11. Twofold Shelf Marine Bioregion

The cool temperate waters of the Twofold Shelf cover an area of 3,230,614 ha, including the coastal and estuary waters from south of the town of Tathra (36°48'S) on the far south coast of NSW, where it extends approximately 22 km seaward, to Corner Inlet in Victoria and extending south to Bass Strait and Tasmanian State waters including the Kent Group of islands (around 39°25'S).

The Bioregion is characterised as having submaximally exposed coastline with long sandy beaches broken by rocky headlands and numerous coastal lagoons. The mean annual sea-surface temperature reflects the influence of warmer waters brought into Bass Strait by the East Australian Current.[232]

Along the NSW section coastal oceanographic circulation is influenced mainly by northwards setting coastally trapped waves generated in Tasman Sea waters, although inshore a northerly flowing tongue of Bass Straight water is generally present. Intermittent upwellings occur along parts of the east Gippsland coast.[42]

The NSW and northern Victorian sections are bordered by the Lachlan Fold Belt. It contains numerous occurrences of Palaeozoic sediments and granites.[42]

The continental shelf is relatively narrow, becoming much broader (and shallower) in the southern area of the Gippsland Basin.[42] Changes in shelf width are associated with marked changes in coastline orientation, from east-facing in the north to south-southeast facing in the south. Orientation in the Victorian section varies from south-east to Lakes Entrance, south to Rame Head and then south-east to the NSW border. North of this, the coastline faces generally east-south-east.[42]

The continental shelf shows a very steep inshore profile (0–20 m), with a less steep inner (20–60 m) to mid (60–120 m) shelf profile, and a generally flatter outer shelf plain (120–160 m) south-west of Cape Howe.[42] Seaward the sediments are poorly sorted, with a median of 92% sand and 8% gravel; they are composed of organic material, with a median of 64.5% calcium carbonate.[42]

The fauna is characterised by distinctive species assemblages of reef fish, echinoderms, gastropods and bivalves.[42] Reefs are generally dominated by warm temperate species that occur commonly in southern NSW, including the large sea urchin *Centrostephanus rodgersii,* which removes macroalgae from shallow reefs, creating a coralline algal encrusted habitat.[42]

The NSW marine jurisdiction of the Bioregion (as defined in the Broadscale Biodiversity Assessment of the Batemans Shelf and Twofold Shelf Marine Bioregions) is about 62,620 ha or just 2% of the entire Bioregion. This section extends south from Wallagoot Lake to the Victoria Border and out to the 3nm limit. The biodiversity of the NSW section differs significantly from that of the Victorian and Tasmanian sections.

The NSW section of the Bioregion contains 19 small estuaries totalling about 4,920 ha ranging in size from 3 ha to 3,000 ha.

[232] IMCRA, 1998

11.1. Existing Marine Protected Areas

There are three marine protected areas within the Victorian section of the Twofold Shelf marine Bioregion; Ninety Mile Beach (2,750 ha), Point Hicks (4000 ha) and Cape Howe (4050 ha) Marine National Parks. Estuarine ecosystems and habitats are not well represented within the Victorian marine protected areas.[233]

There are no Marine Parks or Aquatic Reserves in the NSW section of the Twofold Shelf marine Bioregion. However, there are nine National Park estate marine extensions covering eight intermittent estuaries and one freshwater estuary totalling approximately 190 ha or 0.3% of the NSW section of the Bioregion and 4% of the NSW sections estuaries. There are no restrictions on fishing in these marine extensions.

Table 121: Twofold Shelf Bioregion existing Marine Protected Areas

National Park	Estuary	Ecosystem	Opening	Age	Area (ha)
Nadgee NR	Merrica L	Intermittent	Intermittent	Intermediate	11
	Nadgee L	Intermittent	Semi - mature		97
	Nadgee R	Intermittent	Intermittent	Mature	15
	Table/Little Ck	Intermittent	Intermittent		4
	Wirra Birra Ck	Intermittent	Intermittent		3
Ben Boyd NP	Bittangabee Ck	Intermittent	Intermittent		4
	Woodburn Ck	Intermittent	Intermittent		9
	Saltwater Ck	Intermittent	Intermittent	Semi mature	7.5
Bournda NP	Bondi L	Freshwater			39
Total					**189.5**

[233] Breen, Avery and Otway, 2005.

11.2. Ecosystems, Habitats and Species

11.2.1. Estuarine Ecosystems

There are 19 mapped estuaries in the NSW section of the Twofold Shelf Bioregion ranging in size from 4 ha to 3084 ha. In total they cover an area of about 4920 ha or about 8% of the NSW section of the Bioregion. Only 4% of the estuaries in the NSW section of the Bioregion are in marine protected areas. However, these National Park marine extensions provide no restrictions on fishing. There are no estuary ecosystems represented in either IUCN Category Ia sanctuaries or IUCN Category VI reserves in the NSW section of the Twofold Shelf Bioregion.

