Nowhere Else on Earth:
Tasmania's Marine Natural Values

AQUENAL

ENVIRONMENT TASMANIA
The Conservation Council

ENVIRONMENT TASMANIA
The Conservation Council

Environment Tasmania is a not-for-profit conservation council dedicated to the protection, conservation and rehabilitation of Tasmania's natural environment. Australia's youngest conservation council, Environment Tasmania was established in 2006 and is a peak body representing over 20 Tasmanian environment groups.

Prepared for Environment Tasmania
by Dr Karen Parsons of Aquenal Pty Ltd.

Report citation: Parsons, K. E. (2011) Nowhere Else on Earth: Tasmania's Marine Natural Values. Report for Environment Tasmania. Aquenal, Tasmania.

ISBN: 978-0-646-56647-4

Graphic Design: onetonnegraphic www.onetonnegraphic.com.au

Online: Visit the Environment Tasmania website at: www.et.org.au or Ocean Planet online at www.oceanplanet.org.au

Partners: With thanks to the The Wilderness Society Inc for their financial support through the WildCountry Small Grants Program, and to NRM North and NRM South.

Front Cover: Gorgonian fan with diver (Photograph: © Geoff Rollins).

Waterfall Bay cave (Photograph: © Jon Bryan).

Acknowledgements

The following people are thanked for their assistance with the compilation of this report: Neville Barrett of the Institute for Marine and Antarctic Studies (IMAS) at the University of Tasmania for providing information on key features of Tasmania's marine environment and useful literature; Fiona Scott of IMAS for summary information on Tasmania's rare algae; Vanessa Lucieer of IMAS for providing maps and habitat data; Gretta Pecl of IMAS for literature and unpublished accounts of the Southern Calamary; Eric Woehler of Birds Tasmania for literature and generously reviewing bird lists; Kerry Swadling of IMAS for zooplankton literature; Rachael Alderman of the Department of Primary Industries, Parks, Water and Environment (DPIPWE) for information on seabirds and marine mammals; Gustaaf Hallegraeff of IMAS for summary text on key attributes of phytoplankton communities; Peter Last of CSIRO for information on endemic fishes; Christian Bell for useful publications and information on marine conservation hotspots; Graham Edgar of Aquenal for reviewing the paper; Sasha Migus of Aquenal for meticulous editing; and various additional researchers who provided copies of their publications.

The majority of the photographs in the report were generously provided by Graham Edgar, while the following additional contributors are also acknowledged: Neville Barrett, Jane Elek, Sue Wragge, Chris Black, Jon Bryan, Jan Leiser, David Maynard of Australian Maritime College, Geoff Rollins, Alan Fletcher, Vishnu Prahalad, Judy Crees-Morris of Australian Maritime College, and Karen Gowlett-Holmes (permission via Environment Tasmania); Gretta Pecl of IMAS; Gustaaf Hallegraeff of IMAS; Anita Slotwinski of IMAS (with permission of Kerrie Swadling); Natalie Moltschaniwskyj of the University of Newcastle; Biodiversity Monitoring Section, DPIPWE (with permission of Kris Carlyon); Valeria Ruoppolo and Eric Woehler of Birds Tasmania (with permission of Eric Woehler); Caroline Fisher of Caroline Fisher Photography; various photographers from the Australian Antarctic Division (with permission of Jessica Fitzpatrick); Thor Carter of CSIRO Marine and Atmospheric Research (with permission of Alastair Graham); and Ron Mawbey, Adam Davey, Karen Parsons and additional staff at Aquenal.

Graphics were prepared specifically for this report by Nathanael Jeanneret of onetonnegraphic, while maps were generated using Seamap data by Vanessa Lucieer of IMAS. Pre-existing illustrations were provided by: Parks and Wildlife Service, Tasmania (with permission of Fiona Rice); CSIRO Marine and Atmospheric Research (with permission of Craig Macaulay); Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) of the Australian Government (with permission of Sandy Stefanac); Birds Australia (with the permission of Eric Woehler); Richard Mount; IMAS (with permission of Jeremy Lyle); and the Tasmanian Planning Commission.

Southern Sea Anemone (*Phlyctenanthus australis*) (Photograph: © Geoff Rollins).

Executive Summary

Tasmania has a spectacular coastline and diverse marine environments which form an integral part of the lifestyle of many Tasmanians. Our coastal waters also have extraordinary natural values that are of global conservation significance on the basis of high biodiversity, unusually large numbers of unique species found nowhere else, and rare ecosystems within pristine underwater wilderness areas that rival World Heritage listed lands. From magnificent Giant Kelp forests to ancient relic species, Critically Endangered fish, pristine seabird islands, commercially important fish nurseries, unique tannin-stained estuaries, luxuriant seagrass meadows, and a myriad of other productive habitats and rare species, our small island state is a hotspot for diverse marine life forms and important conservation values.

Yet the hidden nature of marine environments means that their outstanding values may not be widely appreciated or understood, as reflected by the current protection of just 2.6% of waters around Tasmania as opposed to 40% of land environments. The purpose of this paper is to summarise what we know about Tasmania's natural marine values, and to describe what makes our state, including the mainland coast, offshore islands and spectacular subantarctic Macquarie Island, totally unique. The location and physical attributes of the sea and seabed around Tasmania make it unusual within national and international contexts, with this physical rarity matched by a biological rarity within marine plant and animal communities. In particular, Tasmania possesses:

- A disproportionately long and highly complex coast, with Tasmania accounting for only 0.9% of Australia's area and yet 8.2% of its coastline, and including numerous estuaries and embayments and more than 6,000 islands and smaller rocky islets;
- Extreme variation in wave exposure due to a highly indented coast, being the only state in Australia to experience waves from every direction, and incorporating the only section of Australian coast lying in the path of the Roaring 40s westerly winds;
- A very wide diversity of coastal landforms and submarine topography, and a complex geology that is exceptionally well exposed on the coast, including the oldest rock types in eastern Australia and a greater similarity to Antarctica than other parts of Australia;
- A high level of tidal variation due to the broad Bass Strait shelf and associated islands creating a larger tidal range in the north than experienced around the shallower shelf in the south;
- As a result of this complex coastline, rich geology and variable wave exposure and tides, an exceptionally wide variety of marine ecosystems that are amongst the most diverse and productive on earth, including estuaries, wetlands and sheltered lagoons, rocky headlands and reefs, sandy beaches, mudflats, saltmarshes, seagrass beds and offshore islands;
- A diverse range of oceanographic influences, with Tasmania located at the meeting point of three major oceanographic currents that result in a unique mix of warm temperate through to subantarctic species that is reflected throughout the food chain (i.e. phytoplankton through to seals and whales); including the northern geographical limits for species of subantarctic origin and the southern limits for a range of warm temperate species;

Low Head Shallows (Photograph: © Geoff Rollins).

- Upwellings of cold, nutrient-rich subantarctic water in the vicinity of Tasmania, which result in higher nutrient levels than in more northern parts of Australia, and are key to: our high marine productivity, the presence of a distinctive 'cool temperate' assemblage, and the presence of subantarctic species that are absent or rare on mainland Australian shores and include some of the largest and fastest growing marine plants in the world;

- A location within a temperate marine region that has been geographically and climatically isolated from other temperate systems for around 65 million years, leading to levels of marine diversity and 'endemism' (i.e. species unique to the region) that are amongst the highest in the world;

- Unusual Gondwanan 'relic' species with ancient ancestries, and some of the most highly restricted marine species in the world, including the first fish listed as Endangered in Australia, one of the world's rarest skates, the only Australian fish recorded from just one estuary, the only marine invertebrates listed as nationally Threatened, and a number of fish, invertebrates and algae limited to only one or two estuaries or sites;

- A significant portion of pristine marine environments, including the most extensive undeveloped coastline in southeastern Australia, an unusually high percentage of undisturbed estuaries, and a large number of remote, pristine islands; many areas are globally rare by virtue of their isolation and lack of pollution from the land;

- Exceptionally wide diversity of estuarine habitat types, due to a steep rainfall gradient, which ranges from 3000 mm per year in the southwest to 600 mm in the northeast, as well as the steep north-south tidal gradient and high geological diversity; all major geomorphological types of estuaries other than fjords are represented;

- A higher diversity and number of wetlands and internationally important bird sites relative to its size than any other Australian state, as well as the highest densities in Australia of a number of resident and migratory species, and a unique location at the most southerly extremity of the East Asian-Australasian Flyway for migratory shorebirds;

- A remarkable hotspot for seabird activity that includes the only nationally listed Critical Habitats for marine species (albatross species), and stronghold populations of Endangered seals;

- A very large number of Threatened species, including 55 species listed within Tasmania or Australia (28 seabirds, six fish, five whales, four turtles, four seals/sea lions, three seastars, two estuarine grasses, one shorebird, one mollusc and one alga), and additional seabird, shorebird and fish species listed as globally Threatened; also, many rare species that are likely to have highly restricted distributions or low population numbers but have received little study and hence are not formally listed as being Threatened by extinction.

As a result of the above unique attributes and diversity of marine assemblages, a large number of 'bioregions' have been identified around Tasmania's coast, each with distinctive physical and biological attributes. These bioregions contain an outstanding variety of ecosystems, some of which have particularly high natural values by virtue of their rarity. Examples of these rare ecosystems, as well as 'stand out' sites with high ecological values within each bioregion, are provided to highlight some of the remarkable features worthy of consideration as the state's system of Marine Protected Areas (MPAs) grows to meet international targets.

Table of Contents

1. THE WILDERNESS BELOW...

A colourful garden of gorgonian corals (Photograph: © Neville Barrett).

Surveys have revealed that the Tasmanian wilderness is now the number one drawcard for visitors to the state and is what people consider to be most special about Tasmania. But when we think about 'wilderness', what images come to mind? For many people it will be majestic ancient trees, jagged mountain ranges, and the beautiful colours of alpine rockeries. These are indeed truly beautiful and uniquely Tasmanian. However did you know that Tasmania's world class wilderness areas extend below the waterline as well? Our unique marine environment is simply an extension of the environment above, with over 25% of the area under Tasmania's jurisdiction located below the high tide mark[1].

The main difference between the images above and those of our towering Giant Kelp forests, majestic underwater pinnacles, and colourful sponge gardens is that fewer people have experienced them first hand. This helps to explain why 40% of the Tasmanian land environment is now formally reserved, whilst only 2.6% of the marine environment around Tasmania is afforded this protection. This falls well short of reserving the 20-30% of the marine environment needed to meet international commitments[2].

Tasmania's marine life is extraordinary, including unique species and communities found nowhere else in Australia or even the world, and including pristine habitats recognised to be of high global conservation significance. Yet the hidden nature of our marine environments means that their outstanding values may not be widely appreciated or understood, and a lack of baseline information means that species approaching extinction may go totally unnoticed.

The purpose of this paper is to summarise what we do know about Tasmania's natural marine values, and to showcase the remarkable and diverse marine life in our waters. It examines what makes Tasmania, including the mainland coast, offshore islands and spectacular subantarctic Macquarie Island, ecologically unique. The area examined extends from the high tide mark to the 3 nautical mile outer limit of Tasmania's coastal waters, and also includes animals (e.g. seals and seabirds) that frequently occur outside this area but rely completely on the marine environment for food.

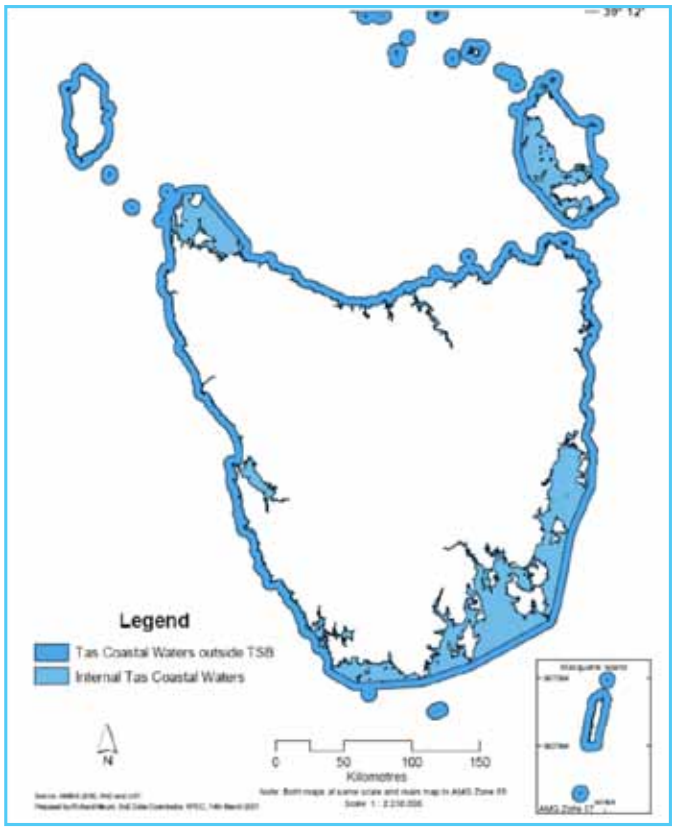
The special qualities of Tasmania's marine environment are apparent at many scales; they are described here for the state as a whole, within different types of ecosystems that are widely dispersed around Tasmania, for significant species that have high conservation values, and within geographically distinct 'bioregions' that have been identified on the basis of types of marine species present. Examples of rare ecosystems, as well as specific sites of high ecological value within each bioregion, are given to illustrate the outstanding diversity along our coast. While we recognise the critical role of the marine environment in climate regulation, sustained food resources, filtration of pollutants from the land, and maintenance of biodiversity, our ability to manage these issues effectively within Tasmania relies on an increased understanding of our marine natural values and priorities for protecting these into the future.

Forest of Giant Kelp
(Photograph: © Neville Barrett).

2. TASMANIA – OUR DIVERSE ISLAND STATE

Bathurst Channel Estuary, south-west Tasmania (Photograph: © Jim England).

Tasmanian coastal waters cover a larger area than you might initially think, extending 200 km north of our mainland coast to nearly touch Wilsons Promontory in Victoria, and 1,500 km south to Macquarie Island, the only subantarctic island under state management in Australia. The first thing you will notice about Tasmania is that it has an extraordinary amount of coastline relative to its size, accounting for only 0.9% of Australia's area and yet 8.2% of its coastline[3]. This reflects not only our unique island status but also the highly indented coastline of Tasmania, with large harbours and embayments, and many major islands that together comprise more than 8,000 km of coast. Tasmania includes a remarkable 374 islands greater than 1 hectare in size and 6,163 islets smaller than 1 hectare[3]. It also has a wide diversity of coastal landforms and submarine topography, and a complex geology that is exceptionally well exposed and includes the oldest rock types in eastern Australia[4]. In addition, Tasmania differs from the rest of Australia in having greater geological as well as biological similarity to Antarctica due to its southerly location and more recent land connection with the Antarctic continent (45 million years ago[5]). Being the only state in Australia subject to waves from every direction, Tasmania experiences a wide range of wave exposures, from the sheltered open or moderately exposed coast in the north that shelves gradually into Bass Strait, to the narrower shelf elsewhere that is sub-maximally exposed in the east and maximally exposed in the west and south[6].



Tasmania's coastal waters, which include internal waters and waters to 3 nautical miles seaward of the 'Territorial Sea Baseline' (TSB)[3].

Tasmania's complex coastline and rich geology have resulted in an exceptionally wide variety of marine ecosystems that are amongst the most diverse on earth including estuaries, wetlands and sheltered lagoons, rocky headlands and reefs, sandy beaches, mudflats, saltmarshes, seagrass beds and offshore islands[7]. These support an abundance of plant and animal life, including a large number of organisms totally unique – or 'endemic' – to this region due to the temperate marine environment surrounding Tasmania being geographically and climatically isolated from other temperate systems of the world for around 65 million years. Approximately 85% of fish species, 90% of echinoderm species (e.g. seastars, sea urchins) and 95% of mollusc species (e.g. sea snails, bivalves) in Tasmanian waters are endemic to the southern waters of Australia[8]. Marine algae (i.e. seaweeds) are equally unique, displaying levels of diversity and endemism that are amongst the highest in the world and producing more luxuriant growth in Tasmania than anywhere elsewhere in Australia due to naturally high nutrient levels and cool water temperatures[9]. Unlike tropical Australia, where almost all marine species range widely throughout the Indo-Pacific region, species in Tasmania often have very localised distributions and small populations of very high conservation value[10]. Some of these species are in fact unusual 'Gondwanan relics', sharing their ancestry with plants and animals of other continents that were originally connected to Australia as part of the ancient Gondwanan landmass[11]. Another highly unusual feature of Tasmania is the significant portion of pristine coastline, particularly in the south west and Furneaux Group, which includes unique, undisturbed environments that are rare globally.

Southern Basket Star (*Conocladus australis*) attached to sea whips (Photograph: © Graham Edgar).

Sweet Ceratosoma (*Ceratosoma amoenum*) (Photograph: © Graham Edgar).

Cluster of blue sponges (Photograph: © Graham Edgar).

The high marine biodiversity of Tasmania is also a reflection of its unique location at the meeting point of three major oceanographic currents, which collectively bring together a mixture of warm nutrient poor waters from the north and west, as well as cold nutrient rich waters from the south[9]. This results in an unusual mixing of subtropical, temperate and subantarctic species and has also contributed to our high levels of species endemism, since convergence zones can create steep environmental gradients which form an ecological barrier to dispersal of some species[12]. The overlapping ocean influences also mean that Tasmania represents the northern geographical limits for species of subantarctic origin, and at the same time the southern limits for a range of warm temperate species. This applies to fully marine communities as well as species that rely on our marine environment primarily for food; for example Tasmania is located at the most southerly point of the East Asian-Australasian Flyway for migratory shorebirds[13], whilst containing the most northerly location for many subantarctic marine mammals and breeding albatross colonies. Added to our diverse oceanographic influences is tidal variation that includes small 'micro-tides' in the south and larger 'meso-tides' in Bass Strait[14], producing a wide range of current flow and intertidal conditions. The close proximity of the steep continental slope and associated deep water in some parts of Tasmania[15], is rare in Australia and results in the presence of deepwater species usually not found so close to the coast.

Tasmanian marine environments are therefore unique physically and biologically, and contain extraordinary natural values that have global conservation significance on the basis of very high biodiversity, unusually large numbers of endemic species, and rare ecosystems[1].

3. TASMANIA'S UNIQUE OCEAN INFLUENCES

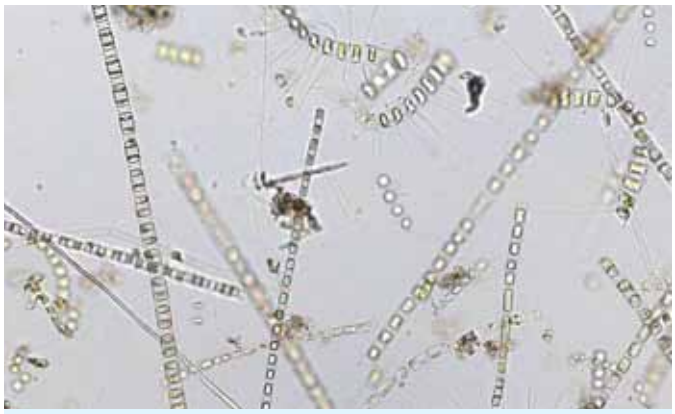
Ocean currents have a dramatic affect on the types of marine plants and animals found in Tasmanian waters, so it is worth taking a more detailed look at how they work and the role they play in our marine diversity. Along Tasmania's coast and in our estuaries, local variation in the strength and direction of water currents is best demonstrated by the tides. The strength and direction of tidal currents affects our recreational activities, for example where we moor the boat to ensure it doesn't get grounded, when we go fishing to coincide with 'runs' of certain fish, or when we go scuba diving to avoid strong currents and therefore overexertion. The effects of the tides and associated currents vary greatly around our island state, with the east, south and west coasts having small 'micro-tides' which range only 0.6-1.4 m in height, whilst our north coast adjacent to Bass Strait has much larger meso-tides which can range as much as 4.4 m[16]. However, at a much broader scale, massive ocean currents operate around Tasmania which dictate how warm our waters are, as well as how salty, how productive and what marine species they contain. Thus our fisheries and marine biodiversity are totally dependent on these currents and the variation they display in response to the climate.

Tasmania is located at the convergence of three major oceanographic currents, resulting in the physical, chemical and biological properties of our coastal waters being totally unique. The currents dominating Tasmania's marine environment include the cool, nutrient-rich Antarctic Circumpolar Current which originates in the Southern Ocean, and two warmer, nutrient-poor currents – the East Australian Current that originates in the Coral Sea and flows south to the Tasmanian east coast, and the Zeehan Current, which is derived from the Leeuwin Current in Western Australia and moves along Tasmania's west coast[9,17]. The Zeehan Current is at it's strongest in winter[12], which means that waters around north western Tasmania including King Island are warmer in winter than elsewhere in Tasmania[17]. In contrast, the East Australian Current is strongest in late summer[9,14], with our east coast therefore experiencing the warmest water temperatures during summer months[18]. The contrasting currents operating around Tasmania contribute significantly to the high marine biodiversity and the variable prevalence of subantarctic, warm and cool temperate species around the coast.

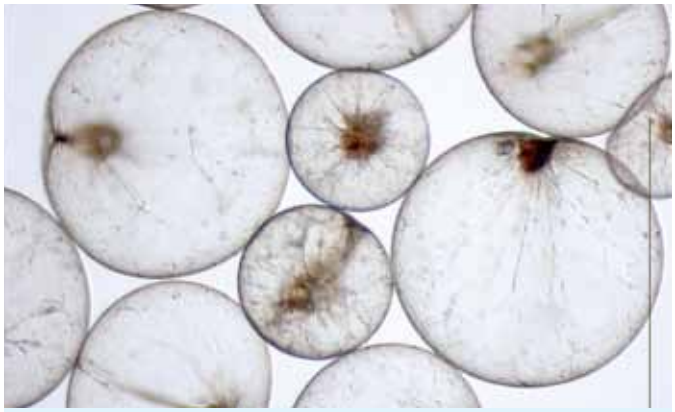
One of the keys to Tasmania's unique marine life and high levels of productivity is the upwelling of cold, nutrient-rich subantarctic water which is carried northward via the Antarctic Circumpolar Current, a current also described as the Global Conveyor Belt and considered to be the powerhouse for global climate[18]. As the cold waters spread northward, they sink below the less dense, warmer and nutrient-poor upper layer in an area known as the Subtropical Convergence[9,17], providing a reservoir of nutrient-rich water in the vicinity of Tasmania. As a result, Tasmanian waters are generally higher in nutrients and more productive than northern regions of Australia and can sustain Giant Kelp forests and other unique marine communities that are absent or rare elsewhere[9,17]. The Subtropical Convergence zone is also important for many fisheries around Tasmania, providing rich food resources that sustain populations of squid and fish.

The climate has a major influence on the oceanographic currents, leading to seasonal as well as annual variation in their strength and effects on the Tasmanian marine environment[9]. Tasmania has a temperate climate with a mean sea surface temperature of 10-12 ˚C in winter and 18-20 ˚C in summer[17], although water temperatures vary significantly around the state due to the effects of the above ocean currents.

Horseshoe Leatherjacket (*Meuschenia hippocrepis*) (Photograph: © Neville Barrett).



Diatom bloom (Photograph: © Gustaaf Hallegraeff).



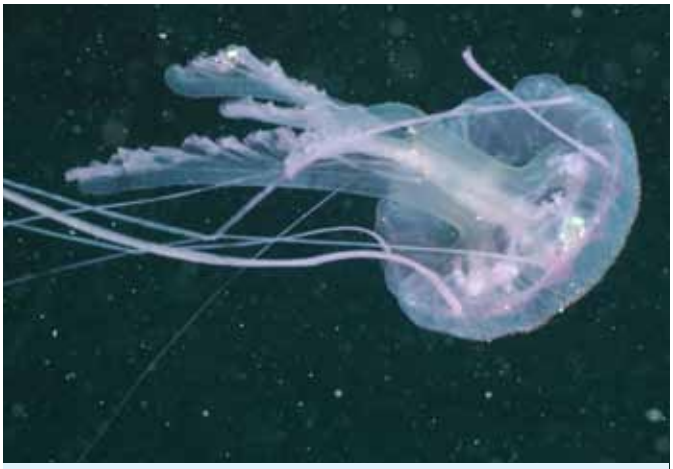
Dinoflagellate (*Noctiluca scintillans*) (Photograph: © Anita Slotwinski, IMAS).

Seasonal influences include alternating periods of high and low pressure systems, the westerly wind belt of the Southern Hemisphere, and El Niño and La Niña events, which are extreme phases of a naturally occurring climate cycle known as El Niño - Southern Oscillation (ENSO)[9]. The system oscillates between El Niño and La Niña conditions on average every 3-4 years, and Tasmania is particularly sensitive to changes in atmospheric and oceanic circulation associated with these climatic events. Significantly, the ENSO cycle affects the strength and position of the East Australian Current and the latitude of the Subtropical Convergence[9,17], thereby influencing the temperature and productivity of Tasmanian waters.

Our ocean currents, as well as the climatic factors that affect them, play a major role in determining the distribution, diversity, larval recruitment and composition of marine species off Tasmania's coast[9,17]. It all starts at the base of the food chain, with the distribution and productivity of microscopic plants called phytoplankton strongly reflecting the locations of the major water masses[12]. Phytoplankton provide food for krill and microscopic animals collectively known as zooplankton, and in turn these form the diet of commercially and ecologically important fish. Several Tasmanian fisheries are based on species that feed at some stage in their life cycle on open-water plankton, such as the Southern Rock Lobster and Striped Trumpeter[9].

Fishes are in turn an important food source for pelagic sharks, as well as seabirds and fur seals during the summer breeding season, while krill are an important food source for whales migrating along the south and east coasts of Tasmania (e.g. Humpback Whales[19]). You can see then that variation in the positions of the water masses around Tasmania leads not only to changes in phytoplankton productivity, but also to changes in abundances of all the species higher in the food chain.

Marine species have varying temperature and salinity tolerances and hence their dispersal is directly linked with oceanographic currents. For example, increasing southerly penetration of the warm East Australian Current[9,20], a possible consequence of global warming, has resulted in the southerly movement of a wide range of warm-water loving plant and animal species and hence in significant changes to the structure of Tasmania's marine communities[7,18,21,22]. Climatic events such as La Niña may exacerbate this effect, pushing warm water unusually far down the Tasmanian east coast, resulting in very low nutrient levels, phytoplankton production and krill production[19]. The Common Jack Mackerel (*Trachurus declivis*), a commercial species captured off Tasmania that feeds off krill, moves into deeper offshore waters at these times, resulting in poor fisheries catches[23]. This demonstrates the critical role of the oceans in the composition and abundance of marine species, with Tasmania's complex current systems providing a particularly dynamic ocean environment.



Purple-streaked Jelly (*Pelagia noctiluca*) (Photograph: © Graham Edgar).

The East Australian, Zeehan and Antarctic Circumpolar currents around the Tasmanian coast (Source: CSIRO Marine and Atmospheric Research).

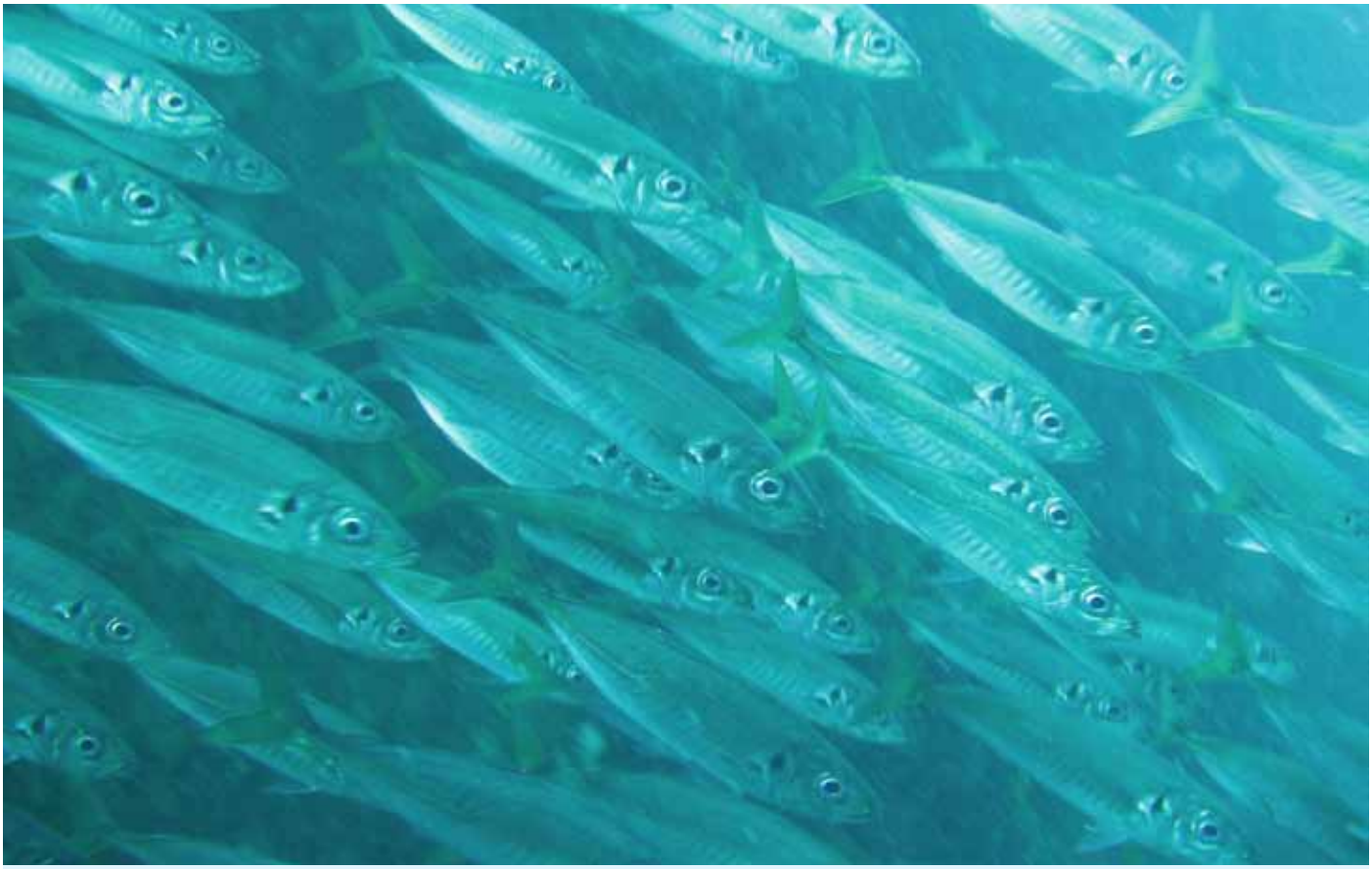
4. KEY FEATURES OF TASMANIA'S MARINE ENVIRONMENT

4.1. Introduction to marine ecosystems...

One of the most useful ways of describing our marine environments is through the identification of distinct 'ecosystems' that have particular physical characteristics and associated biological communities. An ecosystem is a biological environment consisting of all the organisms living in a particular area, as well as all the nonliving, physical components of the environment. Ecosystems are functional units in which organisms present are dependent on each other and on their environment, and hence disturbance to one species or one aspect of the environment affects all other species within it.

