shoreline was 26%. b) Known vector for the introduction of non-native invasive species in seagrass beds. Potential for *Caulerpa taxifolia* to spread via fragments on anchors and from trailers if not properly cleaned.
2. Foreshore development	a) Large proportion of artificial rock walls are within 10 m of a seagrass bed. Change in hardness and slope of shore can increase the intensity and frequency of water turbulence around seagrass beds potentially destabilising them. Seagrasses in shallower depths are more vulnerable to being affected by such increased turbulence. b) Large proportion of private and public wharves and jetties are within 10 m of seagrass (> 58%). The level of potential stress will depend on the depth in which these seagrasses occupy. Wharves and jetties increase boat activity and if surrounding seagrasses are in shallow depths they maybe stressed by such activity. c) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into seagrass habitats is increased by the close proximity of foreshore developments to seagrass.
3. Stormwater and catchment run-off	a) Large proportion of stormwater outlets (> 30%) are within 10 m of a seagrass bed. Increased turbidity, water turbulence and water quality could be having localised but cumulative affects on seagrass condition and bed stabilisation. In addition, the proportion of stormwater catchment to the surface area of Pittwater exceeds 50% potentially affecting water quality and hence seagrass condition in the bay. b) Effectiveness of removal of gross pollutants from stormwater is low (< 50%). Gross pollutants may sink onto seagrass resulting in damage, epiphytic growth and smothering.
4. Commercial vessels	a) Frequency of ferry services that are within 10 m of seagrass habitats during their routes exceeds 8 times a day and potentially interacts with 10 different seagrass beds. Especially prevalent around Scotland Island where surrounding seagrasses have declined over the last 10 years and ferries dock at four different locations around the island. Frequency of interaction with ferries may cause increased turbulence and turbidity affecting growth of seagrass depending on their depth.

Habitat: Mudflats Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and mudflat habitat from shore-based fishing. Annual recreational fishing from the shoreline exceeded 200 hours per kilometre of shoreline in Pittwater and the estimated proportion of mudflat habitat along the shoreline was at least 26%. Interaction between anglers and mudflats can lead to trampling effects on mudflats. b) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. c) Known vector for the introduction of non-native invasive species in mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 2

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and rocky reef habitat from shore-based fishing. Annual recreational fishing from the shoreline exceeded 200 hours per kilometre of shoreline in Pittwater and the estimated proportion of rocky reef habitat along the shoreline was at least 27%. Interaction can result in removal of algae and sessile animals from reefs and fishing gear damage of soft biogenic habitat attached to reefs. b) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs.
2. Foreshore development	a) Proportion of artificial rock walls within 10 m of rocky reefs was approximately 25%. Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around rocky reefs, potentially damaging algal assemblages on them. b) Proportion of private and public wharves and jetties within 10 m of rocky reefs was > 10%. Pylons from wharves and jetties provide substratum for non-native invasives to colonise. Proximity of these structures to rocky reef habitats may facilitate spread of non-native invasives into these natural habitats.

Habitat: Water Column Number of human activities contributing to risk: 1

Human activity	Issues arising
3. Stormwater and catchment run-off	a) Proportion of stormwater catchment to the surface area of Pittwater exceeds 50% potentially affecting water quality in the bay. b) Effectiveness of removal of gross pollutants from stormwater is low (< 50%). Gross pollutants may affect water quality through increased algal growth.

Key knowledge gaps for Pittwater

1. Recreational boating activity (non-fishing) – recreational boating (non-fishing) is a major activity in Pittwater but there is little information on the number of boats participating in these activities, where they go and how many people they carry. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
2. Dredging and sedimentation – dredging and foreshore development has occurred in a number of places in Pittwater particularly in its southern most sections. These activities result in changes to the bathymetry of the bay over time which can lead to erosion and/or accretion of sediments around subtidal habitats, potentially destabilising them. Erosion that can be seen along the foreshore at or above the waterline is well understood in Pittwater. However, the extent of any such erosion and/or sediment accretion subtidally is poorly known. Declines in habitat patches, such as seagrasses, over time may be partly caused by such subtidal sedimentation processes.
3. Studies have determined that there are contaminated sediments in Pittwater (Lawson and Treloar, 2003). Information on the proportion of sediments contaminated and the distribution of these sediments with respect to other estuarine habitats (e.g., seagrass, mangroves, mudflats

and saltmarsh) would enable a better assessment of whether these habitats are at risk of being affected by these contaminated sediments.

4. Effective total nitrogen load of stormwater run-off – there are a substantial number of stormwater outlets that are in close proximity to a number of estuarine habitats within Pittwater. Information on the total effective nitrogen loads from these outlets will enable better assessment of the risk to these habitats to nutrient enrichment from these outlets.
5. Commercial vessels – water taxis are known to be used by both residents and visitors to the bay. Information on their routes with respect to habitats, particularly in shallow areas, the frequency of their use, method of operation (e.g., drop offs and pick ups from beaches or wharves) would enable assessment of their potential level of interaction with estuarine habitats. There are also an unknown number of mooring contractors, rubbish barges and maintenance vessels operating in Pittwater. Information on their number and where they operate in relation to habitats especially in shallow areas is needed.

Key issues to be addressed for Pittwater

1. Fill important knowledge gaps especially regarding recreational boating (non-fishing) activity.
2. Examine the level of interaction between recreational fishing activity (boat and shore-based) with respect to estuarine habitats. A major project by Industry and Investment NSW has recently quantified the magnitude and location of recreational fishing activities within Pittwater and is currently being analysed. The results of that project could be linked to the habitat maps compiled for this project to determine the level of interaction. More targeted assessment of the condition of habitats with high levels of interaction with recreational fishing could then be done.
3. Examine the condition of habitats in shallow subtidal areas close to stormwater outlets, artificial walls, wharves and jetties for evidence of degradation particularly propeller scarring, erosion, smothering, die-off, epiphytic growth and presence of non-native invasives.

(B) COWAN CREEK

Catchment and habitat characteristics

Table B.19. Summary of the catchment and habitat characteristics for Cowan Creek. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action (see Section 2.3).

Characteristic				
Surface water area (ha)	1333.13			
Total length foreshore (km)	97.34			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years**	**Habitat priority**
Seagrass	14.13	1.06	Y	⚑
Mangroves	19.41	1.46	N	
Mudflats	10.00	0.75	U	
Saltmarsh	3.02	0.23	Y	⚑
Rocky reef	6.20	0.47	N	
Sandflats	67.19	5.04	Y	⚑
Deep subtidal	1038.10	77.87	U	
Water column	Not calculated		N	
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	YES			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C2**	(see Table B.2)		

Table B.20. Summary of intolerable and tolerable risk levels for Cowan.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Seagrass	Foreshore development
	Mudflats	Recreational fishing
	Rocky reef	Recreational fishing
Tolerable	Sandflats	Recreational fishing
	Deep subtidal	Recreational fishing
		Aquatic recreation
		Foreshore development

Table B.21. Summary of all risk levels for all estuarine habitats in Cowan for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	A	H	L	A	H	M	IT	H	L	UD	H			H	U	UD	H	U	UD	1	0	2
Mangroves	M	L	A	M	L	A	M	L	A	M	L	UD	M			M	U	UD	M	U	UD	0	0	3
Intertidal mudflats	H	M	IT	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	1	0	2
Saltmarsh	H	L	A	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	0	0	3
Rocky reef	H	H	IT	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	1	0	2
Sandflats	L	H	T	L	L	A	L	L	A	L	L	UD	L			L	U	UD	L	U	UD	0	1	2
Deep subtidal	L	M	T	L	M	T	L	M	T	L	L	UD	L			L	U	UD	L	U	UD	0	3	0
Water Column - P	M	-	-	M	-	-	M	L	A	M	-	-	M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-	-	H	L	A	H	L	A	H	-	-	H	-	-	0	0	2
# Habitats with:																								
INTOLERABLE			2			0			1			UD			0			UD			UD			
TOLERABLE			2			1			1			UD			0			UD			UD			
ACCEPTABLE			3			6			6			UD			1			UD			UD			
% Unknowns			0			33.3			0			66.7			25			80			62.5			

Issues arising for habitats with intolerable risk levels for Cowan

Habitat: Seagrass Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Foreshore development	a) Large proportion of artificial rockwalls are within 10m of a seagrass bed (64%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around seagrass beds potentially de-stabilising them. Seagrasses in shallower depths are more vulnerable to being affected by such increased turbulence. b) A substantial proportion of unsewered housing blocks are within 10 m of a seagrass bed (31%). These riverside dwellings are a potential source of increased nutrients from inadequate on-site sewage treatment (HSC report) and general run-off from the housing blocks. Nutrient enrichment could have localised but cumulative affects on seagrass condition. c) A proportion of private and public wharves and jetties are within 10 m of seagrass (16%). The level of potential stress will depend on the depth in which these seagrasses occupy. Wharves and jetties increase boat activity in the vicinity and if surrounding seagrasses are in shallow depths they maybe stressed by such activity. d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into seagrass habitats is increased by the close proximity of foreshore developments to seagrass.

Habitats: Mudflats Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and rocky reef habitat from shore based fishing. Annual recreational fishing from the shoreline in Cowan was the largest for any bay within the LHE and exceeded 390 hours per kilometre of shoreline and the estimated proportion of rocky reef habitat along the shoreline was 77%. Interaction can result in removal of algae and sessile animals from reefs, entangled fishing gear can damage of soft biogenic habitat attached to reefs and other debris associated with fishing (e.g., bait bags) can also affect biogenic habitat on reefs. b) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs. c) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Cowan

1. Recreational boating activity (non-fishing) – Recreational boating (non-fishing) is a major activity in Cowan but there is little information on the number of boats participating in these activities, where they go and how many people they carry. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based, length of stay within an area for overnight vessels), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
2. Effective total nitrogen load of non-point source pollutants (e.g., overnight vessels) and riverside settlements and flushing times of bays – Concern has been raised in other bays within the LHE of nutrient enrichment from non-point source pollutants, such as overnight recreational vessels (e.g., Pittwater Process study). Given the potentially high level of recreational boating this could also be a problem in Cowan. Furthermore, Cowan has a number of narrow bays in which vessels can anchor or moor enabling them to stay for several days. Data on total nitrogen loads in these bays (including seasonal variation) and the flushing times of bays within Cowan would enable a more accurate assessment of whether estuarine habitats were at risk of nutrient enrichment. Data on effective nitrogen loads from riverside settlements would also better assess the risks to seagrasses within their vicinity.

Key issues to be addressed for Cowan

1. Fill important knowledge gaps, especially regarding recreational boating (non-fishing) activity and nitrogen loads from riverside settlements.
2. Examine the level of interaction between recreational fishing activity (shore-based) with respect to estuarine habitats. A major project by I & I NSW has recently quantified the magnitude and location of recreational fishing activities within Cowan (see Figure B.7 for an example). The results of that project could be linked to the habitat maps compiled for this project to determine the level of interaction. More targeted assessment of the condition of habitats with high levels of interaction with recreational fishing could then be done.
3. Assess the level of bait collection on mudflats and rocky reef within Cowan.
4. Examine the condition of habitats in shallow subtidal areas close to artificial walls, wharves and jetties for evidence of degradation particularly propeller scarring, erosion, smothering, sediment quality, die-off, epiphytic growth and presence of non-native invasives.
5. Examine the condition of seagrass beds within the vicinity of unsewered housing blocks for evidence of degradation particularly die-off, epiphytic growth and the presence of non-native invasives.

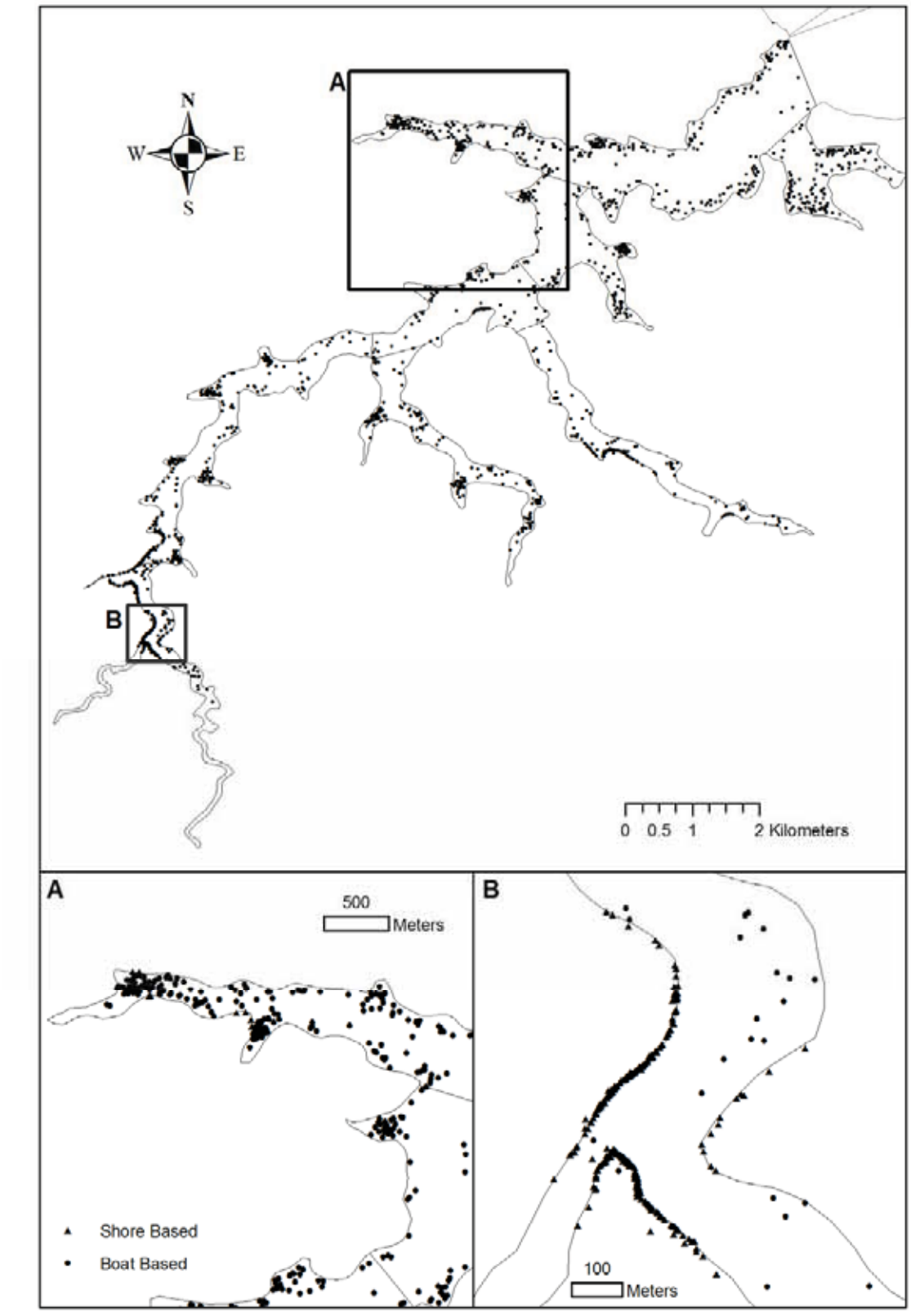

Figure B.7. An example of annual recreational fishing effort in Cowan for 2008/09. The top map shows all of Cowan with both locations shown for boat (circles) and shore-based (triangles) fishing. A) Jerusalem Bay showing distribution of boat-based fishing along the edges. Each circle represents a single boat. B) Bobbin Head showing distribution of shore-based fishing. Each triangle represents a single person fishing.

(C) BEROWRA CREEK

Catchment and habitat characteristics

Table B.22. Summary of the catchment and habitat characteristics for Berowra Creek. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Section 2.3).