Table 122: Twofold Shelf Bioregion (NSW) estuary ecosystems

Ecosystem	Area (ha)
Freshwater	39
Intermittent estuary	347
Ocean embayment	3084
Wave dominated estuary	1486.5
Total	**4956.5**

Table 123: Twofold Shelf Bioregion (NSW) estuaries

Name	Ecosystem	Cond.	Oyster L	RFH	Area (ha)	Status
Back Lagoon	Intermittent	M			38	
Bittangabee Creek	**Intermittent**				**4**	**NPE**
Bondi Lake	**Freshwater**				**39**	**NPE**
Bournda Lagoon	**Intermittent**				**7.5**	
Curalo Lagoon	Intermittent	EM			76.5	
Fisheries Creek	Intermittent				4	
Merimbula Lake	Wave dominated	M	Yes		469.5	
Merrica Lake	**Intermittent**	**NP**			**11**	**NPE**
Nadgee Lake	**Intermittent**	**NP**			**97**	**NPE**
Nadgee River	**Intermittent**	**NP**			**15**	**NPE**
Nullica River	Intermittent	LU		Yes	31	
Saltwater Creek	**Intermittent estuary**	**M**			**7.5**	**NPE**
Pambula Lake	Wave dominated	LU	Yes	Yes	354.5	
Table/Little Ck	**Intermittent**				**4**	**NPE**
Towamba River	Wave dominated	LU	Yes	Yes	289	
Twofold bay	Ocean embayment	M			3084	
Wirra Birra Creek	**Intermittent**				**3**	**NPE**
Womboyn River	Wave dominated	LU	Yes	Yes	374	
Woodburn Creek	**Intermittent**				**9**	**NPE**
Total					**4917.5**	

NPE- National Park marine extension

Table 94 identifies the estuaries of the Twofold Shelf Bioregion (NSW) most suitable for conservation (highlighted and embolden). Conservation effort should focus on the least disturbed estuaries in the Bioregion. In the NSW section of the Twofold Shelf Bioregion there are three Near Pristine estuaries (NP), all within the National Park Estate (NPE). All Largely Unmodified (LU) estuaries of the NSW section of the Bioregion are established Recreational Fishing Havens and have been excluded from selection for conservation.

11.2.2. Estuarine Habitats

Table 124: Twofold Shelf Bioregion (NSW) estuary habitats

Habitat	Area (ha)
Mangrove	76
Saltmarsh	161.5
Seagrass	390.5
Total	**628**

No estuarine habitats in the NSW section of twofold Shelf are represented in IUCN Ia or IUCN VI reserves.

Table 125: Twofold Shelf Bioregion (NSW) estuary vegetation

Vegetation Type	Name	Area (ha)
Mangrove	*A. corniculatum/A. marina*	1
	Avicennia marina	75.5
Saltmarsh	Saltmarsh	161.5
Seagrass	*Halophila sp.*	2.5
	P. australis/Zostera sp.	4
	Posidona australis	118
	Ruppia sp.	38.5
	Zostera sp.	225
	Ruppia sp./Zosteraceae	3.5
Other	Other	18.5
Total		**647.5**

No estuary vegetation types are represented in IUCN Ia or IUCN VI reserves within the NSW section of the NSW section of the Twofold Shelf Bioregion.

11.2.3. Ocean Ecosystems

Table 126: Twofold Shelf Bioregion (NSW) ocean ecosystems

Ecosystem	Area (ha)
0 - 20m	6708.5
20 - 60m	30638.5
60 -200m	20201
Total	**57548**

No ocean ecosystems are represented in IUCN 1a or IUCN 4 reserves within the NSW section of the NSW section of the Twofold Shelf Bioregion.

11.2.4. Coastal Habitat

No coastal habitats are represented in IUCN 1a or IUCN 4 reserves within the NSW section of the Twofold Shelf Bioregion.

Table 127: Twofold Shelf Bioregion (NSW) coastal habitats

Habitat	Area (ha)
Beach	300.5
Islands and rocks	5.5
Reef and shoal	867.5
Rocky intertidal	421.5
Subtidal sand	3201
Total	**4796**

11.2.5. Grey Nurse Shark Aggregation Sites

Table 128: Twofold Shelf Bioregion (NSW) grey nurse shark sites

Location	Site Name	Importance	Status
Merimbula	Tura Head	Medium	None
Eden	Mewstone Rock/South Head	Low	None

No grey nurse shark sites are afforded protection from fishing in the NSW section of the Twofold Shelf Bioregion

11.3. Recommended Additions

Aquatic Reserves

National Park Marine Extensions – 197 ha

Table 100 identifies Twofold Shelf (NSW) estuaries within National Park marine extensions that are suitable to be established as no-take Aquatic Reserves.

Table 129: Twofold Shelf Bioregion (NSW) estuaries recommended as no-take Aquatic Reserves.