Tasmania has a remarkable diversity of marine ecosystems, from rugged, wave exposed reefs favouring unique cold water species, to deep offshore habitats harbouring large oceanic fishes; sheltered mudflats supporting numerous small invertebrates and shorebirds that feed on them; seagrass beds that provide nurseries and refugia for a host of marine species; and estuaries where fresh and marine waters collide to provide a unique mix of freshwater, estuary-adapted and fully marine species. One of the keys to this diversity is the physical and geological complexity of our coast, with features such as seabed substrate, water depth, wave exposure, and water characteristics (e.g. light penetration, turbidity, salinity, nutrient levels) all important in characterising ecosystems and their associated species and communities[24]. Further variation within ecosystems leads to a wide range of 'habitats' in Tasmania, each characterised by specific physical attributes and containing certain types of organisms, such as a shallow sandy and deep silty habitats in the case of soft unvegetated sediments.

Within each ecosystem, there are many 'ecosystem processes' occurring that create biodiversity and protect the integrity of the natural environment. Examples include water and nutrient flows, primary production of plant communities, trophic interactions between organisms in a food chain, oceanography, tidal influences on estuarine salinity, sedimentation, and catchment processes[2]. Ecosystems also perform a number of 'services' which protect the quality and amenity of our environment, such as water quality maintenance, nutrient cycling, defence against sea level rise, waste processing and erosion control. In order to sustain Tasmania's amazing marine diversity, we need to protect important ecosystem services as well as the network of ecosystem processes upon which our ecologically and commercially significant species depend. So for example, attempts to protect a fisheries species may be in vain if they consider the biological characteristics (e.g. reproductive ecology) and stock structure of the species, but neglect to consider the nature of its prey, predators and competitors, nursery habitat and associated processes that combine to provide a healthy ecosystem for the species to live in[2].



The Common Jack Mackerel (*Trachurus declivis*) is an important pelagic species in Tasmania that displays distinct population responses to variation in oceanographic currents (Photograph: © Sue Wragge).

A swarm of small mysid crustaceans (Photograph: © Graham Edgar).

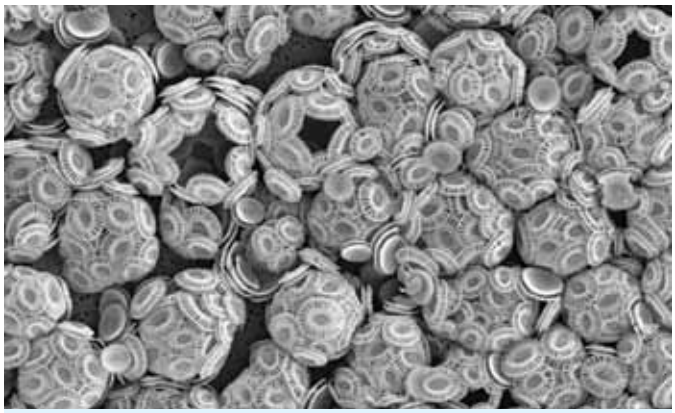
The sections below explore Tasmania's amazing marine ecosystems, including their unique environmental attributes, biological communities, high conservation values and important ecosystem services and processes. Whilst not intended to provide a comprehensive assessment of priorities for marine environmental protection, examples are given of particularly unique types of ecosystems that contain rare physical conditions and hence equally rare biological communities. All of our ecosystems contain important conservation values such as Threatened species or significant nursery habitats; the absence of 'unique' examples for some ecosystems below simply reflects the widely dispersed nature of values or a lack of knowledge of the rare physical features associated with them.

4.2 The water column and open sea

By nature of being no more than 3 nm from the coastline, Tasmania's coastal waters have strong connections with the adjacent land. However, our marine environments extend to maximum depths of around 200 m and are also home to a number of 'pelagic' species (i.e. of the open sea) that occur largely in offshore oceanic habitats. A unique attribute of Tasmania is that in some areas, the separation between the shallow nearshore and deep pelagic zones is relatively narrow because of the close proximity of the continental shelf and the presence of deep water near the shore[15]. The south eastern part of the Tasman Peninsula provides a prime example, and there are few other places in Australia where deep oceanic waters and fish species are so accessible from the coast. The deeper regions are amongst the harshest of our marine environments, being very cold, dark and subject to extreme pressure. In this harsh environment, large fish and predatory sharks occur that are rarely found in shallow nearshore environments. In addition, there are many life forms that occur in shallow waters but spend their life predominantly suspended in the water column. The term 'pelagic' is therefore extended in this section to include these species, since they are not associated with specific benthic (i.e. seabed) habitats, such as rocky reefs or seagrass beds, and hence their values can sometimes be overlooked.

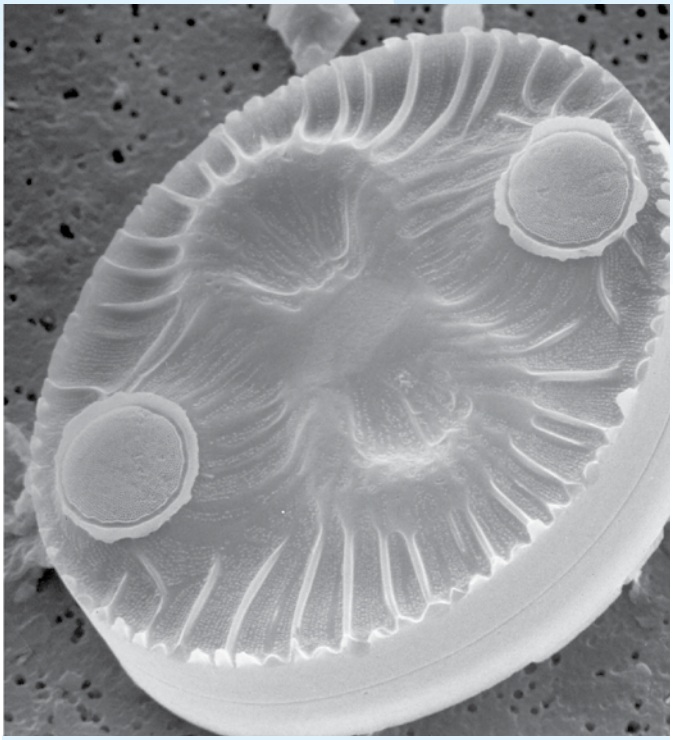
Communities of the pelagic zone comprise two main categories, 'plankton' and 'nekton', according to their locomotory capabilities. The plankton consists of microscopic animals (zooplankton) and plants (phytoplankton) that mostly drift with water currents and tides, while more actively swimming animals such as large invertebrates and adult fishes form part of the nekton[15]. The microscopic phytoplankton are a major source of food for other species and contribute a very large portion of primary productivity in the marine environment as well as playing a key role in carbon and nutrient cycling[2]. Phytoplankton communities in the southern Australia region including Tasmania are very diverse, with descriptions of 541 known species recently compiled, and are dominated by diatoms and dinoflagellates[25].

Zooplankton feed on phytoplankton and are a fascinating and diverse group of animals that include the larval phases of many larger animal species, such as fish, molluscs, lobsters and sea urchins, as well as microscopic animal species that are only found in the plankton such as copepods and cladocerans [26]. Coastal Krill (*Nyctiphanes australis*) is a major component of the zooplankton community in Tasmanian coastal waters and is the dominant prey item for many fish, bird and other species[19]. Tasmanian phytoplankton and zooplankton communities include a unique mix of species due to local temperate communities mixing with tropical and subantarctic species delivered by the major currents operating around our coast[22,27].



White water blooms of the calcareous phytoplankton species *Emiliania huxleyi* are regularly detected off northern Tasmania by satellites. They are attracting increased global interest due to the role of this peculiar and beautiful species in the ocean carbon system and climate change[22] (Photograph: © Gustaaf Hallegraeff).

The 'nekton', or active-swimming pelagic organisms, are predominantly fishes and cephalopods (e.g. squid), but also include marine mammals, penguins and crustaceans (e.g. krill). These species play an important role in the food chain, facilitating the transfer of energy from plankton through to sharks, seals and other animals at the top of the food chain[2]. Strong associations have been identified between upwellings of nutrient-rich subantarctic waters, phytoplankton blooms, krill production and fish aggregations, demonstrating important linkages between nutrients, phytoplankton and fisheries productivity[23]. The nearshore pelagic zone of Tasmania tends to be dominated in number and biomass by a few small-medium fish species, such as the commercial Redbait and Common Jack Mackerel[15, 23, 28]. Further offshore, the pelagic environment is home to a suite of large fish species and sharks such as Blue-eye Trevalla, Gemfish, Shortfin Mako, and Southern Bluefin Tuna, some of which are now identified as internationally Threatened.

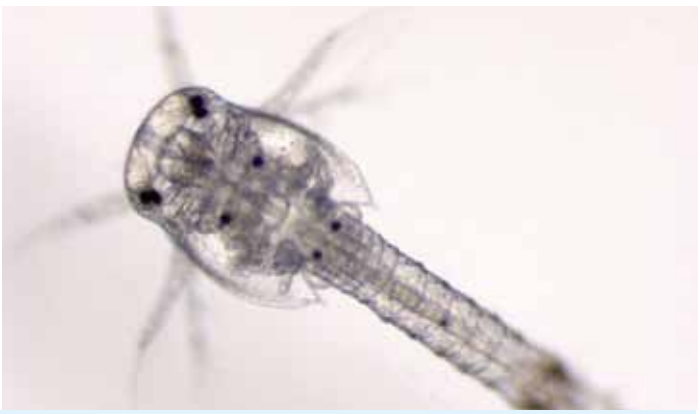


Marine diatom (*Auliscus sp.*)
(Photograph: © Gustaaf Hallegraeff).

The majestic Southern Bluefin Tuna *(Thunnus maccoyi*) reaches nearly 2 m in length and is an oceanic species encountered where the deep waters of the continental slope occur close to the Tasmanian shore. This species is now classified as Critically Endangered at a global level and as Conservation Dependent within Australia
(Photograph: © Jon Bryan).

Tasmania's pelagic environment provides an important migration path for Threatened cetacean species including the Southern Right Whale and Humpback Whale, with the whales foraging on Coastal Krill and other zooplankton species during their migration through our coastal waters[19]. In contrast the 'Beaked whales', such as the Sperm Whale, Killer Whale, and dolphins, as well as a variety of seals, feed primarily on fish and squid. Tasmania is a hotspot in Australia for seabirds, and supports around 60 species that forage exclusively in pelagic environments, including many species at Macquarie Island and on our southern shores that are absent elsewhere in Australia. They have a varying diet that may include krill, fish or squid, or a combination of these. The seabirds and seals represent an important link between land-based breeding habitats and pelagic foraging habitats, since both are critical for their survival.

Southern Right Whales (*Eubalaena australis*) on migration
(Photograph: © Biodiversity Monitoring Section, DPIPWE).



The Coastal Krill (*Nyctiphanes australis*: female with egg sac (left); juvenile (right)) measures less than 2 cm when fully grown and yet represents one of the largest food resources in our coastal seas. Aggregating in massive swarms, it is a key prey species for many fish, seabirds, squid and whales, with fluctuations in its numbers dramatically affecting the abundance and distribution of its predators
(Photographs: © Anita Slotwinski, IMAS).

Complex rocky shoreline on Tasmania's west coast
(Photograph: © Karen Parsons).

4.3 Rocky shores

Many Tasmanians have fond memories of fossicking in the rocky intertidal zone as a young child and having their first encounters with interesting marine creatures such as sea squirts, small fish and shrimps. Our rocky shores provide a highly accessible environment for seeing marine animals and plants first hand, and hence provide an invaluable learning environment without needing to get too wet...

Approximately 50% of the Tasmanian coastline is rocky[29], ranging widely from steep sloping rock faces to relatively flat or gently sloping rock platforms and boulder fields. Intertidal reefs are a prominent feature of our coast, occurring mainly around headlands and often being separated by long stretches of sandy beach[2]. They support a diverse mix of specialist plants and animals which have adapted to the ever changing conditions of the intertidal zone. Barnacles, tube worms, anemones, limpets, chitons, bivalves and periwinkle species are dominant groups[30], however a vast array of additional life-forms such as sponges, seaweeds, crabs and shrimps, sea urchins and sea stars, sea squirts, and fish are found on our shores[31]. Species can usually be found in particular zones or bands based on level of exposure to the air, as determined by the tides, winds and waves[18]. Rock type and availability of habitats such as rock pools and crevices are also important influences on Tasmanian rocky intertidal communities[30].

Van Diemen's Siphon Shell (*Siphonaria diemenensis*)
(Photograph: © Karen Parsons).

Cape Queen Elizabeth on Bruny Island is the southmost known occurrence of the Giant Surf Barnacle (*Austromegabalanus nigrescens*)[30] (Photograph: © Graham Edgar).

Unique elements of Tasmania's wave-washed rocky shore communities were initially overlooked by naturalists who tended to focus on sheltered habitats which provide protection from pounding waves and support 'stragglers' from warmer waters of Australia that do not survive on the more open coasts[31]. However, investigation of the exposed coastline revealed that our intertidal communities are highly unique, including a distinct cool temperate assemblage of numerous algae, seastars, brittle stars, crabs and molluscs not found on mainland Australian shores[32]. The south-east of the state is most differentiated; for example it is home to three endemic seastar species found nowhere else in the world, including one of the world's smallest species that has a reproductive biology highly unusual amongst seastars[33].

Broader differences are also evident, with algal and lichen bands more profuse and extending wider on the shore in Tasmania than in northern temperate waters of Australia[23]. Tasmanian intertidal reefs support the most southerly populations of a number of intertidal organisms, whilst subantarctic Macquarie Island is unique in having a contrasting community structure and lacking bands of barnacles and mussels that characterise temperate shores[34].

In addition to providing habitat for specialist intertidal species, rocky shores provide nursery habitats for fish species and foraging habitats for shorebirds at low tide[2]. In Tasmania, they support internationally significant numbers of Sooty Oystercatchers[35], a shorebird that relies primarily on intertidal reefs and rocky headlands for foraging and breeding habitat[36].

A prominent member of the intertidal algal community, Neptune's Necklace (*Hormosira banksii*) (Photograph: © Graham Edgar).

Lined Chiton (*Ischnochiton lineolatus*) (Photograph: © Graham Edgar).

Grey Periwinkle (*Afrolittorina praetermissa*) (Photograph: © Graham Edgar).

Strapweed (*Lessonia corrugata*), a brown alga that is primarily limited to Tasmania (Photograph: © Graham Edgar).

Colourful lichens at Haunted Bay, Maria Island on the east coast; bands of lichen are more profuse in Tasmania than in more northern Australian waters (Photograph: © Karen Parsons).

Waratah Anemone (*Actinia tenebrosa*) (Photograph: © Jane Elek).

Our rocky shores are the national stronghold for the distinctive Sooty Oystercatcher (*Haematopus fuliginosus*), with an estimated 50% of its total population found in Tasmania[13]. This shorebird uses its long bill to stab at prey or to lever, prise or hammer open food items attached to rocks. It breeds in rocky areas above the tideline, within quick access to dinner on the shore! (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

4.4 Subtidal reefs

Subtidal rocky reefs occupy large areas of the Tasmanian coastline and are one of the most diverse and productive habitats in our coastal waters[18]. Rocky reef structure can vary from a simple flat reef made of consolidated bedrock or cobbles to complex reefs with large boulders and crevices, sheer vertical walls, cascading shelves of rock, canyons, and caves or arches carved out of the seafloor[2,18]. Communities of macroalgae (i.e. seaweed), ranging from the towering Giant Kelp to low encrusting forms are an important feature of rocky reefs, with Tasmanian reefs being more highly vegetated by macroalgae than any other reefs in Australian waters[18]. Our subtidal reefs have particularly high conservation value because a large proportion of their fish, echinoderms, molluscs and macroalgae are totally unique or 'endemic' to the southern temperate region containing Tasmania[8] and represent a globally significant hotspot for both diversity and endemism. Fauna groups containing ascidians, amphipods and bryozoans are also more diverse in this region than any other location of a similar size in the world[23]. The unique rock formations and high biodiversity of Tasmanian rocky reefs combine to provide some of the most spectacular underwater scenery offered in Australia, including complex cave systems, dense kelp forests, and gardens of sponges, anemones, gorgonians and sea whips, the colour and diversity of which rival any tropical coral reef.

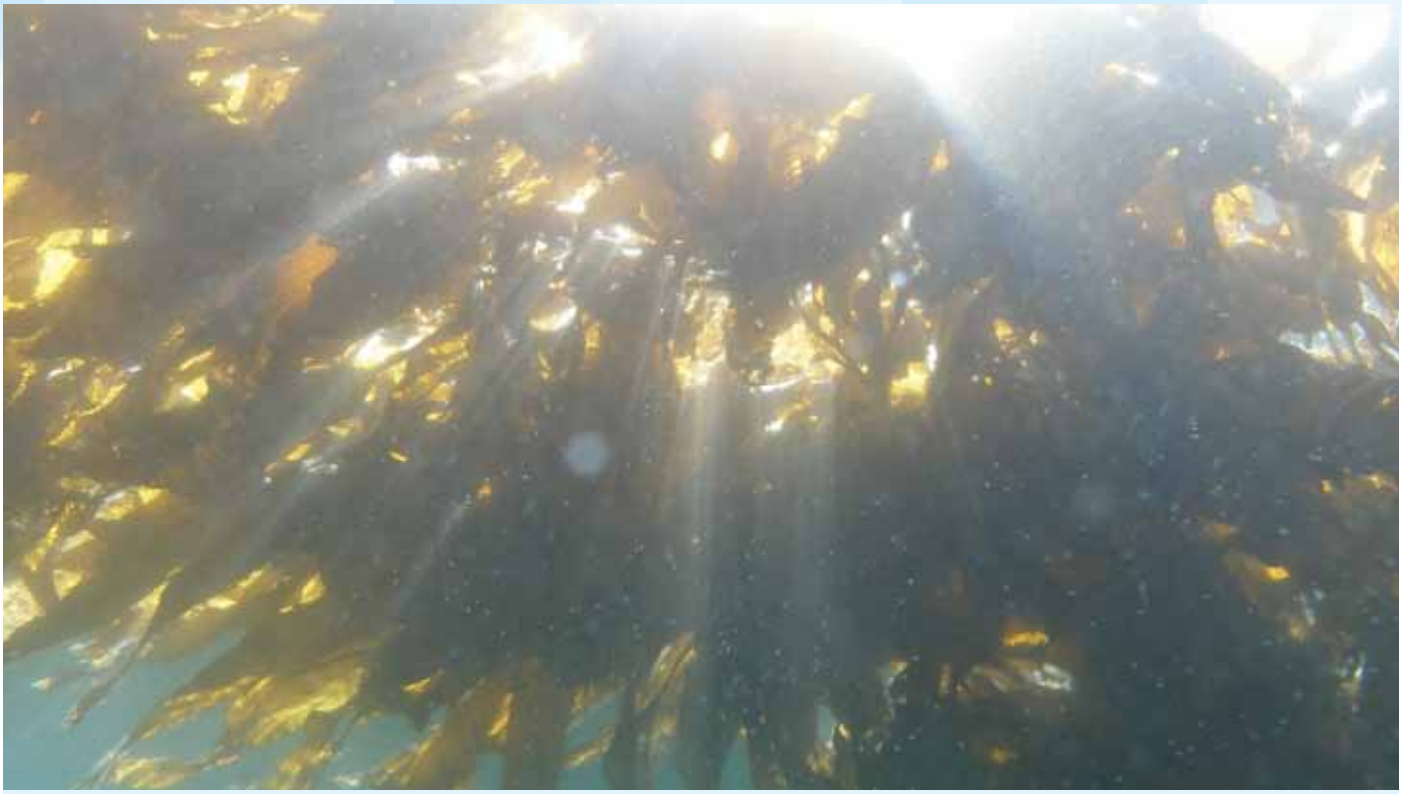
Crayweed (*Phyllospora comosa*)
(Photograph: © Graham Edgar).

Tethygeneia amphipods crowd onto a blade of algae; these small crustaceans achieve remarkable densities amongst algal beds
(Photograph: © Graham Edgar).

Inflated Egg Urchin (*Holopneustes inflatus*)
(Photograph: © Graham Edgar).

Unique Subtidal Reef Ecosystem – Structurally Complex Reefs with Unique Geology

The geology of our rocky reefs plays a major role in their structural complexity and therefore also provides us with some clues about where to find biodiversity hotspots. Areas of diverse or particularly complex rock types provide habitat for a greater range of algae, fish and invertebrate species. Similarly, rock types which are rare within a particular biogeographic region result in an unusual mixture of climatic, oceanographic and seabed characteristics that lead to the formation of rare marine communities. In Tasmania, an example is the ancient Precambrian rock that predominates on our south-west coast but outcrops at a small number of north coast locations as quartzite schist. Rocky Cape is a prime example, consisting of highly folded metamorphic rocks that extend offshore and produce submarine caves and crevices[37]. This type of habitat is rare in that region and hence supports a greater diversity of marine life than more uniform rocky reefs on adjacent sections of the coast[38]. Other unusual and structurally complex rocky habitats include massive submarine cave systems in Tasmania (e.g. Ile des Phoques off the east coast, Waterfall Bay on the Tasman Peninsula) which can reach over 10 m high and 100 m long. These caves contain large colonies of colourful sessile invertebrates (i.e. invertebrates that are permanently attached, not free-moving), such as cnidarians, bryozoans and zoanthids, as well unique fish species that are specialised for cave life[15].



The macroalgal canopy significantly reduces light penetration and therefore has an important influence on the types of communities found on the seabed below (Photograph: © Sue Wragge).

Shallow reefs in Tasmania support a spectacular range of marine plants and animals that are a particularly important because of their high diversity, biological complexity and productivity[6,15]. They differ greatly from reefs in deeper waters due to high levels of light penetration, resulting in dense growth of macroalgae that require light for photosynthesis. These areas may produce up to 10-20 kg of plant material per square metre, making them equivalent to the most productive habitats in the world, including grasslands and seagrass beds[2]. Variation in ocean currents, wave exposure, relief, nutrient levels, siltation and prevalence of sea urchins and other grazers also contribute to the highly variable species distribution and abundance of macroalgae in Tasmania[39].

The Giant Kelp Shell (*Phasianotrochus eximius*) grazes on the surface of a blade of algae (Photograph: © Graham Edgar).

Tasmanian macroalgae communities are amongst the most diverse in the world and include a range of cold-water subantarctic species that are the largest seaweeds in Australia[40] and are rare or absent north of Tasmania. Examples include several dominant members of the macroalgal community, such as the Strapweed (*Lessonia corrugata*), brown alga (Xiphophora gladiata), and the Giant Kelp (*Macrocystis pyrifera*) that only forms dense forests south of Bass Strait[23,37]. A study underway has identified 35 macroalgal species in Tasmania that are categorised as rare, including seven species never recorded outside Tasmania that are dominated by unusual red algal species with highly restricted ranges[41].

The commercial Southern Rock Lobster (*Jasus edwardsii*) is an important reef inhabitant in Tasmania. Following the longest period of larval development known for any marine creature (rock lobster larvae spend between 9 months to 2 years in oceanic waters), juveniles settle to the rocky seabed, preferring crevices and other protected habitats (Photograph: © Neville Barrett).

Magpie Perch (*Cheilodactylus nigripes*) (Photograph: © Graham Edgar).

A school of Barber Perch (*Caesioperca rasor*) (Photograph: © Neville Barrett).

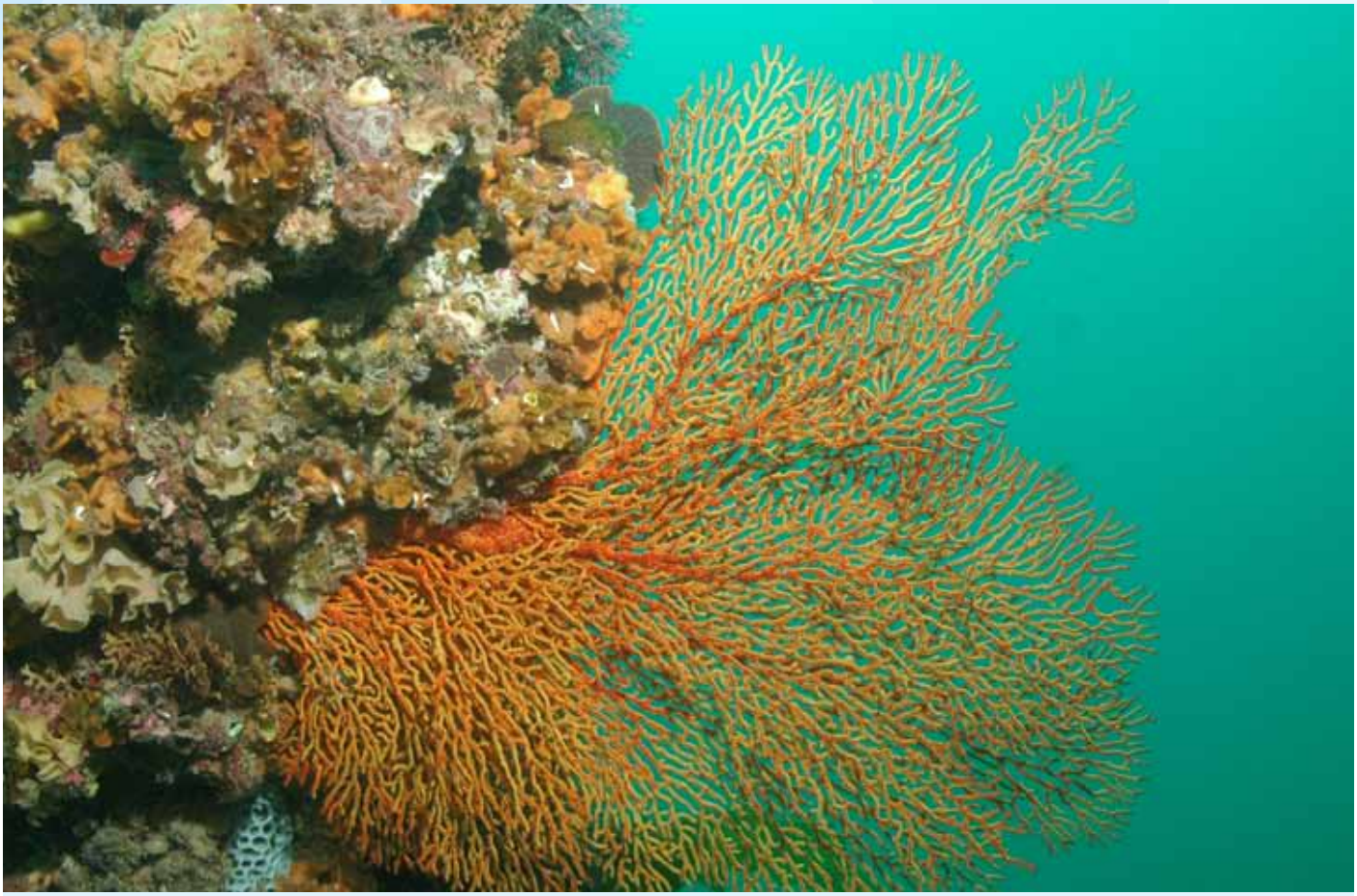
The Yellow Zoanthid (*Epizoanthus karenae*) is one of the most conspicuous animals on coastal reefs and yet was only very recently formally described and named, reflecting our limited knowledge of many marine invertebrates. Zoanthids are colonial organisms related to the anemones; this species forms dense colonies on overhangs or in caves where it provides a spectacular carpet of colour (Photograph: © Neville Barrett).

In clear exposed waters, species such as Common Kelp (*Ecklonia radiata*) may extend to a depth of 45m[42], however at sites with reduced wave exposure or light penetration, kelps and other brown algae are limited to much shallower waters and quickly replaced at greater depth by smaller, delicate red algae tolerant of low light conditions[15,37]. As light becomes limiting even for the red algae, reef communities transform into deeper 'sponge gardens' dominated by sessile filter feeding invertebrates such as bryozoans, ascidians, sponges, hydrozoans, gorgonians, anemones, tube worms, and soft corals[15,42]. These underwater gardens are made up of delicate long-lived creatures which play a vital role in the cycling of nutrients and energy through filtering of tens to hundreds of litres of water per square metre of reef every day[2].

Unique Subtidal Reef Ecosystem – High Current Reefs (e.g. Protruding Headlands, Restricted Channels)

Particular physical features along Tasmania's coast result in unusually strong currents that have a major influence on the marine communities found on rocky reefs. Protruding headlands, particularly those on the north coast and Bass Strait islands that experience higher tidal ranges and current velocities than other parts of the state (e.g. Rocky Cape), as well as narrow estuary entrances and other restricted channels, are characterised by modified and strengthened current flows. These currents create a large food resource in the form of drifting particles, and hence result in the fast growth of sponges and other sessile invertebrate filter feeding species which dominate the habitat at the expense of the usually dominant algae. These invertebrates are typically limited to depths greater than 30 m37, but may form incredibly colourful and diverse communities at 15 m or less in high current areas, providing a rare spectacle at accessible depths. In addition, these areas may include large numbers of pelagic and plankton-feeding fish that are usually more prominent in deeper waters. Where these conditions are associated with deep reefs, or factors that limit light penetration, such as inputs of dark-staining tannins (see Section 4.8), sponge gardens are particularly well developed and contain many unusual and rare species. The high current reef areas denote restricted habitats that have rare physical attributes and equally rare biological communities[38].