Characteristic				
Surface water area (ha)	1297.21			
Total length foreshore (km)	101.196			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	3.93	0.30	Y	⚑
Mangroves	190.29	14.67	N	
Mudflats	149.81	11.55	U	
Saltmarsh	13.56	1.05	Y	⚑
Rocky reef	0.48	0.04	N	
Sandflats	64.96	5.01	N	
Deep subtidal	36.52	2.81	U	
Water column	Not calculated		N	
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	P			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.23. Summary of intolerable and tolerable risk levels for Berowra.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Mudflats	Recreational fishing
	Rocky reef	Recreational fishing
Tolerable	Sandflats	Recreational fishing

Table B.24. Summary of all risk levels for all estuarine habitats in Berowra for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	A	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	U	UD	0	0	4
Mangroves	M	L	A	M	L	A	M	L	A	M	L	A	M			M	U	UD	M	U	UD	0	0	4
Intertidal mudflats	H	M	IT	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	U	UD	1	0	3
Saltmarsh	H	L	A	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	U	UD	0	0	4
Rocky reef	H	M	IT	H	L	A	H	L	A	H	L	A	H			H	U	UD	H	U	UD	1	0	3
Sandflats	L	M	T	L	L	A	L	L	A	L	L	A	L			L	U	UD	L	U	UD	0	1	3
Deep subtidal	L	L	A	L	L	A	L	L	A	L	L	A	L			L	U	UD	L	U	UD	0	0	4
Water Column - P	M	-	-	M	-	-	M	L	A	M	-	-	M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-	-	H	L	A	H	L	A	H	-	-	H	-	-	0	0	2
# Habitats with:																								
INTOLERABLE			2			0			0			0			0			UD			UD			
TOLERABLE			1			0			0			0			0			UD			UD			
ACCEPTABLE			4			7			8			8			1			UD			UD			
% Unknowns			0			33.3			0			50			33.3			80			55.6			

Issues arising for habitats with intolerable risk levels for Berowra

Habitats: Mudflats Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs. b) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Berowra

1. Recreational boating activity (non-fishing) – Recreational boating (non-fishing) is a major activity in Berowra but there is little information on the number of boats participating in these activities, where they go and how many people they carry. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based, length of stay within an area for overnight vessels), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
2. Effective total nitrogen load from sewage treatment plants and non-point source pollutants (e.g., overnight vessels) – Berowra has two sewage treatment plants that discharge into the bay. Although they are tertiary treated their effective total nitrogen loads were unavailable. In addition, as for other bays within the LHE, there is concern of nutrient enrichment from non-point source pollutants, such as overnight recreational vessels (e.g., Pittwater Process study). Given the potentially high level of recreational boating in Berowra data on total nitrogen loads from these two sources would enable a more accurate assessment of whether estuarine habitats were at risk of nutrient enrichment.

Key issues to be addressed for Berowra

1. Fill important knowledge gaps especially recreational boating (non-fishing) activity and nitrogen loads from STP and non-point source pollutants.
2. Assess the level of bait collection on mudflats and rocky reefs within Berowra.

(D) MANGROVE CREEK

Catchment and habitat characteristics

Table B.25. Summary of the catchment and habitat characteristics for Mangrove Creek. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Section 2.3).

Characteristic				
Surface water area (ha)	458.68			
Total length foreshore (km)	62.9			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	0.00	0.00	NA	
Mangroves	195.54	42.63	N	
Mudflats	46.66	10.17	U	
Saltmarsh	126.45	27.57	Y	⚑
Rocky reef	0.00	0.00	NA	
Sandflats	0.00	0.00	NA	
Deep subtidal	10.46	2.28	U	
Water column	Not calculated		N	
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	A			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	U			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C1**	(see Table B.2)		

Table B.26. Summary of intolerable and tolerable risk levels for Mangrove.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Mudflats	Recreational fishing Foreshore development
Tolerable	Mangroves	Foreshore development

Table B.27. Summary of all risk levels for all estuarine habitats in Mangrove for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	U	NP	0	0	0
Mangroves	M	L	A	M	L	A	M	M	T	M	U	UD	M			M	U	UD	M	U	UD	0	1	2
Intertidal mudflats	H	M	IT	H	L	A	H	M	IT	H	U	UD	H			H	U	UD	H	U	UD	2	0	1
Saltmarsh	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	U	UD	0	0	3
Rocky reef	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	U	NP	0	0	0
Sandflats	L	L	NP	L	L	NP	L	L	NP	L	U	NP	L			L	U	NP	L	U	NP	0	0	0
Deep subtidal	L	L	A	L	L	A	L	L	A	L	U	UD	L			L	U	UD	L	U	UD	0	0	3
Water Column - P	M	-	-	M	-	-	M	L	A	M	-	-	M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-	-	H	U	UD	H	L	A	H	-		H	-	-	0	0	1
# Habitats with:																								
INTOLERABLE			1			0			1			UD			0			UD			UD			
TOLERABLE			0			0			1			UD			0			UD			UD			
ACCEPTABLE			3			4			3			UD			1			UD			UD			
% Unknowns			50			33.3			0			100			25			80			50			

Issues arising for habitats with intolerable risk levels for Mangrove

Habitat: Mudflats Number of human activities contributing to risk: 2

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.
2. Foreshore development	a) A proportion of artificial rockwalls are within 10 m of mudflats (13%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around mudflats potentially de-stabilising them. b) A relatively high proportion of private and public wharves and jetties (33%) and moorings (25%) are within 10 m of mudflats. These in-stream structures increase boat activity in the vicinity and, if surrounding mudflats are in shallow depths, sediments may be re-suspended potentially changing their structure and sediment quality. c) A large proportion of oyster leases are within 10 m of mudflats (67%). Most oyster leases are built in these types of habitats. Organic enrichment of benthic sediments from the faecal deposits of oysters can occur immediately below oyster racks. Studies to assess whether this occurs in LHE and if this has flow-on effects to surrounding sediments have not been done. However, studies done elsewhere suggest any such effects are minimal (see Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur. d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into mudflat habitats is increased by the close proximity of foreshore developments to mudflats.

Key knowledge gaps for Mangrove

1. Effective total nitrogen load of non-point source pollutants and catchment run-off (e.g., stormwater) – There are a number of rural settlements higher in the sub-catchment as well as a caravan parks along the foreshore at the lower end. These are potential sources of nutrient enrichment, especially during summer holidays when the caravan parks are continually occupied. Data on the total nitrogen loads from these sources and their seasonal variation would enable a better assessment of the risk to mangroves and saltmarshes in Mangrove.
2. Recreational boating activity (non-fishing) – The presence of riverside caravan parks and some holiday homes indicate that recreational boating (non-fishing) activity could be substantial in Mangrove but probably varies in intensity with the seasons. There is little information on the number of boats participating in these activities, where they go and how many people they carry. Recreational boats are able to move virtually anywhere in the creek, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
3. Recreational fishing activity – Data on the level of recreational fishing activity was collected for only the lower area of Mangrove (near the township of Spencer and above) and included as

part of the main channel of the Hawkesbury. Information on recreational fishing activity (boat and shore-based) further upstream is needed as well as assessing the level of bait collection occurring on mudflats in Mangrove.

4. Location of stormwater culverts – Information on the location of stormwater culverts on roads along the foreshore of Mangrove with respect to their vicinity to estuarine habitats would enable a better assessment of their risk to stormwater outflows.

Key issues to be addressed for Mangrove

1. Fill important knowledge gaps especially nitrogen loads from non-point source pollutants and recreational boating (non-fishing) activity.
2. Assess the level of bait collection on mudflats and in other habitats within Mangrove.
3. Assess the level of increased turbidity in mudflat areas close to artificial walls, wharves, jetties and moorings.

(E) MOONEY MOONEY CREEK

Catchment and habitat characteristics

Table B.28. Summary of the catchment and habitat characteristics for Mooney Mooney. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	798.20			
Total length foreshore (km)	59.83			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	0.06	0.01	N	
Mangroves	73.21	9.17	N	
Mudflats	270.65	33.91	U	
Saltmarsh	8.09	1.01	Y	⚑
Rocky reef	0.23	0.03	N	
Sandflats	<0.01	0.00	N	
Deep subtidal	1.11	0.14	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	A			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.29. Summary of intolerable and tolerable risk levels for Mooney.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Mudflats	Recreational fishing
		Foreshore development
	Rocky reef	Recreational fishing
Tolerable	Mangroves	Recreational fishing
		Foreshore development

Table B.30. Summary of all risk levels for all estuarine habitats in Mooney for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	A	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	0	0	3
Mangroves	M	L	A	M	L	A	M	M	T	M	L	UD	M			M	U	UD	M	U	UD	0	1	2
Intertidal mudflats	H	M	IT	H	L	A	H	M	IT	H	L	UD	H			H	U	UD	H	U	UD	2	0	1
Saltmarsh	H	L	A	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	0	0	3
Rocky reef	H	H	IT	H	L	A	H	L	A	H	L	UD	H			H	U	UD	H	U	UD	1	0	2
Sandflats	L	L	NP	L	L	NP	L	L	NP	L	L	NP	L			L	U	NP	L	U	NP	0	0	0
Deep subtidal	L	L	A	L	L	A	L	L	A	L	L	UD	L			L	U	UD	L	U	UD	0	0	3
Water Column - P	M	-	-	M	-	-	M	L	A	M	-		M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-		H	L	UD	H	L	A	H	-		H	-		0	0	1
# Habitats with:																								
INTOLERABLE			2			0			1			0			0			UD			UD			
TOLERABLE			0			0			1			0			0			UD			UD			
ACCEPTABLE			4			6			5			0			1			UD			UD			
% Unknowns			0			33.3			0			50			25			80			71.4			

Issues arising for habitats with intolerable risk levels for Mooney

Habitat: Mudflats Number of human activities contributing to risk: 2

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.
2. Foreshore development	a) A proportion of artificial rock walls are within 10 m of mudflats (33%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around mudflats potentially de-stabilising them. b) A large proportion of unsewered housing is within 10 m of mudflats (48%). These riverside dwellings are a potential source of increased nutrients from inadequate on-site sewage treatment and general run-off from the housing blocks. Nutrient enrichment could have localised but cumulative affects. c) A proportion of private and public wharves and jetties (73%) are within 10 m of mudflats. These in-stream infrastructures increase boat activity in the vicinity and if surrounding mudflats are in shallow depths sediments may be re-suspended potentially changing their structure and sediment quality. d) A large proportion of oyster leases are within 10 m of mudflats (79%) and a large proportion of the area of mudflats are within 10 m of oyster leases (43%). Most oyster leases are built in these types of habitats. Organic enrichment of benthic sediments from the faecal deposits of oysters can occur immediately below oyster racks. Studies to assess whether this occurs in LHE and if this has flow on effects to surrounding sediments have not been done. However, studies done elsewhere suggest any such affects are minimal (see Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur. e) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into mudflat habitats is increased by the close proximity of foreshore developments to mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and rocky reef habitat from boat based fishing. Annual recreational fishing from boats exceeded 400 hours per hectare of surface water area in Mooney and the estimated proportion of rocky reef in the bay was at least 21%. Interaction between anglers and rocky reef habitat can include entanglement of fishing gear on biogenic structures on reefs and anchor damage. b) Bait collected from rocky reefs intertidally and in the shallow subtidal can alter assemblage structure of animals and algae on and around reefs. c) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Mooney

1. Effective total nitrogen load of non-point source pollutants and catchment run-off (e.g., stormwater) – There are a number of river side settlements in Mooney and these are potential sources of nutrient enrichment. Nitrogen loads from the whole catchment run-off is also undetermined. Data on the total nitrogen loads from these sources would enable a better assessment of the risk to mangroves and seagrasses in Mooney.
2. Recreational boating activity (non-fishing) – Mooney is adjacent to one of the most popular boat ramps in the LHE and therefore recreational boating (non-fishing) activity could be substantial. There is little information on the number of boats participating in these activities, where they go and how many people they carry. Recreational boats are able to move virtually anywhere in the creek, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
3. Location of stormwater outlets and culverts – Information on the location of stormwater outlets and culverts on roads along the foreshore of Mooney with respect to their vicinity to estuarine habitats would enable a better assessment of their risk to stormwater stressors.
4. Dredging and sedimentation – It is not known whether dredging of navigational channels and around wharves has occurred in Mooney or is intended to occur in the future to maintain access for both private and commercial vessels. Information on any occurrences and locations of dredging in Mooney is required to assess whether the potential for subtidal erosional damage to habitats in the vicinity of such dredging.

Key issues to be addressed for Mooney

1. Fill important knowledge gaps especially nitrogen loads from non-point source pollutants and recreational boating (non-fishing) activity.
2. Assess the level of bait collection on mudflats and in other habitats within Mooney.
3. Assess the level of increased turbidity in mudflat areas close to artificial walls, wharves and jetties.

(F) MULLET CREEK

Catchment and habitat characteristics

Table B.31. Summary of the catchment and habitat characteristics for Mullet. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	296.49			
Total length foreshore (km)	16.95			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	7.87	2.65	N	
Mangroves	6.24	2.10	N	
Mudflats	27.28	9.20	U	
Saltmarsh	0.94	0.32	Y	⚑
Rocky reef	0.00	0.00	N	
Sandflats	0.00	0.00	N	
Deep subtidal	3.55	1.20	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	A			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.32. Summary of intolerable and tolerable risk levels for Mullet.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Mudflats	Recreational fishing Foreshore development

Table B.33. Summary of all risk levels for all estuarine habitats in Mullet for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	0	0	4
Mangroves	M	L	A	M	L	A	M	L	A	M	U	UD	M			M	U	UD	M	L	A	0	0	4
Intertidal mudflats	H	M	IT	H	L	A	H	M	IT	H	U	UD	H			H	U	UD	H	L	A	2	0	2
Saltmarsh	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	0	0	4
Rocky reef	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	L	NP	0	0	0
Sandflats	L	L	NP	L	L	NP	L	L	NP	L	U	NP	L			L	U	NP	L	L	NP	0	0	0
Deep subtidal	L	L	A	L	L	A	L	L	A	L	U	UD	L			L	U	UD	L	L	A	0	0	4
Water Column - P	M	-	-	M	-	-	M	L	A	M	-		M			M	U	UD	M	L	A	0	0	2
Water Column - B	H	-	-	H	-	-	H	-	-	H	U	UD	H	L	A	H	-	-	H	-	-	0	0	1
# Habitats with:																								
INTOLERABLE			1			0			1			UD			0			UD			0			
TOLERABLE			0			0			0			UD			0			UD			0			
ACCEPTABLE			4			5			5			UD			1			UD			6			
% Unknowns			0			33.3			0			83.3			25			80			0			

Issues arising for habitats with intolerable risk levels for Mullet

Habitat: Mudflats Number of human activities contributing to risk: 2

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality.
	b) Known vector for the introduction of non-native invasive species in mudflats.
2. Foreshore development	a) A proportion of artificial rock walls are within 10 m of mudflats (25%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around mudflats potentially destabilising them.
	b) A proportion of private and public wharves and jetties (50%) are within 10m of mudflats. These in-stream infrastructures increase boat activity in the vicinity and if surrounding mudflats are in shallow depths sediments may be re-suspended potentially changing their structure and sediment quality.
	c) A large proportion of oyster leases are within 10 m of mudflats (40%) and a large proportion of the area of mudflats are within 10 m of oyster leases (52%). Most oyster leases are built in these types of habitats. Organic enrichment of benthic sediments from the faecal deposits of oysters can occur immediately below oyster racks. Studies to assess whether this occurs in LHE and if this has flow on effects to surrounding sediments have not been done. However, studies done elsewhere suggest any such affects are minimal (see Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur.
	d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into mudflats habitats is increased by the close proximity of foreshore developments to mudflats.

Key knowledge gaps for Mullet

1. Effective total nitrogen load of non-point source pollutants and catchment run-off (e.g., stormwater) – There are a few river side settlements in Mullet and these are potential sources of nutrient enrichment. Nitrogen loads from the whole catchment run-off is also undetermined. Data on the total nitrogen loads from these sources would enable a better assessment of the risk to mangroves and seagrasses in Mullet.
2. Recreational boating activity (non-fishing) – There is little information on the number of recreational boats (non-fishing), where they go and how many people they carry in Mullet. Recreational boats are able to move virtually anywhere in the creek, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight vessels) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.

Key issues to be addressed for Mullet

1. Fill important knowledge gaps especially nitrogen loads from non-point source pollutants and recreational boating (non-fishing) activity.
2. Assess the level of bait collection on mudflats and in other habitats.
3. Assess the level of increased turbidity in mudflat areas close to artificial walls, wharves and jetties.