NP marine extension	Name	Ecosystem	Area (ha)
Nadgee NR	Merrica Lake	Intermittent	11
"	Nadgee Lake	Intermittent	97
"	Nadgee R	Intermittent	15
"	Table/Little Creek	Intermittent	4
"	Wirra Birra Creek	Intermittent	3
Ben Boyd NP	Bittangabee Creek	Intermittent	4
"	Woodburn Creek	Intermittent	9
"	Saltwater Creek	Intermittent	7.5
Bournda NP	Bondi Lake	Freshwater	39
"	Bounda Lagoon	Freshwater	7.5
Total			**197**

The Broadscale Biodiversity Assessment of the Batemans and Twofold Shelfs identifies Bondi and Bournda Lagoons and Saltwater, Woodburn and Bittangabee, Wirra Birra, Table, Little Creeks, Merrica Creeks and Nadgee Rivers and Nadgee Lake as areas of important biodiversity value.

Bondi and Bournda Lagoons are identified as areas of important biodiversity value for their near pristine catchments and slightly affected to pristine waters. Both are recommended in the Coastal Lakes Inquiry for comprehensive protection. These lakes, though freshwater intermittent estuaries, become more saline as the water level diminishes when closed.

Bondi Lagoon is also:
Listed in the Directory of Important Wetlands
Its catchment is wholly within Bournda National Park
Species listed under JAMBA or CAMBA and known to occur within the area include the white-bellied seaeagle (*Haliaeetus leucogaster*), sharp-tailed sandpiper (*Calidris acuminata*), curlew sandpiper (*Calidris ferruginea*), red-necked stint (*Calidris ruficollis*) and common greenshank (*Tringa nebularia*) (ANCA, 1996).

Saltwater, Woodburn and Bitagabee Creeks are identified for their near pristine coastal catchments that are entirely surrounded by Ben Boyd National Park.

Wirra Birra, Table, **Little Creeks**, **Merrica and Nadgee Rivers and Nadgee Lake**, are identified as important areas of biodiversity value as their catchments are wholly within the Nadgee Nature Reserve and Wilderness area

Recommendation 31:

That Merrica Lake, Nadgee Lake, Nadgee River, Table/Little Creek, Wirra Birra Creek (Nadgee Nature Reserve), Bittangabee Creek, Woodburn Creek, and Saltwater Creek (Ben Boyde National Park) and Bondi Lake (Bournda National Park) be established as IUCN Ia no-take Aquatic Reserves.

Table 130: Twofold Shelf Bioregion (NSW) estuary ecosystems in proposed as no-take Aquatic Reserves.

Ecosystem	Area (ha)
Freshwater	39
Intermittent estuary	158
Total	**197**

Marine Parks

Twofold Bay Marine Park-31,395 ha

A Marine Park is recommended between Merimbula Point in the north and Green Cape in the south, taking in the coastal and estuarine waters covering an area of approximately 31, 400 ha. This area includes almost 90% of the estuary area in the NSW section of the Bioregion including three estuaries within National Parks recommended as no-take Aquatic Reserves above.

Approximately 65% of the coastline is within National Park and approximately 40% of Pambula Lake adjoins National Parks.

The Broadscale Biodiversity Assessment of the Batemans and Twofold Shelfs identifies a number of areas in this section of the Twofold Shelf Bioregion as being of important biodiversity value.

Twofold Bay

- The only ocean embayment in the Twofold Shelf bioregion within NSW or Victoria.
- Listed in the Directory of Important Wetlands
- The sheltered rocky shores, beaches, reefs, deep-water areas, sand flats and wetlands around the bay provide important habitat for marine life, cetaceans and threatened and migratory birds (ANCA, 1996)
- The endangered hooded plover (*Thinornis rubricollis*) and the vulnerable shy albatross (*Diomedea cauta*), black-browed albatross (*Diomedea melanophrys*), sooty albatross (*Phoebetria fusca*) and pied oystercatcher (*Haematopus longirostris*) have been recorded from Twofold Bay (ANCA, 1996)
- Humpback whales (*Megaptera novaeangliae*) are regularly sighted here when migrating north and south
- Southern right whales (*Eubalaena australis*) and blue whales (*Balaenoptera musculus*) also visit the bay occasionally as well as other cetaceans including dolphins and pilot whales
- The bay is a known resting locality for cetacean migrants (ANCA, 1996).
- Species listed under JAMBA or CAMBA and known to occur in the area include the shorttailed shearwater (*Puffinus tenuirostris*), australian reef egret (*Egretta sacra*), white-bellied sea-eagle (*Haliaeetus leucogaster*) and grey plover (*Pluvialis squatarola*) (ANCA, 1996)