Colourful sponge gardens may occur in much shallower depths than typical where strong currents result vast amounts of suspended food and hence fast growth of sponges and other filter feeding invertebrates (Photograph: © Graham Edgar).



Zimmer's Sea Fan (*Mopsella zimmeri*): this beautiful animal is a gorgonian, a type of coral readily recognised by its rigid, plant-like shape and consisting of a colony of small living polyps. It thrives on high current reefs and includes a number of colour forms, dominated by yellows, oranges and reds (Photograph: © Graham Edgar).

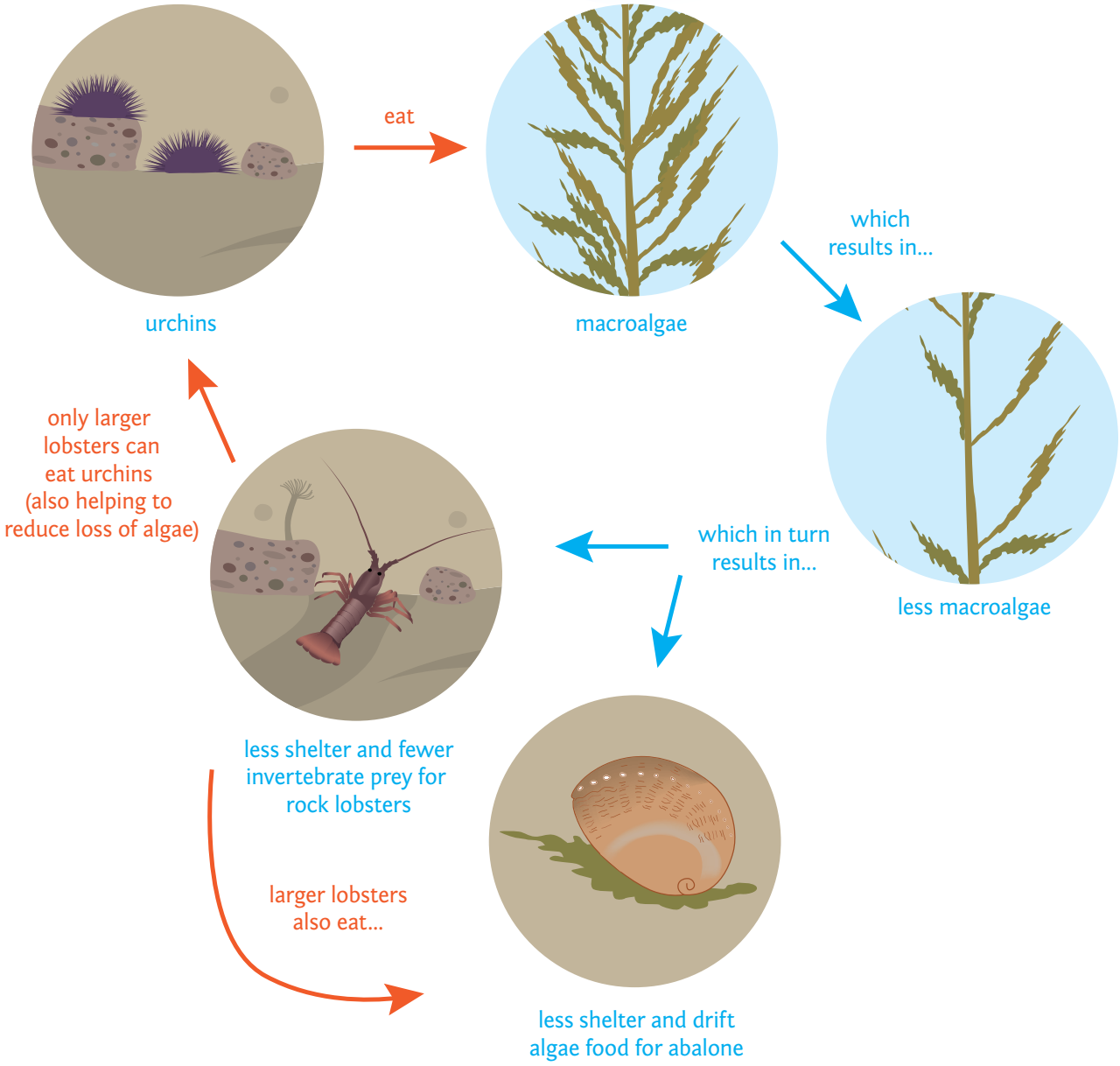
Macroalgae provide habitat for a range of invertebrate and fish species, and in Tasmania are structurally complex, forming five layers ranging from dense kelp fronds floating on the surface (e.g. Giant Kelp) to encrusting coralline algae attached to the seabed. Animals thriving amongst the algae include small crustaceans called amphipods that can reach numbers of 50,000 per square metre, with over 50 species occurring on a single tufted plant[23]. Below the algal canopy, sessile invertebrates include sponges, corals, bryozoans, hydroids and ascidians, while mobile fauna such as gastropods, crustaceans, echinoderms and fishes are abundant. Some of these are important ecologically and for fisheries such as Blacklip and Greenlip Abalone, Southern Rock Lobster, and reef fishes including wrasses, morwongs and trumpeter.

Additional common elements of the Tasmanian reef fish fauna include weedfishes, threefins, sweeps and leatherjackets[15], while the Red Handfish and Ziebell's Handfish provide examples of highly restricted endemic species. The Purple Urchin (*Heliocidaris erythrogramma*) is one of the most widely distributed invertebrates in Tasmanian waters, although the Hollow-spined Urchin (*Centrostephanus rodgersii*) from the mainland east Australian coast has recently expanded its range, leading to overgrazing on reefs of the Tasmanian east coast, and triggering a shift from dense macroalgal beds to sea urchin 'barrens' in some areas[20,43].

Warty Prowfish (*Aetapcus maculatus*): this unusual fish occurs on sheltered and moderately exposed reefs and can be very difficult to detect in its natural habitat since it looks much like the sponges among which it frequently lives! (Photograph: © Graham Edgar).

This has affected the density of commercially fished abalone and rock lobster[20], highlighting important interactions between reef species, such as macroalgae, urchins, abalone and lobsters. Statewide surveys have identified a wide range of biogeographic influences on reef communities, resulting in highly variable algae, fish and invertebrate species composition around the state. This information has been a primary consideration for assigning marine bioregions to distinctive areas of Tasmania's coastline (see Section 6).

Rock Lobster / Abalone / Urchin Interaction



Examples of relationships amongst reef organisms, such as the Hollow-spined Urchin, macroalgae, abalone species and Southern Rock Lobster. Factors that affect numbers of any one of these will ultimately affect other important reef species

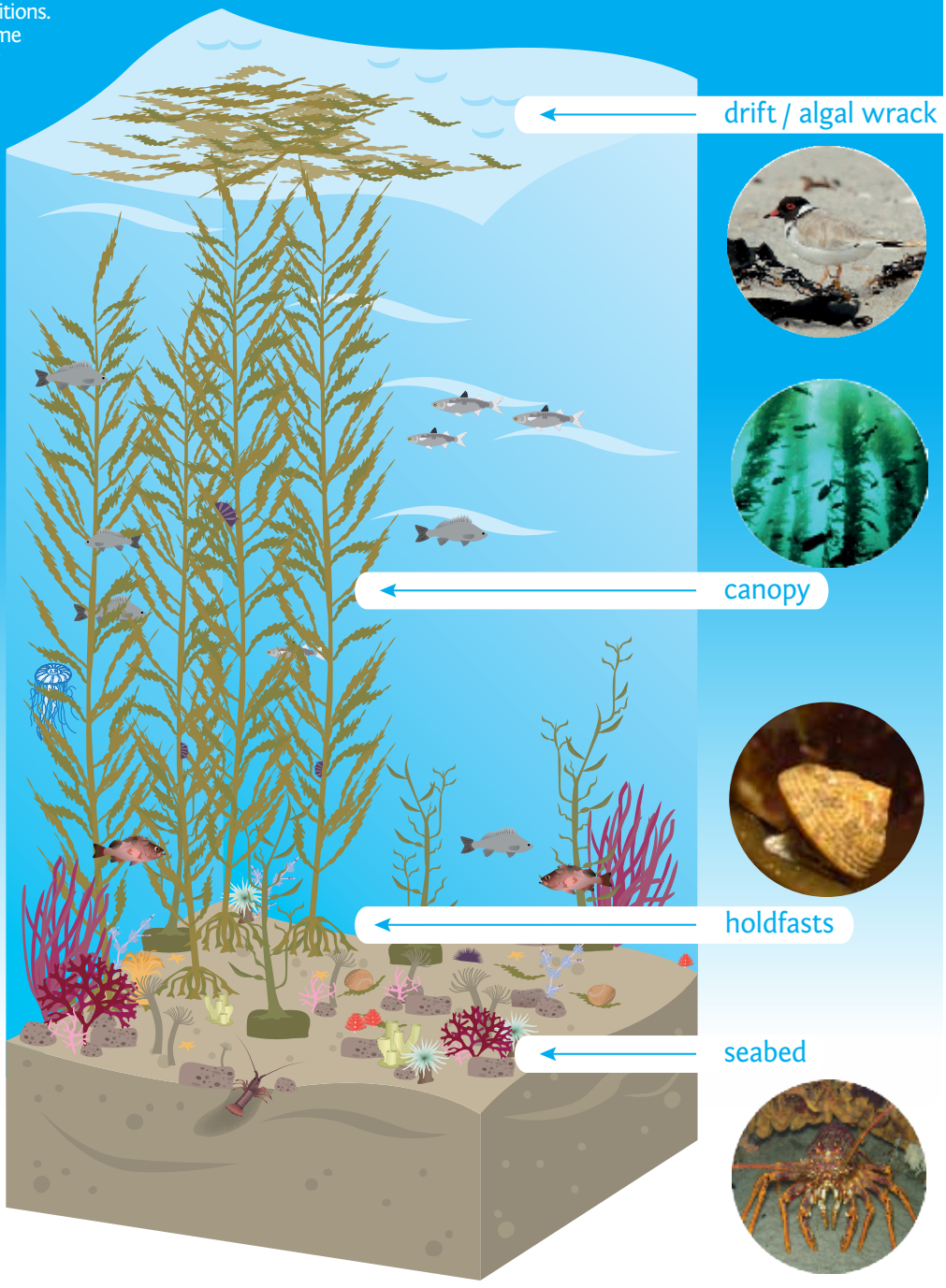
A summary of relationships amongst some important reef organisms (Illustration: Nathanael Jeanneret of onetonnegraphic).

Unique Subtidal Reef Ecosystem – Large and Persistent Giant Kelp Beds

The Giant Kelp (*Macrocystis pyrifera*) forms magnificent kelp forests in Tasmania that are absent from the mainland Australian coastline and therefore represents a highly unique aspect of our reef ecology[9,18]. In these forests, plants grow up to 50 cm a day and spiral to the surface from depths exceeding 20 m, buffering wave action and creating dense canopies at the surface[15]. The Giant Kelp is considered a 'keystone' species, playing a critical role in maintaining the structure of an entire ecological community reliant upon it for shelter, food and breeding habitat. Like trees in a forest on the land, the kelp provides a complex three dimensional structure that supports an enormous number and diversity of animals, such as fish, molluscs (e.g. sea snails), bryozoans (e.g. lace corals), polychaete worms, crustaceans (e.g. crabs, isopods, amphipods), echinoderms (e.g. sea urchins, seastars) and sponges9. Kelp forests provide a settlement substrate for larvae and juveniles, as well as food and shelter for adults living within the canopy, among the kelp fronds, or on the root-like holdfasts that attach the plants to the seafloor. On the seabed below, a wide range of plants and animals occur in the low-light, sheltered environment created beneath the kelp canopy[9]. Dislodged parts of the kelp form floating rafts that also support marine communities, whilst algal wrack on the shore provides foraging habitat for shorebirds and invertebrates.

The Giant Kelp is reliant on cold, nutrient rich waters[9,18] and occurs at the very limits of its environmental tolerances in temperate Australia. This makes it vulnerable to changes in ocean currents and climate, with the increasing southerly penetration of the warm East Australian Current therefore creating less favourable conditions. As a result of this and other factors, some beds of the Giant Kelp have declined or become highly transient, providing an important habitat during favourable conditions but disappearing at other times. However, a number of large and persistent beds have been recorded in semi-exposed areas of the Tasmanian south-east coast. These populations are of high conservation value, since they provide temporally stable habitat and may potentially act as 'source' populations for recovery programs9.

The diversity of habitats and species associated with the 'keystone' Giant Kelp (Illustration: Nathanael Jeanneret of onetonnegraphic).

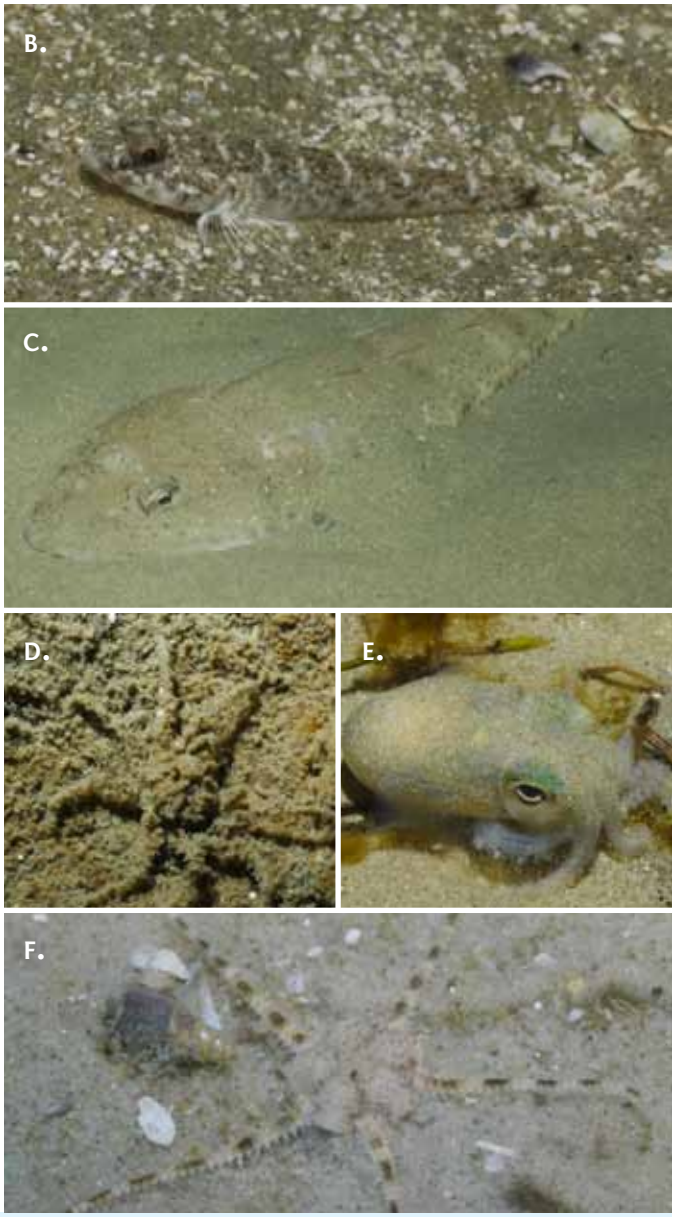


Unique Subtidal Reef Ecosystem – Deep Reefs Close to Shore

Along the majority of Tasmania's coast, rocky outcrops extend to approximately 15 m below the waterline and are subsequently replaced at greater depths by beds of soft sediment. However, some sites include reefs that extend into much deeper waters within close proximity to shore, providing more extensive and diverse reef communities extending to 50 m or even up to 100 m depth. They illustrate the full spectrum of subtidal reef zonation, with brown kelps dominating in shallow waters, low-light tolerant red algae becoming more prevalent at moderate depths, and colourful sessile invertebrates dominating at greatest depths. These reefs contain unique populations of species usually only observed much further offshore from the Tasmanian coast, as well as extensive areas of sponges, gorgonians, soft corals, sea whips, and associated invertebrates that are rare on shallower Tasmanian reefs. Some sites are easily accessible to SCUBA divers, who can experience the marine life of clear oceanic waters within 100 m of the shore (e.g. Governor Island, east coast). Some reefs extend into areas beyond safe diving depths and remain largely a mystery despite being located so close to our coast (e.g. mouth of Tamar Estuary, north coast), emphasising the need to study these areas using underwater video and other remote methods to ensure that their values are identified and appropriately managed to prevent impacts from adjacent land activities.

4.5 Unvegetated soft sediments

Unvegetated areas of soft sediments including sand, mud and unconsolidated substrates containing pebbles and shells, are the dominant feature of subtidal marine environments in Tasmania, comprising around 75% of the seabed in nearshore areas[7]. Soft sediments occur in estuaries and embayments as well as along the open coast where they are frequently associated with beach environments in the intertidal zone. The apparently barren appearance of these areas is deceptive and hides a diversity of life[44], as well as important nursery habitats and rare species limited to Tasmanian waters[45,46]. There are few places to hide, so many species living on sand and mud have developed special mechanisms for protection, such as camouflage or being adept at quickly burrowing into the sediment[44].



An assorted range of fish and invertebrates take turns at being 'invisible': (a) Spotted Flounder (*Ammotretis lituratus*), (b) Girdled Goby (*Nesogobius maccullochi*), (c) Southern Sand Flathead (*Platycephalus bassensis*), (d) Spider crab (*Halicarcinus sp.*), (e) Southern Dumpling Squid (*Euprymna tasmanica*), and (f) Kinberg's Brittle Star (*Ophiura kinbergi*). Camouflage is an important strategy for avoiding predators in soft sediment habitats, and is utilised by a wide range of species in Tasmanian waters (Photographs: © Graham Edgar).

Other animals are brightly coloured and utilise alternative defence strategies, such as this Cocky Gurnard (*epidotrigla modesta*) (top) which has multiple sets of long spines, and Rasping Hermit Crabs (*Strigopagurus strigimanus*) (bottom) which are able to readily retreat into their heavily fortified homes (Photographs: Gurnard – © Graham Edgar, Hermit crabs – © Sue Wragge).

These sediments generally have a lower productivity than seagrass and macroalgal beds due to the absence of large photosynthesising plants, however they are often rich in small invertebrates that live on microscopic algae, bacteria and food particles in the passing water[44]. These in turn provide food for larger surface dwelling (i.e. 'epibenthic') and burrowing (i.e. 'benthic') invertebrates, which in Tasmanian waters are dominated by crustaceans, polychaete worms, and gastropod and bivalve molluscs[14,47]. The only marine mollusc species that is listed as Threatened in Tasmania, the Gunn's Screw Shell (*Gazameda gunnii*), occupies subtidal sandy sediments. These sandy habitats also support a particularly diverse mollusc assemblage including hundreds of beautiful species that are smaller than a match head[44], as well as rare volute species that form part of a relic fauna[17]. In deeper areas and strong currents, sessile invertebrates may form spectacular aggregations similar to the 'sponge gardens' observed on reefs, using shells and cobbles for attachment rather than bedrock or boulders.

Unvegetated habitats are becoming increasingly recognised as an important habitat for juvenile fishes in Tasmania. In fact, unvegetated areas are believed to be more important than vegetated sediments as nurseries for juveniles of commercial finfish species, including Yellow-eye Mullet, Eastern Australian Salmon and Greenback Flounder[45]. Similarly, juvenile Sand Flathead show a preference for unvegetated habitats, and spawning of Sea Garfish is concentrated over shallow unvegetated areas. Trawling over open sandy habitats in depths of 10-100 m around Tasmania has identified 16 commercial fish species, as well as many additional non-commercial species including gurnards, cowfish, globefish, skates and rays. A trend of increasing fish size with depth suggests that shallow coastal waters are significant nursery areas for many species[49]. The Gummy Shark also appears to utilise shallow areas of soft sediment for pupping, since newborns are found in these habitats and there is little evidence of them using adjacent seagrass beds as nurseries[50,51].

Soft sediment habitats are also home to some of Tasmania's most cryptic and unusual fish species. The Endangered Maugean Skate (*Zearaja maugeana*), which is limited to two estuaries in south-west Tasmania, lives in shallow soft sediment habitats where it is believed to feed on burrowing invertebrates. In addition, a new species of sand fish belonging to the genus *Lesueurina* (Family Leptoscopidae) has been identified that is currently only known from shallow sandy habitats on the south coast of Tasmania. These two species may be just the tip of the iceberg in terms of new endemic species identified from our coastal waters[52]. Cryptic fishes such as pipefishes, which are protected in Australia and related to seahorses and the Weedy Seadragon, survive in soft sediment areas by hiding amongst drift algae and seagrass[15].

Unique Un-vegetated Soft Sediment Ecosystem – High Current Channels

Sessile invertebrates need a hard substrate for attachment and therefore commonly occur on reef habitats, however they also form aggregations in soft sediment habitats where there is adequate debris, such as shell material and pebbles, for attachment. Narrow sandy channels and other areas dominated by strong currents create suitable conditions, since the rapidly moving water provides a constant supply of suspended food particles that enable rapid growth of filter feeding invertebrates. It is a careful balance in this situation – since the currents need to be adequate to supply a high volume of food whilst being insufficient to scour the seabed and remove shells and other loose material required for attachment. These sessile communities, which include sponges, seawhips, anemones, tube worms, bryozoans, hydroids and a high diversity of additional colourful and delicate forms, occur in narrow estuarine channels as well as open marine habitats around Tasmania (e.g. D'Entrecasteaux Channel and entrance to Pittwater, in southern Tasmania37,48). However, persistent and diverse assemblages of any significant size have restricted distributions and therefore high conservation value and, as with high current reefs, are best developed where unusually deep habitats occur close to shore or additional factors further reduce light penetration (e.g. tannin inputs; Section 4.8).

Tasmania's seagrasses include a wide range of forms, and each species may harbour a unique range of fish and invertebrates, creating a particularly high diversity of life in areas containing multiple seagrass species. Displayed here is the Southern Paddlegrass (*Halophila australis*). (Photograph: © Graham Edgar).

4.6 Seagrass beds

Seagrasses are flowering plants that produce flowers and seeds like plants on land, but occur on soft sediments in sheltered estuarine and marine environments[53]. They may form sparse patches through to extensive dense 'meadows' and, like shallow subtidal reefs, represent one of the most productive ecosystems on earth, providing important refuges, breeding habitat and feeding grounds for fish and invertebrates[54]. They also provide habitat for epiphytic algae (i.e. small algae that grow on the seagrass), are important for nutrient cycling and trophic pathways, and enhance water clarity as well as reduce coastal erosion through stabilisation of sediments[17,45]. The southern temperate waters of Australia are the centre of diversity for seagrasses because out of 60 seagrass species worldwide, one third of these occur in this region, and at least 14 species occur nowhere else[23]. Our small island state contains seven marine species of seagrass, representing around 10% of species in the world, as well as three additional aquatic *Ruppia* species that provide a similarly productive habitat in estuaries and lagoons.

Recent mapping has revealed 190 km^2 of seagrass beds around Tasmania[55], excluding the two most extensive areas, in the Furneaux Group and Boullanger Bay in the north-west, that are yet to be mapped in detail but have previously been estimated to contain 400-500 km^2 of seagrass[45]. While this may sound a lot, even based on highly conservative estimates seagrass occupies less than 3% of Tasmania's coastal waters due to its dependence on light for photosynthesis and hence confinement to shallow waters generally less than 15 m. Seagrass beds therefore represent a relatively rare ecosystem that accounts for a disproportionately large percentage of marine primary production and biodiversity.

Tasmania possesses a unique mixture of warm and cool temperate seagrass species, with the warm-water loving strapweeds (Southern Strapweed *Posidonia australis* and Fibrous Strapweed *Posidonia angustifolia*) occurring at the very southern boundary of their environmental tolerances in Tasmania and being limited to the north coast and Bass Strait islands. In those areas, the Southern Strapweed forms extensive and luxurious beds which are, along with beds of another north coast dominant – Sea Nymph (*Amphibolis Antarctica*), important for coastal productivity. The Fibrous Strapweed has a restricted distribution and appears to be confined to the north-west[56] and Furneaux Islands[45]. This species represents a rare and unusual occurrence in a biogeographic sense, since it is absent from Victoria and NSW, with the nearest populations located 600 km to the west in South Australia.

The Southern Paddlegrass (*Halophila australis*) and eelgrasses (Tasmanian Eelgrass *Heterozostera tasmanica*, Black-stemmed Eelgrass *Heterozostera nigricaulis* and intertidal Mueller's Eelgrass *Zostera capricorni*) are more widespread in Tasmania, with the cool-water loving Tasmanian Eelgrass unique to Tasmania and Victoria.

Dense meadow of the Southern Strapweed (*Posidonia australis*) (Photograph: © Graham Edgar).

While the Tasmanian seagrasses have distinct environmental preferences on the basis of salinity, sediment grain size, depth and level of wave exposure[54], their overlapping ranges mean that some sites support beds of up to five seagrass species within a very small area either as distinct bands or as intermixed populations[58]. This diversity of seagrass habitats results in high animal species richness, since different seagrass species support unique assemblages of fishes[45]. Research has found that seagrass beds support a higher diversity of fish than unvegetated areas as well as higher levels of invertebrate and fish production[59]. They provide important habitat for many protected species of high conservation significance, such as pipefishes and seahorses. In the intertidal zone, beds of Mueller's Eelgrass provide feeding grounds for resident and migratory shorebirds as well as small fish that disperse to shallow habitats during high tides.

Seagrass beds are utilised by many fish species of commercial and recreational importance, although research suggests that their role as nursery habitat in Tasmania is of primary significance for small resident fishes rather than economically important scalefish species[45]. Nevertheless, our seagrass beds provide critical habitat for other species fished commercially and recreationally in Tasmania, such as the Southern Calamary (or 'squid', *Sepioteuthis australis*) which lays its eggs almost exclusively on beds of Sea Nymph[60].

Seagrass beds of Great Oyster Bay and Mercury Passage comprise the main spawning areas of this species in Tasmania, with the seagrass beds of Great Oyster Bay identified as being particularly important. Surveys in one year using specialised 'fingerprinting' techniques identified that between 55% and 84% of calamary in south-eastern Tasmania – to as far south as Bruny Island - had been born in Great Oyster Bay[61]. This demonstrates the strong links between seagrass habitats and fisheries productivity, and how impacts on seagrass beds in a distant part of Tasmania may have important implications for the success of your fishing trip!

Some small invertebrate species, such as this Wavy Kelp Shell (*Phasianotropchus rutilus*) (top) live on the blades of seagrass plants, whilst larger invertebrates and fish including the Rough Leatherjacket (*Scobinichthys granulatus*) (centre) and the Giant Cuttlefish (*Sepia apama*) (bottom) seek refuge and food amongst the dense vegetation of seagrass meadows (Photographs: © Graham Edgar).

Hooded Plovers (*Thinornis rubricollis*) feeding amongst seagrass wrack (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

Another sea snail that frequently grazes on seagrass blades is the beautiful Rainbow Kelp Shell (or 'Green Maireener', *Phasianotrochus irisodontes*) used for necklace making by Tasmanian Aborigines (Photograph: © Graham Edgar).

Unique Seagrass Ecosystem – Large and Persistent Seagrass Beds

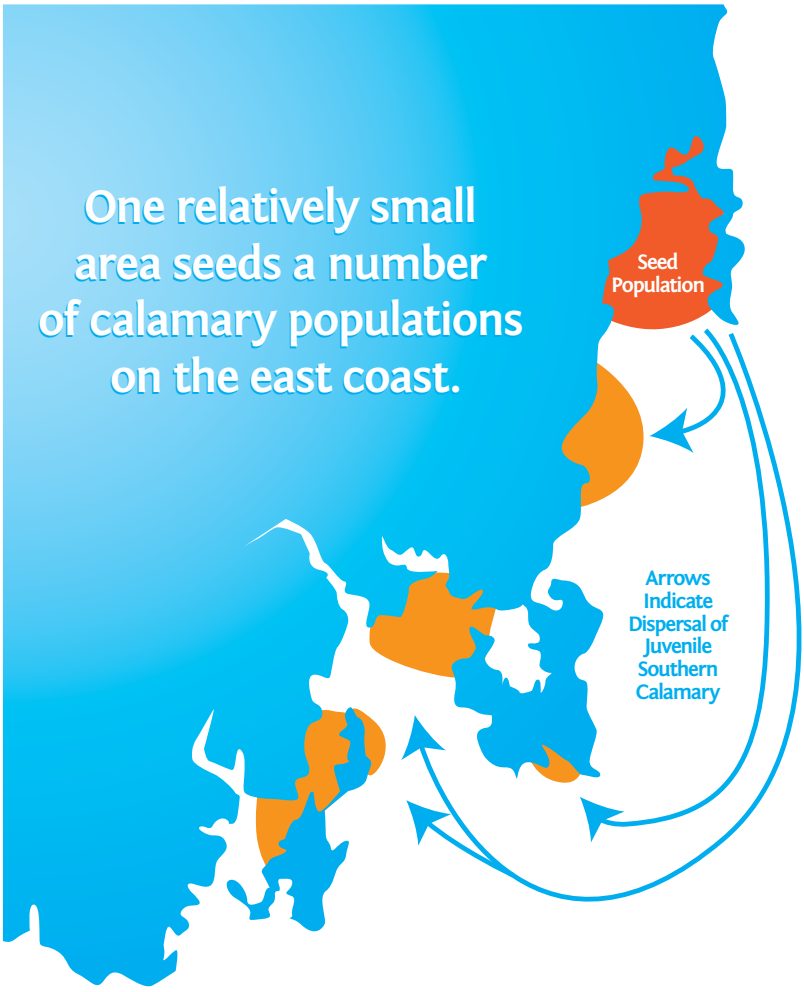
Seagrass beds distributed around Tasmania's coast vary in structure from dense meadows to dense or sparse patches, while some seagrass beds are described as 'ephemeral' meaning that they 'come and go' and exhibit seasonal die-back. Eelgrasses are examples of ephemeral species[57], and tend to recover rapidly following unsuitable seasonal conditions or temporary environmental disturbances. In contrast the strapweeds and Sea Nymph are examples of persistent, long lived species that remain intact throughout the year and are extremely slow to recover from environmental disturbances. These long-lived species, particularly the Southern Strapweed, form large, dense seagrass meadows on Tasmania's north coast and in the Furneaux Group, while Sea Nymph is also important on parts of the east coast. The size, long-lived nature, vulnerability to disturbance, and geographically restricted nature of beds dominated by these persistent species in Tasmania denotes a particularly high natural value. The northern areas of Tasmania also form the majority of the habitat for the Tasmanian Eelgrass, a species with a highly limited distribution in Australia, adding to the biodiversity value of seagrass beds in this region.