(G) PATONGA CREEK

Catchment and habitat characteristics

Table B.34. Summary of the catchment and habitat characteristics for Patonga Creek. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ☞ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	60.39			
Total length foreshore (km)	10.11			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	36.84	61.01	U	
Mangroves	48.02	79.51	U	
Mudflats	4.04	6.69	U	
Saltmarsh	9.43	15.61	U	
Rocky reef	0.00	0.00	U	
Sandflats	4.78	7.91	U	
Deep subtidal	0.00	0.00	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	A			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.35. Summary of intolerable and tolerable risk levels for Patonga.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Seagrass	Aquatic recreation
		Foreshore development
	Mudflats	Recreational fishing
		Aquatic recreation
		Foreshore development

Table B.36. Summary of all risk levels for all estuarine habitats in Patonga for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	A	H	H	IT	H	M	IT	H	U	UD	H			H	U	UD	H	L	A	2	0	2
Mangroves	M	L	A	M	M	T	M	M	T	M	U	UD	M			M	U	UD	M	L	A	0	2	2
Intertidal mudflats	H	M	IT	H	M	IT	H	M	IT	H	U	UD	H			H	U	UD	H	L	A	3	0	1
Saltmarsh	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	0	0	4
Rocky reef	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	L	NP	0	0	0
Sandflats	L	M	T	L	M	T	L	L	A	L	U	UD	L			L	U	UD	L	L	A	0	2	2
Deep subtidal	L	L	NP	L	L	NP	L	L	NP	L	U	NP	L			L	U	NP	L	L	NP	0	0	0
Water Column - P	M	-	-	M	-	-	M	L	A	M	-	-	M			M	U	UD	M	L	A	0	0	2
Water Column - B	H	-	-	H	-	-	H	-	-	H	U	UD	H	L	A	H	-	-	H	-	-	0	0	1
# Habitats with:																								
INTOLERABLE			1			2			2			UD			0			UD			0			
TOLERABLE			1			2			1			UD			0			UD			0			
ACCEPTABLE			3			1			3			UD			1			UD			6			
% Unknowns			50			33.3			0			66.7			25			80			0			

Issues arising for habitats with intolerable risk levels for Patonga

Habitat: Seagrass Number of human activities contributing to risk: 2

Human activity	Issues arising
1. Aquatic recreation	a) The proportion of public access points within 10 m of seagrass beds was 50%. Public access points include boat ramps and recreational parks. Close proximity of seagrass habitat to public access points increases the likelihood of human interaction. Patonga is less than 5 m deep for its whole length, increasing the potential for human interaction which could include propeller scaring from launching boats and damage to plants from trampling. b) There are no "No wash zones" in Patonga creek. Boat wash can be produced from boats moving at low and high speeds. Excessive boat wash can cause erosion of sediments around seagrass beds and increase turbidity. c) Aquatic recreation can be a vector for non-native invasives through boat activity. For example, fragments of *Caulerpa taxifolia* can be trapped in anchors and chains and transferred to new areas. Boat washing at boat ramps may accidently wash fragments off trailers and boats into the surrounding water.
2. Foreshore development	a) All the artificial rock walls are within 10 m of a seagrass bed (100%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around seagrass beds potentially de-stabilising them. Seagrasses in shallower depths are more vulnerable to being affected by such increased turbulence. b) A large proportion of private and public wharves and jetties (53%) and moorings are within 10 m of seagrass (84%). Wharves and jetties increase boat activity in the vicinity. Given all the seagrass beds are in less than 5 m water depth in Patonga they could experience substantial stress from such activity. c) A large proportion of oyster leases are within 10 m of seagrasses (83%) and a large proportion of the area of seagrass is within 10 m of oyster leases (30%). Organic enrichment of benthic sediments from the faecal deposits of oysters can occur immediately below oyster racks. Studies to assess whether this occurs in LHE and if this has flow-on effects to surrounding sediments have not been done. However, studies done elsewhere suggest any such affects are minimal (see Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur. d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into seagrass habitats is increased by the close proximity of foreshore developments to seagrass.

Habitat: Mudflats Number of human activities contributing to risk: 3

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.
2. Aquatic recreation	a) There are no "No wash zones" in Patonga creek. Boat wash can be produced by boats moving at low and high speeds. Excessive boat wash can cause erosion of mudflats and re-suspend sediments increasing turbidity and affecting sediment composition and quality. b) Aquatic recreation can be a vector for non-native invasives.

Habitat: Mudflats continued

Human activity	Issues arising
3. Foreshore development	a) A proportion of unsewered housing blocks (12%) are within 10m of mudflats. Unsewered housing is a potential source of increased nutrients from inadequate on-site sewage treatment and general run-off from the housing blocks. Nutrient enrichment could have localised but cumulative affects. b) A proportion of private and public wharves and jetties (47%) are within 10 m of mudflats. These in-stream structures increase boat activity in the vicinity and, if surrounding mudflats are in shallow depths, sediments may be re-suspended potentially changing their structure and sediment quality. c) A large proportion of oyster leases are within 10 m of mudflats (25%) and a large proportion of the area of mudflats are within 10 m of oyster leases (73%). Most oyster leases are built in these types of habitats. Organic enrichment of benthic sediments from the faecal deposits of oysters can occur immediately below oyster racks. Studies to assess whether this occurs in LHE and if this has flow-on effects to surrounding sediments have not been done. However, studies done elsewhere suggest any such affects are minimal (see Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur. d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into mudflats habitats is increased by the close proximity of foreshore developments to mudflats.

Key knowledge gaps for Patonga

1. Effective total nitrogen load of non-point source pollutants and catchment run-off (e.g., stormwater) – Data on the total nitrogen loads from unsewered riverside housing and stormwater run-off and flushing time of the creek would enable a better assessment of the risk to mangroves and seagrasses in Patonga.
2. Recreational fishing activity – Data on the extent of shore and boat based fishing activity, including bait harvesting on mudflats is needed to assess the level of risk to estuarine habitats in Patonga from recreational fishing.
3. Recreational boating activity (non-fishing) – There is little information on the number of recreational boats (non-fishing), where they go and how many people they carry in Patonga. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based) and location participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.

Key issues to be addressed for Patonga

1. Fill important knowledge gaps especially nitrogen loads from non-point source pollutants, recreational fishing and recreational boating (non-fishing) activity.
2. Examine the condition of seagrass beds in close proximity to public access points particularly propeller scarring, die-off, epiphytic growth and the presence of non-native invasives.
3. Assess the level of bait collection on mudflats and in other habitats.
4. Assess the level of increased turbidity and erosion in mudflat areas close to artificial walls, wharves and jetties.

(H) MARINE REACH

Catchment and habitat characteristics

Table B.37. Summary of the catchment and habitat characteristics for Marine reach. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⌲ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	1711.57			
Total length foreshore (km)	21.91			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	0.00	0.00	NA	
Mangroves	0.00	0.00	NA	
Mudflats	0.00	0.00	NA	
Saltmarsh	0.00	0.00	NA	
Rocky reef	24.06	1.41	N	
Sandflats	92.10	5.38	U	
Deep subtidal	1450.45	84.74	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	A			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	NO			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	YES			
Catchment priority:	**C3**	(see Table B.2)		

Table B.38. Summary of intolerable and tolerable risk levels for Marine reach.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Rocky reef	Recreational fishing
Tolerable	Sandflats	Recreational fishing
	Deep subtidal	Aquatic recreation
	Water column	Aquatic recreation

Table B.39. Summary of all risk levels for all estuarine habitats in the Marine reach for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	U	NP	0	0	0
Mangroves	M	L	NP	M	L	NP	M	L	NP	M	U	NP	M			M	U	NP	M	U	NP	0	0	0
Intertidal mudflats	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	U	NP	0	0	0
Saltmarsh	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	U	NP	0	0	0
Rocky reef	H	H	IT	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	U	UD	1	0	2
Sandflats	L	M	T	L	L	A	L	L	A	L	U	UD	L			L	U	UD	L	U	UD	0	1	2
Deep subtidal	L	L	A	L	M	T	L	L	A	L	U	UD	L			L	U	UD	L	U	UD	0	1	2
Water Column - P	M	-	-	M	-	-	M	L	A	M	-		M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-		H	U	UD	H	L	A	H	-		H	-		0	0	1
# Habitats with:																								
INTOLERABLE			1			0			0			UD			0			UD			UD			
TOLERABLE			1			1			0			UD			0			UD			UD			
ACCEPTABLE			1			2			4			UD			1			UD			UD			
% Unknowns			0			33.3			0			100			20			80			55.6			

Issues arising for habitats with intolerable risk levels for Marine reach

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and rocky reef habitat from shore-based fishing. Annual recreational fishing from shore exceeded 450 hours per kilometre of shoreline and the estimated proportion of rocky reef in the area was at least 38%. Interaction between anglers and rocky reef habitat can include entanglement of fishing gear on biogenic structures on reefs and anchor damage. b) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs. c) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Marine reach

1. Recreational boating activity (non-fishing) – There is little information on the number of recreational boats (non-fishing), where they go and how many people they carry in this area. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight boats) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
2. Commercial vessels – water taxis and commercially operated cruise vessels operate throughout the area. Information on the frequency, routes and method of operation of these vessels would enable better assessment of their potential affects on estuarine habitats.

Key issues to be addressed for Marine reach

1. Fill important knowledge gap on recreational boating (non-fishing) activity.
2. Examine the level of interaction between recreational fishing and estuarine habitats in the area. A major project by I&I NSW has recently quantified the magnitude and location of recreational fishing activities within the fluvial delta. The results of that project could be linked to the habitat maps compiled for this project to determine the level of interaction. More targeted assessment of the condition of habitats with high levels of interaction with recreational fishing could then be done.
3. Assess the level of bait collection on rocky reef.

(I) FLUVIAL DELTA

Catchment and habitat characteristics

Table B.40. Summary of the catchment and habitat characteristics for Fluvial delta. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	4252.24			
Total length foreshore (km)	98.07			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	28.88	0.68	N	
Mangroves	200.03	4.70	N	
Mudflats	120.67	2.84	N	
Saltmarsh	19.12	0.45	Y	⚑
Rocky reef	27.44	0.65	N	
Sandflats	9.01	0.21	Y	
Deep subtidal	1691.76	39.79	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	P			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.41. Summary of intolerable and tolerable risk levels for Fluvial delta.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Seagrass	Recreational fishing
	Mudflats	Recreational fishing
		Aquatic recreation
		Foreshore development
	Rocky reef	Recreational fishing
Tolerable	Mangroves	Recreational fishing
		Aquatic recreation
		Foreshore development
	Sandflats	Recreational fishing
	Deep subtidal	Recreational fishing
		Foreshore development
	Water column	Aquatic recreation

Table B.42. Summary of all risk levels for all estuarine habitats in the Fluvial delta for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	M	IT	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	U	UD	1	0	2
Mangroves	M	M	T	M	M	T	M	M	T	M	U	UD	M			M	U	UD	M	U	UD	0	3	0
Intertidal mudflats	H	H	IT	H	M	IT	H	M	IT	H	U	UD	H			H	U	UD	H	U	UD	3	0	0
Saltmarsh	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	U	UD	0	0	3
Rocky reef	H	H	IT	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	U	UD	1	0	2
Sandflats	L	H	T	L	L	A	L	L	A	L	U	UD	L			L	U	UD	L	U	UD	0	1	2
Deep subtidal	L	M	T	L	L	A	L	M	T	L	U	UD	L			L	U	UD	L	U	UD	0	2	1
Water Column - P	M	-	-	M	-	-	M	L	A	M	-	-	M			M	U	UD	M	U	UD	0	0	1
Water Column - B	H	-	-	H	-	-	H	-	-	H	U	UD	H	L	A	H	-	-	H	-	-	0	0	1
# Habitats with:																								
INTOLERABLE			3			1			1			UD			0			UD			UD			
TOLERABLE			3			1			2			UD			0			UD			UD			
ACCEPTABLE			1			5			5			UD			1			UD			UD			
% Unknowns			0			33.3			0			66.7			33.3			80			55.6			

Issues arising for habitats with intolerable risk levels for Fluvial delta

Habitat: Seagrass Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and seagrass habitat from shore based fishing. Annual recreational fishing from the shoreline exceeded 500 hours per kilometre of shoreline and the estimated proportion of seagrass habitat along the shoreline was 33%. b) Known vector for the introduction of non-native invasive species in seagrass beds. Potential for *Caulerpa taxifolia* to spread via fragments on anchors and from trailers if not properly cleaned.

Habitat: Mudflats Number of human activities contributing to risk: 3

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and mudflat habitat from shore based fishing. Annual recreational fishing from the shoreline exceeded 500 hours per kilometre of shoreline and the estimated proportion of mudflat habitat along the shoreline was 33%. b) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. c) Known vector for the introduction of non-native invasive species in mudflats.
2. Aquatic recreation	a) The proportion of public access points within 10 m of mudflats was 27%. Public access points include boat ramps, recreational parks and swimming baths. Close proximity of mudflat habitat to public access points increases the likelihood of human interaction. However the level of stress depends on the depth in which the mudflats occur. b) There is a marina within 10 m of mudflats. Sediments beneath marinas have been found to be contaminated (HSC report). Contaminated sediments can be transported over time to surrounding areas potentially affecting the quality of mudflat habitat for infauna and microalgae. c) Aquatic recreation can be a vector for non-native invasives through boat activity. For example, fragments of *Caulerpa taxifolia* can be trapped on anchors and chains and transferred to new areas. Boat washing at boat ramps may accidently wash fragments off trailers into the surrounding water.
3. Foreshore development	a) A proportion of artificial rockwalls are within 10 m of mudflats (28%). Change in hardness and slope of shore can increase the intensity and frequency of water turbulence in around mudflats potentially de-stabilising them. Mudflats in shallower depths are more vulnerable to being affected by such increased turbulence. a) A proportion of unsewered housing blocks (16%) are within 10 m of mudflats. Unsewered housing is a potential source of increased nutrients from inadequate on-site sewage treatment and general run-off from the housing blocks. Nutrient enrichment could have localised but cumulative affects. b) A proportion of private and public wharves and jetties (24%) are within 10 m of mudflats. These in-stream structures increase boat activity in the vicinity and, if surrounding mudflats are in shallow depths, sediments may be re-suspended potentially changing their structure and sediment quality. c) A large proportion of oyster leases are within 10 m of mudflats (45%) and a large proportion of the area of mudflats are within 10 m of oyster leases (35%). Most oyster leases are built in these types of habitats (see notes in Mooney and Commercial Fishing section). Disturbance to sediments from boating activity associated with oyster farming may occur. d) Foreshore developments can be a vector for non-native invasives by providing a substrate for attachment. The potential for some of these species to spread into mudflats habitats is increased by the close proximity of foreshore developments to mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Large potential for interaction between recreational fishers and rocky reef habitat from shore based fishing. Annual recreational fishing from shore exceeded 500 hours per kilometre of shoreline and the estimated proportion of rocky reef in the area was at least 46%. Interaction between anglers and rocky reef habitat can include entanglement of fishing gear on biogenic structures on reefs and anchor damage. b) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs. c) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Fluvial delta

1. Effective total nitrogen load of from the upper catchment, STPs and non-point source pollutants – Data on the total nitrogen loads originating in the upper catchment, outputs from the STP within the fluvial delta as well as STPs further upstream of the LHE and loads from unsewered riverside housing and other non-point sources would enable a better assessment of the risk to mangroves, saltmarsh and seagrasses in this area.
2. Recreational boating activity (non-fishing) – There is little information on the number of recreational boats (non-fishing), where they go and how many people they carry in this area. Recreational boats are able to move virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight boats) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
3. Dredging and sedimentation – Dredging has occurred around Brooklyn in the past but information on whether there is subtidal erosion or sediment accretion around habitats in the vicinity is lacking. Information is lacking on the proportion of sediments that might be contaminated around marinas and their location and projected movement with respect to nearby estuarine habitats. Such data would enable a better assessment of the risk of degradation of habitats in this area.
4. Stormwater outlets – Information is needed on the location of stormwater outlets with respect to estuarine habitats and the nutrient loads of their outflows. This is particularly important in the more densely populated townships such as Brooklyn and Dangar Island.
5. Commercial vessels – water taxis and commercially operated cruise vessels operate throughout the area. Information on the frequency, routes and method of operation of these vessels would enable better assessment of their potential affects on estuarine habitats.

Key issues to be addressed for Fluvial delta

1. Fill important knowledge gaps particularly total nitrogen loads, recreational boating (non-fishing) activity, contaminated sediments and stormwater outlets.
2. Examine the level of interaction between recreational fishing and estuarine habitats in the area. A major project by I&I NSW has recently quantified the magnitude and location of recreational fishing activities within the fluvial delta. The results of that project could be linked to the habitat maps compiled for this project to determine the level of interaction. More targeted assessment of the condition of habitats with high levels of interaction with recreational fishing could then be done.
3. Assess the level of bait collection on mudflats and in other habitats.

4. Examine the condition of habitats in shallow subtidal areas close to artificial walls, wharves, jetties, unsewered housing and public access points for evidence of degradation particularly propeller scarring, erosion, smothering, sediment quality, die-off, epiphytic growth and presence of non-native invasives.

(J) RIVERINE CHANNEL

Catchment and habitat characteristics

Table B.43. Summary of the catchment and habitat characteristics for Riverine channel. Y – yes, N – no, A – absent, P – present, NA – not applicable, U – unknown, ⚑ – habitat priority for action. (see Sections 2.3).

Characteristic				
Surface water area (ha)	1200.49			
Total length foreshore (km)	66.57			
Habitat	**Area**	**% of water surface area**	**Decline in last 10 years?**	**Habitat priority**
Seagrass	0.00	0.00	NA	
Mangroves	250.31	20.85	N	
Mudflats	14.68	1.22	N	
Saltmarsh	107.15	8.93	Y	⚑
Rocky reef	9.61	0.80	N	
Sandflats	0.00	0.00	N	
Deep subtidal	528.85	44.05	U	
Water column	Not calculated			
Human activities	**Presence/Absence**			
Recreational fishing	P			
Aquatic recreation	P			
Foreshore development	P			
Stormwater/catchment run-off	P			
Sewage	P			
Dredging	P			
Commercial vessels	P			
i) Vulnerable/endangered ecological communities	YES			
ii) Non-native invasive species	NO			
iii) % sub-catchment urbanised/industrial ≥ 20%	NO			
Catchment priority:	**C3**	(see Table B.2)		

Table B.44. Summary of intolerable and tolerable risk levels for Riverine channel.