Merimbula Lake

- The second largest barrier estuary in the NSW section of the Bioregion (calculations based on available data suggest this is incorrect – these calculations suggest that Merimbula Lake is significantly larger that Pambula Lake).
- The largest area of seagrass habitat in the NSW section of the Bioregion.
- The second largest area of mangrove in the NSW section of the Bioregion.
- The largest area of saltmarsh in the NSW section of the Bioregion.
- Southern limit for river mangrove (*Aegiceras corniculatum*)
- A significant population of the saltbush *Sclerostegia arbuscula* (Adam, 1992, in ANCA, 1996).
- Listed in the Directory of Important Wetlands
- The endangered hooded plover (*Thinornis rubricollis*) and vulnerable Australasian bittern (*Botaurus poiciloptilus*), sooty oystercatcher (*Haematopus fuliginosus*) and pied oystercatcher (*Haematopus longirostris*) have been recorded from the lake (ANCA, 1996)
- Species listed under JAMBA or CAMBA and known to occur in the area include the great egret (*Ardea alba*), white-bellied sea-eagle (*Haliaeetus leucogaster*), latham's snipe (*Gallinago hardwickii*), bar-tailed godwit (*Limosa lapponica*), eastern curlew (*Numenius madagascariensis*) and whimbrel (*Numenius phaeopus*) (ANCA, 1996).

Pambula Lake

- The largest wave dominated barrier estuary in the NSW section of theTwofold Shelf bioregion (cf above).
- The second largest area of seagrass in the NSW section of the Bioregion
- The largest area of mangrove in the NSW section of the Bioregion

- The third largest area of saltmarsh in the NSW section of the Bioregion
- This type of estuary occurs in the Victorian section of the bioregion but is not represented in marine protected areas
- Areas upstream of the lake include channels, sand flats, mangroves, saltmarsh, and brackish and freshwater assemblages listed in the Directory of Important Wetlands

Ocean coast between Twofold Bay and Wonboyn River

The largest area of mapped inshore reef in NSW south of Tuross Heads.
Small areas of inshore islands and rocks
The largest area of intertidal rocky shore of all sections in the Batemans Shelf bioregion or the NSW section of the Twofold Shelf bioregion.

Recommendation 32:

That a Marine Park (31,500 ha) be established, and appropriately zoned, between Merimbula Point and Green Cape in the NSW section of the Twofold Shelf Marine Bioregion, including all estuarine and coastal waters out to the 3nm limit of the NSW marine jurisdiction.

Table 131: Twofold Shelf Bioregion (NSW) estuary ecosystems in proposed Twofold Marine Park.

Ecosystem	Area (ha)	Proposed MP (ha)	Proposed MP (%)
Freshwater	39	0	0
Intermittent estuary	347	132	38
Ocean embayment	3084	3084	100
Wave dominated estuary	1486.5	1112.5	75
Total	**4956.5**	**4328.5**	**87.5**

Table 132: Twofold Shelf Bioregion (NSW) estuary habitats in proposed Twofold Marine Park.

Habitat	Area (ha)	Proposed MP (ha)	Proposed MP (%)
Mangrove	76	76	100
Saltmarsh	161.5	101.5	63
Seagrass	390.5	330.5	84.5
Total	**628**	**508**	**81**

Table 133: Twofold Shelf Bioregion (NSW) estuary vegetation in proposed Twofold Marine Park.

Community	Name	Area (ha)	Proposed MP (ha)	Proposed MP (%)
Mangrove	*A. corniculatum/A. marina*	1	1	100
	Avicennia marina	75.5	75.5	100
Saltmarsh	Saltmarsh Communities	161.5	108.5	67
Seagrass	*Halophila sp.*	2.5	2.5	100
	P. australis/Zostera sp.	4	4	100
	Posidona australis	118	117.5	99.5
	Ruppia sp.	38.5	8.5	22
	Zostera sp.	225	198	88
	Ruppia sp./Zosteraceae	3.5	0	0
Other	Other	18.5	10.5	57
Total		**647.5**	**526**	**81**

Table 134: Twofold Shelf Bioregion (NSW) ocean ecosystems in proposed Twofold Marine Park.

Ecosystem	Area (ha)	Proposed MP (ha)	Proposed MP (ha)
0 - 20m	6,708.5	2,976.5	44.5
20 - 60m	30,638.5	12,374	40.5
60 -200m	20,201	11,545.5	57
Total	**57548**	**26896**	**47**

Table 135: Twofold Shelf Bioregion (NSW) coastal habitats in proposed Twofold Marine Park.

Habitat	Area (ha)	Proposed MP (ha)	Proposed MP (%)
Beach	300.5	165	55
Islands and rocks	5.5	5.5	100
Reef and shoal	867.5	541.5	62.5
Rocky intertidal	421.5	299	71
Subtidal sand	3201	1112	35
Total	**4796**	**2123**	**44.5**

Aquatic Reserves

Cape Howe Aquatic Reserve – 4776 ha

This recommended no-take Aquatic Reserve of about 4,776 ha abuts the Victorian Cape Howe Marine National Park (4,050 ha). An IUCN Ia marine sanctuary here would provide a very large cross-border marine sanctuary in an area of immense biological significance that encompasses the boundary between south eastern temperate, southern temperate and cosmopolitan marine species.[234]