Unique Seagrass Ecosystem – Unusually Deep Seagrass Beds

In some areas of Tasmania, due to exceptional water clarity, the distribution of seagrass beds extends to considerably greater depths than typically recorded elsewhere in Tasmania or mainland Australia. Along most areas of the coast, seagrass beds are concentrated in depths less than 10-15 m, particularly in areas that are affected by catchment inputs and hence reduced water clarity. However, in very clear conditions in northern Tasmanian waters, extensive beds of seagrass may occur to much greater depths. The Furneaux Islands and Kent Group in Bass Strait provide good examples of this, where single species stands of the Southern Strapweed or a mixture of this species and the Tasmanian Eelgrass have been recorded to depths of 20 m or more, whilst monitoring at the Kent Group has revealed sparse patches of the Southern Paddlegrass to at least 40 m[64]. This is very unusual and reflects highly restricted communities at those depths[65]. Other relatively deep seagrass beds have also been recorded at Waterhouse Point on the adjacent mainland Tasmanian coast[66], highlighting again the high value of our northern seagrass communities.

The Importance of Nursery Habitats

Research indicates that Great Oster Bay may be the birthplace for more than half of the Southern Calamary found in more southern areas of Tasmania.



mature calamary laying eggs in seagrass beds

calamary eggs attached to seagrass

juvenile calamary

fully grown calamary

The importance of Great Oyster Bay for Southern Calamary abundance throughout south-east Tasmania
(Photographs: adults - © Gretta Pecl, IMAS; juveniles - © Caroline Fisher Photography; eggs - © Natalie Moltschaniwskyj, University of Newcastle).

FEATURE: A unique insight into the world of the Southern Calamary (*Sepioteuthis australis*)

(Including extracts from an unpublished paper 'Southern Calamary in Great Oyster Bay' by Dr Gretta Pecl)

The Southern Calamary is a 'squid' – the term calamary is used to describe a group that contains both squid and cuttlefishes. In Tasmania waters, we have both the smallest squid in the world, the pygmy squid at a tiny 2 cm, and the largest squid – the giant squid, which could produce squid rings as big as truck tyres[62]! The Southern Calamary falls between these two size extremes and lives 'life-in-the-fast-lane', being fast growing, short-lived (<1 year), and moving at lightening speeds – in fact it is one of the fastest moving squid species in the world[63]! The juveniles hatch directly from eggs laid on the seagrass and are immediately able to function as adept 'miniature adults', capable of inking, changing colour, hunting and avoiding predators[60].

Young Southern Calamary (Photograph: © Graham Edgar).

Squid communicate with each other through changes in body colour patterns and posture; they do this with the help of pigment-filled sacs called 'chromatophores' on their skin that enable them to change the patterns on their body in a millisecond – more rapidly than a chameleon can[62]! The sexes are separate and although courtship and mating is behaviourally complex and can last for hours, the transfer of sperm from the male to the female takes less than 2 seconds[60]. The male rapidly passes a packet of sperm to the female, at the same time adopting a colour display that has been nicknamed 'the postman' because it shows that a package has been successfully delivered[62]!

Some of the most fascinating aspects of calamary reproductive behaviour highlight the unique way that squids communicate with each other, and demonstrate that they can have two conversations at once (even the male squid)[62]! A common example involves the intense male competition for females on the spawning grounds. If an amorous male is swimming alongside a female he can say one thing to her with one side of his body ("How about it beautiful?"), and send a different message at the same time with the other side of his body to any other single males hanging around ("Back off buddy!"). The female squid may respond with several signals from "I wouldn't mate with you if you were the last squid on earth" to "sure honey"[62]. To avoid male-male aggression, some single males resort to rather sneaky tactics to secure a mate. These males, aptly called 'sneaker males', sometimes show the body patterns of females, so that the paired male thinks the intruder is a female and therefore nothing to worry about. However, such tactics have their downside as 'sneaker males' often attract unwanted attention from other single males[62]! Such complex behaviours showcase the personality and uniqueness of our marine life and may help to foster a whole new appreciation of species such as the humble squid...

Southern Calamary mating (Photograph: © Gretta Pecl, IMAS).

Level of wave action is one of the major determinants of sandy beach communities, with Tasmania's diverse coastline including highly sheltered beaches through to maximally exposed areas experiencing Australia's biggest waves (Photograph: © Graham Edgar).

4.7 Sandy beaches and dunes

Tasmania has over 1,600 sandy beaches, including 1,269 recorded on the mainland and 348 on our major islands[16], which occupy approximately 36% of our coastline[29]. These are major areas for coastal recreation and provide spectacular scenery, with several Tasmanian beaches voted as amongst the most beautiful in the world. They also provide physically and biologically diverse environments, with Tasmania having a wide range of beach types due to our diverse geology and highly variable ocean and wave conditions. Being an island that receives waves from every direction, has a highly convoluted coastline, and experiences variable micro- to meso- tidal ranges, it is no surprise that Tasmania includes the full spectrum of high through to low energy beaches[16]. Beaches range from sheltered gently sloping shores in the south-east, to the steep, semi-exposed granite sand beaches of the north-east and maximally exposed beaches of the west coast[67] that have recorded some of the biggest waves in the world[23].

While we tend to think of a 'beach' as solely the part that is visible to us and provides suitable habitat for beach cricket and building sand castles (!), beaches technically extend from the upper limit of wave swash ~ 3 m above the high tide mark, and seaward to the depth at which average waves can move sediment shoreward[16]. Based on this definition, some of our beaches on the high wave energy west coast are the widest in the world, extending as far as several kilometres offshore[16] and having massive surf zones up to 500 m wide[23]. These maximally exposed beaches are categorised as 'dissipative' beaches, since they are protected by offshore banks that act to dissipate, or reduce, the energy of the waves. This beach type is common along Tasmania's west coast but comparatively rare elsewhere in Australia, and is known to support a higher diversity of burrowing fauna than other beach types[23].

A 'dissipative' beach protected by offshore banks that act to reduce the energy of the waves; a common beach type along Tasmania's west coast but comparatively rare elsewhere in Australia (Photograph: © Karen Parsons).

Shell detail: beaches may be littered with pebbles, shells or algal debris which alters the beach environment and hence the types of animals found there (Photograph: © Karen Parsons).

Sparsely-spotted Stingaree (*Urolophus paucimaculatus*) (Photograph: © Graham Edgar).

Beaches occupy a dynamic position between sea and land, and include both marine and terrestrial species that are adapted to highly unstable conditions, including variable exposure to wave action and seawater inundation, erosion, drying by the sun, extremes of temperature and rainfall[67]. Like other unvegetated soft sediment ecosystems, beaches have a low primary productivity and can appear barren at first glance, however microscopic algae, tiny animals collectively known as 'meiofauna' (i.e. < 1 mm, just visible to the naked eye) and decomposing algal matter provide the basis for a food chain that supports a diverse range of life. The lower shore is dominated by many species of burrowing worms, molluscs, and small crustaceans called amphipods, while the upper shore is home to a range of insects and air-breathing crustaceans including crabs, sandhoppers and isopods (slaters). This upper 'strandline' zone is biologically unique in Tasmania and includes a host of undescribed animals and endemic sandhopper species with highly restricted distributions[67]. The invertebrates of the lower shore are a major source of food for fish such as flathead, flounder, whiting and sandfishes – including species totally unique to Tasmania[68], many of which have adapted to life in the surf zone through burying in the sand[15]. While beaches generally lack attached macroalgae, a rare phenomenon occurring at a small number of Tasmanian locations is the proliferation of red filamentous algae within recirculating cells of the surf zone, which turns the sea a deep red colour[23].

Bivalve molluscs are a particularly important component of animal communities of sandy beaches and vary in their preference for wave exposure. For example, the Elongate Surf Clam (*Paphies elongata*) (left) is a dominant member of surf beach communities, while the Fine Tawera (*Tawera lagopus*) (centre) prefers more sheltered ocean beaches, and the Thin-ribbed Cockle (*Fulvia tenuicostata*) (right) occurs on sheltered sands and muds (Photographs: © Graham Edgar).

Short-tailed Shearwater (or 'Muttonbird', *Puffinus tenuirostris*) rookery: individual rookeries can be as large as nearly 6 million birds. This species provides a classic example of synchronised breeding, with the birds returning each year to the same burrow on the same day, with egg laying, chick hatching and juvenile fledging also occurring on predicable dates year after year[36] (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

Beach and dune in background at Crescent Beach, Tasman Peninsula (Photograph: © Karen Parsons).

Coastal dunes are also important environments in Tasmania and are well distributed around our coast. Both dunes and beaches provide critical foraging and breeding habitats for shorebirds and seabirds, including a range of Threatened and migratory species of high conservation significance. Tasmanian beaches support internationally significant numbers (1% or higher of total global population) of the resident Hooded Plover, a true ocean beach 'specialist' which forages and nests on beaches. The low density and small total population size of this species means that even beaches with just a few breeding pairs are of considerable conservation importance[69]. The Vulnerable Fairy Tern, Endangered Little Tern, and the Pied Oystercatcher categorised as a conservation concern in Tasmania[13], also nest on Tasmanian beaches and nearby dunes. Internationally significant numbers of migratory species also occur in these environments, including the Ruddy Turnstone[70] which forages amongst rocks and algae on beaches, and the Short-tailed Shearwater or Muttonbird which breeds largely in stabilised dune soils and creates an amazing spectacle as millions of birds return to Tasmania each year around 20th September[36]. Tasmania is also the Australian stronghold for the Little Penguin, which lands on sandy beaches and other habitats on its way to neighbouring breeding sites located in coastal grasslands and herbfields[36].

Like other marine ecosystems, Tasmanian beaches and dunes perform important services that contribute to the health and stability of our waterways and marine environments. Beaches have an important role in cycling nutrients between coastal and nearshore environments, with high energy south and west coast beaches housing a particularly high diversity and density of organisms and exporting nutrients to the ocean[16]. Dunes are an important natural sea defence in low-lying areas, protecting estuaries and wetlands from storm surge flooding and erosion, with this role made possible by important communities of stabilising coastal vegetation[2].

A Hooded Plover (*Thinornis rubricollis*) and nest containing eggs. Shorebird nests are generally simple constructions being a shallow scrape or depression on the ground usually with little or no nesting material, and are often situated just above the high tide mark or on raised banks or dunes. Eggs are well camouflaged and nests are invariably in the open enabling parent birds full view of the surroundings and any approaching threats. Some species such as the Hooded Plover and Pied Oystercatcher require a territory (or 'exclusive zone') of several hundred metres, which they will defend by driving out other birds or potential threats, and may remain faithful to the same site year after year. In contrast, the terns nest colonially and combine forces to drive off natural predators, with nests often being only a few metres apart[13] (Photographs: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

Shaw's Cowfish (*Arcana aurita*) (Photograph: © Graham Edgar).

4.8 Estuaries

Estuaries are the lifeblood of many Tasmanian towns and cities and lie at the interface of marine, freshwater, and terrestrial systems, receiving freshwater drainage from rivers and streams as well as tidal seawater from the ocean. With 84% of Tasmanians living within estuarine catchments, the way we manage our terrestrial and river environments has a major bearing on estuarine quality. A total of 113 estuaries covering an area of approximately 111,000 ha occur around Tasmania and associated Bass Strait Islands, each possessing unique environmental and biological characteristics that vary with shape, size, aspect, topography, and degree of tidal flows, as well as catchment attributes such as rainfall and runoff, rock and soil type, erosion, vegetation cover and human activities[14,71]. Tasmania has an exceptionally wide diversity of estuarine habitat types, due to a steep rainfall gradient, which ranges from 3000 mm per year in the southwest to 600 mm in the northeast, a steep meso-tidal to micro-tidal north-south gradient (see Section 3), and a great geological diversity, including dolerite, granite, acid volcanics, sandstone, quartzite, basalt, limestone and dolomite. Potential evaporation in Tasmania is the lowest in Australia, and all major geomorphological types of estuaries other than fjords are represented[14], with some providing spectacular landscapes that have high aesthetic as well as environmental value. Tasmania is also unusual in a global sense in possessing many estuaries with little human influence; remarkably, 37 of our estuarine catchments (33% of the total statewide) have been identified as 'pristine'[14].

Habitat diversity in estuaries occurs vertically in the water column as well as between areas of different tidal exposure and seabed substrate. When freshwater meets seawater, layering (or 'stratification') frequently occurs because lighter freshwater floats above the dense seawater[72], creating variable conditions within the water column[14].

An example of a barrier estuary at Southport Lagoon, with large sand banks that are constantly changing in size and position in response to storm events, tides and riverine flooding (Photograph: © Adam Davey).

The Spotted Shore Crab (*Paragrapsus gaimardii*) is a common inhabitant of Tasmania's estuaries (Photograph: © Graham Edgar).

At the same time, Tasmanian estuaries contain a mixture of beaches, rocky foreshores, marshes and other wetlands, mudflats, seagrass meadows, kelp forests and rocky reefs[40]. Our estuaries can be classified into five main geomorphological types, including the large drowned river valleys (e.g. Tamar, Derwent and other major estuaries), fast flowing river estuaries, barrier or bar estuaries, saline coastal lakes and lagoons, and enclosed coastal inlets with limited freshwater inputs[14]. Estuaries in northern Tasmania are all open to the sea and possess the highest tidal ranges, while many estuaries in eastern Tasmania and Bass Strait islands are intermittently closed by sand barriers, and those located in the south and west are dominated by river estuaries and small open estuaries in high rainfall areas remote from human activity[14]. West coast estuaries have nutrient levels amongst the lowest in the world due to the shallow soils and nutrient-poor rock types in their catchments[72], with the deficiency in nutrients having major effects on biological communities.

Unique Estuarine Ecosystem – Tannin Estuaries

Southern and western Tasmania are home to the tannin estuaries, highly unique systems that support some of the most unusual estuarine plant and animal communities in the world. The inland areas of these catchments fall within the south-west wilderness area where vast areas of buttongrass plains and heathlands result in a dominance of peaty soils containing tannic acid and other dark compounds derived from plants. High rainfall in the south-west results in these compounds leaching into rivers and eventually into the estuaries where they form a deeply stained freshwater surface layer overlying a clearer seawater layer below. These conditions do not occur in any other part of Australia[73], and result in an unusual phenomenon called 'deepwater emergence' whereby organisms usually found in very deep waters beyond diving limits provide a magnificent display in accessible shallow waters. Light-loving brown algae typically recorded elsewhere in Tasmania to depths of 10-20 m may be absent or limited to the top few metres[74], and are replaced by delicate and unusual red algae including species not recorded from any other environment. At depths as shallow as 5 m, algae diminish and the seabed is dominated by a colourful and diverse range of delicate, filter feeding marine invertebrates such as gorgonians, sponges, lace bryozoans, anemones, sea whips, seapens, soft and hard corals, and tubeworms, some of which are not recorded below 60 m depth elsewhere[75]. Fish and mobile invertebrates are also highly unusual, including species or even whole communities that are more typical of deep waters offshore[76].

The most extreme example of a tannin estuary is Port Davey-Bathurst Harbour in the south-west, a system recognised as having global conservation significance on the basis of its pristine state and unique tannin-influenced ecology (see Section 6.6), while additional major estuaries affected by tannins include Macquarie Harbour and the Huon Estuary. These areas contain endemic and other rare species of fish, algae and invertebrates, including some of the most localised marine species in Australia[68]. The tannin estuaries provide a clear example of how unique attributes of Tasmania's terrestrial landscape (e.g. the amazing south-west wilderness area) are transferred directly to the marine environment, creating an equally remarkable wilderness area below the waterline.

In tannin estuaries, stained freshwater mixes with clear marine water to create a highly unusual aquatic environment (Photograph: © Jan Lieser).

Delicate soft corals (Erect Soft Coral, *Drifa erecta*) growing in abundance at unusually shallow depths in the inky waters of Bathurst Channel in south-west Tasmania (Photograph: © Graham Edgar).

Southern Sea Whip (*Primnoella australasiae*) (Photograph: © Graham Edgar).

Plumed Gorgonian (*Pteronisis plumacea*) (Photograph: © Graham Edgar).

The Cream Sea Lace bryozoan (*Hornera robusta*) and sponges (Photograph: © Graham Edgar).

Dense estuarine bed of the Black-stemmed Eelgrass (*Heterozostera nigricaulis*) (Photograph: © Graham Edgar).

As a result of the combination of marine and freshwater influences, estuaries are considered to be amongst the most productive environments on earth[23], producing more organic matter per year than equivalent areas of forest, grassland or agricultural land[7]. They are also unique in being dominated by species that rarely occur abundantly in fully marine or freshwater systems and are specially adapted for life at the margin of the sea[23]. In Tasmania, the composition of estuarine plant and animal communities is most closely associated with tidal, salinity and rainfall characteristics, size of estuary and presence of a seaward barrier[14]. Up to 150 fish species[77] and 350 invertebrates including encrusting as well as sediment-dwelling forms[78], have been identified in some individual estuaries. Tasmanian estuarine environments contain Endangered species known nowhere else in the world, such as the Spotted Handfish, Maugean Skate, and Derwent Seastar[18,23], all of which are limited to just one or two of our estuaries.

The iconic Spotted Handfish (*Brachionichthys hirsutus*): adult with eggs wrapped around stalked *Sycozoa ascidians* (top), one of the favoured spawning substrates of this species; and a baby Spotted Handfish yet to develop the distinctive spotted markings (bottom). This tiny species measuring up to 12 cm is only found in the Derwent Estuary and was the first fish to be listed as Endangered in Australia (Photographs: © Sue Wragge).

Banded Stingaree (*Urolophus cruciatis*) (Photograph: © Graham Edgar).

Nearly 80% of estuarine habitat in Tasmania has been classified as having very high conservation value[7], and contains a documented 86 special values reflecting the presence of Threatened species or other distinctive features[71]. Our estuaries contain many wetlands of national conservation significance as well as internationally important 'Ramsar' wetland sites (see Section 4.10). Large areas of intertidal and subtidal soft sediment contain diverse and productive infaunal invertebrate communities[7,23] that in turn provide a rich food source for fish and shorebirds. Estuaries are often called the 'nurseries of the sea'[1], providing food, spawning habitat and shelter for juveniles to develop. Many ecologically, recreationally and commercially valuable fish species depend on Tasmanian estuaries during some point in their life cycles, and large numbers of migratory shorebirds also rely on our estuaries as resting and feeding grounds during their long journeys[40]. Besides serving as important habitat for wildlife, estuarine habitats play an important role in nutrient cycling and pollutant filtration and therefore in the quality of our waterways[7,77].

4.9 Intertidal mudflats

Intertidal mudflats occur in sheltered estuaries and embayments and are created through the deposition of fine sediments via tidal movement and catchment runoff. They are constantly changing, being gradually immersed in water during tidal floods and then becoming exposed again to the air during tidal ebbs. Mudflats may appear quite lifeless on first glance since, with the exception of intertidal seagrass beds (Mueller's Eelgrass, *Zostera capricorni*) in some areas, they support few visible plants, and also few large surface-dwelling macroinvertebrates. However, in Tasmania these areas are incredibly rich in microalgae and invertebrate life that provide important food resources for juvenile fish as well as critical foraging habitat for internationally significant populations of resident and migratory shorebirds.

Despite the limited number of identifiable invertebrates on the surface, dense burrows as far as the eye can see are testament to the high productivity of mudflats (Photograph: © Annette Harrison).

Whilst generally referred to as mudflats, sediments of tidal flats range from fine silts and clays (i.e. 'muds') to fine-medium sands[79] depending on level of wave exposure, while other environmental attributes such as shore slope, tidal regime, and levels of nutrients, organic matter and oxygen in the sediments, also play a major role in determining the types of plants and animals found there. Microalgae are represented by rich and abundant communities in the sediments and shallow waters of Tasmanian mudflats, with 55 species of diatoms and dinoflagellates recorded on one mudflat alone[80]. The invertebrates that rely on these and other food sources are primarily burrowing species found in the top 10 cm of the sediment, with studies of Tasmanian mudflats recording more than 11,000 animals per m^2 – representing a staggering 17 billion animals in total – on the most productive mudflat studied[79]. This certainly contrasts sharply with any perception of mudflats being barren places! Across nine mudflats, 255 species of macroinvertebrates have been recorded, with up to 135 species recorded per mudflat, dominated by crustaceans, molluscs and polychaete worms. During tidal floods, fish species such as young flounder, blennies, gobies, hardy heads and Australian Salmon forage over the mudflats[79], making the most of the diverse range of invertebrate food offerings.

The Southern Soldier Crab (*Mictyris platycheles*) occurs in huge abundances on some Tasmanian mudflats, ingesting large quantities of sediment in order to extract small food particles (Photographs: Overview – © Edward Forbes, Close-up – © Graham Edgar).

The Fragile Air-breather (*Salinator fragilis*) is a sea snail that occurs in countless millions on estuarine mudflats (Photograph: © Graham Edgar).

visitors or 'vagrants'[13,81,82], including Endangered and protected migratory species. Some Tasmanian mudflats support populations of many hundreds of shorebirds, with bird counts at individual sites occasionally exceeding 1,000 during summer months[83]. Mudflat sites vary in the diversity of resident and migratory waders they contain, with the Pied Oystercatcher and Red-capped Plover being the most significant resident waders, and migratory species including a range of mudflat specialists, such as the Bar-tailed Godwit, Great Knot, Red Knot and Endangered Eastern Curlew, that cannot forage in any other habitat[69]. Not all invertebrates living in the sediments of mudflats are suitable bird prey, however based on primary 'bird food' species, research has shown that individual mudflats in Tasmania may support up to 20 tonnes of food at certain times through the year[84], again emphasising their high productivity and ecological significance.

The Endangered Eastern Curlew (*Numenius madagascariensis*) (Photograph: © Alan Fletcher).

In addition to supporting a rich diversity of life and important bird species, our mudflats perform a number of important ecosystem processes that help to protect the health of estuaries and sheltered embayments. These areas frequently receive nutrients from catchment inputs which may reduce water quality and also impact on biodiversity. The mudflats help to remove nutrients from the water column through microbial denitrification processes, while the invertebrates also play a major role in sediment chemistry and nutrient cycling through their burrowing activities[79].

4.10 Saltmarshes and other coastal wetlands

Tasmania's highly indented coast creates a range of sheltered environments that are exposed to tides but are protected from the scouring action of waves. Within these sheltered areas, there are coastal wetlands that are permanently or seasonally saturated with marine or brackish water and provide habitats for a fascinating range of plants and animals adapted to living at the interface of the land and sea. Tasmania is unique in having proportionately more wetlands for its size than any other Australian state[81], and in having a highly diverse range of wetlands due to its complex geomorphology and coastal landforms. In fact of 40 wetland types recognised nationally, 19 are represented in the small state of Tasmania and are dominated by marine and coastal zone wetlands[85]. Tasmania's wetlands also contain a large number of endemic and Threatened species, a disproportionately large percentage of all of the State's vascular plant species, and relic Gondwanan biota not evident on mainland Australia[85].

There are 44 marine and coastal wetlands in Tasmania that are listed on the Directory of Important Wetlands of Australia, while eight of these are also listed as internationally significant 'Ramsar' wetlands, including marine sites at Pitt Water-Orielton Lagoon in southern Tasmania, Moulting Lagoon on the east coast, Lavinia on King Island, and Logan Lagoon on Flinders Island. These important wetlands support populations of rare and Threatened plants and animals, as well as nationally and globally significant numbers (i.e. > 1%) of resident and migratory shorebirds, while many also have important hydrological roles and high biogeographical significance[85,87].

Tasmania supports internationally significant numbers of the resident Pied Oystercatcher (*Haematopus longirostris*), a wader that particularly favours estuarine mudflats where flocks exceeding 400 birds have been recorded (Photograph: © Annette Harrison).

Haswell's Shore Crab (*Helograpsus haswellianus*) forms abundant populations at the lower end of marshes, with its burrowing activity at one site found to increase the effective surface area of the marshes by 360% (Photograph: © Graham Edgar).

While mudflats, sandflats, estuaries (including lagoons), rocky shores, sandy beaches and shallow marine ecosystems such as seagrass beds have also been classified as 'wetlands'[81], they have been considered in more detail elsewhere in this report due to their unique characteristics. The focus here is on the saltmarshes, which provide particularly strong linkages between terrestrial and marine ecosystems. Saltmarshes consist of plant and associated animal communities that develop along low energy, temperate coastlines between the mean high and low water tide lines, and hence are tolerant of high soil salinity and tidal inundation[71,88]. The predominance of saltmarshes in temperate areas is reflected by patterns of species biodiversity, with Tasmania recording a very high diversity of approximately 60 saltmarsh plants compared with a low diversity of about 10 in northern Australia[23]. In total, 336 saltmarshes, covering a total area of 57 km^2, have been mapped in Tasmania, with nearly 50% of this area identified as having high or very high conservation value and management priority[71]. They are distributed sporadically along most sections of the Tasmanian coast, but are most extensive and biologically diverse along the highly indented south-east coast and in the far west of the north coast[88,89].

Elevation above sea level, tidal inundation, soil salinity, water table fluctuations, drainage, and soil aeration have all been suggested as factors that affect the composition of saltmarsh communities[86]. At the most marine influenced sites, saltmarshes are dominated by succulent herbs and shrubs, while tussock species and non-succulent herbs are more prominent at brackish sites (e.g. in upper estuaries)[91]. Tasmania's communities are not only highly diverse, but also include a substantial portion of plants and animals (e.g. crustaceans and molluscs) that are totally confined to saltmarsh habitats[89]. Invertebrate communities contain a unique mixture of fully marine, freshwater, semi-terrestrial and terrestrial species[92] and include animals such as crabs, amphipods, worms, molluscs, spiders and various insects[90].

Diversity of fauna is greatest in the highly productive lower marsh, where invertebrate burrows greatly increase the effective surface area of the marshes and aid with nutrient cycling[90]. Coastal saltmarshes also provide important nesting and roosting habitat for resident shorebird species, as well as providing roosting sites for migratory birds such as the Endangered Eastern Curlew.

Saltmarshes provide roosting habitat for shorebirds; picture here, an Endangered Eastern Curlew (Photograph: Alan Fletcher).

The saltmarshes on King Island provide critical habitat and food sources for the Endangered Orange-bellied Parrot[81], demonstrating strong links between saltmarshes and terrestrial conservation values.

Saltmarshes are of considerable importance in both marine and terrestrial food chains[88], and perform valuable ecosystem services such as stabilising the coast and preventing erosion, filtering out pollutants, and forming a natural barrier against the effects of flooding, currents, waves and storms. These services will become increasingly important as climate change contributes to sea level rise and increasing storm frequency and intensity[2]. However the environmental importance of saltmarshes and other wetlands has frequently been overlooked and they are now considered to be amongst the most threatened ecosystems in the world[81].

4.11 Coastal islands

Generally when we think about islands around Tasmania, the major islands such as King Island, the Furneaux Group, Maria Island, and Bruny Island, as well as perhaps Hunter Island, Three Hummock Island, Robbins Island, and Macquarie Island to Tasmania's south[3], are first to come to mind. However, there are around 600 named islands[40], as well as numerous additional rocky islets and reefs present around the Tasmanian coast, many representing remote specks of rock in the ocean and yet able to support a diversity of lifeforms. These islands and islets provide a total coastline length equivalent to 72% of the length of the Tasmanian mainland coast, greatly increasing the availability of coastal habitats in our state. While offshore islands incorporate a range of marine, intertidal and coastal environments, they are distinctly important due to their isolation, and hence less disturbed biological communities, lower incidence of introduced pests and more pristine state[2].

The rugged 'Needles', Maatsuyker Island Group off Tasmania's south coast (Photograph: © Adam Davey).

Tasmania's offshore islands are wild, spectacular places that provide important refuge habitats for seabirds, seals and other unique species of high conservation significance[40]. Seabirds and certain shorebirds (e.g. Sooty Oystercatcher) together breed on 90% of the islands[17], and include 21 breeding species around Tasmania[36] and a further 19 on Macquarie Island[95]. While breeding colonies occur above the high tide line, marine environments provide the entire food supply and are as critical to seabird conservation as land-based nesting habitats. Tasmania's islands are home to some highly restricted endemic seabirds, such as the Shy Albatross which only breeds on three Tasmanian islands[96] and the Royal Penguin which breeds only on Macquarie Island[35]. Of the five areas that are currently listed as critical habitat for Threatened species in Australia, three occur on Tasmanian offshore islands to protect Vulnerable and Endangered albatross species. In addition, of the internationally significant Important Bird Areas (IBAs) (see Section 5.2) recognised on coastal islands of Australia, nearly one third of them are located around the small state of Tasmania[35].

Unique Coastal Island Ecosystem – Australian Fur Seal Breeding Habitat

Australian Fur Seals (*Arctocephalus pusillus*) at West Moncoeur Island in Bass Strait (Photograph: © Biodiversity Monitoring Section, DPIPWE).

The Australian Fur Seal (*Arctocephalus pusillus*) is one of the rarest seals in the world[12], and only occurs in Tasmania and adjacent parts of south eastern Australia. It breeds primarily in Bass Strait on a small number of rocky islands, although occasional pups have been recorded as far south as haul-out sites at Ile De Phoques off eastern Tasmanian and The Friars off southern Bruny Island[93]. Tasmanian islands are of special significance for the Australian Fur Seal, supporting one fifth of the total population and including a larger number of breeding colonies than found in other states of Australia. The increasing southerly penetration of the warm East Australian Current, combined with observations of occasional pups at islands on the east and south coasts, suggest that Tasmania could increase in importance for this species and support a more southerly expansion of the breeding range if sea temperatures continue to rise as a result of global climate change[94]. The most important site in Tasmania is Judgement Rocks, north-west of the Flinders Group, where nearly 2,500 seal pups have been observed in one breeding season, while Reid Rocks and Moriarty Rocks south of King Island and the Flinders Group respectively are also important sites, with smaller numbers of pups recorded at eight additional breeding colonies[94]. Whilst not listed as Threatened, the geographically restricted range of this species combined with a strong association with Tasmanian islands denotes a high natural value for our state.