Risk Level	**Habitat**	**Human activity contributing to risk**
Intolerable	Mudflats	Recreational fishing
	Rocky reef	Recreational fishing
Tolerable	Mangroves	Aquatic recreation
		Foreshore development
	Deep subtidal	Foreshore development

Table B.45. Summary of all risk levels for all estuarine habitats in the Riverine reach for all human activities. See Appendix 3 for details of stressor analysis for each human activity on each habitat type. P – physical, B – biochemical, V – vulnerability level, Th – threat level, R – risk level, H – high, M – medium, L – low, IT – intolerable, T – tolerable, A – acceptable, dash – not applicable, U – unknown. UD – undetermined due to high percentage of unknowns. % unknowns indicate the proportion of stress measures for an activity where no information was available. Sewage only assessed for the water column habitat (see explanation in Note for Table B.12).

	Recreational fishing			Aquatic recreation			Foreshore development			Stormwater/ catchment			Sewage			Dredging/Sedimentation			Commercial vessels			# Activities for each habitat with		
Habitats	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	V	Th	**R**	**IT**	**T**	**A**
Seagrass	H	L	NP	H	L	NP	H	L	NP	H	U	NP	H			H	U	NP	H	-	NP	0	0	0
Mangroves	M	L	A	M	M	T	M	M	T	M	U	UD	M			M	U	UD	M	L	A	0	2	2
Intertidal mudflats	H	M	IT	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	1	0	3
Saltmarsh	H	L	A	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	0	0	4
Rocky reef	H	M	IT	H	L	A	H	L	A	H	U	UD	H			H	U	UD	H	L	A	1	0	3
Sandflats	L	L	NP	L	L	NP	L	L	NP	L	U	NP	L			L	U	NP	L	-	NP	0	0	0
Deep subtidal	L	L	A	L	L	A	L	M	T	L	U	UD	L			L	U	UD	L	L	A	0	1	3
Water Column - P	M	-	-	M	-	-	M	L	A	M	-		M			M	U	UD	M	L	A	0	0	2
Water Column - B	H	-	-	H	-	-	H	-		H	U	UD	H	L	A	H	-		H	-		0	0	1
# Habitats with:																								
INTOLERABLE			2			0			0			UD			0			UD			0			
TOLERABLE			0			1			2			UD			0			UD			0			
ACCEPTABLE			3			4			4			UD			1			UD			6			
% Unknowns			0			33.3			0			100			20			80			44.4			

Issues arising for habitats with intolerable risk levels for Riverine channel

Habitat: Mudflats Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Bait can be collected from mudflats via pumping for shrimps and worms. Effects of trampling and extraction of bioturbators can affect sediment composition and quality. b) Known vector for the introduction of non-native invasive species in mudflats.

Habitat: Rocky reef Number of human activities contributing to risk: 1

Human activity	Issues arising
1. Recreational fishing	a) Bait collected from rocky reefs intertidally and shallow subtidal can alter assemblage structure of animals and algae on and around reefs. b) Known vector for the introduction of non-native invasive species.

Key knowledge gaps for Riverine channel

1. Effective total nitrogen load of from the upper catchment, STPs and non-point source pollutants – Data on the total nitrogen loads originating in the upper catchment, outputs from STPs further upstream of the LHE and loads from unsewered riverside housing and other non-point sources would enable a better assessment of the risk to mangroves in this area.
2. Recreational boating activity (non-fishing) – There is little information on the number of recreational boats (non-fishing), where they go and how many people they carry in this area. Recreational boats are able to go virtually anywhere in the bay, depending upon their size, and so can potentially interact with all types of estuarine habitats. Information is needed on the magnitude of activity (e.g., number of boats, number of people per boat, number of hours of recreational activity that is boat-based), location and size of boats (smaller day boats compared to larger overnight boats) participating in recreational activities. Such information should be collected to ensure differences in activity between seasons, week days and weekends and school and non-school holiday periods can be assessed.
3. Stormwater outlets – Information is needed on the location of stormwater outlets with respect to estuarine habitats and the nutrient loads of their outflows.

Key issues to be addressed for Riverine channel

1. Fill important knowledge gaps particularly total nitrogen loads and recreational boating (non-fishing) activity.
2. Assess the level of bait collection on mudflats and in other habitats.

6.3.2.4. Commercial fishing

(A) ESTUARY GENERAL AND ESTUARY PRAWN TRAWL

Estuary General (EG) and Estuary Prawn Trawl (EPT) are the two wild capture fisheries occurring in the LHE. These fisheries have been operating in the estuary since about the 1940s and contribute substantially to the provision of seafood in NSW. EG and EPT underwent environmental impact assessments in 2001 and 2002 respectively under both state and Commonwealth legislation (NSW Fisheries 2001, 2002). In the case of the Commonwealth assessments, fisheries had to demonstrate they were ecologically sustainable in order to be approved to export their product. Both fisheries have met these criteria and have implemented fishery management strategies (FMS) under state legislation (NSW Fisheries 2003a,b). These strategies must also adhere to the principles of ESD (National Fisheries Ecologically Sustainable Development, 2009) to be approved.

The assessment of the overall threat level to estuarine habitats from these two fisheries was determined by extracting the ecological assessment of their potential impacts and the measures in place to mitigate these potential impacts from the Environmental Impact Statements (EIS) and FMS of these fisheries (NSW Fisheries 2003a, b). Although a different ecological risk assessment method was used for these fisheries than elsewhere in this report (the current method was developed after the completion of the EIS for these two fisheries), the adequacy of the assessments was confirmed by the successful approval of their FMS by state and Commonwealth agencies (Department of the Environment, Water, Heritage and the Arts, 2009).

Table B.46 summarises the stressors, potential outcomes and the management actions in place for each estuarine habitat with which the EG and EPT fisheries can interact. Generally, it shows that the potential threats from the fisheries are mitigated by restrictions on fishing in specific habitat types, extensive area closures in sub-catchments and reaches, controls on the use of gear types and a code of conduct for operating in estuarine habitats. Commercial fishing closures have been implemented in a large proportion of the LHE which protects substantial areas containing multiple habitat types (Table B.47). In addition, the EG and EPT FMS have undertaken to identify environmentally sensitive habitats and areas where no trawling occurs in order to designate specific landing areas to reduce potential impacts from fishing operations. The mapped habitats from this study will contribute to this process. Based on these assessments the overall threat to all estuarine habitats in the LHE from these fisheries was considered low.

Issues arising for EG and EPT

Now that habitat maps have been produced for the LHE, the process for designating landing sites for hauling nets for the EG fishery and mapping non-trawled areas for the EPT fishery can be further developed as per their respective FMS. It should also be noted that potential effects from other human activities on estuarine habitats could have flow-on effects to the operation of these fisheries. Other human activities (e.g., increased nutrients from run-off, aquatic recreation intensity in and around seagrasses and mangroves) may make current fishing areas less productive and result in fishers moving their operations to other parts of the LHE which may place more pressure on habitats in these areas.

Table B.46. Summary of the stressors, potential outcomes and management measures in place for each estuarine habitat type for EG and EPT fisheries.

Fishery	Stressors (these can occur in a range of habitats, i.e., not habitat specific)	Habitat	Potential Outcomes	Management Actions Implemented
EG	Nets dragging over substratum; Trampling on foreshore to retrieve gear; Snagging of fishing line on parts of habitat; Contact of traps with substratum; Boat operations in shallow water depth; Hauling of boats on shoreline.	Seagrass	Removal of epiphytes, periphyton or epifauna from seagrass blades; Removal of or damage to seagrass blades or shoots; Reduction of growing conditions from increased turbidity or destabilisation of sediments.	Prohibition of use of hauling nets over *Posidonia australia* seagrass; Prohibition of all prawn hauling and prawn seining methods over seagrass; Designation of landing sites for hauling nets where seagrass exists around shoreline areas (being developed as habitat mapping is completed); Code of conduct for operating near seagrass beds.
		Mangroves	No actual fishing occurs within mangroves Trapping and hauling can occur in channels and flats beside mangroves, therefore may disturb sediments, increasing turbidity within mangroves; Compaction of vegetation or sediments on seaward edge to retrieve gear in adjacent/nearby habitats.	Code of conduct for operating near mangroves
		Saltmarsh Soft strata – mud and sandflats	No actual fishing occurs within saltmarsh. Compaction of vegetation or sediments on seaward edge to retrieve gear in adjacent/nearby habitats; Decline in saltmarsh plants; Lower ground level from compaction, retaining more water during low tide affecting plant survival; Damage or removal of fauna and flora reducing habitat complexity.	Code of conduct for operating near saltmarsh Reduction in maximum allowable length of fish hauling nets to 500m and restriction of one shot per day;

Table B.46. cont'd.

Fishery	Stressors (these can occur in a range of habitats, i.e., not habitat specific)	Habitat	Potential Outcomes	Management Actions Implemented
EG	See above	Soft strata – mud and sandflats	Destabilised sediments, increasing erosion, decreasing water quality; Resuspension of sediments and possible contaminants; Transfer material, covering or smothering previously exposed sediment	Fishing closures throughout the estuary (see Table B.47)
		Rocky reef	Damage or removal of fauna and flora reducing habitat complexity	Reduction in maximum allowable length of fish hauling nets to 500m and restriction of one shot per day; Fishing closures throughout the estuary (see Table B.47)
		Deep subtidal	Traps may disturb sediment but most EG fishing gear not suitable for deep subtidal habitat	Fishing closures throughout the estuary (see Table B.47)
		Water column	Resuspension of sediments; decreased light in shallow areas from increased turbidity; introduction of contaminants from sediments	Reduction in maximum allowable length of fish hauling nets to 500m and restriction of one shot per day; Fishing closures throughout the estuary (see Table B.47)
EPT	Trawl gear dragging over substratum.	Seagrass	Removal of or damage to seagrass blades, shoots or rhizomes; Reduction of growing conditions from increased turbidity or destabilisation of sediments	Prohibition of all trawling over seagrass beds; Code of conduct for operating near seagrass
		Mangroves	No actual fishing occurs within mangroves	
			Trawling can occur in areas in front of mangroves, therefore may disturb sediments, increasing turbidity within mangroves;	Fishing closures throughout the estuary (see Table B.47); Code of conduct for operating near mangroves
		Saltmarsh	No actual fishing occurs within saltmarsh	N/A

Table B.46. cont'd.

Fishery	Stressors (these can occur in a range of habitats, i.e., not habitat specific)	Habitat	Potential Outcomes	Management Actions Implemented
EPT	See above	Soft strata – mud and sandflats	Damage or removal of fauna and flora reducing habitat complexity; Destabilised sediments, increasing erosion, decreasing water quality; Resuspension of sediments and possible contaminants; Transfer material, covering or smothering previously exposed sediment.	Prohibition of all trawling over environmentally sensitive aquatic habitats; Clearly defining environmentally sensitive areas and non-trawled areas where trawling is permitted in LHE (being developed as habitat mapping is completed); No increase in current total area trawled within the LHE.
		Rocky reef	Gear not suitable for rocky reef habitat.	Prohibition of all trawling over environmentally sensitive aquatic habitats; Clearly defining environmentally sensitive areas and non-trawled areas where trawling is permitted in LHE (being developed as habitat mapping is completed); No increase in current total area trawled within the LHE
		Deep subtidal	Destabilised sediments, increasing erosion, Decreasing water quality.	Prohibition of all trawling over environmentally sensitive aquatic habitats; Clearly defining environmentally sensitive areas and non-trawled areas where trawling is permitted in LHE (being developed as habitat mapping is completed); No increase in current total area trawled within the LHE; See also Note 1.
		Water column	Resuspension of sediments; decreased light in shallow areas from increased turbidity; introduction of contaminants from sediments.	Prohibition of all trawling over environmentally sensitive aquatic habitats; Clearly defining environmentally sensitive areas and non-trawled areas where trawling is permitted in LHE (being developed as habitat mapping is completed)No increase in current total area trawled within the LHE.

Table B.46. Note 1: An FRDC funded study done in the Clarence estuary assessed the potential impacts of estuary prawn trawling on deep benthic soft sediment assemblages (Underwood, 2007). It found no evidence of impacts due to trawling in the existing habitat. This indicates that the deep subtidal sediment habitat is unlikely to be substantially affected by current trawling activities.

Table B.47. Summary of commercial fishing area closures for each sub-catchment and reach in the LHE. These are based on all year closures irrespective of gear types. For specific information on location and gear restrictions please consult the Department of Industry and Investment website.

Fishery:	Estuary General		Estuary Prawn Trawl	
Subcatchment/Reach	Area (ha)	% of water surface area closed	Area (ha)	% of water surface area closed
Pittwater	-	90	-	100
	920.8		1333.1	
Cowan	3	69.07	3	100.00
Berowra	0.00	0.00	633.91	48.87
Mangrove	0.00	0.00	66.08	14.41
Mooney	0.00	0.00	0.00	0.00
Mullet	0.00	0.00	296.49	100.00
Patonga	60.39	100.00	60.39	100.00
Broken Bay to western point of Pittwater	0.00	0.00	462.50	27.02
Western point of Pittwater to Spencer	0.00	0.00	778.56	18.31
Spencer to Wisemans Ferry	11.45	0.95	11.45	0.95

(B) OYSTER FARMING

Oyster farming is the only commercial aquaculture industry operating in the LHE. Oyster farms exist throughout the estuary and they produce both Sydney rock and Pacific oysters. Due to an outbreak of QX disease in the estuary in 2004, production has been significantly reduced in the last 4 years. Since 2004 oysters farmers, in conjunction with I&I NSW, have developed methods to cultivate disease-resistant Sydney rock oysters and triploid Pacific oysters. Triploid strains are naturally non-fertile and therefore should have no impacts on local native oysters. Pacific oysters now make up the majority of production in the LHE. In 2007/2008, 5,500 dozen Sydney rock oysters were produced from the estuary and 48,321 dozen Pacific oysters were produced state-wide from tray culture (estuary specific production figures unavailable).

In the last two years the industry has undertaken extensive work to remove the in-stream infrastructure of oyster leases no longer in use in the LHE. Recently, the NSW Oyster Industry produced a Sustainable Aquaculture Strategy in partnership with the NSW Government (NSW Oyster Industry, 2006).

Oyster farmers in the Hawkesbury use the single seed method of cultivation which involves transferring newly-settled spat on to floating structures such as fine mesh baskets and trays. Farmers purchase triploid Pacific oyster sprat from a shellfish culture company in Tasmania. There are no stick cultures in the LHE. Oyster farmers in the LHE have made a commitment to using only plastic material or timber covered plastic material on their in-stream structures such as posts, supporting trays and boundary markers in response to reports of the dangers of the old tar covered material releasing contaminants into the water and sediment (Smith, 2008). All tar-covered

structures have been removed from the LHE. Because oysters require high quality water for growth and purification to meet human consumption standards, the oyster industry is acutely attuned to water quality issues within the LHE. The Sustainable Aquaculture Strategy sets guidelines for water quality variables that are essential for the healthy growth of oysters and farmers regularly monitor water quality in their growing areas accordingly. What benefits the oysters will also benefit other estuarine biota, including biogenic habitats such as seagrasses. Oyster farmers are currently implementing an Environmental Management System which assesses industry-related and external risks to the industry.

The assessment of the overall threat level to estuarine habitats from oyster farms was determined by extracting the relevant information from the Sustainable Aquaculture Strategy on the potential stressors from the operation of oyster farms and the management strategies in place to mitigate any potential impacts from these stressors. These are summarised in Table B.48. Generally it shows that the oyster industry minimises its impact on estuarine habitats by confining their activities to within the boundaries of their leases, using low impact methods (such as single layer trays and use of plastic material), no disposal of waste material within the waterway and keeping stocking densities below the carrying capacity of the estuary. There appears to have been no specific studies done on the impacts on the sediments and benthic biota beneath oyster farms in the LHE. Oysters can deposit substantial quantities of faecal material from their filter feeding onto the seabed below. This can lead to an enrichment of organic material. However, risk assessments done on similar oyster farms elsewhere have shown minimal effects from organic enrichment to benthic sediments, including in surrounding areas outside leases (Crawford, 2003). Based on all the above information the overall threat to all estuarine habitats in the LHE from oyster farming was considered low.