Many species are at their most southerly and easterly limits here and distinct assemblages of reef fish, echinoderms, gastropods and bivalves are present.[44] Many species from warmer northern waters reach their southern limit at Cape Howe.[44] A diverse array of sponges, hydroids, ascidians and gorgonians are reported from the sandstone reefs of this area.[44]

Low profile reefs are covered in a dense forest of the brown seaweed *Phyllospora* or Crayweed that reaches to over 2 metres in length.[44] Beneath this canopy many smaller seaweeds, red sea-tulips, sponges, colourful seastars, brittle-stars, pillbugs, brightly coloured worms, sea squirts and many large molluscs are sheltered.[44] Off this section of the coast, the seafloor tilts steeply down into deeper water where there is not enough light for the large brown seaweeds, and the low sandstone reefs are covered with small patches of leafy red seaweeds, and attached animals such as sea-whips are common.[44]

The rocky habitats of Cape Howe have complex forms and structures, including low-profile reefs eroded into pits and gutters, and heavy boulder reefs with gutters and ridges up to three metres high.[44] Extensive offshore reefs have been identified at Cape Howe, isolated from those mapped inshore. The recommended Cape Howe Aquatic Reserve encompasses an area of mapped offshore reef that appears to be a large pinnacle that rises from almost 60m to less than 20m. It is highly likely that this feature would harbour species and habitats unique in NSW waters.