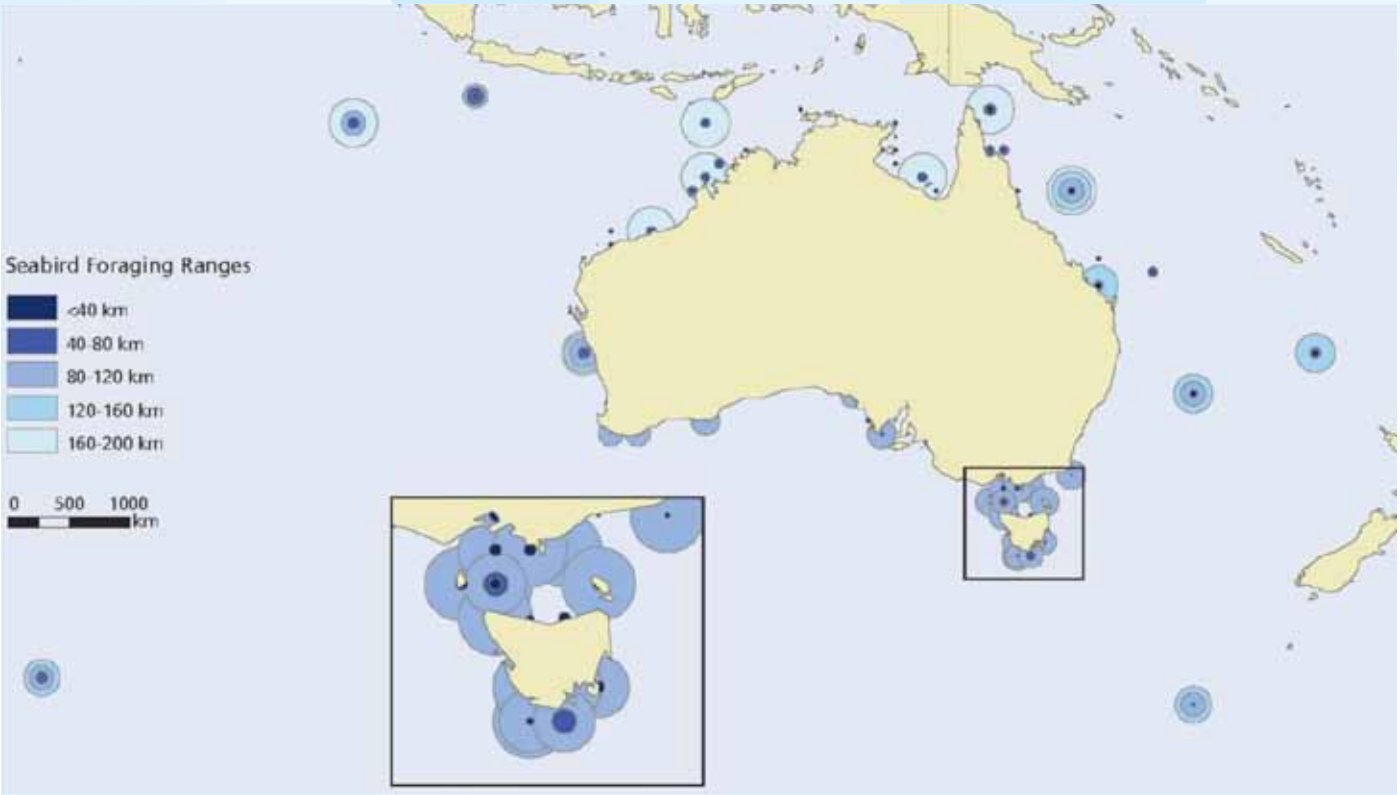
Unique Coastal Island Ecosystem – Critical Albatross Breeding Habitat

Shy Albatross (*Thalassarche cauta*) breeding site at Albatross Island, north western Tasmania. This endemic species is less pelagic than many other albatross species, regularly venturing close to shore and remaining near breeding colonies once they have reached maturity (Photograph: © Biodiversity Monitoring Section, DPIPWE).

Three offshore island habitats in Tasmania have been declared as Nationally Critical for Threatened albatrosses, including the Shy Albatross (*Thalassarche cauta*) on three islands dispersed around Tasmania's coast, and the Wandering Albatross (*Diomedea exulans*) and Grey-headed Albatross (*Thalassarche chrysostoma*) on Macquarie Island[97]. These island habitats, including adjacent marine feeding grounds, are recognised as critical to the survival and genetic viability of these species nationally and globally. The Shy Albatross is the only albatross species totally unique to Australia, and is a Tasmanian breeding endemic, with colonies limited to three islands: Albatross Island off Tasmania's north west, and Mewstone and Pedra Branca off the Tasmanian south coast[36]. Adults remain close to their breeding colonies year-round, whereas juvenile birds – predominantly from the Mewstone colony – have been recorded foraging at sites as distant as southern Africa[96]. The Wandering Albatross may live for up to 80 years and has the largest wingspan of any living bird species (almost 3.5 m), and is also famous for its complex and spectacular nuptial 'dance'. Both this and the Grey-headed Albatross mate for life and breed only on subantarctic islands, being exclusive to Macquarie Island within Australian waters.

The Endangered Wandering Albatross (*Diomedea exulans*) only breeds at Macquarie Island in Australia (Photographs: with chick – © Kerry Steinberner, Australian Antarctic Division; courtship display – © Christo Baars, Australian Antarctic Division).

Breeding populations of the Endangered Grey-headed Albatross (*Thalassarche chrysostoma*) are also exclusive to Macquarie Island within Australia (Photograph: © Kerry Steinberner, Australian Antarctic Division).



The foraging range of inshore seabirds in Australia, highlighting Tasmania's coastal islands as a national seabird 'hotspot' (Source: Dutson et al.2009) [35].

Tasmania's offshore islands support massive aggregations of seabirds, including the largest colonies (up to 6 million birds) of the migratory Short-tailed Shearwater in Australia, as well as being the stronghold for the world's smallest penguin species, the Little Penguin, and for the Sooty Oystercatcher and Black-faced Cormorant. These species, as well as the dainty Fairy Prion, are found on nearly all of our offshore islands and display a distinct preference for these remote habitats[36]. Breeding sites of some other seabirds, such as the Australasian Gannet, Shy Albatross, Sooty Shearwater, White-fronted Tern and Australian Pelican are entirely confined to offshore islands[36]. The Bass Strait islands, including King Island, the Furneaux Group and numerous smaller islands, are particularly important for many of these seabirds, and also support large numbers of White-faced Storm-Petrels, and rare breeding populations of the Threatened Fairy Tern[98]. Macquarie Island has outstanding ecological significance for its enormous concentration of 3.5 million breeding seabirds, including subantarctic penguins and many other seabird species not found further north in Australian waters.

Tasmania's coastal islands also provide critical breeding habitats for Threatened seals, including some species that breed no-where else in Australia. Maatsuyker Island and several other small islands off Tasmania's south coast provide the only breeding habitat in Tasmania for the Rare New Zealand Fur Seal[33], while Maatsukyer is also a haul-out site and produces small numbers of pups of the Endangered Southern Elephant Seal[94]. Other than occasional visits, the latter species does not occur north of Tasmania. Macquarie Island is the Australian stronghold for the Southern Elephant Seal, supporting 70-80,000 seals that represent 10% of the world population[94,99], and also supports the most important Australian breeding population of the Endangered Subantarctic Fur Seal[100]. Australian Fur Seals are endemic to south eastern Australia including Tasmania and primarily breed on rocky islands in Bass Strait, with 20% of the total population occurring in Tasmanian coastal waters[93].

Unique Coastal Island Ecosystem – 'Pristine' sites with little or negligible human disturbance

Sites that have received little human interference denote a high natural value for several reasons. Firstly it is more likely that their natural populations of animals and plants have remained intact than in more human-influenced areas, and that there have been fewer introductions of exotic species generally associated with human habitation (e.g. rats, mice, rabbits, cats, dogs, and foxes).

Secondly, it has been shown, particularly in the marine environment, that where natural levels of biodiversity have been sustained, the community has a greater resilience to natural or human-induced environmental disturbances, such as introduction of introduced marine pests. This is not to suggest that coastal island populations have reduced susceptibility to human impact; the impacts from our history of culling seals as well as albatrosses (for export of their feathers), and evidence of albatross bycatches from longline fishing, are testimony to this.

However remote and pristine offshore islands provide important refuge habitats for species with declining habitat availability or quality in developed areas, while their populations may respond more slowly to natural environmental disturbances than those already stressed by human-induced processes. Species such as the Little Penguin provide a good example, with many of its mainland Tasmanian habitats degraded or under threat, whilst the offshore islands continue to provide healthy habitat for large numbers of birds. High natural values built around these concepts of isolation, resilience and naturalness are no better demonstrated than in the case of remote offshore islands, however Tasmania is also unique in having large areas of pristine habitat on the mainland coast of our remote south-west.

5. TASMANIA'S REMARKABLE MARINE SPECIES

Tasmania's marine environments include an unusually high number of rare and beautiful species that have been recognised to be Threatened at state, national or international levels, while many additional fauna are listed as protected migratory and marine species in Australia. Fifty-five of our marine species are considered to be Threatened in Tasmania or Australia at large, including 28 seabirds, six fish, five whales, four turtles, four seals/sea lions, three seastars, two estuarine grasses, one shorebird, one mollusc and one alga. An additional range of species found here are listed as globally Threatened, including fish, seabird and shorebird species, while some areas occupied by Threatened species are also listed as Critical Habitat at a national level (see Section 5.2).

Threatened animals and plants are of very high conservation value due to declining populations or highly restricted distributions, with formal listings including many important species. However due to the 'hidden' nature of our marine world and very limited baseline information, Threatened species listed in legislation may only represent a small portion of those that are in fact threatened with extinction[101]. In addition, some marine populations have shown gradual declines in response to human activities and provide an example of the *sliding baseline syndrome*, whereby the expectation of what a healthy ecosystem or population looks like changes over time[101]. Catch statistics indicate that numbers of many major fisheries species have declined by >50% or even >80% over three generations – meeting the international criteria for Endangered and Critically Endangered status respectively. Similarly, declines of up to 65% have been recorded amongst shorebird species since the 1950s[7], seagrass beds have declined by an estimated 25% and Giant Kelp beds by 50% over the same period, and inshore mollusc biodiversity has decreased by nearly 70% over the last 100 years[101,102]. This suggests that many additional marine species that are currently not acknowledged on formal lists may have very high conservation values.

The sections below describe significant marine species in Tasmanian waters, with a focus on formally recognised Threatened and protected species, however examples of other known endemic (i.e. limited to Tasmania), highly restricted or declining species and communities are presented based on available information.

5.1. Marine mammals and reptiles

More than 40 species of marine mammals are found in the waters and on coastlines around Tasmania and Macquarie Island. They include seals and sea lions, which belong to a group called the 'pinnipeds', as well as whales and dolphins, which together are known as 'cetaceans'. Like terrestrial mammals, pinnipeds and cetaceans breathe air, have warm blood, give birth to live young that resemble the parents and are fed milk by their mothers. Tasmania has no resident marine reptile species, however we have regular or occasional visits from a number of turtle species foraging at the very southern limit of their distributional ranges. Many cetacean, pinniped and turtle species are of high conservation value in our waters and comprise the charismatic 'megafauna' at the top of our coastal food chains.

5.1.1. Pinnipeds (seals and sea lions)

Colonies of pinnipeds occur mainly on rocky, remote parts of our coast, particularly in southern Tasmania, the Bass Strait islands and Macquarie Island, where they form breeding populations or 'haul-out' (i.e. resting, non-breeding) aggregations. Tasmania supports a very diverse range of pinniped species compared with other parts of Australia because of a unique combination of temperate and subantarctic fauna, with seven of ten recorded species rarely venturing north of Tasmanian waters. All pinniped species regularly observed in Australia[103] have been confirmed as occurring here either as residents or occasional visitors, with five forming breeding colonies including the Endangered Southern Elephant Seal and Subantarctic Fur Seal, as well as the Antarctic Fur Seal, Rare New Zealand Fur Seal, and Australian Fur Seal. Colonies of the former three species are limited to or occur primarily on Macquarie Island, however Tasmania's south coast islands provide breeding habitat for New Zealand Fur Seals and small numbers of Southern Elephant Seals[33,95]. Our Bass Strait Islands support important breeding colonies of Australian Fur Seals (see Section 4.11), although this species occurs widely around the Tasmanian coastline where it forms additional haul-out colonies. The Vulnerable Australia Sea Lion, and four additional species of subantarctic seals (Leopard Seal, Crabeater Seal, Weddell Seal, Hookers Sea Lion) are occasionally seen on our shores[33,95,100].

Some well established seal colonies form the basis of tourism ventures, with participants guaranteed to see large numbers of these playful and sometimes highly vocal creatures swimming and cavorting within the colony. We are privileged to witness this sight; populations of seals were heavily impacted by the sealing industry in the 1800s and 1900s and are only gradually recovering, with some populations still about one third of their estimated pre-sealing sizes[40]. The seals rely completely on the marine environment for food; most feed on small pelagic fish and squid, however the New Zealand Fur Seal consumes additional small numbers of seabirds such as Little Penguins and shearwaters[104], and the Leopard Seal is a formidable marine predator that regularly preys on birds and other seals[105].

The Endangered Southern Elephant Seal (*Mirounga leonina*; a bull pictured here at Macquarie Island) is the largest of all living seals, with males weighing nearly 4 tonnes and reaching up to 6.5m in length. It has an interesting social structure, with the largest and most experienced males attempting to gather and control harems of up to 100 females, while assistant bulls patrol sections of the largest harems on their behalf. This species belongs to the 'true' seals that lack external ears and are less agile on land than the 'eared' seals which include sea lions and fur seals. It is nevertheless an animal that has truly adapted to both land and sea; dividing its time between the two and being capable of diving to 1,700 m depth and remaining submerged for more than an hour at a time during hunting excursions[100]
(Photograph: © Christo Baars, Australian Antarctic Division).

Australian Fur Seal (*Arctocephalus pusillus*) pup
(Photograph: © Biodiversity Monitoring Section, DPIPWE).

Australian Fur Seals at Tenth Island, northern Tasmania
(Photograph: © Biodiversity Monitoring Section, DPIPWE).

104 Subantarctic Fur Seal (*Arctocephalus tropicalis*) at Macquarie Island (Photograph: ©Nick Gales, Australian Antarctic Division).

5.1.2. Cetaceans (whales and dolphins)

Tasmania's cetacean fauna is also remarkably diverse, consisting of 34 known species that include a large number of Threatened and protected species, as well as mysterious species that are known only from stranding events[106,94]. Tasmania's east coast is particularly important as a migration path for the Endangered Southern Right and Humpback whales as they move between their summer subantarctic feeding grounds and winter birthing grounds along Australia's south east coast[33,94]. These two species come close to the coast and so Tasmanians are lucky enough to get the first glimpse of these whales during their northerly migration[77]. Additional Threatened species include the Endangered Blue Whale and Vulnerable Fin and Sei whales, while the Sperm Whale is categorised as globally Threatened. Many cetaceans are listed as protected migratory species due to their broad oceanic ranges and hence international significance. Most of the larger species are 'baleen' whales which feed by sieving tonnes of krill, small squids and fish through a series of plates or 'baleen' (e.g. Southern Right Whale, Humpback Whale), while the toothed whales actively hunt fish and birds – and even other marine mammals – using teeth to grab or tear at their prey (e.g. Sperm Whale, Killer Whale, dolphins).

A Humpback Whale (*Megaptera novaeangliae*) breaching (Photograph: © Nick Gales, Australian Antarctic Division).

The Endangered Southern Right Whale (*Eubalaena australis*) is the most significant cetacean species for Tasmania, because in addition to migratory habitat, our coastal waters provide critical calving habitat for recovering populations of this species[94]. Tasmania was the former stronghold for breeding populations, with our east coast historically recognised as the Australian centre for calving activity. This area includes many protected bays and inlets with soft sediments, which present ideal habitat for the Southern Right Whale, which calves close to shore. Courtship and mating are ritualistic events for whales, with displays including lunging, chasing, jaw clapping, head butting, spiralling and strong vocalisation or 'singing'[33]. Rumours of noise complaints from whale song in the early history of Hobart reflect the once very abundant populations of this species. While calving ceased in Tasmanian waters as a result of the whaling industry during the 19th century, there has been a gradual recovery of populations and recent exciting evidence of Southern Right Whales calving again in small numbers in Tasmanian waters[94] (Photographs: mother and calf – © Biodiversity Monitoring Section, DPIPWE; underwater – © Aquenal).

Tasmania is unique for its high occurrence and diversity of whale strandings, with two thirds of Australian stranding events occurring on our shores[94]. In addition, the stranded animals include a wide range of unusual species rarely observed elsewhere on Australia's coast, such as the Pygmy Right Whale and Hector's Beaked Whale. The stranding frequency is a possible reflection of our long and complex coastline combined with variable seabed topography, whilst the diversity of species may be due to a large number of Antarctic and subantarctic species occurring more frequently around Tasmania than the Australian mainland[107]. Of the toothed whales, the most commonly sighted in Tasmanian waters are the charismatic Common Dolphin and Bottlenose Dolphin, although at least five

additional dolphin species may occur here. Large pods of more than 300 dolphins are sometimes observed[104], with the sea 'coming alive' with the breaching of these beautiful streamlined animals. An additional species is the majestic Orca, one of the top predators in the ocean and the largest predator of warm-blooded animals in the world, which is more frequently sighted in Tasmania than most other areas of Australia[108].

Bottlenose dolphin (*Tursiops truncatus*)
(Photograph: © Judy Crees-Morris, Australian Maritime College)

A small pod of Orcas (*Orcinus orca*) playing with Southern Elephant Seals (Photograph: © Australian Antarctic Division).

5.1.3. *Turtles*

Four species of marine turtle occur in Tasmanian waters and all are of high international conservation significance due to their oceanic distributions and broad migratory pathways. The Loggerhead and Leatherback turtles are listed in Australia as Endangered, and Green and Hawksbill turtles as Vulnerable, while threats to the Leatherback and Hawksbill turtles are categorised as 'critical' at a global scale. They have large Indo-Pacific ranges, with the Loggerhead and Green turtles migrating up to 3,000 kilometres between feeding and breeding areas[33]. The worldwide decline of marine turtles has heightened awareness about their high conservation value and the need to protect them within both their breeding and foraging ranges. Marine turtles are very long lived, with some species not reaching maturity until 30 or even 50 years of age and then only breeding every five to six years. None of the turtles breed in Tasmania, however the Leatherback Turtle is a regular inhabitant and has been recorded on all Tasmanian coastlines[33]. Congregations of this species have been observed in Bass Strait where southward flowing warm currents converge with the edge of the continental shelf, and plentiful supplies of jellyfish and other soft-bodied food items are available[109].

The Endangered Leatherback Turtle (*Dermochelys coriacea*)
(Photograph: © Graham Edgar).

5.2. BIRDS

Tasmania, including Macquarie Island, provides breeding or foraging habitat for around 90 shorebird and seabird species, as well as at least 20 additional species that are very occasional visitors or 'vagrants'[13,36,95,106,110]. These species represent an incredible diversity of life on our shores, and have wide ranging habitat preferences and life histories, including both resident and migratory species. Twenty-nine species consisting primarily of seabirds are listed as Threatened at state or national levels, while four additional species are listed as globally Threatened and 46 species are of international significance due to their large migratory ranges. Each country falling within the migratory pathway of these species has committed to protecting them within their jurisdiction to facilitate a global conservation effort. Significant terrestrial birds also have close associations with marine environments, such as the Endangered Orange-bellied Parrot that breeds only in Tasmania and is dependent on saltmarshes for foraging habitat during its annual northerly migration[81].

Around the world, Important Bird Areas (IBAs) have been identified that are recognised as internationally important for bird conservation and known to support key bird species. Relative to its size, Tasmania has a higher number of these important bird areas than any other state or territory of Australia, as well as the highest overall percentage of land designated to them[35]. The 43 IBAs (=14% of the IBAs in Australia) covering 18% of Tasmania include a large number of islands that are important for seabirds, particularly in Bass Strait and along the south coast, as

The Vulnerable Shy Albatross (*Thalassarche cauta*) breeds only on Tasmanian offshore islands (Photograph: © Biodiversity Monitoring Section, DPIPWE).

well as beaches and mudflats on the Tasmanian coast that are of global significance for shorebirds[35]. Further information on Tasmania's amazing array of significant bird species is provided below for seabirds, which are categorised here as species that feed in open marine environments and may spend extended periods at sea, as well as the shorebirds which feed primarily in intertidal habitats such as beaches, rocky shores and mudflats.

5.2.1. Seabirds

Tasmania is a global hotspot for seabird activity, with more than 60 species observed foraging or in breeding colonies around Tasmania and Macquarie Island[95,106], including over half of the world's albatross species[110] and all of the formally recognised critical seabird habitats within Australia[106]. Twenty-eight species are listed as Threatened in Tasmania and nationally, including 14 albatrosses, seven petrels, four terns, two cormorants and one prion, while an additional albatross species and two subantarctic penguins not listed in Australia are Threatened at the global scale. Tasmania's seabird fauna is unique within Australia due to its diverse range of subantarctic species not found further north, as well as unusually high aggregations of several temperate and migratory species that thrive on our many offshore islands (see Section 4.11). These seabirds rely entirely on the ocean for food and are an important part of Tasmania's marine food chains, feeding largely on krill, squid and fish, and in turn providing food for marine mammals and sharks. They utilise a diverse range of ecosystems, occurring in sheltered inlets and estuaries through to our open coasts and seas[36].

Breeding seabirds include 15 species around Tasmania and an additional 20 at Macquarie Island[36,95], with nest sites ranging widely from stabilised dune soils on headlands to burrowing habitat amongst tussock grass or herbfields, beaches and sandy spits, and ledges of rocky islets and stacks. Breeding colonies around the Tasmanian coast include two Endangered species – the Little Tern and Soft-plumaged Petrel – and three Vulnerable species, the Shy Albatross, Fairy Tern and White-fronted Tern. Macquarie Island supports magnificent aggregations of seabirds including breeding populations of 13 Threatened species, seven of which are Endangered and therefore of particularly high conservation significance: the Wandering, Grey-headed, and Black-browed albatrosses, as well as the Antarctic Tern, Fairy Prion (southern), and Southern Giant and Soft-plumaged petrels[99]. Breeding sites for the Shy Albatross around Tasmania, and the Wandering and Grey-headed albatrosses at Macquarie Island are listed as Critical Habitats in Australia[106]. Breeding populations of Threatened species are in some cases largely or entirely confined to Tasmanian coasts.

The Shy Albatross is endemic to three Tasmanian offshore islands (see Section 4.11), while the Royal Penguin listed as globally Vulnerable only breeds on Macquarie Island. Several additional nationally protected marine species are restricted to southern Australia including Tasmania, such as the Black-faced Cormorant and Pacific Gull[35], while Tasmania supports a very high proportion of the Australian population of the Vulnerable Fairy Tern (12%[7]).

Tasmania's seabirds include numerous protected migratory species, with a total of 26 recorded species including albatrosses, petrels, shearwaters and one tern. The migrators fall within two major categories based

The only known breeding site for the endemic Royal Penguin (*Eudyptes schlegeli*) is at Macquarie Island (Photograph: © Rowan Butler, Australian Antarctic Division).

Tasmania is reported to be the Australian stronghold for the Little Penguin (*Eudyptula minor*)[36], the world's smallest penguin. This amazing little bird is a competent climber and may ascend heights of up to 100 m above sea level in search of suitable breeding sites. It uses song and displays varying from a 'half-trumpet display' to a fever pitch of sound and flipper, beak and body movements to attract mates, repel intruders and, as a duet, unite a pair's attachment to each other[111] (Photograph: © Graham Edgar).

Tasmania, 31 include globally significant populations (i.e. > 1% of world population) of seabird species, 25 on offshore islands and six around the mainland Tasmanian coast[35]. These sites are particularly important for Short-tailed Shearwaters, Little Penguins, Black-faced Cormorants, Australasian Gannets, White-faced Storm-Petrels, Fairy Prions and Pacific Gulls[35,36,98]. Tasmania supports Australia's largest populations of the Little Penguin, Black-faced Cormorant and Short-tailed Shearwater, with an incredible 18 million of the latter migratory species arriving on Tasmanian shores every spring[36].

5.2.2. Shorebirds

Tasmania has a diverse shorebird fauna of 43 species, representing 64% of the shorebird species recorded nationally[13]. Several species are included on Threatened species lists, with the Eastern Curlew classified as Endangered in Tasmania, and the Red Knot as Vulnerable and Hooded Plover, Black-tailed Godwit and Asian Dowitcher as Near Threatened at the international level. The conservation value of shorebirds appears to be highly underestimated on the basis of current Threatened species listings, with numerous unlisted species identified as a conservation concern and recommended for Threatened species assessment[13]. These birds occupy a diverse range of intertidal habitats, and include the 'waders' that probe for invertebrate food on sheltered mudflats (e.g. Eastern Curlew), as well as beach specialists (e.g. Hooded Plover), and rocky shore specialists capable of hammering prey attached to rocks (e.g. Sooty Oystercatcher). The full range of habitats used by these species is vast, and includes spits, estuaries, river mouths, tidal mudflats, saltmarshes, saline wetlands, sand dunes, sandy beaches and rocky coastlines[13].

Tasmania is particularly important for 20 protected migratory species that, with the exception of the Double-banded Plover, breed in northern China, Mongolia, Siberia and Alaska during our winter and then migrate to Tasmania in summer to feed. These birds utilise a migration route termed the East Asian-Australasian Flyway, one of the world's major flyways that represents an extremely significant component of global shorebird populations, extending up to 12,000 km, including 23 countries and a minimum of 8 million birds[112]. Being the most southerly point of this flyway, Tasmania represents the southerly extremity of the distribution range of Palaearctic migratory shorebirds and serves as the final resting and feeding site for many individuals before they return to breeding grounds[13]. During the summer migratory season, Tasmania has an estimated total population of 40,000 shorebirds[70], while during winter our shores support the highest densities in Australia of the Double-banded Plover that migrates from New Zealand to feed[13].

Tasmania also supports the highest densities in Australia of several resident species (i.e. species that spend their entire life within Tasmania), and includes around 20-30% the total Pied Oystercatcher, Sooty Oystercatcher, and Hooded Plover populations[7,13,36]. Our coast provides important breeding habitats for these species, with nests often occurring singularly and being defended within a territory (or 'exclusive zone') of several hundred metres, as opposed to the mostly colonial nesting sites of seabirds. These species, like many seabirds, remain faithful to the same mate and nesting site year after year and hence any loss of these sites is a major threat to breeding success[13].

With consideration of both resident and migratory species, 16 internationally significant shorebird sites have been identified in Tasmania on the basis of supporting 1% or more of individuals within the East Asian-Australasian Flyway or global population of a species[35,70,112,113]. These sites are well dispersed around the Tasmanian coastline, and are significant primarily for the resident Pied Oystercatcher (13 sites), Sooty Oystercatcher (8) and Hooded Plover (8), and the migratory Ruddy Turnstone and Double-banded Plover (4 each), while smaller numbers of sites are significant for seven additional migratory species including the Endangered Eastern Curlew. Tasmania's remarkable aggregations of shorebirds have contributed to the listing of several internationally recognised 'Ramsar' wetland sites, with population numbers suggesting that additional sites also meet the criteria for listing.

Hooded plovers (*Thinornis rubricollis*), juvenile and adult (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

Pied Oystercatchers (*Haemotopus longirostris*) (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

The Ruddy Turnstone (*Arenaria interpres*) picks invertebrates from decomposing seaweed (Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

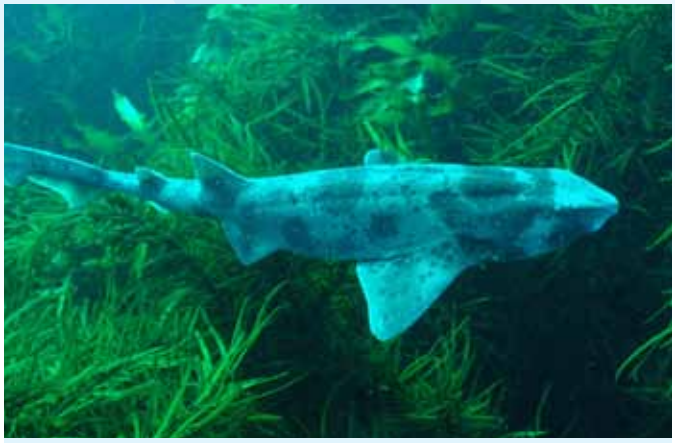
5.3. FISH

Vulnerable Great White Shark (*Carcharodon carcharias*) (Photograph: © Chris Black).

Tasmania's marine fish fauna is highly diverse and includes more than 600 species[17], with 85% of these unique to southern Australia[8] and some representing bizarre and rare forms that are only found in Tasmania. Our state, and particularly its south-east, is a global hotspot for endemic fishes, with new species continuing to be discovered[52]. Six species are listed as Threatened in Australia; the Spotted Handfish and Maugean Skate as Endangered and the Great White Shark, Australian Grayling, Red Handfish and Ziebell's (/Waterfall Bay) Handfish as Vulnerable. These Threatened species cover a wide range of habitats and life histories, from the reef and soft sediment dwelling marine handfishes, to the estuarine Maugean Skate, the diadromous (i.e. migrating between fresh and salt water) Australian Grayling, and the pelagic wide-ranging Great White Shark.

The conservation significance of some commercial species has also been increasingly recognised, with the School Shark, Orange Roughy, Eastern Gemfish and Southern Bluefin Tuna categorised as 'Conservation Dependent', and the latter species as well as the Spotted Handfish categorised as Critically Endangered at the international scale. Many of Tasmania's shark species are listed as globally Vulnerable (e.g. Spotted Dogfish, School Shark, Shortfin Mako), while our coastal waters include key nursery sites for sharks, rays and skates that have been designated as protected Shark Refuge Areas[40]. Tasmanian waters contain a diverse range of protected fish in the family Syngnathidae, including the colourful and iconic Weedy Seadragon, listed as Near Threatened globally, and the graceful Bigbelly Seahorse that is described as a 'flagship' species for marine conservation. Many fish species are of commercial or recreational significance, with 50 species fished in total, dominated by 15-20 species such as the widespread Bastard Trumpeter, Striped Trumpeter and Warehou[17].