Issues arising for Oyster Farming

Oyster farmers monitor the state of their harvest areas on a regular basis, which is at a smaller spatial scale and over a long time scale than monitoring regimes of most government management agencies are able to undertake. This information could be a useful addition to monitoring changes to the estuary under different environmental and human induced conditions at the larger spatial scale sometimes undertaken by management agencies. Consequently, co-operation between oyster farmers in the LHE and other management agencies that enables appropriate data to be collected (e.g., Scanes *et al.*, 2007) and exchanged could assist in the management of human activities and their potential impact on habitats.

Table B.48. Summary of the stressors, potential outcomes and management strategy in place for each estuarine habitat type for oyster farming.

Stressors (not habitat specific)	**Habitat**	**Potential Outcomes**	**Management Strategy**
Shading from in-stream structures; Biodeposits; Plot maintenance, including removal/movement of in-stream structures in and out of sediment; Wave attenuation; Flow modification from in-stream structures; Waste disposal; Operation of motor boats and pumping equipment.	Seagrass	Reduction of growing conditions from decreased light; organic enrichment of seabed; alteration of sediment structure; resuspension of sediment from plot maintenance.	No new leases to be established over *Posidonia* and *Zostera* seagrass beds; Current leases over seagrass should use methods that minimise shading such as single layer stick culture, floating cultivation; Ensure activities do not interfere with vegetation inside lease areas.
	Mangroves	nil	Ensure activities do not interfere with vegetation outside lease areas; Ensure activities do not degrade conservation areas and care for unique natural resources; Activities confined to within lease boundaries.
	Saltmarsh	nil	Ensure activities do not interfere with vegetation outside lease areas; Ensure activities do not degrade conservation areas and care for unique natural resources.
	Soft strata – mud and sandflats	organic enrichment of seabed; alteration of sediment structure; resuspension of sediment from plot maintenance.	Minimal effects from organic enrichment to benthic sediments, including in surrounding areas outside leases (Crawford, 2003); Guidelines to keep stocking densities below the carrying capacity of the estuary; No disposal of oyster shells or byproducts within lease area or adjoining waterways.

Table B.48 cont'd.

Stressors (not habitat specific)	Habitat	Potential Outcomes	Management Strategy
See above	Rocky reef	nil	Activities confined to within lease boundaries.
	Deep subtidal	organic enrichment of seabed; alteration of sediment structure	Minimal effects from organic enrichment to benthic sediments, including in surrounding areas outside leases (Crawford, 2003); Guidelines to keep stocking densities below the carrying capacity of the estuary; no disposal of oyster shells or byproducts within lease area or adjoining waterways; In-stream infrastructure from all dis-continued leases to be removed
	Water column	Alteration in flushing of nutrients around structures; spread of non-native invasive species	irrigation pumps must not pollute waterway; outboard motors kept in good condition; Guidelines to keep stocking densities below the carrying capacity of the estuary; disposal of waste material only via authorised disposal sites, not within estuary; wave barrier fencing made of non-prohibited material, not exceed 50cm above or below the water surface; farmers engage in practices that minimise spread of *Caulerpa taxifola* such as checking propellers for fragments.

7. DISCUSSION

This study, for the first time, has assessed the risk to estuarine habitats from a range of human activities occurring in the LHE. Previously, ecological risk assessments have only been done for commercial fishing (e.g., NSW Fisheries 2001) or for specific developments (e.g., marina construction). Undertaking an extensive ecological risk assessment for a large range of human activities has brought into focus where there is potential for interactions between these activities and estuarine habitats which may have been previously overlooked. For example, the intensity of recreational fishing activity along the shoreline and from boats in shallow water in some sub-catchments has shown that the potential for this activity to interact with estuarine habitats such as mangroves, seagrass and mudflats is substantial.

A unique feature of this ecological risk assessment was the use of maps of human disturbances within the LHE, such as the location of seawalls, foreshore parks and unsewered housing. These maps enabled the development of measures of the stress from these activities on the estuarine habitats (e.g., number of seawalls within 10 m of a habitat). These maps and the measures derived from them enabled a spatially explicit assessment of the risks. Such an assessment gives management agencies two important pieces of information. First, it identifies where the potential threats are in relation to specific habitats. For example, mangroves within 10 m of a recreational park are more at risk than mangroves surrounded by natural bushland. Second, it identifies what is contributing to a habitat being at risk. The proximity of a recreational park to a mangrove, for example, indicates that trampling could be a potential disturbance. Knowledge of the nature and specific location of potential threats gives direction in how resources can be allocated to manage the risks.

The ecological risk assessment brought to light the substantial knowledge gaps in our understanding of the interactions between human activities and estuarine habitats in the LHE. There were two types of knowledge gaps. First, there was a lack of knowledge in the direct measures of some of the stressors of human activities. As a result indirect measures had to be used. For example, the proximity of seawalls to a seagrass bed was an indirect measure of the level of sedimentation and/or erosion that could occur in and around the seagrass bed from increased turbulence due to changes to water flow resulting from the vertical seawall. A more direct measure would be to determine whether erosion or sedimentation was occurring in the seagrass bed. Obtaining such detailed information, however, requires considerable time and resources and therefore is often not practical to collect for an ecological risk assessment. In such cases, indirect measures of the stressors are considered adequate to guide management to where it would be worth gathering more detailed information.

Second, there were extensive knowledge gaps about the extent and magnitude of a number of human activities at the sub-catchment or reach scales. This resulted in not being able to determine the level of risk for these activities. Aquatic recreation (non-fishing), dredging, commercial vessels and sub-catchment run-off were the major activities that had a consistently high percentage of knowledge gaps. These knowledge gaps mean that we do not know what the level of overall threat these activities pose to estuarine habitats, and hence the level of risk is unknown. Therefore, the knowledge gaps in themselves are a risk to the successful implementation and outcomes of the management plans of HNCMA and HSC because they are unable to manage these unknown risks.

Another aspect highlighted by this risk assessment is the lack of consistency in reporting of data for some stressors to local management agencies. For example, a number of estuary process studies were relied upon for information. In broad terms the information was similar between reports, but the actual presentation of the data was inconsistent. For example, in one estuary process study,

nutrients were reported as kilograms per year but in another they were only reported as milligrams per litre. This made it difficult to find the same data for the stressors being measured across sub-catchments. Some of the guidelines for reporting water quality variables need to be brought into line with the results of current research (e.g., Scanes *et al.*, 2007) which would make them more relevant to assessing the stressors on estuarine habitats. Furthermore, other information needs to be included in estuary process studies that are more relevant to assessing impacts on habitats. For example, there was little or inconsistent information on stormwater outlets, their nutrient loads and their location in the estuary. Although sediment contamination was reported in some detail, information on the location of contaminated sediments with respect to adjacent habitats and an estimation of the proportion of sediments contaminated was not clearly available. Revision of the guidelines for estuary process studies would help consultants and councils to collect information that enables them to better assess potential human impacts on habitats.

Future work should be directed to four main areas.

First, future work should make an assessment of the state of those habitats that had intolerable levels of risk to determine whether they are experiencing degradation and if so to what extent. For those habitats showing degradation, the relationship between the relevant aspects of the condition of a habitat and the stressor should be quantified and analysed to determine if there is a significant correlation. This is an important and necessary step because the measures of stressors used in this risk assessment were often surrogates in lieu of more quantitative and direct measures of stress. Quantifying the condition of the habitat and the stressors potentially affecting it is needed to gain a more accurate assessment of the extent of habitat degradation and its possible causes. Establishing patterns between habitat condition and human stressors will enable management agencies to allocate their resources to habitat conservation in a more efficient and effective manner by clearly identifying where management is most needed.

Second, an assessment of the magnitude, frequency and duration of some of the major human activities where there are large knowledge gaps (e.g., aquatic recreation) is necessary to determine the risks from all the major human activities to estuarine habitats within LHE. For example, aquatic recreation, which includes boating (non-fishing), foreshore picnicking, swimming and personal watercraft, is a diverse and major human activity that occurs throughout the LHE. It has a large potential to interact with all estuarine habitats. Because there is currently no measure of the magnitude, frequency, distribution and duration of these diverse activities throughout the LHE the level of potential stress this pressure is placing on estuarine habitats is unknown. It could be substantial in some areas and therefore maybe putting some habitats at intolerable levels of risk. Consequently, management will be unable to adequately manage this potential risk.

Third, management agencies should monitor their progress in reducing the level of risks identified by addressing the key issues for each sub-catchment and reach. The management programmes that agencies already have in place should be checked to determine to what extent they address the issues. Additional management action should be put in place to address those issues not already covered. It should be noted that not addressing some issues may have flow-on effects to other human activities. For example, degradation of some seagrass habitats from catchment run-off may result in a change in commercial or recreational fishing intensity as fishers shift their effort to more productive locations, increasing the pressure on previously low risk habitats. Furthermore, in determining what knowledge gaps should be filled, management agencies should consider whether their current level of information is sufficient for them to act without pursuing further data. The key knowledge gaps identified in the report for each sub-catchment or reach would be a helpful guide for such decision making.

Incorporated into monitoring progress in reducing risk levels should be a regular cycle of review of the qualitative risk assessment of all estuarine habitats. The same method of qualitative ecological

risk assessment applied in this report should continue to be used in future assessments to enable evaluation of whether human stresses on habitats have declined or increased over time. New information, as knowledge gaps are addressed and data on direct stressor measures obtained can be easily incorporated into future risk assessments to provide a more robust evaluation. In addition, future assessments should also include relevant stressors of climate change and measures of habitat patchiness and heterogeneity if appropriate data is available.

Fourth, the detailed maps of estuarine habitats and location of human activities within the LHE will enable a vulnerability assessment of the effects of climate change on estuarine habitats to be undertaken. The effects of climate change may increase the risks to some estuarine habitats by increasing their exposure to stressors such as increased inundation times and changes to salinity regimes (e.g., Short and Neckles, 1999). A vulnerability assessment will be able to determine which habitats in which sub-catchments and reaches are most exposed to the potential stressors of climate change. In addition, it will assess whether current human activities negatively affect the ability of habitats to adapt to climate change impacts and what mitigative action could be taken to ensure this is minimised.

In conclusion, there are many habitats within the LHE that are in relatively good condition and currently at low risk to human activities based on current information. For an estuary in such close proximity to a high population urban area as Sydney this is rare. But this risk assessment should alert all those responsible for this estuarine ecosystem to be vigilant in continuing to keep these habitats in good condition. Diligent attention, via adequate resourcing and holistic management approaches, to the issues identified will substantially aid this task.

PART C

8. RECOMMENDATIONS

1. The condition of habitats that had intolerable levels of risk should be quantified and analysed for any signs of degradation.
2. Management agencies should give priority action to reduce intolerable levels of risk on habitats to acceptable levels.
3. Priority habitats with acceptable levels of risk (e.g., saltmarsh) should continue to be appropriately managed to ensure stressors from human activities do not increase within the areas they occur and monitored to ensure no deterioration in their risk level.
4. Each responsible management agency should address the key knowledge gaps for its jurisdiction, including those in areas for which there is overlap with other jurisdictions such as in the Fluvial Delta of Hawkesbury River in a coordinated management approach.
5. Each responsible management agency should address the key issues for its jurisdiction, including those issues in areas for which there is overlap with other jurisdictions such as in the Fluvial Delta of Hawkesbury River in a coordinated management approach.
6. All management agencies in the LHE are encouraged to undertake a joint study to quantify the magnitude, frequency, distribution and duration of aquatic recreational activities, including foreshore activities, and their associated impacts throughout the LHE.
7. Land-use mapping for each sub-catchment and reach should be regularly checked and re-done where necessary.
8. The bathymetric data used in this project was an unfinished product. The final layer should be obtained from DECCW. This data should then be reviewed, data gaps or inconsistencies identified, and updated where necessary either via the incorporation of other data if available or by resurvey. A layer highlighting the spatial variability and accuracy of the original data used in the creation of this bathymetric data may also be useful.
9. Sediment data for the LHE should to be compiled and reviewed. Layers indicating the distribution of substrate sediments should be created to assist in the mapping of geomorphic zones.
10. Mapping of the estuarine geomorphic zones should be completed. This mapping would be enhanced by the incorporation of better bathymetric and sediment data as listed above.
11. Government agencies and other natural resource organisations implement of a cycle of review for a qualitative risk assessment of all estuarine habitats in the LHE on a three to five year basis.
12. A revision of guidelines by NSW DECCW for information presented in estuary process studies is needed to ensure consistency in reporting so that it is relevant for habitat protection.
13. For the spatial data to be incorporated into the GIS databases of management agencies to inform land management planning and compliance.
14. A vulnerability assessment be done on climate change impacts on estuarine habitats within the LHE.

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10. APPENDICES

Appendix 1. Area or number of features within 10m of estuarine habitat for each subcatchment.

SUBCATCH: PITTWATER

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	17	16	0	2	8	30	3
Housing blocks	25	26	0	0	11	181	0
Boat ramps	3	0	0	0	0	2	1
Swimming baths	2	1	0	0	1	3	1
Marinas	0	1	0	0	0	4	5
Wharves/jetties	348	17	0	0	87	22	104
No boat wash zones	40.186	3.656183	0	0.188426	5.125	66.263	1241.177
Oyster leases No.	0	0	0	0	0	0	0
Oyster leases Area (Ha)	0	0	0	0	0	0	0
Moorings	483	2	0	1	2	14	2212
Artificial Rock Wall (No.)	31	25	0	1	19	52	6

SUBCATCH: COWAN

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	2	2	0	0	0	2	0
Housing blocks	9	0	0	0	0	0	26
Boat ramps	1	0	0	0	0	0	0
Swimming baths	1	1	0	0	0	1	0
Marinas	0	0	0	0	1	0	3
Wharves/jetties	8	0	0	0	1	1	44
No boat wash zones	7.9778	15.57384	0	0.162736	3.674	50.897	1038.092
Oyster leases No.	0	0	0	0	0	0	0
Oyster leases Area (Ha)	0	0	0	0	0	0	0
Moorings	0	0	0	0	0	0	0
Artificial Rock Wall (No.)	9	4	0	0	2	6	8

SUBCATCH: BEROWRA

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	0	0	0	0	0	0
Housing blocks	0	18	0	0	0	5	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	8	0	0	0	4	0
No boat wash zones	3.685	42.801973	24.371	3.562537	0.478	41.041	36.515
Oyster leases No.	0	12	12	0	0	3	0
Oyster leases Area (Ha)	0	7.746	19.993	0	0	3.77	0
Moorings	0	0	0	0	0	0	0
Artificial Rock Wall (No.)	0	11	0	0	0	3	0

SUBCATCH: MANGROVE

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	0	0	0	0	0	0
Housing blocks	0	48	2	1	0	0	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	30	11	2	0	0	0
No boat wash zones	0	0.36936	0	0.086081	0	0	10.456
Oyster leases No.	0	0	2	2	0	0	0
Oyster leases Area (Ha)	0	0	2.439	2.439	0	0	0
Moorings	0	0	6	0	0	0	0
Artificial Rock Wall (No.)	0	8	1	0	0	0	0

SUBCATCH: MOONEY

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	0	0	0	0	0	0
Housing blocks	0	74	128	3	0	0	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	6	35	0	0	0	0
No boat wash zones	0	0	0	0	0	0	1.112
Oyster leases No.	0	14	83	0	0	0	0
Oyster leases Area (Ha)	0	19.394	117.27	0	0	0	0
Moorings	0	0	5	0	0	0	0
Artificial Rock Wall (No.)	0	1	1	0	0	0	0

SUBCATCH: MULLET

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	0	0	0	0	0	0
Housing blocks	0	0	1	0	0	0	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	1	1	0	0	0	0
No boat wash zones	0	0	0	0	0	0	3.553
Oyster leases No.	0	1	12	0	0	0	0
Oyster leases Area (Ha)	0	0.237	14.268	0	0	0	0
Moorings	0	0	0	0	0	0	0
Artificial Rock Wall (No.)	0	2	1	0	0	0	0

SUBCATCH: PATONGA

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	1	0	0	0	0	1	0
Housing blocks	2	7	14	0	0	0	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	8	3	7	0	0	0	0
No boat wash zones	0	0	0	0	0	0	0
Oyster leases No.	10	9	3	1	0	0	0
Oyster leases Area (Ha)	11.25	8.354	2.937	0.506	0	0	0
Moorings	48	0	0	0	0	0	0
Artificial Rock Wall (No.)	1	0	0	0	0	1	0

SUBCATCH: MARINE REACH

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	0	0	0	0	1	2
Housing blocks	0	0	0	0	0	0	0
Boat ramps	0	0	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	1
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	0	0	0	0	0	0
No boat wash zones	0	0	0	0	0	0	0
Oyster leases No.	0	0	0	0	0	0	0
Oyster leases Area (Ha)	0	0	0	0	0	0	0
Moorings	0	0	0	0	0	0	1
Artificial Rock Wall (No.)	0	0	0	0	0	0	0

SUBCATCH: WESTERN POINT OF PITTWATER TO SPENCER

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	1	4	3	1	0	1	1
Housing blocks	0	110	93	12	27	2	134
Boat ramps	0	1	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	1	1	0	0	0	0
Wharves/jetties	2	61	75	0	16	1	147
No boat wash zones	15.162	62.921446	44.701	2.378316	3.615	1.598	274.459
Oyster leases No.	8	20	47	0	21	3	0
Oyster leases Area (Ha)	5.895	15.421	42.664	0	1.293	1.162	0
Moorings	9	0	13	0	18	0	118
Artificial Rock Wall (No.)	0	9	8	1	2	0	9

SUBCATCH: SPENCER TO WISEMANS

Developments	Seagrass	Mangrove	Intertidal mudflats	Saltmarsh	Rocky reef	Sand flats	Deep subtidal >5m
Recreational parks	0	2	0	1	0	0	1
Housing blocks	0	70	0	13	0	0	9
Boat ramps	0	1	0	0	0	0	0
Swimming baths	0	0	0	0	0	0	0
Marinas	0	0	0	0	0	0	0
Wharves/jetties	0	42	2	2	0	0	30
No boat wash zones	0	74.249287	3.264	7.596	0.018	0	41.527
Oyster leases No.	0	0	0	0	0	0	0
Oyster leases Area (Ha)	0	0	0	0	0	0	0
Moorings	0	0	2	0	0	0	8
Artificial Rock Wall (No.)	0	17	0	1	0	0	9

Appendix 2. Rationale for stress measures and susceptibility thresholds.