This marine area is the most isolated in NSW and is likely to include some of its least disturbed marine habitats.

[234] Parks Victoria, 2006,

Recommendation 33:

That a no-take Aquatic Reserve (4776 ha) be established between Black Rock and Cape Howe at the southernmost limit of the NSW marine jurisdiction out to the 3nm limit.

Table 136: Twofold Shelf Bioregion (NSW) ocean ecosystems in proposed Cape Howe Aquatic Reserve.

Ecosystem	Area (ha)	Proposed AR (ha)	Proposed AR (%)
0 - 20m	6,708.5	554.5	8.5
20 - 60m	30,638.5	1,845	6
60 -200m	20,201	2,373	12
Total	**57,548**	**4772.5**	**8.5**

Table 137: Twofold Shelf Bioregion (NSW) coastal habitats in proposed Cape Howe Aquatic Reserve.

Habitat	Area (ha)	Proposed AR (ha)	Proposed AR (%)
Beach	300.5	7.5	2.5
Islands and rocks	5.5	0	0
Reef and shoal	867.5	132	15
Rocky intertidal	421.5	13.5	3
Subtidal sand	3201	265	8.5
Total	**4796**	**418**	**9**

Tura Head Aquatic Reserve – 550.5 ha

Tura Head is a grey nurse shark site. While no sightings were made in recent surveys, anecdotal evidence suggests that they are present at times. This site is one of only two sites in the Bioregion were grey nurse sharks are still sighted, making this site near to the population's southern limit. This is an important recovery site for the grey nurse shark and a high conservation priority.

Recommendation 34:

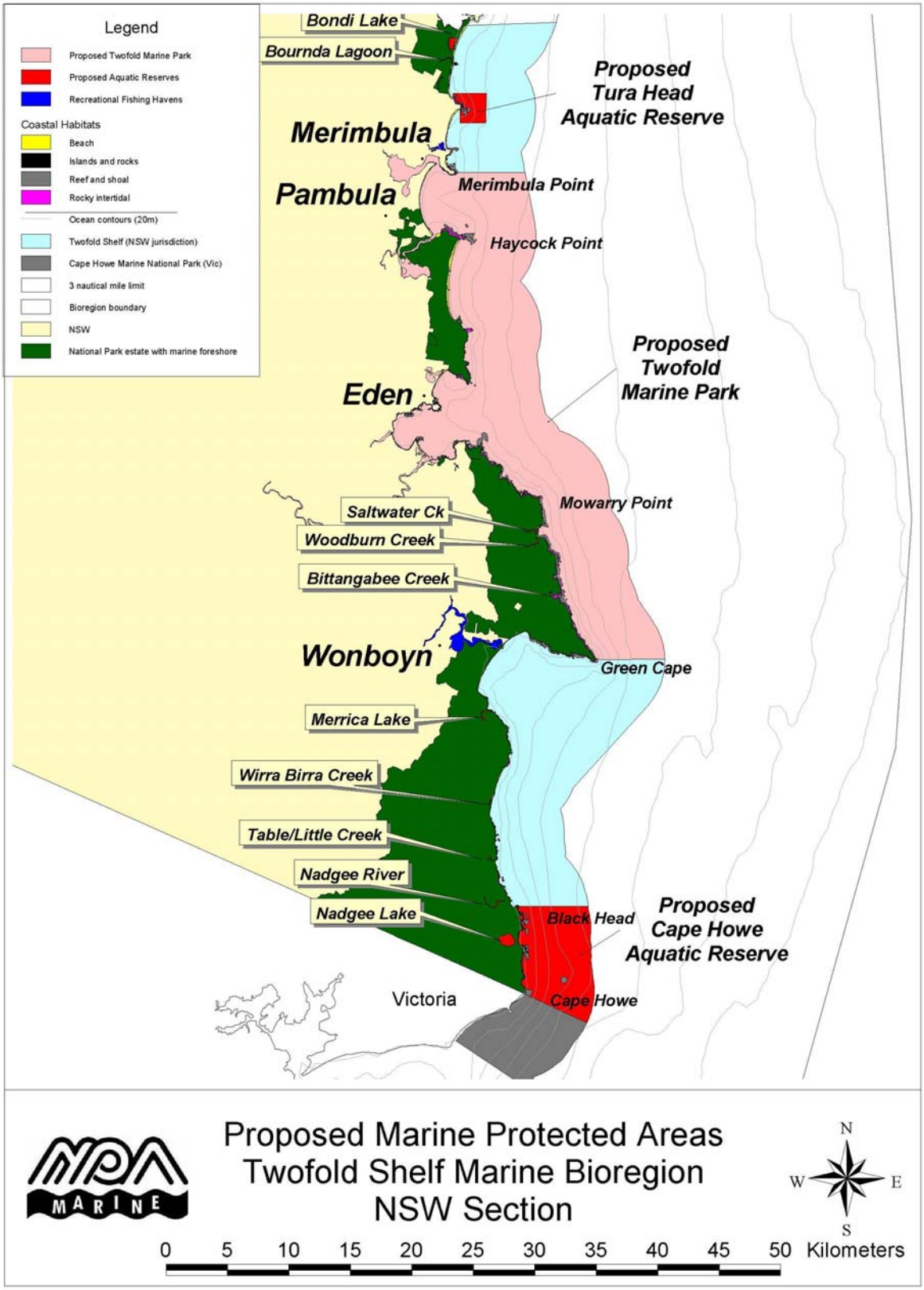
That a no-take Aquatic Reserve (550.5 ha) be established at Tura Head in the NSW section of the Twofold Shelf marine bioregion.