The beautiful Weedy Seadragon (*Phyllopteryx taeniolatus*) (Photograph: © Graham Edgar).



Draughtboard Shark (*Cephaloscyllium laticeps*) (Photograph: © Graham Edgar).

Potbelly Seahorse (*Hippocampus bleekeri*) (Photograph: © Geoff Rollins).

A school of Bastard Trumpeter (*Latridopsis forsteri*), an important commercial species in Tasmania (Photograph: © Sue Wragge).

The handfishes are amongst Tasmania's most unique and Threatened fishes, represented by species with extremely localised distributions and a range of unusual forms[114]. The 14 known handfish species are all confined to southern Australia, with 11 of these found in Tasmania and seven endemic (i.e. totally unique) to our state. Four are endemic to shallow coastal waters, primarily within the south-east, including the above three Threatened species and a newly described species known only by the scientific name of *Brachiopsilus dianthus* that is also likely to be of high conservation significance[114]. The best known of the handfishes is the Spotted Handfish, which is confined to the Derwent Estuary and has a total estimated population of just 1,000 to 1,800 mature individuals occupying an area less than 3 km^2 [115,116].

Another highly unusual Tasmanian species is the Endangered Maugean Skate, a 'Gondwanan relic' that is the oldest lineage of skate in the world, and most closely related to New Zealand and South American species that evolved when the southern land masses were still connected[11,46]. It was only discovered in 1988 and is confined to the low salinity upper reaches of two biologically unique estuaries, Bathurst and Macquarie Harbours on Tasmania's west coast. This 'micro'endemic fish is the only skate worldwide to occur mainly in brackish water, and also the only skate with such a highly restricted distribution[68]. Its total population size has been estimated at less than 2,500, while its area of occupancy is not more than 100 km^2 [117]. Other rare and endemic fish species have recently been identified in Tasmania, with a new species of sand fish (*Lesueurina* sp.) confined to our south coast, and studies underway suggesting the presence of many additional endemic species including gobies and clingfishes[52].

Species that spend part of their life cycle in freshwater streams as well as the ocean represent important ecological links between these aquatic habitats. The Vulnerable Australian Grayling is one such species that is limited to south-eastern Australia, occurring in estuaries around much of the Tasmanian coast. The basic biology of this species including migratory behaviour remains poorly understood, however marine habitats are important for the first six months of life when larvae develop into juveniles ready to return to the rivers[33]. Whilst not listed as Threatened, the Tasmanian Whitebait (or 'Derwent Whitebait') is also a significant species on the basis of its endemic Tasmanian distribution and description as commercially threatened[118]. It has a distinct migratory 'run' from marine to fresh waters and a life cycle of just one year, meaning that any factors threatening the success of recruitment in any particular year have serious implications for the conservation of the species[119].

The Vulnerable Red Handfish (*Thymichthys politus*) (top) and recently described handfish *Brachiopsilus dianthus* (bottom) are endemic to Tasmania and have highly restricted distributions primarily in the south-east of the state. The handfishes are related to the anglerfish, using an in-built 'lure' on the front of their head to attract prey, comparable to angling using a fishing rod. They are slow moving fishes that 'walk' using modified hand-like fins, and lay eggs on the seabed that hatch into fully formed baby handfishes. This mode of reproduction, which lacks a free-swimming larval phase, greatly limits the ability of the handfishes to disperse and means that they cannot readily colonise a new area if their habitat comes under threat (Photographs: © Karen Gowlett-Holmes).

The pictured Endangered Maugean Skate (*Zearaja maugeana*) is a preserved specimen since this extremely rare and little known species has not been photographed in its natural habitat (Photograph: © Thor Carter, CSIRO Marine and Atmospheric Research).

5.4. INVERTEBRATES

Tasmania's marine environments support rich and colourful marine invertebrate communities, including a diverse range of both mobile and sessile (i.e. permanently attached, not free-moving) forms. As described for the fishes, Tasmania, and particularly the south-east of the state, is a hotspot for endemic marine invertebrates that have highly localised distributions, and contains the only marine invertebrates listed as Threatened at a national level. These are the Critically Endangered Derwent River Seastar and the Vulnerable Live-bearing Seastar, while Gunn's Screw Shell and the seastar *Smilasterias tasmaniae* are listed as Vulnerable and Rare respectively in Tasmania. The small number of listed Threatened invertebrate species here and nationally is highly unrepresentative of the conservation value of this group, and reflects their often hidden nature and lack of monitoring data needed to detect population declines[101].

Moon Jelly (*Aurelia aurita*)
(Photograph: © Graham Edgar)

High diversities and levels of endemism have been recorded across a wide range of invertebrate groups. Tasmania's mobile fauna includes more than 1,000 molluscs (e.g. sea snails, sea slugs, scallops, squid)[102], with 95% of these endemic to the southern temperate Australian region containing Tasmania, while 90% of our echinoderms (e.g. seastars, sea urchins, brittle stars, sea cucumbers) are also endemic to this region[8]. Crustaceans are represented by numerous subgroups (e.g. lobsters, crabs, shrimps, sandhoppers) and include species totally unique to Tasmania[67], while sessile communities provide magnificent displays of sponges, anemones, ascidians (or 'seasquirts'; these have a backbone as larvae but share many attributes with invertebrates), tubeworms, lacy bryozoans, feather-like hydroids, sea fans, gorgonians, seawhips, seapens[53] and 'keystone' cold water coral species that provide habitat for many other animals[1]. Of the >500 sponges recorded from Tasmania and adjacent areas of southern Australia, 60% are endemic, while two thirds of the 200 recorded ascidian species and ~500 bryozoan species in the same region are also endemic. The latter colonial, 'moss like' animals reach their greatest species diversity in temperate waters where they comprise 80% of the shelf sediments, representing the equivalents of the tropical reef building corals[17].

Tasmania's unique invertebrates

Tasmania's echinoderms are highly unique, including three Threatened seastars that are totally confined to the south-east of our state and occupy areas as small as <1 to 3 ha[10,120]. The brightly coloured Live-bearing Seastar is also significant due to its unusual mode of reproduction, since this species gives birth to live young that are miniature replicas of the adults, and is one of only five seastars worldwide to do this[121].

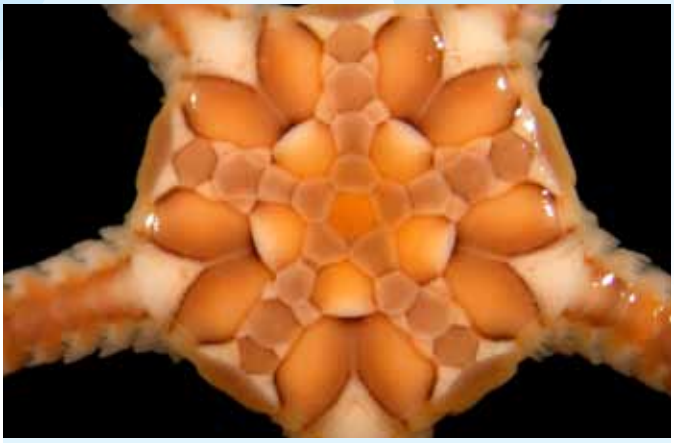
Pink-tipped Anemone (*Epiactis australiensis*)
(Photograph: © Neville Barrett).

Doughboy Scallop (*Mimachlamys asperrimus*)
(Photograph: © Graham Edgar).

The endemic Live-bearing Seastar (*Parvulastra vivipara*) is unique in so many ways: it is one of the most restricted marine species in Australia, being limited to a handful of sites in south-eastern Tasmania with a total area not greater than 3 ha10; it is one of the smallest seastars in the world, reaching just 1.5 cm when fully grown[53]; it produces live young which emerge from the exposed surface of the adult, a reproductive strategy known from only five seastars worldwide[121]. The adult is both 'mum' and 'dad' due to this species being a hermaphrodite, and the babies appear as tiny bright orange seastars just 1-2 mm in diameter[33]
(Photograph: © Graham Edgar).

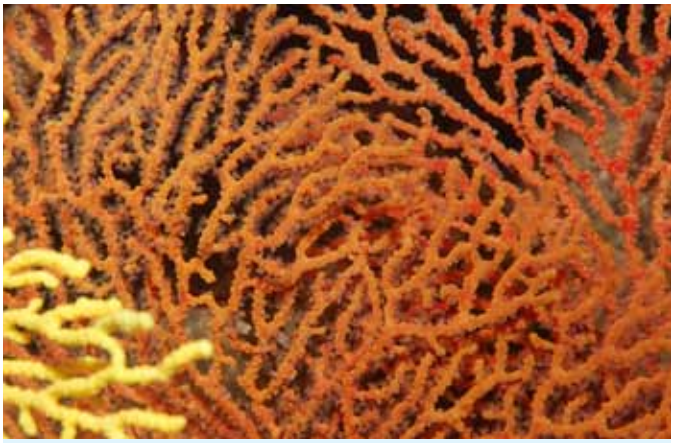
Superb Feather Hydroid (*Gymnangium superbum*)
(Photograph: © Graham Edgar).

Ornate Sea Slug (*Sagaminopteron ornatum*)
(Photograph: © Graham Edgar).



Britttlestar detail
(Photograph: © Adam Davey).

Purple Urchin
(Photograph: © Graham Edgar).



Colourful gorgonian corals (Photograph: © Neville Barrett).

The Vulnerable Gunn's Screw Shell (*Gazameda gunnii*)
(Photograph: © Graham Edgar).

Spotted Seastar detail (*Nectria ocellata*)
(Photographs: © Neville Barrett).

Henderson's Hermit Crab (*Strigopagurus strigimanus*)
(Photograph: © Rebecca Hubbard).

Octopus hiding amongst rocks
(Photograph: © Neville Barrett).

The Wavy Volute (*Amoria undulata*); a morph lacking the characteristic waved pattern (Photograph: © Graham Edgar).

One of Tasmania's most valuable fishery species is the Southern Rock Lobster (*Jasus edwardsii*) (Photograph: © Geoff Rollins).

The Native Flat Oyster (*Ostrea angasi*) was once abundant in southern Australian waters but now only forms distinct beds at a single site on Tasmania's east coast (Photograph: © Graham Edgar).

Tasmania's highly diverse molluscan fauna also contains many treasures, from the delicate Paper Nautilus to rare volutes and cowries representing a relic fauna in Tasmania and southern Australia[17], and hundreds of tiny 'micro-molluscs' that are smaller than a match head[44]. Early studies identified parts of Tasmania as being biologically distinct from the rest of Australia primarily on the basis of a large number of endemic molluscs. The Vulnerable Gunn's Screw Shell is a beautiful high spired marine snail that is now Threatened on the basis of population declines, while many additional molluscs are rarely seen and may also be threatened with extinction[102]. The commercial Native Flat Oyster (not to be confused with the cultured Pacific Oyster, which is an introduced species) was once common in temperate Australia but now only forms distinct reefs at one site in Tasmania, where it denotes a rare and high value habitat[122,123]. Marine invertebrates include many other significant commercial species in Tasmania, most notably the Southern Rock Lobster, Giant Crab (the largest crab in the world by weight), Blacklip Abalone, Greenlip Abalone, Southern Calamary, Commercial Scallop and Maori Octopus[17].

5.5. MARINE FLORA

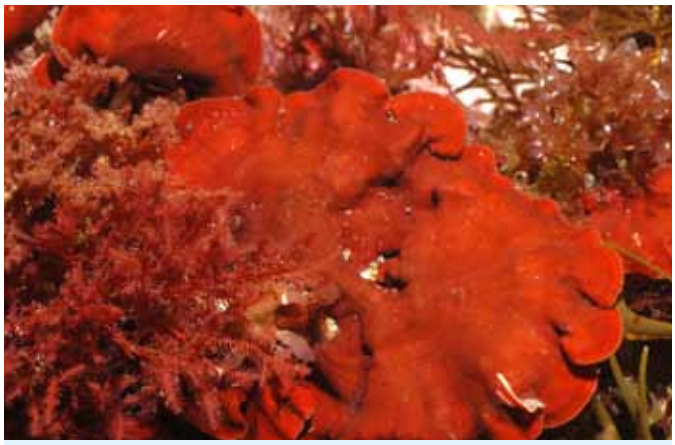
The marine flora in Tasmania's waters include seaweeds or 'algae', which are non-flowering and use spores to reproduce much like ferns and mosses, as well as the seagrasses that produce flowers and are classified as 'angiosperms' like our terrestrial flowering plants. Algae range from single celled microalgae through to massive macroalgae such as the Giant Kelp, and include brown, green and red colour forms. Both algae and seagrasses obtain their energy from 'photosynthesis', a process that uses sunlight and carbon dioxide to produce sugars with the help of photosensitive pigments in their tissues, such as chlorophyll. This reliance on light means that marine plants are limited to relatively shallow depths where there is sufficient light penetration, with depth ranges varying amongst species partly on the basis of the types of pigments they use. For example the pigments used by red algae capture blue light, which passes most easily through water, allowing the red algae to extend to greater depths than the green or brown algae.

Algae and seagrasses are the 'backbone' of marine food chains, being responsible for the 'primary production' of food resources that sustain the small animals that in turn provide food for larger predators. Within Tasmania, levels of algal species richness and endemism (uniqueness) are amongst the highest in the world, whilst our seagrass beds include a unique mixture of warm and cool temperate species that greatly enhance the diversity of Tasmania's marine soft sediment habitats.

5.5.1. Algae (seaweeds)

The southern Australian coastline incorporating Tasmania is unusual in a global sense because of the very high diversity of its algal flora, with the >1,300 recorded species substantially more than identified along coastlines of comparable length and latitudinal range elsewhere in the world[23]. This high diversity has been attributed to a long period of geological isolation, coupled with south-east Australia containing the longest ice-free coastline in the world[9]. Levels of endemism in this region are also high with 60% of species being unique[17], while parts of Tasmania have the highest numbers of localised endemic algal species in Australia[6,124]. One half of Australia's temperate species are present in our small island state, with an estimate of 635 for Tasmania and its offshore islands, excluding Macquarie Island[125], likely to greatly increase with on-going research[41]. Many elements of Tasmania's algal flora still remain unknown, as reflected by the recent discovery of a new species of red algae near Hobart that has no known close relatives[28]. The macroalgal flora of Tasmania is typically cold temperate, but also includes a unique element of colder water subantarctic species[17] that are rare or totally absent from mainland Australia. The photographs displayed in this section illustrate the huge diversity in macroalgal forms within our marine environment.

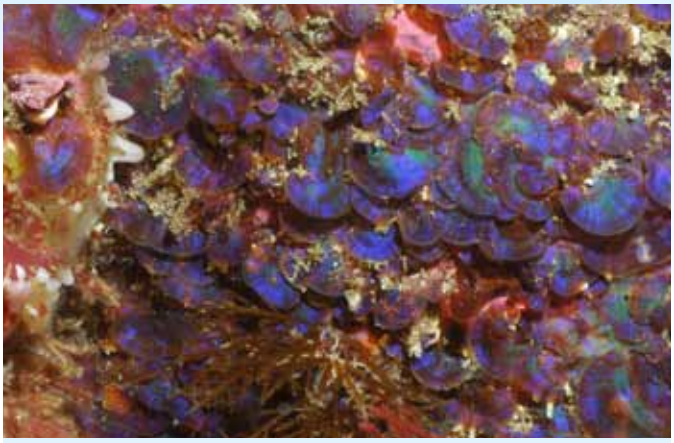
Brown's Cystophora (*Cystophora brownii*) found on Tasmania's north coast (Photograph: © Graham Edgar).



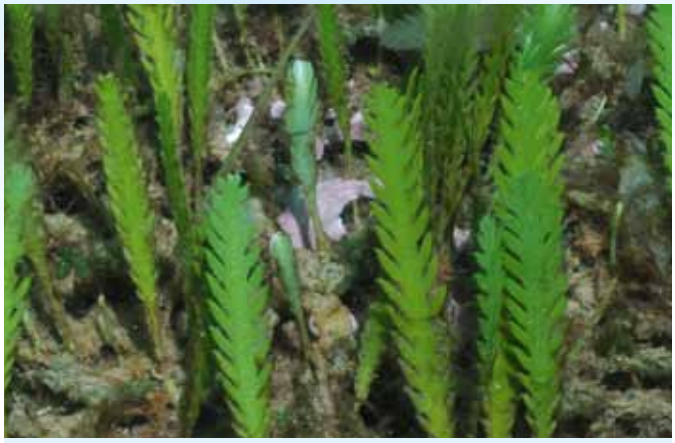
New Holland Seafan (*Peyssonnelia novaehollandiae*) (Photograph: © Graham Edgar).

Mueller's Fern Caulerpa (*Caulerpa flexilis var. muelleri*) (Photograph: © Graham Edgar).

Formal listing of Threatened algal species has been greatly hindered by a lack of knowledge, and only the Rare Three-node Seaweed (*Cystoseira trinodis*) that is limited to Blackman Bay in the south-east[24] is currently listed in Tasmania, whilst no species in Australia have been listed as Threatened nationally or internationally[101]. However research underway has revealed 35 species categorised as rare in Tasmania, with seven of these endemic to our state, and three recommended as vulnerable and potentially endangered due to highly restricted distributions[41].

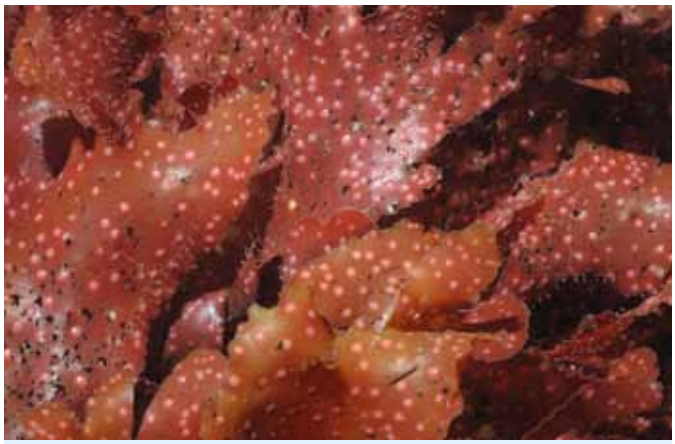


Southern Peacockweed (*Distromium flabellatum*)
(Photograph: © Graham Edgar).



Serrated Caulerpa (*Caulerpa scalpelliformis*)
(Photograph: © Graham Edgar).

Amulet Caulerpa (*Caulerpa hodgkinsoniae*)
(Photograph: © Graham Edgar).

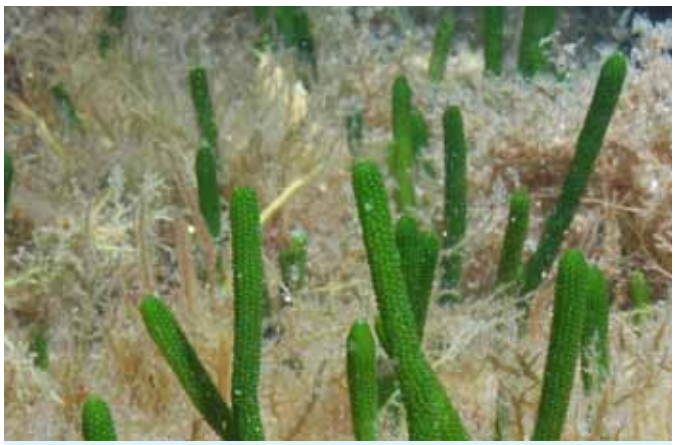


Gunn's Sea Lettuce (*Myriogramme gunniana*)
(Photograph: © Graham Edgar).

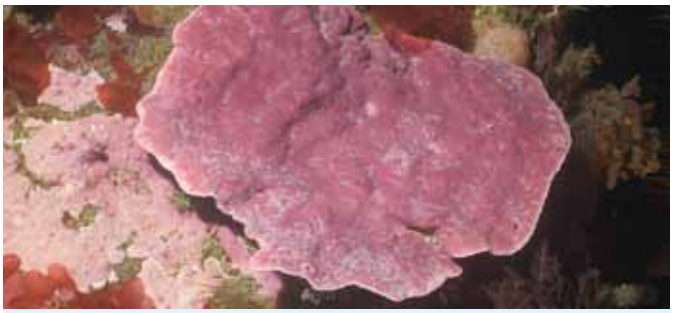
The majority of the endemic species are red algae, and include two species in the genus *Pterothamnion* that are only known from one site each in southern Tasmania. Tasmania's rare algae tend to be associated with unusual combinations of physical parameters such as reef topography, exposure, salinity and light penetration[41].

In addition to endemic species, there are at least five subantarctic macroalgae in Tasmania that have not been recorded elsewhere in Australia, but have been found along cooler coasts overseas[126]. In addition, the magnificent forest-forming Giant Kelp (*Macrocystis pyrifera*) forms major beds only off the Tasmanian coast, generating a major attraction for divers[9]. This kelp is the largest alga in the world and is recognised as a 'keystone' species, providing habitat for a myriad of animals including commercial species such as abalone and rock lobster[1,9] (see Section 4.4).

Other cold temperate algae in Tasmania are also amongst the largest Australian species, including Bull Kelp, Strap Kelp, Common Kelp and other large brown algae such as Crayweed[17,127]. Due to the dominance of these kelps, algal beds in Tasmania have a different structure to those in the warmer temperate latitudes of Australia and have greater affinity with plants in New Zealand and South America[23]. Some kelps are also of commercial significance, such as Bull Kelp (*Durvillaea potatorum*), a species harvested at King Island where it washes onto beaches in large quantities.



Simple-branched Caulerpa (*Caulerpa simpliciuscula*)
(Photograph: © Graham Edgar).



Fan Coralline (*Phymatolithon masonianum*)
(Photograph: © Graham Edgar).

The beautiful Giant Kelp (*Macrocystis pyrifera*) is a 'keystone' species that is important for many marine animals and only forms forests in Tasmania south of Bass Strait (Photograph: © Graham Edgar).

5.5.2. Seagrasses

Seagrasses form luxuriant meadows on parts of Tasmania's seabed and include seven marine species as well as three aquatic grasses in estuaries that support similar ecosystem processes. None of the marine grasses are listed as Threatened, however two of the aquatic grasses, the Large-fruit Seatassel (*Ruppia megacarpa*) and the Tuberous Seatassel (*Ruppia tuberosa*) are listed as Rare in Tasmania. Both species occur in the east and south-east of the state, the Large-fruit Seatassel preferring estuaries and lagoons and the Tuberous Seatassel occurring in channels and saltmarshes[40]. The *Ruppia* species are the only aquatic grasses capable of surviving the highly variable salinities within their upper estuary ranges and, like fully marine grasses, are important for primary production, stabilisation of sediments and provision of structural habitat[128] and food for fish, invertebrates and birds.

Whilst not being listed as Threatened, the marine seagrasses have high conservation values and provide key nursery and foraging habitats for marine animals, including protected and commercially significant species[15,17,63]. Several types of seagrass beds have particularly high natural values, including large and persistent stands of the long-lived Southern Strapweed (*Posidonia australis*) and very deep beds in the clear waters of Bass Strait, whilst beds of Sea Nymph (*Amphibolis antarctica*) on the east coast are critical for fished species such as the Southern Calamary. Further information on these significant areas and the importance of particular seagrass species in our coastal ecology is provided in Section 4.6.

Beds of aquatic *Ruppia* grasses include two estuarine species listed as Threatened in Tasmania (Photograph: © Graham Edgar).

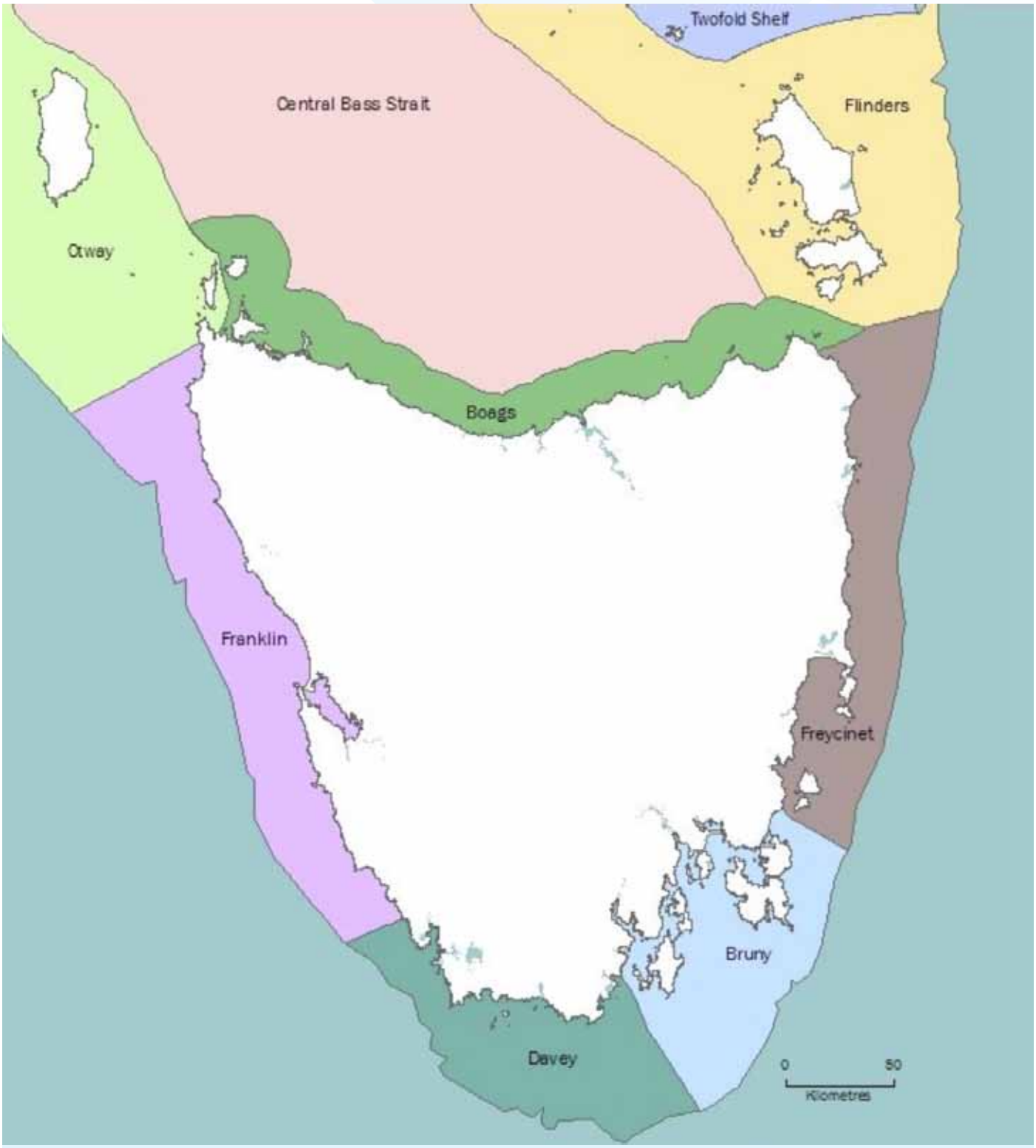
6. MARINE BIOREGIONS – WHAT IS UNIQUE ABOUT YOUR PART OF TASMANIA?

Tasmania's high diversity of marine environments, as reflected by variable ocean currents and temperatures, tidal influences, wave exposure, geology and coastal landforms, has a major influence on the biological communities present around our coast[37]. Variation in these physical features is reflected by distinct changes in the composition of rocky reef fish, invertebrate and algal communities, as well as beach-washed shells and beach-seine collections of coastal and estuarine fishes[126]. On the basis of biological differences, the Tasmanian marine environment has been divided into bioprovinces (scale of 1,000s km) and smaller bioregions (100s to 1,000s km) as part of the Integrated Marine and Coastal Regionalisation of Australia (IMCRA)[129]. This has been undertaken primarily for marine planning and management purposes, and specifically to help establish a National Representative System of Marine Protected Areas (NRSMPA). Relative to its size, Tasmania includes a very large number of bioregions, reflecting the diverse physical conditions and highly localised distributions of our unique marine species.

Four bioprovinces have been identified around Tasmania, as well as an additional bioprovince incorporating Macquarie Island. The majority of the mainland Tasmanian coast falls within the Tasmanian IMCRA Province, which is characterised by a cool temperate assemblage unique from the warm temperate communities of mainland Australia, while the north coast and Bass Strait islands fall into three warm temperate bioregions that share greater similarities with south-east mainland Australia. At a finer scale, Tasmanian state waters include eight bioregions, five that are entirely confined to Tasmania and three that are shared with Victoria, SA, and NSW. A ninth bioregion occurring in central Bass Strait is not considered here because it lacks offshore islands or other state coastal waters. Each of the marine bioregions has distinctive biological and physical attributes that have been acknowledged to be unique to their region and suitable for representation in a system of Marine Protected Areas (MPAs).

A national goal is to establish at least 10% of each marine bioregion within MPAs by 2012[130], and subsequently increase this to 20-30% in line with international commitments. In Tasmania, we are currently falling well short of these targets. Four bioregions - Franklin, Flinders, Otway and Boags - do not contain any MPAs in Tasmanian coastal waters. A total of 21 MPAs have been established across the remaining bioregions, encompassing 2.6% of coastal waters around Tasmania, or 5.7% when the fully reserved 'no take' waters of Macquarie Island are included. An additional consideration is that aside from Macquarie Island, less than half of the total area allocated to MPAs is fully protected as 'no take' (42%), whilst 38% allows limited recreational fishing and the remaining 20% has no restrictions on recreational fishing; hence just 1% of waters around Tasmania are fully protected.

So what is unique and important about the coastal waters near you? The sections below showcase the remarkable diversity of Tasmanian marine environments and biological communities by describing the unique attributes of each bioregion, and the Macquarie Island Province. Also included are some examples of special sites that contain high conservation values and may also be particularly representative of their bioregion - some already declared as MPAs and others not. These incorporate a range of 'standout' sites purely on the basis of ecological attributes, although do not consider other factors necessary for application of the 'Comprehensiveness, Adequacy and Representativeness' (CAR) principles that underpin MPA planning. Numerous additional sites are worthy of consideration during selection processes that apply these principles to the expansion of Tasmania's MPA system. In addition, the marine ecosystems of many remote sections of Tasmania's coastline remain unexplored and hence additional studies are needed to determine their natural values.