This appendix provides the rationale for each of the measures of stress and their susceptibility thresholds used to determine the overall level of threat from each human activity for each habitat. It also provides an explanation of the how the data for each measure were obtained. Clearly, measures and their thresholds can be changed or added to as more detailed information and data emerges. Changes to the measures and thresholds would produce different results in the levels of risk to each habitat.

Recreational fishing

Data for recreational fishing effort was obtained from a separate study currently being done by researchers in I&I NSW called 'Recreational fishing surveys in the Greater Sydney Region'. Two types of effort data were collected in this project – boat-based and shore-based fishing. Boat-based fishing was the number of boats that were observed during a survey period which had occupants who were fishing. The survey did not count the number of people in each boat fishing, only the number of boats who had people fishing irrespective of the number of people. The data were expressed as total party hours meaning the number of hours spent fishing from a boat irrespective of the number of people in a boat. Shore-based fishing was the number of individuals who were observed fishing from the shore during a survey period. The data were expressed as total angler hours (i.e., the number of hours spent fishing from the shoreline)**.** Note that boat-based fishing and shore-based fishing cannot be added together to get total effort of recreational fishing because they were measured in different units – number of boats and number of individuals respectively. The stress measure for recreational fishing was the number of hours per water surface area of the sub-catchment or reach for boat-based and the number of hours per kilometre of shoreline for shore-based. This allowed assessment of the relative density of fishing in each area. Note that the measure for shore-based fishing assumes that all shoreline in a sub-catchment or reach is accessible to people for fishing, which may not be true everywhere. As most boat-based fishing occurred around the edges of sub-catchments and reaches, this type of fishing effort was expressed proportionally according to the area of shallow (<5 m) subtidal and deep subtidal (>5 m) water. Ninety percent of the fishing effort was allocated to the shallow subtidal and ten percent to the deep subtidal.

To assess the level of interaction between recreational fishing and estuarine habitats, the area of each habitat was also included as part of the stress measure, based on the assumption that the larger the area of habitat the more likely a recreational fishing activity would encounter that habitat. Area of habitat was expressed as the proportion of the water surface area of the sub-catchment or reach or kilometre of shoreline. The latter was derived from the length of shoreline which had either natural soft substratum (mangroves, seagrass, mud or sand flats) or natural hard substratum (rocky reef). To assess the interaction with boat-based fishing, habitats that occur primarily in the shallow subtidal and intertidal(seagrass, mangroves, saltmarsh, mudflats, sandflats) were expressed as a proportion of the total shallow subtidal area and those habitats that occur primarily in the deep subtidal (e.g., rocky reef) as a proportion of the total deep subtidal area.

Recreational fishing

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/Sh ha; >6/D ha; >20/T ha & Hab: >0.2	Boat hr: <50/ha Sh; <6/ha D; <20/ha T & Hab: >0.2	Fishing from boats was a measure of the level of stress from fishing based activities such as fishing line entanglement and anchor damage. Fishing effort was divided into three divisions – shallow (Sh) subtidal, deep (D) subtidal and total (T), whole estuary. Area of habitat was also divided into these three divisions to make appropriate comparisons with the fishing effort. *Susceptibility level*: Thresholds for fishing effort was set to capture the highest levels of fishing above the average for each division. Threshold for the proportion of habitat was set conservatively to capture disproportionate distribution of habitats.
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/km & Hab: >0.2	Shore hr: <200/km & Hab: <0.2	Fishing from shore was a measure of the level of stress from fishing based activities such as fishing line entanglement and trampling. *Susceptibility level*: Threshold for fishing effort was set to capture the highest levels of fishing above the average. Threshold for the proportion of habitat was set conservatively to capture disproportionate distribution of habitats.
3. Is bait collected in this habitat?	Yes	No	A measure of trampling and damage caused from extraction of biota. *Susceptibility level*: No data was available on levels of bait collection so only the potential that bait could be collected from a habitat was determined.
4. Is this known to be a vector for non-native invasive species?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: No data was available on level colonisation of non-native invasive species so only the potential that these species could be carried was determined.

Aquatic recreation

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2	A measure for trampling from people walking, swimming or boating around a habitat. Public access points included foreshore recreational parks, boat ramps and swimming baths. 10m was chosen as a conservative estimate of the aerial extent people could roam from these points. The number of boat ramps, recreational parks and swimming baths within 10m of a habitat was expressed as a proportion of the total number of these foreshore features within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: >0.2/ha & Hab: >0.2	No. boats: <0.2/ha & Hab: <0.2	Recreational boats less than 7m was a measure of the stress from day boating activity (non-fishing) such as anchoring and trampling. The number of boats in each sub-catchment and reach was counted from aerial photos from Google earth as no other data source was available at the time. These aerial photos were a composite of several photos taken at different times of the day and dates. Therefore, there data were an under estimate of this type of boating activity. These data were expressed as the water surface area of the sub-catchment or reach to allow assessment of the relative density of activity in each area. Habitat was also expressed as a proportion of the water surface area. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses and an under estimate.
3. Proportion of habitat within no wash zones	< 0.1	> 0.1	A measure of the proportion of habitat that could be stressed from increased wave action from boat activity, such as erosion. The more habitat within a no wash zones the greater the proportion that is protected. *Susceptibility threshold:* 0.1 was considered conservative to take into account that this was an indirect measure of the stresses.

Aquatic recreation cont'd

Stress Measure	Susceptible	Not Susceptible	Rationale
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: >0.2/ha & Hab: >0.2	No. boats: <0.2/ha & Hab: <0.2	Recreational boats greater than 7m was a measure of the stress from overnight boating activity (non-fishing) such as gross pollutants and trampling. The number of boats in each sub-catchment and reach was counted from aerial photos from Google earth as no other data source was available at the time. These aerial photos were a composite of several photos taken at different times of the day and dates. Therefore, there data were an under estimate of this type of boating activity. These data were expressed as the water surface area of the sub-catchment or reach to allow assessment of the relative density of activity in each area. Habitat was also expressed as a proportion of the water surface area. Susceptibility threshold: 0.2 was considered conservative to take into account that this was an indirect measure of the stresses and an under estimate.
5. Number of marinas within 10m of a habitat	>0	0	A measure of the stresses from the concentration of boating and people activity around these structures such as increased turbidity and gross pollutants. The total number of marinas in a sub-catchment or reach was used as there were few marinas relative to the surface area of the bays and reaches. Susceptibility threshold: 0 set as the threshold because this was an indirect measure of the stresses and the presence of a marina should be a trigger for further investigation.
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. Susceptibility level: No data was available on level of colonising of non-native invasive species so only the potential that these species could be carried was determined.

Foreshore development

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Proportion of artificial rock wall within 10m of a habitat	> 0.1	≤ 0.1	A measure of the stress that can occur from changed slope and hardness of foreshore such as increased water turbulence. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of artificial rock walls within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
2. Proportion of habitat shore length within 10m of an artificial wall	> 0.02	≤ 0.02	A measure of the amount of habitat that is in close proximity to these features and hence exposed to the stress that can occur from changed slope and hardness. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The length of shoreline which had either natural soft substratum (mangroves, seagrass, mud or sand flats) or natural hard substratum (rocky reef) was used. *Susceptibility threshold:* 0.02 was considered conservative to take into account that this was an indirect measure of the stresses and to capture disproportionate distribution of habitats.
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	A measure of the stress that can occur from nutrient enriched run-off from riverside settlements. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of housing blocks within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.1 was considered conservative to take into account that this was an indirect measure of the stresses.
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	A measure of the stress that can occur from increased human activity around these structures such as increased turbidity, propeller scarring and trampling. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of wharves and jetties within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.1 was considered conservative to take into account that this was an indirect measure of the stresses.

Foreshore development cont'd

Stress Measure	Susceptible	Not Susceptible	Rationale
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01	A measure of the stress from contaminated sediments known to be associated beneath some marinas (ref). This measure was only applied to the deep subtidal habitat because the distribution of other habitats with respect to contamination was unknown. The area of a marina was calculated from aerial photos from Google earth and included the moored boats as well as the physical structure. Hence, it is only an approximate measure. Marina area was expressed as a proportion of the area of deep subtidal habitat of the sub-catchment or reach. *Susceptibility threshold:* 0.01 was considered conservative to take into account that this was an indirect measure of the stresses.
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	A measure of the stress that can occur from increased human activity around these structures such as increased turbidity. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of moorings within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.1 was considered conservative to take into account that this was an indirect measure of the stresses.
7a. Proportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	A measure of the stress that can occur from increased human activity around these structures such as increased turbidity. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of oyster leases within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.1 was considered conservative to take into account that this was an indirect measure of the stresses.
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	A measure of the amount of habitat that is in close proximity to these features and hence exposed to the stress that can occur from oyster leases. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses and to capture disproportionate distribution of habitats. When calculating the overall threat level from this human activity only (a) or (b) was used in the calculation, which ever had the best data.
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: No data was available on level of colonisation of non-native invasive species so only the potential that these species could be carried was determined.

Stormwater & catchment runoff

Stress Measure	Susceptible	Not Susceptible	Rationale
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	A measure of the stress of stormwater flow and nutrient input on water quality. The catchment area of each stormwater outlet that emptied into a bay was estimated from GIS data. The total stormwater catchment area was expressed as a proportion of the water surface area of the sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	A measure of the stress from increased nutrients from catchment run-off. Estimates of landuse area were expressed as a proportion of the water surface area of the sub-catchment or reach to allow an assessment of the level of threat. This measure was used when information on stormwater catchment area was not available. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
2. Flushing time of bay, days	> 2	< 2	A measure of the capacity of a sub-catchment or reach to exchange catchment run-off with inputs from the main channel or coastal waters and hence help mitigate negative effects of excessive nutrient loads. *Susceptibility threshold:* 2 days was considered short to account for intra-annual variability in flushing times and precautionary for inaccurate estimates.
3. Effective TN load, mg/m^2/day	≥3	<3	A measure of the stress of nutrient enrichment from stormwater. Total nitrogen load was considered the best variable to indicate excessive nutrient input (Scanes *et al.,* 2007. *Susceptibility threshold:* 3 mg/m^2/day was based on advice from DECC from the results of their modelling and extensive field surveys of all major estuaries in NSW (P. Scanes, DECC, pers. comm., July 2009).
4a. Proportion of gross pollutants removed to water surface area of bay (annual)	< 5t/ha	< 5t/ha	A measure of the stress from rubbish washed down through stormwater and overland into a bay. Expressed as a proportion of the water surface area of the sub-catchment or reach to allow assessment of the level of the threat. *Susceptibility threshold:* 5 tonnes was a conservative figure based on loads removed from the most densely populated sub-catchment of Pittwater.
4b. Percent effectiveness of gross pollutant traps on stormwater	<50%	>50%	A measure of the stress from rubbish washed down through stormwater and overland into a bay. This measure was used if data on amount removed was not available. *Susceptibility threshold:* 50% was considered conservative.

Stormwater & catchment runoff cont'd

Stress Measure	Susceptible	Not Susceptible	Rationale
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	A measure of the stress the outflow of a stormwater pipe may have on habitats within its vicinity such as scouring, erosion and changes to water quality. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. The number of stormwater outlets within 10m of a habitat was expressed as a proportion of the total number within a sub-catchment or reach to allow an assessment of the level of threat from these features. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: No data was available on level colonisation of non-native invasive species so only the potential that these species could be carried was determined.

Sewage outfalls/treatment

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	A measure of the stress that can occur from untreated sewage from ineffective on-site sewage treatment of riverside settlements. The area of riverside settlement was calculated from the shore length of housing by the depth of an average housing block. The area was expressed as a proportion of the surface area of the sub-catchment or reach to allow assessment of the level of threat from this source. *Susceptibility threshold:* 0.02 was considered conservative to take into account that this was an indirect measure of the stress and the small areas of riverside settlements.
2. Number of sewage treatment plants (STP) in bay	>0	0	A measure of the potential stress from increased nutrients from sewage treatment. *Susceptibility threshold:* 0 set as the threshold because this was an indirect measure of the stresses and the presence of an STP should be a trigger for further investigation.
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	A measure of the effectiveness of reducing pollutants from sewage outflows. *Susceptibility threshold:* Primary and secondary treated sewage effluent would have the greater loads of pollutants than tertiary treated.
4. Total N loads from STP to water surface area, mg/m^2/day	≥3	<3	A measure of the stress of nutrient enrichment of sewage from STP. Total nitrogen load was considered the best variable to indicate excessive nutrient input (Scanes *et al.,* 2007. *Susceptibility threshold:* 3 mg/m^2/day was based on advice from DECC from the results of their modelling and extensive field surveys of all major estuaries in NSW (P. Scanes, DECC, pers. comm., July 2009).
5. Total N loads from non-point source pollutants (e.g., vessels > 6m) to water surface area, mg/m^2/day	≥3	<3	A measure of the stress of nutrient enrichment from non-point source sewage. Total nitrogen load was considered the best variable to indicate excessive nutrient input (Scanes *et al.,* 2007. *Susceptibility threshold:* 3 mg/m^2/day was based on advice from DECC from the results of their modelling and extensive field surveys of all major estuaries in NSW (P. Scanes, DECC, pers. comm., July 2009).
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: No data was available on level colonisation of non-native invasive species so only the potential that these species could be carried was determined.

Dredging and sedimentation

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	A measure of the stress from changes to bathymetry as a result of dredging such as increased flow rates. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. Dredged area expressed as proportion of the water surface area of the bay to assess the level of threat. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
2. Sedimentation rate from human activities	≥3.0mm/yr	<3.0mm/yr	A measure of the stresses from sediment accretion such as smothering. *Susceptibility threshold:* 3.0mm was considered a relative fast rate and conservative to take into account that this was an indirect measure of the stresses.
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	A direct measure of the stress of erosional processes as a result of sedimentation and dredging effects. Area eroded was expressed as a proportion of the total area of the habitat in the sub-catchment or reach. *Susceptibility threshold:* 0.2 was considered conservative.
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	A measure of the stress posed to habitats from pollutants accumulated in sediments. The area of sediments contaminated within a habitat was expressed as a proportion of the total area of that habitat in the sub-catchment or reach or as the total water surface area of the sub-catchment or reach. *Susceptibility threshold:* 0.2 was considered conservative to take into account that this was an indirect measure of the stresses.
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: No data was available on level colonisation of non-native invasive species so only the potential that these species could be carried was determined.