Table 138: Twofold Shelf Bioregion (NSW) ocean ecosystems in proposed Tura Head Aquatic Reserve.

Ecosystem	Area (ha)	Proposed AR (ha)	Proposed AR (%)
0 - 20m	6,708.5	197	3
20 - 60m	30,638.5	347.5	1
60 -200m	20,201	0	0
Total	**57,548**	**544.5**	**1**

Table 139: Twofold Shelf Bioregion (NSW) coastal habitats in proposed Tura Head Aquatic Reserve.

Habitat	Area (ha)	Proposed AR (ha)	Proposed AR (%)
Reef and shoal	867.5	35	4
Rocky intertidal	421.5	16	4
Subtidal sand	3201	74.5	2.5
Total	**4796**	**125.5**	**2.5**



Map 25: Twofold Shelf Bioregion proposed Marine Protected Areas

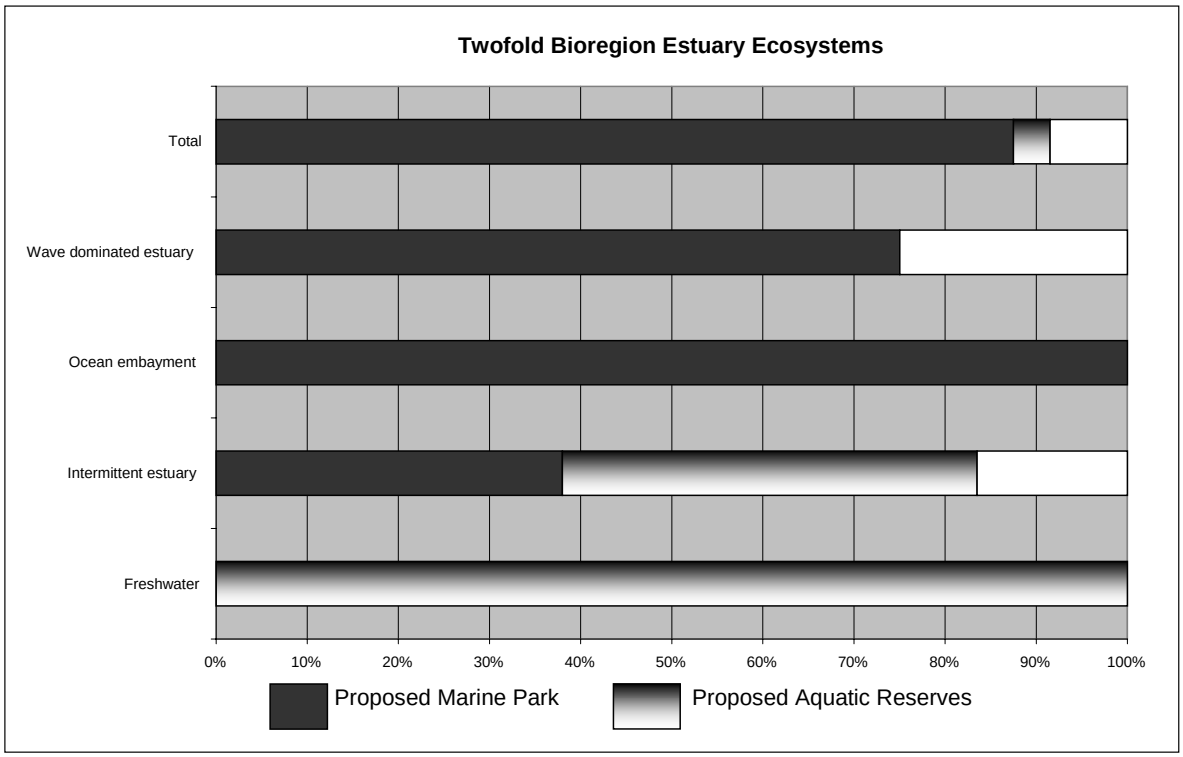


Fig.32: Twofold Shelf Bioregion (NSW) estuary ecosystems in proposed marine protected areas

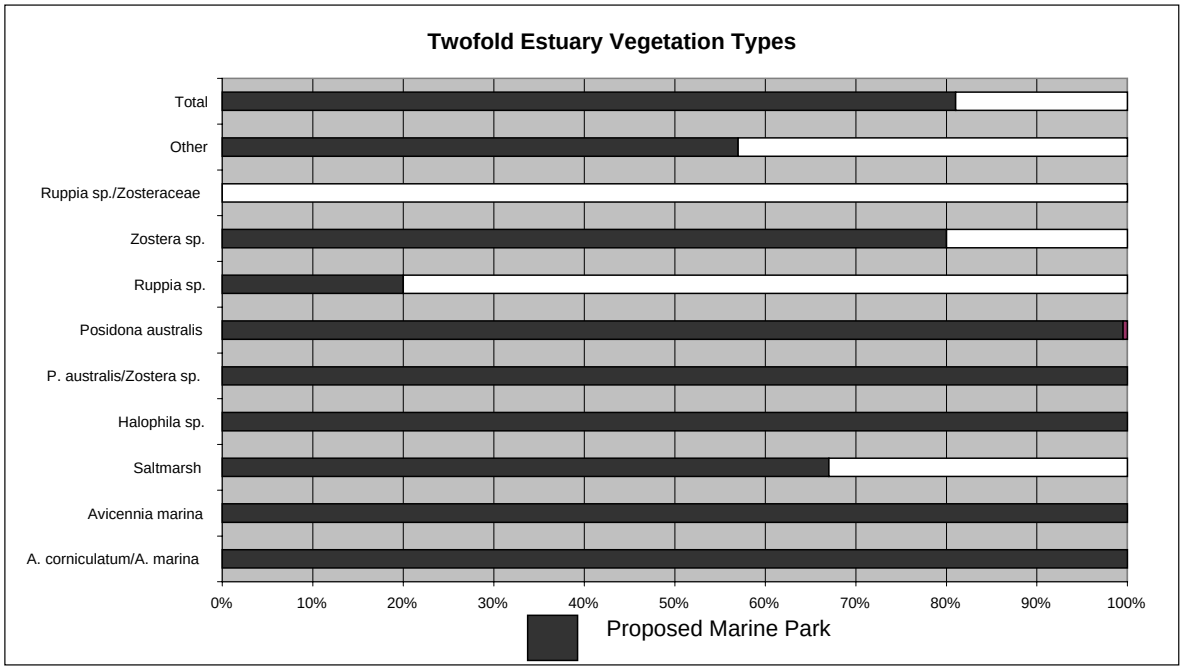


Fig.33: Twofold Shelf Bioregion (NSW) estuary vegetation types in proposed marine protected areas