Bioregions in Tasmania's coastal waters (Source: Tasmanian Planning Commission, based on Edgar et al. 1995[126] and IMCRA 1998[131]).

6.1. BOAGS BIOREGION – SEAGRASS HAVEN

The base of the Nut at Stanley
(Photograph: © Chris Black).

The name of this bioregion refers to Jimmy Boags[126], a historical identity and founder of a major company that produces a highly popular beverage... Magnificent features characteristic of his region include: the southern-most beds of a conspicuous and long-lived seagrass, the Southern Strapweed (*Posidonia australis*), as well as the majority of habitat for another seagrass, Sea Nymph (*Amphibolis antarctica*); long sandy beaches broken by prominent and geomorphologically unique rocky headlands that extend underwater to depths of ~ 20 m[131]; a high tidal range of 3-4.4 m which creates strong currents and associated diverse communities of sessile filter feeding invertebrates; a high fish diversity; and characteristic Bass Strait rocky reef species that are rare or absent further south, including fishes (e.g. Ornate Cowfish, Snook, Yellow-striped Leatherjacket, Scalyfin), macroinvertebrates (e.g. Mosaic Seastar, Greenlip Abalone), and brown macroalgae (e.g. *Cystophora monilifera* and *Xiphophora chondrophylla*)[126]. This bioregion has a sheltered open coastline, protected from high ocean waves, but is still partly exposed to westerly winds[16].

Major bands of rock type in Tasmania generally run in a north-south direction, changing as you move from west to east. The Boags Bioregion therefore provides a 'cross section' of all the major types and has a highly varied geology[16], ranging from ancient Precambrian (> 600 million years) rocks to more 'recent' Jurassic (~150-200 million years) dolerite, and provides outstanding examples of relic dune systems and beach ridges formed during geological uplift events[1]. The varied rock types in turn provide a wide range of reef structures and substrates that influence the type and diversity of marine species present.

Mosaic Seastar (*Plectaster decanus*)
(Photograph: © Graham Edgar).

Scalyfin (*Parma victoriae*)
(Photograph: © Graham Edgar).

Tidal currents around mainland Tasmania are strongest in this region because of the higher tide range on the wide Bass Strait shelf and more constricted flow around the many offshore islands, inlets and estuaries[16]. Large 'meso-tidal' river estuaries are a major although geographically restricted category of estuary in Tasmania, consisting of 15 estuaries that all occur in this region[71]. Large headlands that 'jut out' into Bass Strait also modify currents and create areas of variable wave exposure and high biodiversity. The Boags Bioregion contains internationally important areas for resident and migratory shorebirds[112], including the top four Tasmanian sites in terms of shorebird diversity, and sites that are the stronghold for many migratory species[13]. Islands within this region provide breeding habitat for large numbers of seabirds[36], and have invertebrate strandline faunas that are amongst the most diverse in Tasmania[67].

Ornate Cowfish (*Aracana ornata*) (Photograph: © Graham Edgar).

High Value Site – Boullanger Bay/ Robbins Island and Passage

In the very north west of our state lies a bird watchers paradise, a biological 'gem' rich in bird life which contains extensive intertidal feeding areas[132] and additional highly productive marine habitats. This area is the most important site for migratory shorebirds in Tasmania, containing the highest diversity of species (12 species[13]) and being of greatest international significance[35]. Bird numbers exceed 1% of national population estimates for seven species, and exceed 5% of estimates for three of these (Double-banded Plover, Red-necked Stint and Ruddy Turnstone)[113]. It is the only site in Tasmania that supports significant numbers of the Grey Plover and Red Knot[113], and is also the Tasmanian stronghold for the Great Knot, Sharp-tailed Sandpiper, Grey-tailed Tattler, Bar-tailed Godwit, Lesser Sand Plover, and Pacific Golden Plover[13]. It is internationally significant for the Endangered migratory Eastern Curlew, and for the resident Pied Oystercatcher, Sooty Oystercatcher and Near Threatened Hooded Plover[70], while the coastal saltmarsh supports the Critically Endangered Orange-bellied Parrot during its migration season[133].

This area also contains exceptional and extensive seagrass beds, including the most prolific beds of the Southern Strapweed in the region, and one of only two known Tasmanian sites for a warm temperate seagrass species, the Fibrous Strapweed (*Posidonia angustifolia*)[56]. Whilst updated seabed mapping is required in this area, 1990s data suggest that this small section of Tasmania's coast may contain more than 10% of our seagrass beds.

Red-necked Stint (*Calidris ruficollis*)
(Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

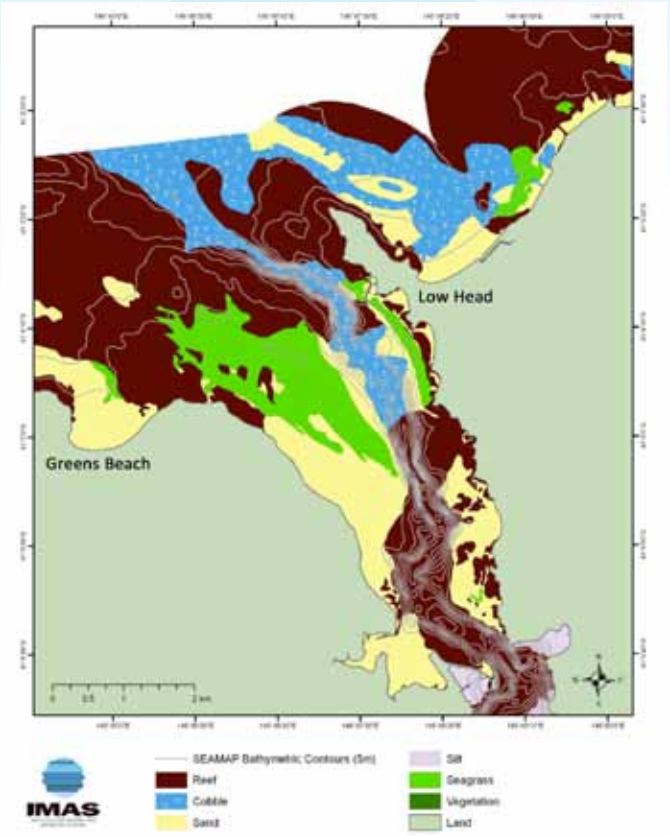
Sooty Oystercatcher (*Haematopus fuliginosus*)
(Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

High Value Site – Lower Tamar Estuary

The Tamar Estuary is totally unique within Tasmania, being the only drowned river valley with a large tidal range[14], whilst the lower estuary is characterised by strong tidal currents and very deep habitats rarely encountered so close to shore (55 m[134])[44]. An extremely diverse range of marine habitats is represented, including sandy beaches, rocky shores, algal and sponge dominated reefs, seagrass beds, soft sandy bottoms and coastal vegetation utilised by seabirds[44]. The Tamar Estuary is unusual in possessing extremely high algal, invertebrate and fish diversities, and a large component of species not recorded in other Tasmanian estuaries[14]. A survey of 111 estuaries recorded the Tamar as having the highest or second highest number of invertebrates and fish in the state[14], whilst this estuary is the only known location to support as many as 300 species of algae[41]. Seagrass communities are also diverse, supporting five out of the seven Tasmanian species[58] within an area less than 4 km^2 [134], with the different seagrass species supporting distinct fish communities[45] and containing shark nursery habitats within a protected Shark Refuge Area[58].

The strong currents and deep consolidated reef and cobble habitats of the estuary channel provide ideal conditions for development of extensive, spectacular 'sponge gardens' that are dominated by sponges, soft corals and gorgonians, and cover an estimated 5.4 km^2 in depths ranging from 15 to 55 m[44,134].

The only other estuary containing such highly developed sessile invertebrate communities is Bathurst Channel in the south-west, but the two systems are totally distinct due to contrasting water clarity, nutrient levels and biogeographic (i.e. warm versus cool temperate) influences.



Diverse habitats and depth profiles at the entrance to the Tamar Estuary (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

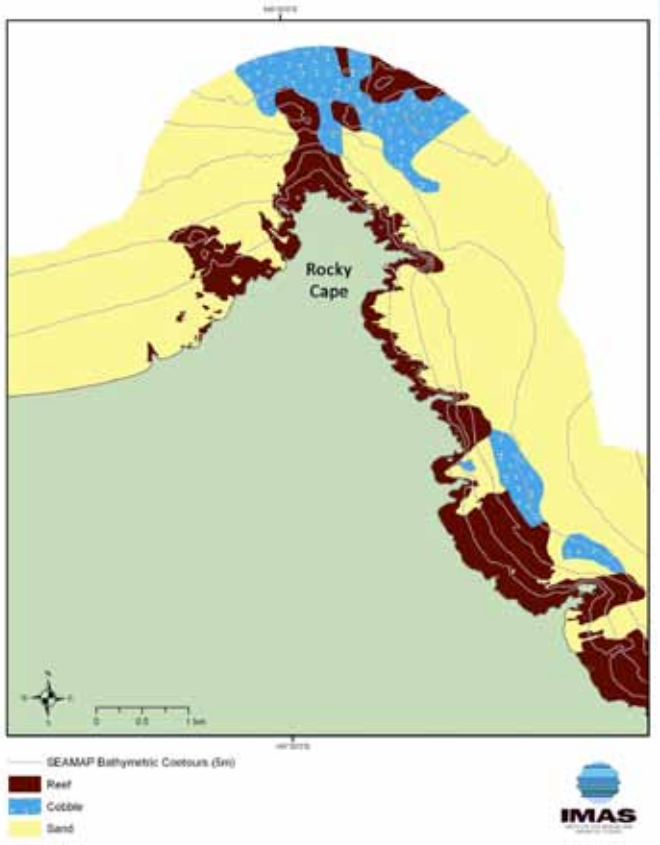
Little is currently known about the deepwater assemblages of the Tamar, but early indications suggest a great wealth of species[44]. As an additional 'feather in its cap', the diversity of shorebirds in the lower Tamar is amongst the highest in the state (eight residents, ten migratory species[13]), while a population of the Little Penguin is of high conservation value[37] and provides a unique tourist attraction for the area.

Spectacular sponge garden, Lower Tamar Estuary (Photograph: © David Maynard, Australian Maritime College)

High Value Site – Rocky Cape

The rocky reefs of this location are exceptional due to a diversity of habitats and species, similarly high geomorphological diversity, relatively low level of anthropogenic disturbance, and high recreational value to divers[126]. The unique assemblages of Rocky Cape are in part a reflection of its unusual physical characteristics, with this site the only area on the north coast where ancient Precambrian rock outcrops into coastal and marine habitats[16]. This rock consists of highly folded metamorphic quartzite that extends offshore as moderately-structured reef, with caves and crevices providing a complex range of habitats for marine life[37]. Unique conditions are also formed by reefs dropping off quickly into deeper water (>25 m), and by the large cape protruding into Bass Strait, causing acceleration of currents and variable exposure to prevailing westerly conditions. The reefs of Rocky Cape are therefore more 'current driven' than typical for the north coast, with the combination of depth and high current resulting in extensive sponge gardens which supplement the high diversity of algal-dominated reef, sparse seagrass and soft sediment habitats found in shallower waters. The combination of reef complexity, and variable currents over a broad depth range has no doubt contributed to the outstanding species richness of the area[37].

Rocky Cape also lies at the very eastern boundary of a marine biological province known as the 'Western Bass Strait Transition' which extends westwards to South Australia[129]. The highly diverse communities of macroalgae, invertebrate and fish at Rocky Cape therefore contain representatives of this province[126] that are absent or uncommon in more eastern parts of the Boags Bioregion or elsewhere to the south in Tasmania.



Complex rocky reefs of variable depths and exposures to prevailing westerly conditions at Rocky Cape (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

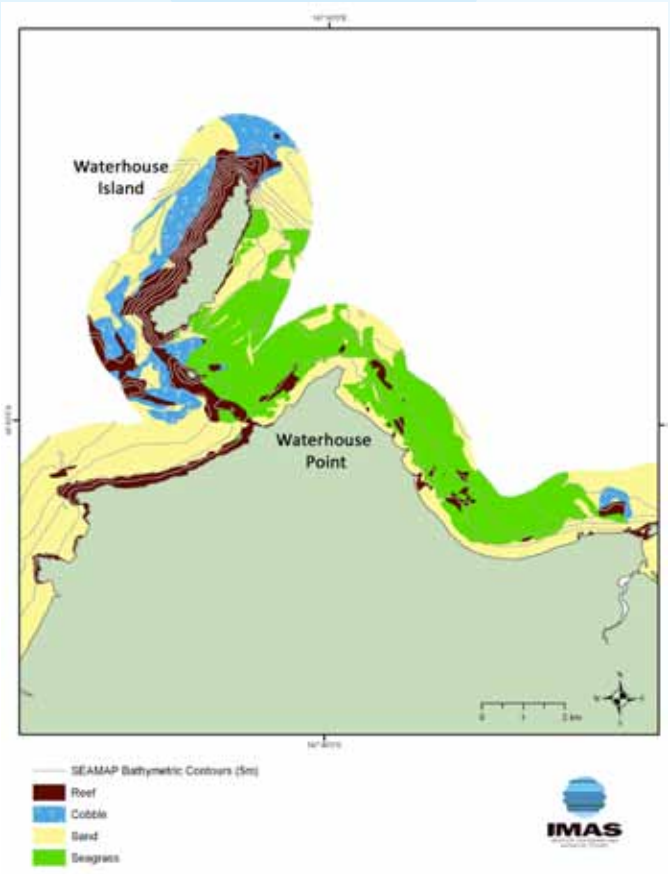
Verco's Nudibranch (*Tambja verconis*), Rocky Cape (Photograph: © Graham Edgar).

High Value Site – Waterhouse

This site shares some attributes with Rocky Cape, however its contrasting geology, biogeographic affinities, unique island association and dominance of seagrass communities make this site outstanding in its own right. The most notable feature is the extensive cover of seagrass that occurs in response to the shelter provided from the prevailing westerly winds by the islands, reef ridge and Waterhouse Point. These dense seagrass beds are dominated by the Southern Strapweed, but also include extensive areas of Sea Nymph and the Tasmanian Eelgrass[37], and extend into deeper waters than typical due to the high water clarity of the area.

Horseshoe Leatherjacket (*Meuschenia hippocrepis*) (Photograph: © Graham Edgar).

Like Rocky Cape, Waterhouse Point and Waterhouse Island 'protrude' into Bass Strait, therefore creating locally strong and variable tidal currents, exacerbated by the restricted channel between the island and mainland. It also includes substantial development of structurally complex reefs that extend into deep waters up to 35 m and experience highly variable wave exposure. Rock types are more geologically recent than found at Rocky Cape, including highly structured dolerite boulder fields and lower relief granites that provide a wide range of habitats[37]. Algal growth on reefs is very dense, often approaching 100% cover, and supports a diverse fish assemblage containing species highly representative of the central 'Bass Strait Province'. Abundant fish species are largely restricted to the north coast, such as the Magpie Perch, Old Wife, Zebrafish, Yellowstriped Leatherjacket, Horseshoe Leatherjacket, Rainbow Fish and Scalyfin. The outstanding species richness of this location can be attributed overall to high habitat diversity within a small geographical area, including reefs and sandy areas with highly variable depths, exposures and current strengths[37]. The shoreline includes a mix of sandy beaches and rocky intertidal habitat, and is also of geological interest due to relict terrestrial dune systems originally sourced from the dry bed of Bass Strait during glaciation events[1].



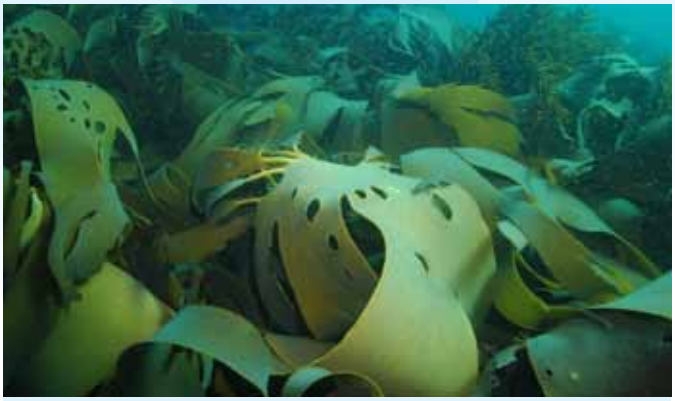
Extensive seagrass areas and diverse reef habitats at Waterhouse Point and Island (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

Brownstriped Leatherjacket (*Meuschenia freycineti*) (Photograph: © Graham Edgar).

6.2. OTWAY BIOREGION – WAVES AND WINTER WARMTH

'High energy' is the best way to describe the remote and magnificent coastline of the Otway Bioregion, which is named with reference to Cape Otway on the Victorian coast. Exposure to strong wave action, steep seabed profiles and fast currents through the western entrance to Bass Strait[131] create a paradise for plants and animals demanding high water movement. An example is the Bull Kelp, a large brown alga endemic to the exposed rocky coastlines of Tasmania and south east mainland Australia which thrives in the high wave action of this region and has become the basis of a kelp industry on King Island.

The Otway Bioregion also includes western Victoria and eastern SA[129], and hence our Otway coasts have an affinity with these areas[131] as demonstrated by the close similarities of King Island and Cape Otway intertidal faunas[126]. The tail of the Leeuwin Current originating in Western Australia and travelling eastwards across the Great Australian Bight extends into this region during winter months, bringing with it warm temperate SA species such as the Queen Morwong that are uncommon elsewhere in Tasmania, and resulting in the warmest water temperatures in the state[126]. In Tasmanian waters, the majority of coastal waters of this bioregion are located around King Island, however it also includes the rugged north-western tip of mainland Tasmania and offshore islands that are critical for our seabirds and marine mammals. Contained within the region is one of the largest Tasmanian breeding colonies of the Australian Fur Seal – the only colony in western Bass Strait – as well as Nationally Critical albatross habitat. Upwellings of cool, nutrient rich waters in this region[131] are likely to provide a rich food source for these foragers of the open sea. The Otway Bioregion also has outstanding geological diversity and geoconservation values, including outcrops of ancient Precambrian rocks and a diverse range of more recent rock types such as granites, marine dolomites and limestones[16,135].



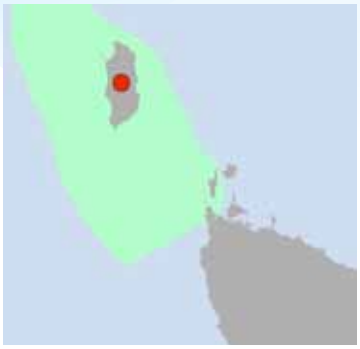
The Bull Kelp (*Durvillaea potatorum*) thrives in the exposed conditions of the Otway Bioregion (Photograph: © Graham Edgar).

Cushion Star (*Petricia vernicina*) (Photograph: © Graham Edgar).

Red Bait Crab (*Plagusia chabrus*) (Photograph: © Graham Edgar).

Castelnau's Wrasse (*Dotalabrus aurantiacus*) (Photograph: © Graham Edgar).

High Value Site – King Island



While King Island covers a broad area, sites of high value for different types of marine communities are widely distributed on this remote and unique slice of Tasmania and more detailed studies are required to identify the areas that best represent its outstanding conservation values. The coastal environment of this island has a character all its own, located in the path of the infamous Roaring 40's gales and therefore frequently experiencing winds exceeding 100 km/hour. The geological diversity of King Island is renowned and reflected by a structurally complex seafloor and a range of spectacular coastal formations such as sea-caves, sheer cliffs and outstanding beaches[1]. The coastal waters are important for commercial species such as crayfish, abalone and Bull Kelp, and contain reef fish, invertebrate and algal communities distinct from other areas of the state[6,126]. The Christmas and New Year Islands off the northwestern coast of King Island have particularly diverse marine habitats and have been recognised as a conservation hotspot for marine life. These islands contain the greatest range of marine habitats and highest biodiversity in the vicinity of King Island, including extensive seagrass beds and abundant populations of species rarely found elsewhere in Tasmania, such as Troughton's Seastar and the red alga *Plocamium preissianum*[126].

King Island also has high conservation value for resident and migratory shorebirds, being recognised as internationally significant for resident seabirds including the Pied Oystercatcher, Sooty Oystercatcher and Near Threatened Hooded Plover, as well as the migratory Ruddy Turnstone[98,112]. King Island supports large colonies of Little Penguins and Short-tailed Shearwaters, while recent surveys found that it holds two thirds of the breeding population of the Vulnerable Fairy Tern and more than half of the Endangered Little Tern, making it the most important Tasmanian locality for these Threatened species[136]. Almost 20 migratory shorebird species have been recorded[98], with similar diversities and species composition to the important Boullanger/Robbins Passage site in the Boags Bioregion, suggesting an interchange of shorebirds and potentially critical reliance between these two areas[136]. King Island's saltmarshes within the Sea Elephant estuary of the Lavinia Nature Reserve are of high significance as foraging habitat for the Critically Endangered Orange-bellied Parrot. This internationally significant 'Ramsar' wetland represents 10% of the saltmarsh habitat that is classified as having a high conservation value statewide[71].

Toothbrush Leatherjacket *(Acanthaluteres vittiger)* (Photograph: © Graham Edgar).

Greenlip Abalone (*Haliotis laevigata*) (Photograph: © Graham Edgar).

King Island's beaches and dunes are important for shorebirds including Threatened tern species (Photograph: © Karen Parsons).

The Black Cowry (*Zoila friendii*), a species limited to the north west in Tasmania (Photograph: © Graham Edgar).

High Value Sites – Seabird Islands: Albatross Island and Black Pyramid

The Otway Bioregion includes numerous small offshore islands that support prolific seabird populations. However two provide refuges for particularly unique seabird populations that are very rare elsewhere in Tasmania or indeed the world. Listed nationally as Critical Habitat, Albatross Island has been described as appearing 'almost white with birds' and is home to 5000 pairs of the Tasmanian endemic and Vulnerable Shy Albatross[36], representing 40% of the total known population of this species. To cap off its status as a seabird haven, this island also supports breeding populations of six additional species, including 30,000-50,000 breeding pairs of the Fairy Prion. It is a regular haul-out for both the Australian Fur Seal and the Rare New Zealand Fur Seal, and is occasionally visited by Endangered Southern Elephant Seals and Vulnerable Australian Sea Lions[36].

Black Pyramid Rock is a spectacular tear-drop shaped island with sheer cliffs surrounding much of the island. It is on this isolated rocky outcrop that more than 12,000 pairs of the Australasian Gannet breed each year, with carefully measured pecking distances between nest sites reflected by the uniform pattern of birds within the colony[36]. This represents the largest breeding population of this species, and one of only three colonies, in Tasmania. At a global scale, this rocky island accounts for 20% of the total Australasian Gannet population[133].

Australasian Gannet (*Morus serrator*) breeding site (Photograph: © Biodiversity Monitoring Section, DPIPWE).

6.3. FLINDERS BIOREGION – CLEAR WATER ISLANDS

The Flinders Bioregion is named after Flinders Island and refers to Matthew Flinders, the navigator who made the remarkable discovery of a broad and island-dotted strait separating Tasmania from the land mass to the north. Outstanding features of this region include diverse island archipelagos with distinctive granite shores, a wide range of exposures and tidal currents, extensive sandy beaches, protected shallow habitats supporting vast seagrass beds[131], and unusually high estuarine biodiversities[14]. This bioregion is dominated by the Furneaux Group, which includes more than 60 islands and numerous additional islets, but also includes the small Curtis and Hogan Island groups to the north-west[28,126].

Eastern shores are exposed to strong swells from the Tasman Sea, while other areas are relatively protected but experience strong tidal currents due to constricted flows around and between islands[16]. Remarkable coastal features include the calcarenite cave system on the Flinders Island south-west coast, spectacular parallel dune systems enclosing brackish lagoons along the east coast of the Furneaux Islands, and the saline lagoon systems of Cape Barren Island[1].

Giant Cuttle (*Sepia apama*)
(Photograph: © Graham Edgar).

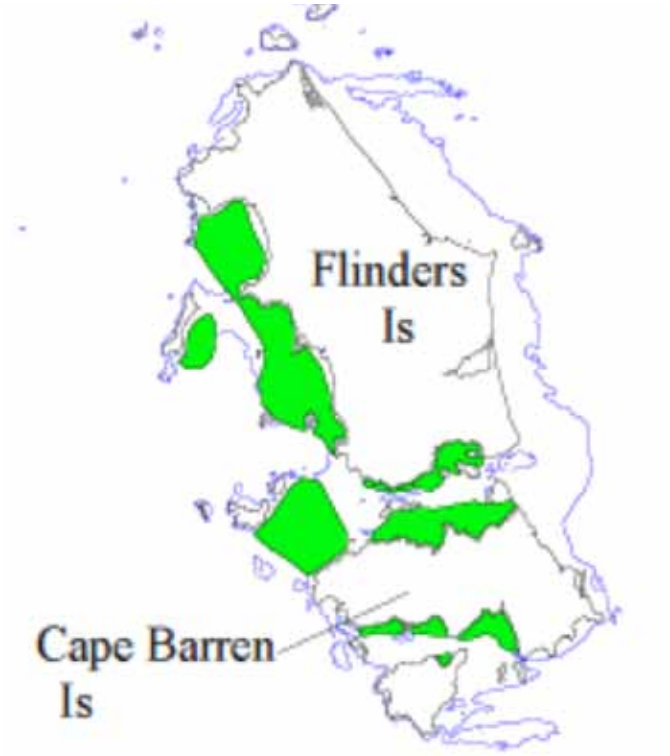
A colourful nudibranch (Shorttail Ceratosoma, *Ceratosoma brevicaudatum*) grazing on the surface of a gorgonian coral (Photograph: © Graham Edgar).

Pink Top shell (*Calliostoma armillatum*)
(Photograph: © Graham Edgar).

Old Wife (*Enoplosus armatus*)
(Photograph: © Graham Edgar).

Southern Six-armed Star (*Meridiastra medius*)
(Photograph: © Graham Edgar).

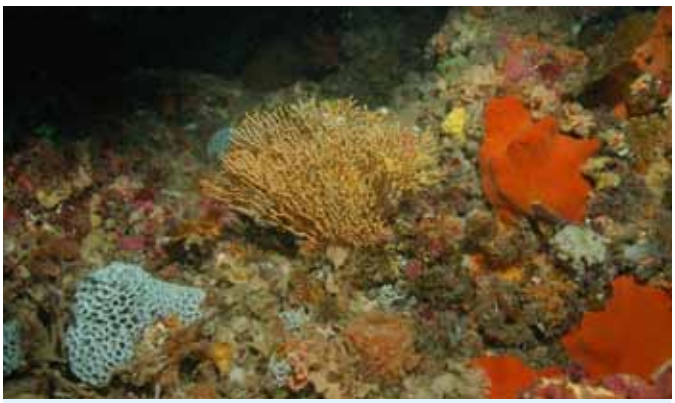
The Furneaux Group contains extensive areas of protected habitat that are particularly significant for seagrass, with limited mapping data suggesting that these islands may contain more than 50% of Tasmania's total seagrass habitat. Reef plants and animals in this region contrast with those of other parts of Tasmania, while invertebrates are highly variable even between the various island groups[126]. This bioregion is also remarkable for its estuarine biodiversity and naturalness, containing nearly one third of 48 Tasmanian estuaries categorised as having critical or high conservation significance. Cape Barren Island alone has a total of seven pristine estuaries[7], while the Furneaux Group, together with the north-east of mainland Tasmania, contains a range of estuarine species that are not found elsewhere in Tasmania[14].



Seagrass beds (green) mapped in the 1990s in the Furneaux Group (Source: Jordan et al. 1998)[45].

The Flinders Bioregion has high conservation value for seabirds and shorebirds, containing more than 20% of Tasmanian sites listed as internationally Important Bird Areas (IBAs)[35]. These areas contain significant populations of resident shorebirds, including the Hooded Plover, Pied Oystercatcher, and Sooty Oystercatcher[137], while several sites at Flinders Island are of international significance for the migratory Sanderling, Curlew Sandpiper and Red-necked Stint[112]. The Furneaux Group is also a hotspot for seabirds such as terns, containing breeding habitat for four species including the Vulnerable Fairy and White-fronted terns[36] and supports more than 250,000 pairs of Little Penguins, 7.5 million pairs of Short-tailed Shearwaters, and 60,000 pairs of White-faced Storm-Petrels[98]. The Flinders Bioregion is the Tasmanian stronghold for the Australian Fur Seal and supports 90% of the Tasmanian breeding population, or 18% of the total population of this endemic south-east Australian species[93].

Red-necked Stints (*Calidris ruficollis*)
(Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).



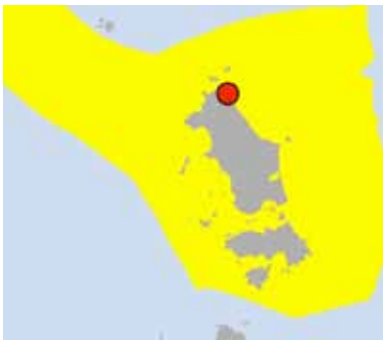
Colourful sponge and coral garden, Flinders Island
(Photograph: © Graham Edgar).

Prickly Rose Sponge (*Dendrilla cactos*) Flinders Island
(Photograph: © Graham Edgar).

Blue-ringed Octopus (*Hapalochlaena maculosa*)
(Photograph: © Graham Edgar).

The Seagrass Egg Urchin (*Amblypneustes sp. 1*) grazing on another seagrass species, Sea Nymph (*Amphibolis Antarctica*) (Photograph: © Graham Edgar).

High Value Site – North East Inlet and Adjacent East Coast Beaches



North East Inlet is located at the northern end of Flinders Island and is one of ten estuaries identified statewide as having critical conservation significance[14]. This estuary possesses exceptional species richness, and provides habitat for a quantum level more invertebrate and fish species than all other Tasmanian estuaries apart from the almost comparably diverse Tamar Estuary. The estuarine fauna includes numerous invertebrate and fish species not recorded in other Tasmanian estuaries, as well as fish species not recorded at any other location around the state[28].