Commercial vessels

Stress Measure	Susceptible	Not Susceptible	Rationale
1. Number of ferry vessels operating (car or passenger)	≥1	<1	A measure of the level of potential stress from the operation of ferries. *Susceptibility threshold:* 1 was set given the relative small areas of the bays in which vessels could operate, more than one indicates potentially a greater density of vessels.
2. Frequency of ferry services per day (car or passenger)	≥8	<8	A measure of the magnitude of stress from disturbance due to operation of ferries. *Susceptibility threshold:* 8 based on the lowest number of runs on a ferry timetable operating in the LHE.
3. Frequency of water taxis per day	≥8	<8	A measure of the level of potential stress from the operation of water taxis. *Susceptibility threshold:* 8 was set as the minimum number of services given the relative small areas of the bays in which vessels could operate.
4. Frequency of commercial cruise vessels operating per day	≥4	<4	A measure of the level of potential stress from the operation of commercial cruise vessels. *Susceptibility threshold:* 4 was set as the minimum number of vessels advertised to operate within a bay.
5. Number of habitats within 10m of routes of ferry services	≥2	<2	A measure of the level of disturbance a ferry vessel could have on habitats during its normal operation. 10m was chosen as a conservative estimate of the aerial extent stresses could occur. *Susceptibility threshold:* 2 was set as the minimum number of habitats a vessel could encounter during its normal operation.
6. Number of habitats within 10m of routes of water taxi services	≥2	<2	A measure of the level of disturbance a water taxi could have on habitats during its normal operation. 10m was chosen as a conservative estimate of the aerial extent stresses could occur *Susceptibility threshold:* 2 was set as the minimum number of habitats a vessel could encounter during its normal operation.
7. Number of habitats within 10m of routes of commercial cruise ships	≥2	<2	A measure of the level of disturbance a cruise vessel could have on habitats during its normal operation. 10m was chosen as a conservative estimate of the aerial extent stresses could occur *Susceptibility threshold:* 2 was set as the minimum number of habitats a vessel could encounter during its normal operation.

Commercial vessels cont'd

Stress Measure	Susceptible	Not Susceptible	Rationale
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	A measure of the stress from increased turbulence due to operation of vessels in close proximity to habitats. *Susceptibility threshold:* 1 hour was set as the minimum time habitats could still function without being affected by increased turbidity
9. Is this activity a known vector for non-native invasive species in this habitat?	Yes	No	Non-native invasive species can have several means of colonising a habitat. *Susceptibility level*: as for other human activities

Appendix 3. Results of detailed threat analysis for each human activity.

This appendix presents the detailed threat analysis for each human activity and habitat for each sub-catchment and reach. Levels for overall threat were allocated by dividing the total number of stress measures for a human activity by 3, rounding down for fractions. For example, there were four stress measures for recreational fishing which resulted in the following threat levels: Low ~ 0 – 1, Medium ~ 2, High ~ >2. Where stress measures were not applicable to a habitat the total number of stress measures was reduced by the number not applicable and the threat levels adjusted accordingly.

Pittwater

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. Note: Boat and shore based fishing cannot be added together to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.31	-	S
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	0.26	S
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Mangroves

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.03	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	0.26	S
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Pittwater cont'd

Recreational fishing cont'd

			Mudflats								
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.00	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	0.26	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

			Saltmarsh								
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.004	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Pittwater cont'd

Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.01	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	0.27	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.15	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	0.26	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Pittwater cont'd

Recreational fishing cont'd

Deep subtidal

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	0.68	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportions		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/ NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	56.10	52.91	3.00	2.83	20.30	19.15	1	-	NA
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					275.76	218.49	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		
No. Susceptible stressors											0
Overall threat level											

Pittwater cont'd

Aquatic Recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.56	S	0.44	S	0.00	NS	0.05	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.34	0.10	NS	0.010	NS	0.00	NS	0.00	NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.22	NS	0.21	NS	0.00	S	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	2.31	0.10	NS	0.010	NS	0.00	NS	0.0015	NS
5. Number of marinas within 10m of a habitat	> 0	0		0.00	NS	1.00	S	0.00	NS	0	NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					2		3		2		1
Overall threat level					L		M		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.23	S	0.90	S	0.13	NS	-	
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.34	0.01	NS	0.05	NS	0.68	S	-	
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.46	NS	0.75	NS	1.00	NS	-	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	2.31	0.01	NS	0.05	NS	0.68	S	-	
5. Number of marinas within 10m of a habitat	> 0	0		0.00	NS	4.00	S	5.00	S	-	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	-	
No. Susceptible stressors					1		2		4		0
Overall threat level					L		L		M		-

Pittwater cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0.40	S	0.32	S	0.00	NS	0.01	NS	0.25	S	0.68	S	0.078	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.04	S	0.01	NS	0.04	S	NA		0.03	S	0.04	S	NA	NS	NA	
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0.06	NS	0.06	NS	0.00	NS	0.00	NS	0.03	NS	0.44	S	0	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0.51	S	0.03	NS	0.00	NS	0.00	NS	0.13	S	0.03	NS	0.154	S		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													0.013	S		
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0.09	NS	0.00	NS	0.00	NS	0.00	NS	0.0006301	NS	0.004	NS	0.697	S	1.73	S
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	NA															
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	NA															
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors				4		2		2		1		4		4		4		2
Overall threat level				M		L		L		L		M		M		M		L

Stormwater & catchment runoff

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	0.58	S																
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	NA																	
2. Flushing time of bay, days	> 2	< 2	1	NS																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	0.052	NS																
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	40	S																
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2			0.33	S	0.21	S	0.05	NS	0.07	NS	0.00	NS	0.27	S	0.07	NS	1.00	S
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS																
No. Susceptible applying to all habitats				2		1		1		0		0		0		1		0		1
Total no. susceptible						3		3		2		2		2		3		2		3
Overall threat level						M		M		L		L		L		M		L		M

Pittwater cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.032	S
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	2.05	NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Pittwater cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	2		S												S		S
2. Frequency of ferry services per day (car or passenger)	≥8	<8	9-29		S												S		S
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2		10	S											2	S		
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					4		1		1		0		1		1		4		3
Threat level					M		L		L		L		L		L		M		L

Cowan

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.048	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	0.18	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mangrove

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.065	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	0.18	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Cowan cont'd

Recreational fishing cont'd

Mudflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	0.1828	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Saltmarsh

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.0102	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Cowan cont'd

Recreational fishing cont'd

Rocky reef

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.006	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	0.7736	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Sandflat

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.2596	-	S
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	0.1828	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Cowan cont'd

Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	0.7787	-	S
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	218.09	203.07	6.94	6.46	54.05	50.33	1	-	NA
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					411.37	393.29	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Cowan cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.571	S	0.429	S	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.074		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.565	NS	0.803	NS	0	NS	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.398	0.011	NS	0.015	NS	0	NS	0.002	NS
5. Number of marinas within 10m of a habitat	> 0	0		0.000	NS	0.000	NS	0	NS	0	NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					2		2		1		1
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.000	NS	0.429	S	0.000	NS	-	
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.074		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.593	NS	0.659	NS	1.000	NS	-	NS
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.398	0.005	NS	0.058	NS	0.779	S	-	
5. Number of marinas within 10m of a habitat	> 0	0		1	S	0	NS	3	S	-	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	-	
No. Susceptible stressors					1		1		3		0
Overall threat level					L		L		M		

Cowan cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0.643	S	0.286	S	0	NS	0	NS	0.143	S	0.429	S	0.571	S		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.000	NS	0.002	NS	0	NS	NA	NS	0.004	NS	0.000	NS	NA			
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0.310	S	0.000	NS	0	NS	0	NS	0.000	NS	0.000	NS	0.897	S		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0.163	S	0.000	NS	0	NS	0	NS	0.020	NS	0.020	NS	0.898	S		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													0.009	NS		
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.000	NS	0	NS	0	NS	0.000	NS	0.000	NS	0.000		0.151	S
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	NA															
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	NA															
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors				4		2		1		1		2		2		4		2
Overall threat level				M		L		L		L		L		L		M		L

Cowan cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	NA																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	0.37521	S																
2. Flushing time of bay, days	> 2	< 2	U																	
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%																		
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS																
No. Susceptible applying to all habitats				1		0		0		0		0		0		0		0		0
Total no. susceptible						1		1		1		1		1		1		1		1
Overall threat level						L		L		L		L		L		L		L		L

Cowan cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.0019	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				0
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Cowan cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	0																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	0																
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	NA																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					1		1		1		0		1		1		1		1
Threat level					U		U		U		U		U		U		U		U

Berowra

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

									Seagrass		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.0031	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	0.46	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

									Mangrove		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.15	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	0.46	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Berowra cont'd

Recreational fishing cont'd

Mudflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.12	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	0.46	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Saltmarsh

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.01	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Berowra cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.01	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	0.49	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.05	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	0.46	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Berowra cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	0.03	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	18.09	16.57	69.51	63.70	19.57	17.93	1	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					146.31	172.03	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Berowra cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.000	NS	0.000	NS	0.000	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.032		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.937	NS	0.225	NS	0.163	NS	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.167		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NS	0	NS	0	NS	0	NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					1		1		1		1
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.032		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		1	NS	0.632	NS	1.000	NS		NS
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.167		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NS	0	NS	0	NS		
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S		
No. Susceptible stressors					0		0		1		0
Overall threat level					L		L		L		-

Berowra cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.688	S	0.000	NS	0	NS	0	NS	0.188	S	0	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.000	NS	0.000	NS	0.000	NS	NA	NS	0.003	NS	0.000	NS	NA	NS		
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0.000	NS	0.079	NS	0.000	NS	0	NS	0	NS	0.022	NS	0	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.048	NS	0.000	NS	0	NS	0	NS	0.024	NS	0	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													0.034	S		
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.000	NS	0.000	NS	0	NS	0	NS	0.000	NS	0	NS		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.211	S	0.211	S	0	NS	0	NS	0.053	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	0.000		0.041	NS	0.133	NS	0	NS	0	NS	0.058	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors				1		3		2		1		1		2		2		1
Overall threat level				L		L		L		L		L		L		L		L

Berowra cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	NA																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	2.409576	S																
2. Flushing time of bay, days	> 2	< 2	2	S																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%																		
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS																
No. Susceptible applying to all habitats				2		0		0		0		0		0		0		0		0
Total no. susceptible						2		2		2		2		2		2		2		2
Overall threat level						L		L		L		L		L		L		L		L

Berowra cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.010	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	2	S
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	T	NS
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	U	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Berowra cont'd

Commercial vessels

CONT – continuous, U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	1																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	CONT																
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2		0		0		0		0		0		0		1	NS	1	
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					1		1		1		0		1		1		1		1
Threat level					U		U		U		U		U		U		U		U

Mangrove

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M –medium, H – high. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Mangrove

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mangrove cont'd
Recreational fishing cont'd

									Mudflat		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

									Saltmarsh		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Mangrove cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-		
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Mangrove cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial								
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	included as part of fluvial							-	
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	included as part of fluvial						-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Mangrove cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		NA	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.031								
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		NA		0	S	0	S	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.035		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		NA	NS	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		NA		Y	S	Y	S	Y	S
No. Susceptible stressors					0		2		2		1
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.031								
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		NA		NA		0	S	0	-
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.035		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	NA	NA	0	NA	0	NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S		-
No. Susceptible stressors					0		0		2		0
Overall threat level					L		L		L		-

Mangrove cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	NA	NS	1.000	S	0.125	S	0.000	NS	0	NS	0	NS	0	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	NA	NS	0.002	NS	0.010	NS	NA	NS	0	NS	0.010	NS	NA	NS		
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	NA	NS	0.366	S	0.015	NS	0.008	NS	0	NS	0	NS	0	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	NA	NS	0.882	S	0.324	S	0.059	NS	0	NS	0	NS	0	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													NA			
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	NA	NS	0.000	NS	0.250	S	0.000	NS	0	NS	0	NS	0	NS		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	NA	NS	0.000	NS	0.667	S	0.667	S	0	NS	0	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	NA	NS	0.000	NS	0.052	NS	0.019	NS	0	NS	0	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	NA		Y	S	Y	S	Y	S	NA		NA		Y	S	Y	S
No. Susceptible stressors				0		4		5		2		0		0		1		1
Overall threat level				L		M		M		L		L		L		L		L

Mangrove cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	U																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	U																	
2. Flushing time of bay, days	> 2	< 2	U																	
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS																
No. Susceptible applying to all habitats				0		0		0		0		0		0		0		0		0
Total no. susceptible						0		0		0		0		0		0		0		0
Overall threat level						U		U		U		U		U		U		U		U

Mangrove cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.021	S
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Mangrove cont'd

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	0																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	NA																
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	0																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	NA																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	NA																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		NA		Y	S	Y	S	N	NS	NA		NA		Y	S	Y	S
No. Susceptible					0		1		1		0		0		0		1		1
Threat level					U		U		U		U		U		U		U		U

Mooney

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	8E-05	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mangrove

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0.0917	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mooney cont'd

Recreational fishing cont'd

Mudflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0.339	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Saltmarsh

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0.0101	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Mooney cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0.2104	-	S
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-	NA	
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Mooney cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	0.0014	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	5.76	5.37	459.71	428.60	6.40	5.97	1	-	NA
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					23.82	7.97	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Mooney cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.004		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	S	0	S	0	S	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.045		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					2		2		2		1
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.004		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	S	NA		0	S	0	-
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.045		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	-	-
No. Susceptible stressors					1		0		2		0
Overall threat level					L		L		L		-

Mooney cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.333	S	0.333	S	0	NS	0	NS	0	NS	0	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.018	NS	0.007	NS	0.018	NS	NA	NS	0.002	NS	NA	NS	NA	NS		
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0		0.275	S	0.476	S	0.011		0		0		0			
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.125	S	0.729	S	0	NS	0	NS	0	NS	0	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													NA			
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.000	NS	0.100	NS	0	NS	0	NS	0	NS	0	NS		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.133	S	0.790	S	0	NS	0	NS	0	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	0	NS	0.265	S	0.433	S	0	NS	0	NS	0	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	Y	S	NA		Y	S	Y	S
No. Susceptible stressors				1		6		6		1		1		0		1		1
Overall threat level				L		M		M		L		L		L		L		L

Mooney cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	0.047255	NS																
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	NA																	
2. Flushing time of bay, days	> 2	< 2	14	S																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2					1.00	S												
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N																	
No. Susceptible applying to all habitats				1		0		1		0		0		0		NA		0		0
Total no. susceptible						1		2		1		1		1		0		1		1
Overall threat level						L		L		L		L		L		L		L		L

Mooney cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.012	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				0
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Mooney cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	0																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	NA																
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	NA																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					1		1		1		0		1		1		1		1
Threat level					U		U		U		U		U		U		U		U

Mullet

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

									Seagrass		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0.0268	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

									Mangrove		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0.0213	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mullet cont'd

Recreational fishing cont'd

			Mudflat								
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0.093	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

			Saltmarsh								
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0.0032	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Mullet cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		NS
3. Is bait collected in this habitat?	Yes	No							Y	NA	
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y	NA	
No. Susceptible stressors											0
Overall threat level											L

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-		NS
3. Is bait collected in this habitat?	Yes	No							Y	NA	
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y	NA	
No. Susceptible stressors											0
Overall threat level											L

Mullet cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	0.012	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	10.19	13.32	93.53	122.23	11.21	14.65	1	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					60.06	20.83	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Mullet cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.024		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	S	0	S	0	S	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.057		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					2		2		2		1
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.024		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		NA		NA		0	S	0	-
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.057		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	-	-
No. Susceptible stressors					0		0		2		0
Overall threat level					L		L		L		-

Mullet cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.500	S	0.250	S	0	NS	0	NS	0	NS	0	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.003	NS	0.008	NS	0.003	NS	NA	NS	0	NS	0.003	NS	NA	NS		
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0	NS	0.000	NS	0.042	NS	0	NS	0	NS	0	NS	0	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.500	S	0.500	S	0	NS	0	NS	0	NS	0	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													NA			
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	NA															
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.033	NS	0.400	S	0	NS	0	NS	0	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	0	NS	0.038	NS	0.523	S	0	NS	0	NS	0	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	NA		NA		Y	S	Y	S
No. Susceptible stressors				1		3		5		1		0		0		1		1
Overall threat level				L		L		M		L		L		L		L	L	

Mullet cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	U																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2																		
2. Flushing time of bay, days	> 2	< 2	8	S																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N																	
No. Susceptible applying to all habitats				1		0		0		0		0		NA		NA		0		0
Total no. susceptible						1		1		1		1		1		1		1		1
Overall threat level						U		U		U		U		U		U		U		U

Mullet cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.0062	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				0
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Mullet cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	0																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	NA																
3. Frequency of water taxis per day	≥8	<8	0																
4. Frequency of commercial cruise ships operating per day	≥4	<4	0																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	NA																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	NA																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	NA																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	NA																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	NA		NA		Y	S	Y	S
No. Susceptible					1		1		1		0		0		0		1		1
Threat level					L		L		L		L		L		L		L		L

Patonga

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Mangrove

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Patonga cont'd

Recreational fishing cont'd

Mudflat

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Saltmarsh

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Patonga cont'd

Recreational fishing cont'd

Rocky reef

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		NS
3. Is bait collected in this habitat?	Yes	No							Y	NA	
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y	NA	
No. Susceptible stressors											0
Overall threat level											L

Sandflat

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Patonga cont'd

Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area							-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-	NA	
3. Is bait collected in this habitat?	Yes	No							NA		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	No data collected for this area						1	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2	No data collected for this area						-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0