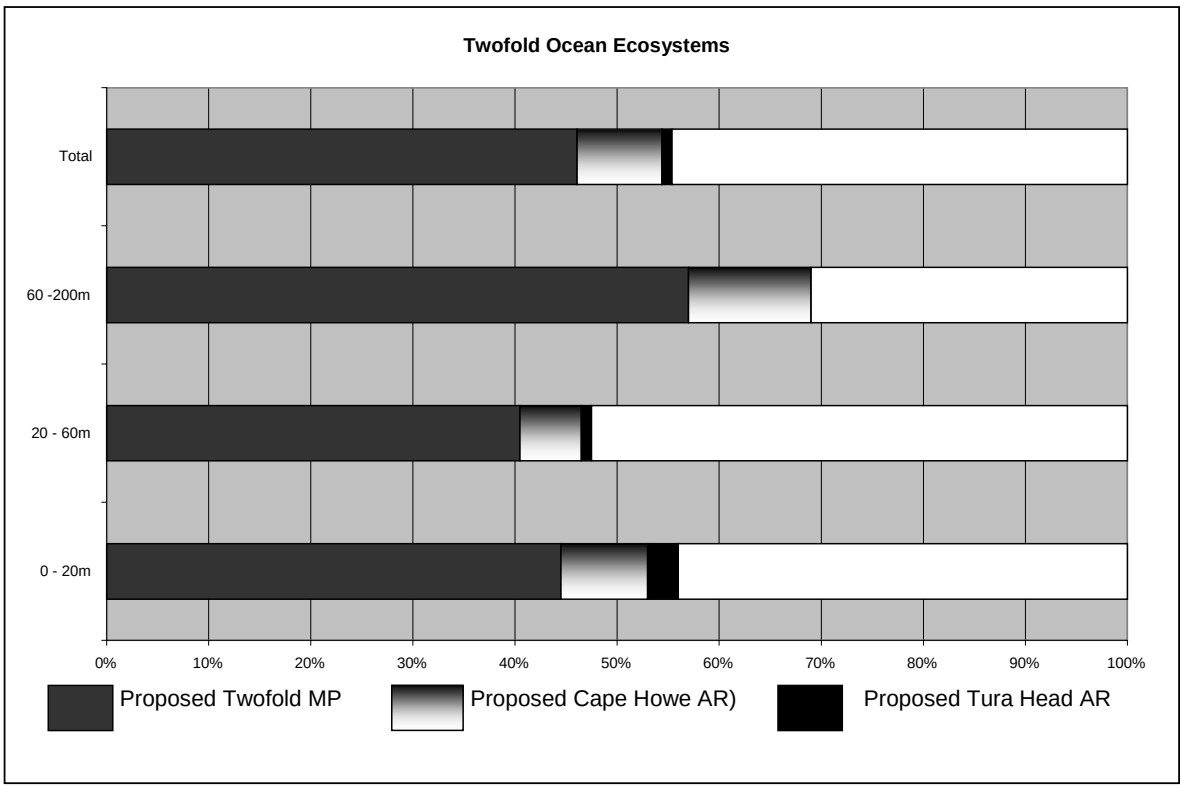


Fig.34: Twofold Shelf Bioregion (NSW) ocean ecosystems in proposed marine protected areas

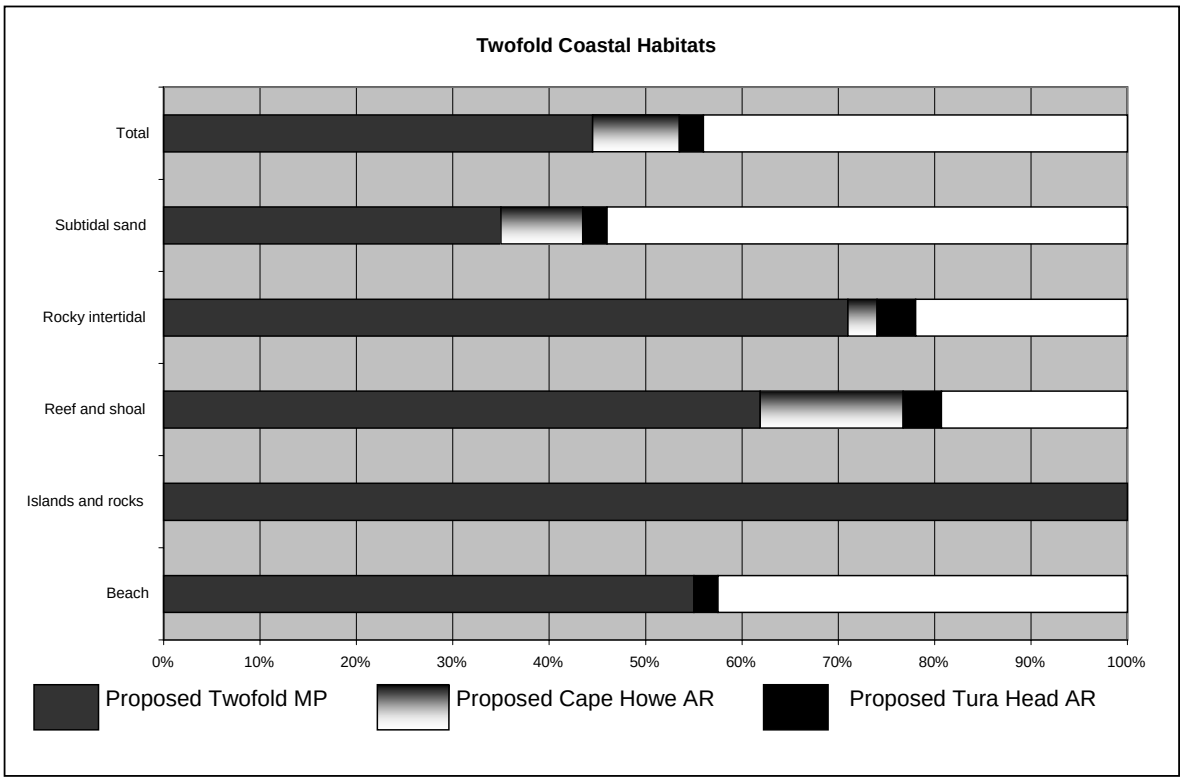


Fig.35: Twofold Shelf Bioregion (NSW) coastal habitats in proposed marine protected areas