Patonga cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.5	S	0	NS	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0		NS		NS		NS		N
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	S	0	S	0	S	NA	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	NA		NA		NA		NA		NA
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					3		2		2		1
Overall threat level					H		M		M		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0.5	S	0	NS	0	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0								
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		NA		0	S	NA		0	-
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	NA		NA		NA		NA		NA
5. Number of marinas within 10m of a habitat	> 0	0		0	NA	0	NA	0	NA	0	NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	NA		Y	-
No. Susceptible stressors					0		2		0		0
Overall threat level					L		M		L		-

Patonga cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	Susceptible	Not Susceptible	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS	Prop'n - #, A	S/NS
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	1.000	S	0.000	NS	0.000	NS	0	NS	0	NS	1	S	0	NS		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.002	NS	0.000	NS	0.002	NS	NA	NS	NA	NS	0.002	NS	NA			
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0.018	NS	0.062	NS	0.124	S	0	NS	0	NS	0	NS	0	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0.533	S	0.200	S	0.467	S	0	NS	0	NS	0	NS	0	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													NA			
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0.842	S	0.000	NS	0.000	NS	0	NS	0	NS	0	NS	0	NS		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	0.833	S	0.750	S	0.250	S	0.083	NS	0	NS	0	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	0.305	S	0.174	NS	0.727	S	0.054	NS	0	NS	0	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	NA		Y	S	NA		Y	S
No. Susceptible stressors				6		3		5		1		0		2		0		1
Overall threat level				M		M		M		L		L		L		L		L

Stormwater & catchment runoff

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	Susceptible	Not Susceptible	Data	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS	Prop'n	S/NS
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	0.559989	S																
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	NA																	
2. Flushing time of bay, days	> 2	< 2	U																	
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2			1.00	S														
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N																	
No. Susceptible applying to all habitats				1		1		0		0		0		NA		0		NA		0
Total no. susceptible						2		1		1		1		1		1		1		1
Overall threat level						U		U		U		U		U		U		U		U

Patonga cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

Sewage outfalls/treatment

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.057	S
2. Number of sewage treatment plants (STP) in bay	>0	0	0	NS
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	NA	
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	
No. Susceptible				1
Overall threat				L

Patonga cont'd

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	0																
2. Frequency of ferry services per day (car or passenger)	≥8	<8	NA																
3. Frequency of water taxis per day	≥8	<8	0																
4. Frequency of commercial cruise ships operating per day	≥4	<4	0																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	NA																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	NA																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	NA																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	NA																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	NA		Y	S	NA		Y	S
No. Susceptible					1		1		1		0		0		1		0		1
Threat level					L		L		L		L		L		L		L		L

Marine reach

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

									Seagrass		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	NA	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

									Mangrove		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	NA	NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Marine reach cont'd
Recreational fishing cont'd

Mudflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	NA	NS
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Saltmarsh

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Marine reach cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0.0166	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	0.383	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0.3489	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	0.1908	NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Marine reach cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	0.8474	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	92.913	115.971	1.87886	2.34513	15.92	19.87	1	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					579.19	457.55	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Marine reach cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2									
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0								
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	NA	0	NA	0	NA	0	NA
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0								
5. Number of marinas within 10m of a habitat	> 0	0	0		NA		NA		NA		NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		NA		NA		NA		NA	
No. Susceptible stressors					0		0		0		0
Overall threat level					L		L		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2						1	S	1	-
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0								
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0	NA	0	NA	0	NA	0	NA
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0					0.847			
5. Number of marinas within 10m of a habitat	> 0	0	0		NA		NA		NA		NA
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	Y	-
No. Susceptible stressors					0		0		2		0
Overall threat level					L		L		M		-

Marine reach cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	NA		NA		NA		NA		0	NS	NA		0			
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	NA		NA		NA		NA		0	NS	NA		NA			
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	NA		NA		NA		NA		0	NS	NA					
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	NA		NA		NA		NA		0	NS	NA					
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01	NA		NA		NA		NA		NA		NA					
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0		0		0		0		0	NS	0		1	S		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	NA															
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	NA															
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	NA		NA		NA		NA		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors				0		0		0		0		1		1		2		1
Overall threat level				L		L		L		L		L		L		L		L

Marine reach cont'd

Stormwater & catchment runoff

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	U																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	U																	
2. Flushing time of bay, days	> 2	< 2	1	NS																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N																	
No. Susceptible applying to all habitats				0		0		0		0		0		0		0		0		0
Total no. susceptible						0		0		0		0		0		0		0		0
Overall threat level						U		U		U		U		U		U		U		U

Marine reach cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	>5	S
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	T	NS
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Marine reach cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	1	NA															S
2. Frequency of ferry services per day (car or passenger)	≥8	<8	9-29	NA													S		S
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2		NA										1	NS	1	NS		
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		NA		NA		NA		NA	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					0		0		0		0		1		1		2		3
Threat level					U		U		U		U		U		U		U		U

Fluvial tidal delta

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

										Seagrass		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.01	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	0.33	S
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

										Mangrove		
			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.08	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	0.33	S
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Fluvial tidal delta cont'd
Recreational fishing cont'd

Mudflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.045	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	0.33	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Saltmarsh

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.0072	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Fluvial tidal delta cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.016	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	0.463	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.003	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	0.33	S
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											3
Overall threat level											H

Fluvial tidal delta cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
			2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	0.40	-	S
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
			2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	44.77	44.39	7.82	7.75	31.10	30.83	1	-	NA
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					546.68	717.17	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Fluvial tidal delta cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.091	NS	0.455	S	0.273	S	0.091	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.077		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.525		0.315		0.370		0.124	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.182		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0			NS	1	S	1	S		NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors					1		3		3		1
Overall threat level					L		M		M		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.000	NS	0.091	NS	0.091	NS	0.000	-
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.077		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.132		0.177		0.162		0.000	
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.182		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0			NS		NS		NS	0	-
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	N	NS	Y	S	Y	-
No. Susceptible stressors					0		0		1		0
Overall threat level					L		L		L		-

Fluvial tidal delta cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0.000	NS	0.321	S	0.286	S	0.036	NS	0.071	NS	0.000	NS	0.321	S		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	0.013	NS	0.016	NS	0.013	NS	NA	NS	0.009	NS	0.013	NS	NA			
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0.000	NS	0.188	S	0.159	S	0.021	NS	0.046	NS	0.003	NS	0.229	S		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0.006	NS	0.192	S	0.236	S	0	NS	0.050	NS	0.003	NS	0.462	NS		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01													0.003	NS		
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0.014	NS	0.000	NS	0.020	NS	0	NS	0.027	NS	0.000	NS	0.179	S		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	0.077	NS	0.192	S	0.452	S	0	NS	0.202	S	0.029	NS	0	NS		
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	0.204	S	0.077	NS	0.354	S	0	NS	0.047	NS	0.129	NS	0	NS		
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S	Y	S
No. Susceptible stressors				2		5		6		1		2		1		4		1
Overall threat level				L		M		M		L		L		L		M		L

Fluvial tidal delta cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	0.015917	NS																
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	NA																	
2. Flushing time of bay, days	> 2	< 2	3-5	S																
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N																	
No. Susceptible applying to all habitats				1		0		0		0		0		0		0		0		0
Total no. susceptible						1		1		1		1		1		1		1		1
Overall threat level						U		U		U		U		U		U		U		U

Fluvial tidal delta cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.007477	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	>4	S
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	T	NS
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	U	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Fluvial tidal delta cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	1		S														S
2. Frequency of ferry services per day (car or passenger)	≥8	<8	17		S														S
3. Frequency of water taxis per day	≥8	<8	U																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2		1												1			
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					3		1		1		0		1		1		1		3
Threat level					U		U		U		U		U		U		U		U

Riverine channel

Recreational fishing

Sh – shallow, D – deep, SA – surface area, T – total, Len – length, Hab – habitat, Y – yes, N – no, S – susceptible, NS – not susceptible, L – low, M – medium, H – high. **Note:** Boat and shore based fishing **cannot be added together** to get total fishing effort as they were measured in different units, number of boats and number of individuals respectively. See Appendix 2 for detailed explanation.

Seagrass

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Mangrove

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0.37	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		NS
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Riverine channel cont'd
Recreational fishing cont'd

Mudflat

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0.02	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Saltmarsh

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0.16	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							N		NS
No. Susceptible stressors											0
Overall threat level											L

Riverine channel cont'd
Recreational fishing cont'd

Rocky reef

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0.02	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		NS
3. Is bait collected in this habitat?	Yes	No							Y		S
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											2
Overall threat level											M

Sandflat

			Fishing hrs/ Sh SA		Fishing hrs/ D SA		Fishing hrs/ T SA or Len		Proportion		
Stress Measure	**Susceptible**	**Not Susceptible**	2007/ 08	2008/ 09	2007/ 08	2008/ 09	2007/ 08	2008/ 09	SA	Len	S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-		NS
3. Is bait collected in this habitat?	Yes	No							NA		
4. Is this known to be a vector for non-native invasive species?	Yes	No							NA		
No. Susceptible stressors											0
Overall threat level											L

Riverine channel cont'd
Recreational fishing cont'd

Deep subtidal

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	0.44	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-	NA	
3. Is bait collected in this habitat?	Yes	No							N		NS
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		S
No. Susceptible stressors											1
Overall threat level											L

Water column

Stress Measure	Susceptible	Not Susceptible	Fishing hrs/ Sh SA 2007/ 08	Fishing hrs/ Sh SA 2008/ 09	Fishing hrs/ D SA 2007/ 08	Fishing hrs/ D SA 2008/ 09	Fishing hrs/ T SA or Len 2007/ 08	Fishing hrs/ T SA or Len 2008/ 09	Proportion SA	Proportion Len	Proportion S/NS
1. Total boat fishing hours per surface area of bay (annual total) plus proportion of area of habitat in bay	Boat hr: >50/ Sh ha; >6/ D ha; >20/ T ha & Hab: >0.2	Boat hr: <50/ Sh ha; <6/ D ha; <20/ T ha & Hab: >0.2	3.51	4.70	0.50	0.67	2.19	2.93	1	-	NS
2. Total shore fishing hours per length of foreshore of bay (annual total) plus proportion of length of habitat in bay	Shore hr: >200/ km & Hab: >0.2	Shore hr: <200/ km & Hab: <0.2					28.33	45.71	-	NA	
3. Is bait collected in this habitat?	Yes	No							Y		NA
4. Is this known to be a vector for non-native invasive species?	Yes	No							Y		NA
No. Susceptible stressors											0
Overall threat level											

Riverine channel cont'd

Aquatic recreation

SA – surface area, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0	NS	0.429	S	0.000	NS	0.143	NS
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.007		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1			NA	0.000	S	0.000	S		NA
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ ha & Hab: >0.2	No. boats: < 0.2/ ha & Hab: <0.2	0.033		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0		0	NS		NS		NS		NS
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		NA		Y	S	Y	S	Y	S
No. Susceptible stressors					0		3		2		1
Overall threat level					L		M		L		L

				Rocky reef		Sandflats		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**#/ha**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**	**Prop'n, #**	**S/NS**
1. Proportion of public access points within 10m of a habitat	> 0.2	≤ 0.2		0.000	NS	NA	NS	0.143	NS	0.000	-
2. Number of boats <7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.007		NS		NS		NS		NS
3. Proportion of habitat within no wash zones	< 0.1	> 0.1		0.000	S	NA		0.000	S		NA
4. Number of boats >7m per SA bay & proportion of habitat	No. boats: > 0.2/ha & Hab: >0.2	No. boats: < 0.2/ha & Hab: <0.2	0.033		NS		NS		NS		NS
5. Number of marinas within 10m of a habitat	> 0	0			NS		NS		NS		-
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		N	NS	NA	NS	Y	S	Y	-
No. Susceptible stressors					1		0		2		0
Overall threat level					L		L		L		-

Riverine channel cont'd

Foreshore development

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**	**Prop'n - #, A**	**S/NS**
1. Proportion of artifical rockwall within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.654	S	0.000	NS	0.038	NS	0	NS	0	NS	0.346	S		
2. Proportion of habitat shore length within 10m of an artifical wall	> 0.02	≤ 0.02	NA	NS	0.003	NS	0.005	NS	NA	NS	0.001	NS	NA	NS	NA			
3. Proportion of housing blocks (unsewered) within 10m of habitat	> 0.1	≤ 0.1	0	NS	0.357	S	0.000	NS	0.066	NS	0	NS	0	NS	0.046	NS		
4. Proportion of wharves & jetties within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0.689	S	0.033	NS	0.033	NS	0	NS	0	NS	0.492	S		
5. Proportion of marina area to deep subtidal	> 0.01	≤ 0.01	NA															
6. Proportion of moorings within 10m of a habitat	> 0.1	≤ 0.1	0	NS	0	N	0.034	NS	0	NS	0	NS	0	NS	0.138	S		
7a. Porportion of oyster leases within 10m of a habitat	> 0.1	≤ 0.1	NA															
7b. Proportion of habitat area within 10m of oyster lease	> 0.2	≤ 0.2	NA															
8. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	NA		Y	S	Y	S	Y	S	Y	S	NA		Y	S	Y	S
No. Susceptible stressors				0		4		1		1		1		0		4		1
Overall threat level				L		M		L		L		L		L		M		L

Riverine channel cont'd

Stormwater & catchment runoff

A – area, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Prop'n – proportion, # – number, Y – yes, N – no, L – low, M – medium, H – high.

					Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1a. Proportion of stormwater catchment to water surface area of bay	≥0.2	<0.2	U																	
1b. Proportion of urban, industrial & commercial landuse to water surface area of bay	≥0.2	<0.2	U																	
2. Flushing time of bay, days	> 2	< 2	U																	
3. Effective total nitrogen (TN) load, mg/ m^2/ day	≥3	<3	U																	
4a. Proportion of gross pollutants removed to water surface area of bay (annually)	< 5t/ ha	< 5t/ ha	U																	
4b. Percent effectiveness of gross pollutant traps on stormwater	< 50%	>50%	U																	
5. Proportion of stormwater outlets with 10m of a habitat	≥0.2	<0.2	U																	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	NA																	
No. Susceptible applying to all habitats				0		0		0		0		0		0		0		0		0
Total no. susceptible						0		0		0		0		0		0		0		0
Overall threat level						U		U		U		U		U		U		U		U

Riverine channel cont'd

Sewage treatment

TN – total nitrogen, NA – not applicable, U – unknown, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Water Column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**S/NS**
1. Proportion of unsewered housing to water surface area of bay	≥0.02	<0.02	0.0097	NS
2. Number of sewage treatment plants (STP) in bay	>0	0	>3	S
3. Level of treatment of the effluent from STP under normal conditions	Primary, secondary	Tertiary	T	NS
4. TN loads from STP to water surface area, mg/ m^2/ day	≥3	<3	NA	
5. TN loads from non-point source pollutants (e.g. vessels > 6m) to water surface area, mg/ m^2/ day	≥3	<3	U	
6. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS
No. Susceptible				1
Overall threat				L

Dredging and sedimentation

U – unknown, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

			Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Proportion of dredged area within 10m of a habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
2. Sedimentation rate from human activities	≥3.0mm/ yr	<3.0mm/ yr	U		U		U		U		U		U		U		U	
3. Proportion of habitat eroded from changed bathymetry due to human activities	≥0.2	<0.2	U		U		U		U		U		U		U		U	
4. Proportion of sediments contaminated per habitat	≥0.2	<0.2	U		U		U		U		U		U		U		U	
5. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS	N	NS
No. Susceptible				0		0		0		0		0		0		0		0
Threat level				U		U		U		U		U		U		U		U

Riverine channel cont'd

Commercial vessels

U – unknown, NA – not applicable, Prop'n – proportion, S –susceptible, NS – not susceptible, Y – yes, N – no, L – low, M – medium, H – high.

				Seagrass		Mangrove		Mudflat		Saltmarsh		Rocky reef		Sandflat		Deep subtidal		Water column	
Stress Measure	**Susceptible**	**Not Susceptible**	**Data**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**	**Prop'n**	**S/NS**
1. Number of ferry vessels operating (car or passenger)	≥1	<1	2																S
2. Frequency of ferry services per day (car or passenger)	≥8	<8	CONT																S
3. Frequency of water taxis per day	≥8	<8	0																
4. Frequency of commercial cruise ships operating per day	≥4	<4	U																
5. Number of habtiats within 10m of routes of ferry services	≥2	<2	0																
6. Number of habtiats within 10m of routes of water taxi services	≥2	<2	U																
7. Number of habtiats within 10m of routes of commercial cruise ships	≥2	<2	U																
8. Duration of increased turbidity from operation of vessels	> 1hr	< 1hr	U																
9. Is this activity known to be a vector for non-native invasive species in this habitat?	Yes	No		Y	S	Y	S	Y	S	N	NS	Y	S	Y	S	Y	S	Y	S
No. Susceptible					1		1		1		0		1		1		1		3
Threat level					U		U		U		U		U		U		U		U

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