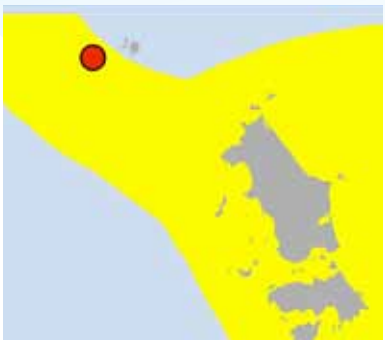
While much of the Flinders Island coastline is important for shorebirds, the extensive east coast beaches between Pot Boil Point and North East Inlet are of particular significance and contain a disproportionately high number of resident shorebirds[137]. Based on recent surveys, this stretch of coast holds 84% of the Hooded Plovers, 55% of Pied Oystercatchers and 77% of the Red-capped Plovers recorded around the Flinders Island coast. Given the large numbers of resident shorebirds, and additional suitable nesting habitat for small terns, this area is of highest conservation value to nesting shorebirds and small terns on Flinders Island[137].

High Value Site – West Coast Furneaux Seagrass Beds

Mapping in the 1990s revealed exceptional seagrass beds along the western shores of Flinders Island that are impressive in areal magnitude, density and unusually large depth range[45,56]. Vast beds, extending as far as 10 km offshore from the coast were detected, and are likely to be a major contributor to nutrients in eastern Bass Strait. While the dominant species, the Southern Strapweed, generally occurs to maximum depths of 15 m[53], beds have been recorded in depths of up to 20 m along the west coast of Flinders Island, reflecting the exceptional water clarity in this region. Even at this depth, the limit of surveying, seagrass reaches a high density suggesting that the beds extend into even deeper water[45]. This area is only one of two locations in Tasmania where the related Fibrous Strapweed has been observed[45], and is highly unusual in being located 600 km to the east of the mainland Australian distributional limit of this species[53].

The Furneaux Group supports very large beds of seagrass, particularly the Southern Strapweed (*Posidonia australis*) (Photograph: © Graham Edgar).

High Value Site – Judgement Rocks



Judgement Rocks are a remote and spectacular group of rocky islets located to the north west of the Furneaux Group. They are the most important site for the Australian Fur Seal in Tasmanian waters, supporting by far the largest breeding colony, with nearly 2,500 pups recorded in most recent annual counts[36,93]. Nearly 60% of the Tasmanian population and 10% of the total population of this species occupy these small islets[93]. The main island referred to as Judgement Rock has impressive granite cliffs, caves and gulches and a broad rocky plateau that provides the habitat so desired by breeding seals, while the seals also haul-out onto three adjacent rock stacks[36]. In addition to its high population numbers, this site is especially significant because, unlike other Tasmanian colonies, it is secure from high seas when the pups are young and vulnerable. The choice of such a site is well justified, especially as Orcas (Killer Whales), a natural predator of seals, are known to peruse the area... [36]

Judgement Rock, supporting the largest breeding population of the Australian Fur Seal (*Arctocephalus pusillus*) in Tasmania (Photograph: © Biodiversity Monitoring Section, DPIPWE).

Playful Australian Fur Seals (Photograph: © Jane Elek).

High Value Sites – Franklin Sound and Banks Strait

Franklin Sound is the island-dotted area of water separating Flinders Island and Cape Barren Island. It has been identified as an Important Bird Area (IBA), supporting internationally significant populations of the Black-faced Cormorant, White-faced Storm-Petrel, Short-tailed Shearwater and Sooty Oystercatcher[35]. Underwater, the entrance to Franklin Sound is particularly interesting because it contains a huge diversity of habitats, including sand and reef habitats in both shallow and deep water, and extensive seagrass beds containing the Southern Strapweed and Sea Nymph. This area has a high recorded biodiversity and its location directly next to a National Park reflects complementary marine and terrestrial conservation values. The area of southwestern Flinders Island from Badger Corner to Trousers Point and extending for 1 km offshore is considered to be most representative of the high values of Franklin Sound[126].

To the south of the Furneaux Group lies Banks Strait, the south-eastern opening of Bass Strait into the Tasman Sea. The constriction of water flow through this entrance creates strong tidal currents as evidenced by deep scouring around the southern islands of the group. The channel separating Passage Point on Cape Barren Island from Passage Island provides an example of this, where currents race through and have scoured a deep channel. The habitat here in some ways parallels the deep channel entrance of the Tamar Estuary on the north coast, however the water here is much clearer, more influenced by the warm East Australian Current, and is fully marine with minimal freshwater or catchment inputs. It therefore represents a highly restricted habitat that is likely to support unusual biological communities, although its marine life remains largely a mystery at this stage[38].

Granular Seastar (*Uniophora granifera*) (Photograph: © Graham Edgar).

6.4. TWOFOLD SHELF BIOREGION – WHERE THREE BIOPROVINCES MEET

The Twofold Bioregion is primarily located along the Victorian and New South Wales coasts, and is named after a representative area, 'Twofold Bay', in the latter state. However, the unique and beautiful islands of the Kent Group within the north-eastern Bass Strait waters of Tasmania have a high affinity with these coasts and provide the only Tasmanian representatives in this Bioregion[6]. The waters surrounding the Kent Group are reserved and currently represent the largest Marine Protected Area in Tasmanian waters other than Macquarie Island. They are strongly influenced by the warmer waters brought into Bass Strait by the East Australian Current and include a diversity of reef habitats, including encrusting coralline-algal reefs with very few macroalgae as well as the more typical macroalgal-dominated reefs[64], and a range of fish and other species not found further south in Tasmania[131].

As a whole, the Twofold Bioregion is characterised by an exposed coastline with variable wave energy, long sandy beaches broken by rocky headlands, and numerous coastal lagoons[131]. In Tasmanian waters, we associate it more specifically with spectacular offshore islands that contain pristine marine habitats ranging from beaches to deep reefs, and support a rich community of intermixed warm- and cool-temperate plants and animals.

Green Solitary Coral (*Scolymia australis*) (Photograph: © Neville Barrett).

Irregular Seastar (*Smilasterias irregularis*) (Photograph: © Graham Edgar).

Southern Maori Wrasse (*Opthalmolepis lineolatus*) (Photograph: © Graham Edgar).

Kent Group scenery (Photograph: © Graham Edgar).

Fish and invertebrate communities at a shipwreck site, Kent Group (Photograph: © Graham Edgar).

High Value Site – Kent Group of Islands

The Kent Group has been recognised as having outstanding conservation values due to its unique biogeographical location at the convergence of the three southern Australian marine biological provinces[138], incredibly high biodiversity, and exceptional water clarity resulting from its isolation from major sources of runoff or pollution[10]. This group is located approximately half way between Wilsons Promontory and Flinders Island, and consists primarily of the Deal, Erith and Dover islands and the wide Murray Passage running through the centre of the group. A diverse range of habitats reflect the unusual bathymetry, oceanography and geomorphology of the region, and include rocky reefs of varying exposure and depth, sheltered coves with seagrass, sandy habitats and very extensive sponge beds (> 100 km^2)[64]. Local currents are variable and can be particularly strong in Murray Passage, while the islands' granitic structure results in structurally complex reefs dominated by large granite blocks with associated clefts, ledges and caverns[10]. This adds to the habitat diversity of the reefs, which extend from shallow waters to impressive depths of up to 60 m[139]. Seagrass habitats extend deeper than 20 m due to the unusually clear water[140], representing a rare habitat in Tasmanian waters[65]. The strong influence of the warm East Australian Current (EAC) on the biota, coupled with a lack of estuaries and a steep underwater depth gradient, differentiates this area from the adjacent Furneaux Group Islands[138].

Southern Hinge-back Shrimp (*Rhynchocinetes australis*) (Photograph: © Graham Edgar).

Hollow-spined Urchin (*Centrostephanus rodgersii*) detail (Photograph: © Graham Edgar).

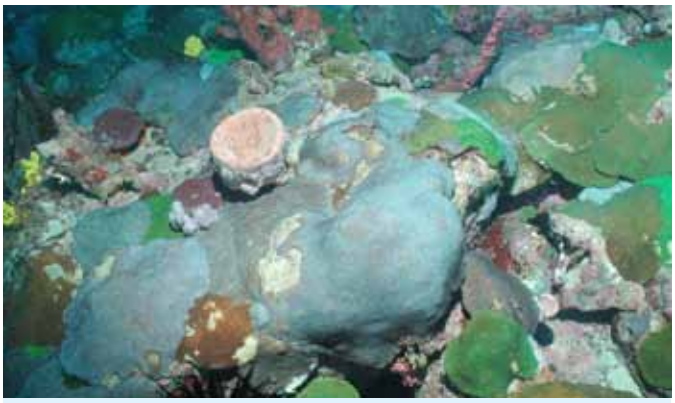
Butterfly Perch (*Caesioperca Lepidoptera*) in coral gardens (Photograph: © Graham Edgar).

Complex shoreline and marine habitats at the Kent Group, with notably large surrounding areas of sponge habitat (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

Sponge garden detail
(Photograph: © Neville Barrett).

The Kent Group supports a higher diversity of marine plants and animals than most neighbouring areas of Bass Strait due largely to the influx of warm temperate faunal species via the EAC[65]. The fish fauna reflects a strong NSW influence, while the marine plants are most similar to those in SA, and cold temperate species limited to the Tasmanian region are also present[6,10]. The 'character' of reefs is also distinct due to the presence of shallow reefs that are encrusted by coralline algae and generally lack macroalgae due to the grazing activities of another typical NSW species, the Hollow-spined Urchin (*Centrostephanus rodgersii*)[126]. The Kent Group has a rich fish fauna compared to other areas of Tasmania, with 35% of species either not recorded from other Tasmanian coastal waters or limited to the north coast (e.g. Eastern Blue Grouper and Crimson Banded Wrasse)[65]. Mobile invertebrate communities are also distinctive due to the presence of species rarely found further south (e.g. Multi-spined Seastar, Pale Mosaic Seastar)[138], while sponge gardens cover a remarkable 40% of habitats in depths › 40 m and include encrusting, erect and branching sponges, as well as many ascidians, octocorals, soft corals, anemones and bryozoans[64]. A coral community that partly covers the seabed of Murray Passage at 30 m depth is particularly unusual[28]. The islands of the Kent Group support many species of breeding seabirds that are dependent on the surrounding marine environment for food, with the strong tidal influence and turbulent waters of Murray Passage acting to concentrate food for predators such as Little Penguins[140].

Palm sponge gardens
(Photograph: © Graham Edgar).



Coral garden in Murray Passage, Kent Group
(Photograph: © Graham Edgar).

6.5. FRANKLIN BIOREGION – RUGGED, REMOTE BEACHES

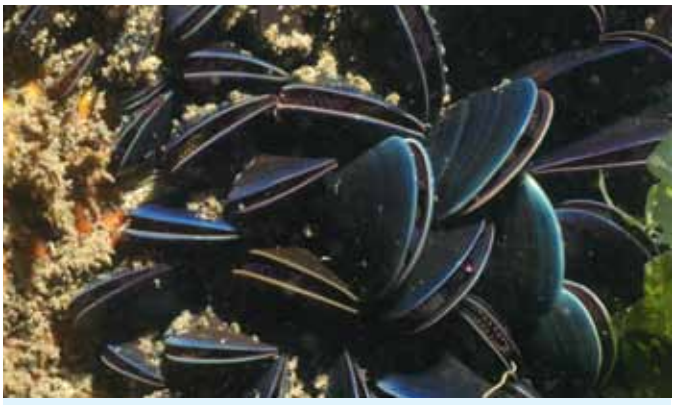
The Franklin Bioregion occupies the majority of Tasmania's west coast and refers to the Franklin River, an iconic feature of our Wilderness World Heritage Area[126]. The remote and largely pristine coastline of this region lies in the path of strong westerly winds of the Roaring 40s and is subject to some of the most extreme weather on earth. Waves build up over thousands of kilometres in the southern Indian and Atlantic oceans before breaking on the Tasmanian west coast. The largest wave recorded in temperate Australian coastal waters was measured in this region – a 19.8 m giant off Ocean Beach[23]! The exposed open coastline has many long sandy beaches that are separated by rocky headlands[131], with few comparable undisturbed, high energy rocky and sandy coasts found in the world's temperate zones. A diversity of landforms includes outstanding coastal features such as raised marine terraces that provide Australia's most complete record of sea level in relation to tectonic uplift[1]. The only deviation from the characteristic high-energy coastline is Macquarie Harbour, a massive inlet on the central west coast that receives high volumes of freshwater from the King and Gordon rivers and forms Tasmania's largest estuarine system.

Rather than possessing characteristic plants or animals, the biological communities of this region are distinctive for their low diversity of reef plants and animals, soft-sediment fish communities, estuarine fish and macroinvertebrate assemblages, and molluscs in collections of beach-washed shells[14,126]. This has been attributed to a combination of very high wave energy on the open coast[131] and low nutrient, dark stained waters in estuaries that restrict algal growth and hence primary production[14]. Despite the low diversity, some attributes of the Franklin Bioregion's fauna are unique, and this vast length of coastline has considerable conservation value on the basis of its largely pristine state. Beach habitats of the region are important for both resident and migratory shorebirds, with Ocean Beach internationally significant for the migratory Sanderling[112], and also supporting high numbers of Double-banded Plovers and Red-necked Stints. The north-west coast provides extensive stretches of suitable nesting habitat for resident Hooded Plovers, Pied Oystercatchers, Sooty Oystercatchers and Vulnerable Fairy Terns[132].

Unique geology of Tasmania's west coast (Photograph: © Karen Parsons).

Red Velvetfish (*Gnathanacanthus goetzeei*) (Photograph: Graham Edgar).

Warrener (*Turbo undulatus*) (Photograph: © Graham Edgar).



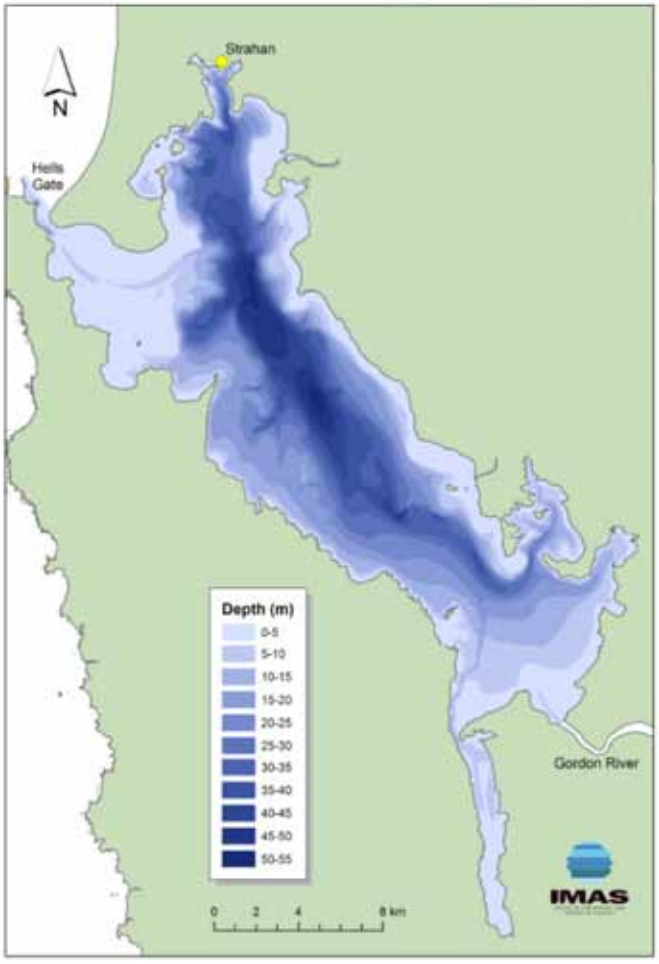
Blue Mussel (*Mytilus galloprovincialis*) (Photograph: © Graham Edgar).

The unique and picturesque Macquarie Harbour (Photograph: © Adam Davey).

High Value Site – Macquarie Harbour

Macquarie Harbour is unique within the Franklin Bioregion and Australia at large. This massive inlet, which is one of the largest estuarine systems in the country, covers 295 km² [7] and is therefore six times the size of Sydney Harbour! It has highly unusual physical and hydrological characteristics, with the only similar water body in Tasmania being Bathurst Harbour further to the south[73]. These two estuaries are unique in Australia, having highly stratified waters, a darkly stained brackish surface layer, and relatively deep (>30 m) basins separated from the sea by shallower areas. Macquarie Harbour is however distinctive from the Bathurst system due to higher nutrient levels[73], more restricted marine flows at its narrow entrance, and its 'three-layer' system comprising a surface layer of mixed marine and freshwater origin, a marine bottom layer, and also an intermediate slowly changing mid-layer[141].

Biological studies within Macquarie Harbour have also revealed a remarkable discovery. The Endangered Maugean Skate is an endemic western Tasmanian species that was only discovered in 1988 and is limited to brackish upper estuary waters (see Section 5.3). This species was initially believed to be confined entirely to Port Davey in Tasmania's south-west, however it was subsequently recorded in Macquarie Harbour, where it is in fact more abundant and widespread[46]. The highly limited distribution of this 'micro-endemic' fish means that protection of its habitat is a very high conservation priority[38].



Macquarie Harbour depth contours, illustrating the presence of a deep basin separated from the sea by a shallow entrance (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

High Value Sites – Sloop Rocks and Point Hibbs

The marine habitats of the open coast are poorly known in the Franklin Bioregion, however amongst the sites examined during reef surveys, the Sloop Rocks area south of the entrance to Macquarie Harbour is considered to contain the best known representation of the reef assemblages in this region[126]. The area from Dunes Creek to Gorge Point (including offshore Sloop Rocks) contains deep as well as shallow reefs and some shelter to the prevailing westerly swells, and is therefore expected to contain a high proportion of the Franklin open coast biodiversity. The environment around Point Hibbs has not been surveyed but includes an even wider range of wave exposure, and may also provide a wider range of tidal currents and other conditions given the presence of a protruding headland and associated small island (Hibbs Pyramid). This site is worthy of investigation, since it may yet prove to best represent the range of open coast habitats within the rugged Franklin Bioregion[126].

Eleven-armed Seastar (*Coscinasterias muricata*)
(Photograph: © Graham Edgar).

Bluethroat Wrasse (*Notolabrus tetricus*)
(Photograph: © Graham Edgar).

High Value Site – Wanderer Estuary

The remote Wanderer River Estuary located 60 km south of Macquarie Harbour is one of ten estuaries statewide that has been classified as having critical conservation significance[14]. This estuary is very unusual in that despite having a large catchment and occurring in a high rainfall area, it is occasionally closed by a sand barrier. Such an estuary is more typical of the dry east coast where low rainfall and hence freshwater flows provides greater opportunity for accumulation of sand around estuary entrances. In a characterisation of 111 estuaries around Tasmania on the basis of physical variables, the Wanderer Estuary was one of only two estuaries (the other being the Tamar Estuary, see Section 6.1) that formed its own unique group within the nine estuary groups identified. The fish and invertebrate assemblages in the estuary are very different to those of other barrier estuaries, and contain very few species as well as low animal abundances. The value of this estuary therefore lies not in high biodiversity, nor in it being representative of the Franklin Bioregion, but instead to it being highly pristine and the only estuary of its type in Tasmania[14].

Wavy Top Shell (*Clanculus undatus*)
(Photograph: © Graham Edgar).

Bramble coral (*Acabaria sp.*) in Bathurst Channel (Photograph: © Graham Edgar).

6.6. DAVEY BIOREGION – PRISTINE MARINE WILDERNESS

Named with reference to Port Davey, the Davey Bioregion has the most extensive undeveloped coastline in southeastern Australia[126], and extraordinary marine values that contribute to the international significance of the broader south-west Tasmanian Wilderness World Heritage Area[1]. It has an extremely exposed open coastline[131], experiencing persistent westerly air streams, high rainfall and heavy ocean swells[68] that are reflected by its dramatic coastal landforms. Extensive rocky headlands occur along the coast and are separated by sandy beaches[131], while the diverse ecosystems include maximally and sub-maximally exposed rocky coastlines, numerous spectacular offshore islands, and the sheltered estuarine areas of Bathurst Channel and Harbour. The region is globally unique by virtue of its isolation, lack of disturbance and lack of pollution from the land, while the southern shores and offshore islands provide a strong ecological link with the Southern Ocean[68]. It contains many pristine estuaries, including four out of ten categorised statewide as having critical conservation significance[14]. New River is arguably the most pristine integrated coastal, estuarine and freshwater system in Australia[1], while the Port Davey/ Bathurst Harbour system is the most geomorphologically prominent feature of the region and has globally significant conservation values associated with its highly unusual physical attributes and biological communities[126]. The majority of the latter estuary is located within the only Marine Protected Area declared to date in this bioregion.

The major biological features of the Davey Bioregion are an algal flora that includes elements very distinct from those found elsewhere, and a low diversity of reef fish[14,126] associated with high wave exposure on the open coast, and combined influences of low productivity and high freshwater inputs in estuaries. However, fish communities include a large number of highly restricted endemic species, including an Endangered relic skate, sandfish, cave dwelling ling and clingfishes[68]. Algal communities are unique due to unusual conditions both in estuaries and on the open coast; in the tannin-affected estuaries, brown kelps are replaced at shallow depths by a range of delicate red algae usually found much deeper, while heavy wave exposure on the open coast has the reverse effect of pushing Bull Kelp to much greater depths than recorded elsewhere[68]. Marine invertebrate communities contain many potentially endemic species recorded from only one location[73,142], while the high diversity of beach sandhoppers and relatives in undisturbed habitats is globally unique and has facilitated study of the transition of life from sea to land[68]. The Davey Bioregion contains significant bird populations, particularly on remote offshore islands, including critical albatross habitat, approximately five million seabirds dominated in number by Short-tailed Shearwaters and Fairy Prions, and internationally significant (i.e. > 1% of total population) numbers of three resident shorebird species[133]. These islands also include the only breeding habitats around Tasmania for two Threatened seal species.

Cream Sea lace (*Hornera robusta*) (Photograph: © Graham Edgar).

Map showing the localities of Port Davey, Bathurst Channel and Bathurst Harbour (Source: Parks and Wildlife Service, Tasmania).

High Value Site – Port Davey/Bathurst Harbour

This outstanding and globally significant drowned river valley represents one of the most unique and complex of Tasmania's marine environments[126], and the only large estuarine system in southern Australia without significant human impact. Whilst not of glacial origin, it has many characteristics of fjords, including a shallow entrance, deep channel connecting an almost land-locked harbour to the sea, and unique populations of endemic sessile invertebrates[11,74]. Its unusual physical attributes include possibly the lowest recorded nutrient levels for any temperate estuary worldwide[143], and distinct layering ('stratification') due to dark tannin-stained surface waters overlying clear marine waters and preventing light penetration to depth. The latter results in 'deepwater emergence'[74], a process not known to occur on the same scale elsewhere around Australia[138], whereby typical shallow water species are replaced by fascinating deepwater communities rarely encountered within diving access[76].

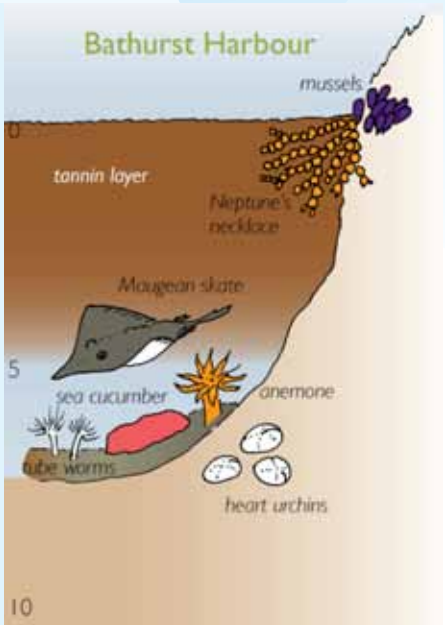
Communities vary along the length of the estuary in response to gradients in nutrient availability, light penetration and water stratification[74,144], with the inner sheltered harbour, deep channel and more exposed seaward entrance each supporting distinct types of animals and plants[144].

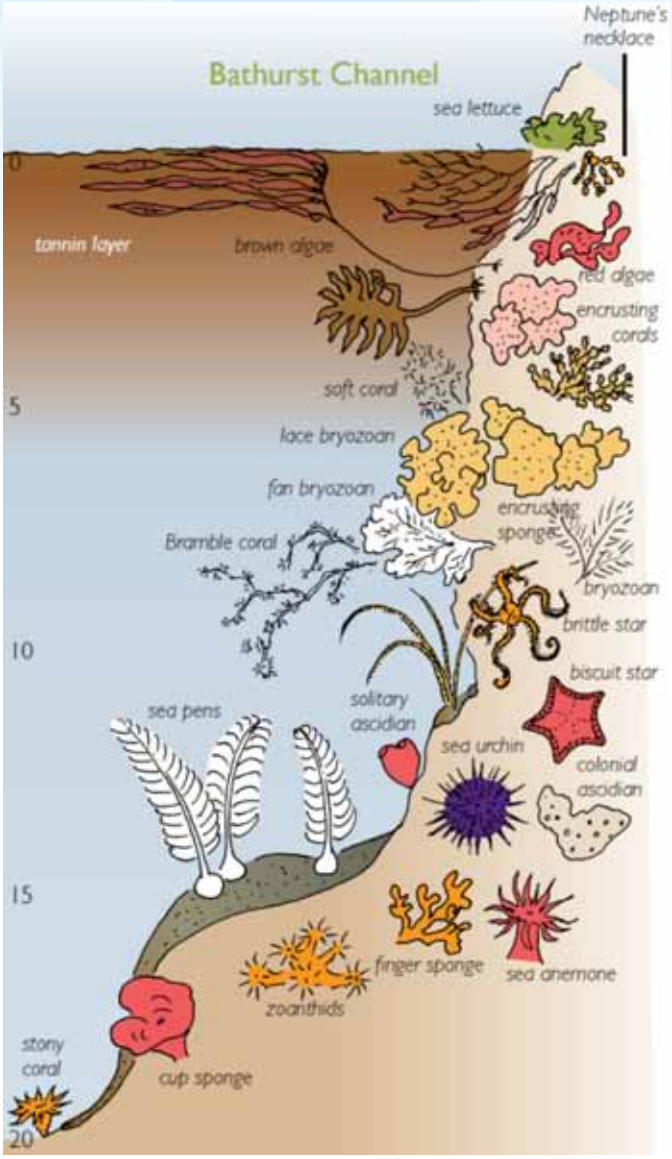
Many species vary in their depth distribution along the estuarine cline, for example foliose algae reach 20 m depth in Port Davey, 5 m depth at the western entrance of Bathurst Channel, but do not penetrate below 1 m depth in eastern Bathurst Channel. The estuary includes a high number of endemic fish and invertebrates, such as the Endangered Maugean Skate found only in Bathurst Harbour and one other west coast estuary[11,74], and is the only Australian estuary with a fish species not recorded elsewhere (a cusk-eel, *Microbrotula*). Fish communities are dominated by sharks, skates and rays more common in deep offshore waters rather than the usual mixture of wrasses, leatherjackets and other common coastal reef fish[74].

The dark waters of Bathurst Channel experience strong currents, providing ideal conditions for filter feeding invertebrates which provide a magnificent display of more than 500 delicate species, many usually found in water depths of 60-220 m as opposed to 5-12 m in this channel[75]. Their presence on such a large scale is unique to the nearshore environment of Australia[68] and includes soft coral species found no-where else as well as large numbers of the iconic sea pens[11]. An exposed coast extension of the tannin estuary system occurs in part of Port Davey forming a unique 'overlap' zone with clearer, high wave energy waters[144]. Shallow inlets in this area, and particularly Kelly Basin, are of high conservation value due to their diverse habitats and pristine status. They contain the only seagrass beds and nursery habitats in the Davey Bioregion, as well as unusual algal beds, very high mollusc densities, and foraging habitats for resident shorebirds[68,144]. The small islands of Port Davey are important for seabirds and support internationally significant numbers of the Short-tailed Shearwater, Fairy Prion, Little Penguin and Black-faced Cormorant[133].

The marine life of the Port Davey/Bathurst Estuary depicting some of the animals and plants typically found at a range of depths in Bathurst Harbour (left) Bathurst Channel (right), and Port Davey (next page)

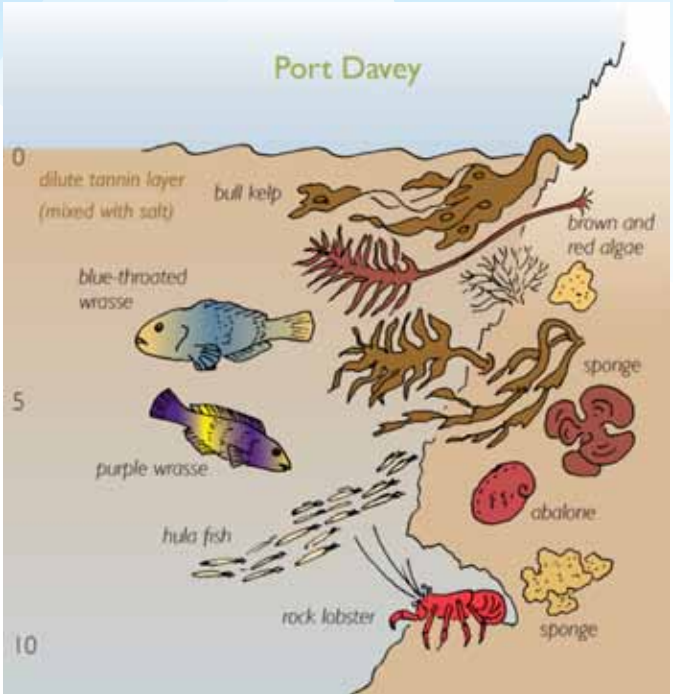
(Source: artist Janet Fenton, with permission of the Parks and Wildlife Service, Tasmania).





Great Sea Pens (*Sarcoptilis grandis*), Port Davey (Photograph: © Fred Bavendam).

Southern Basket Star (*Conocladus australis*) (Photograph: © Graham Edgar).



High Value Site – Maatsuyker Island

Maatsuyker is a jagged rocky island that rises steeply from the sea to an altitude of 278 m and is the home of Australia's southern-most constructed landmark, the Maatsuyker Island Lighthouse[104]. It incorporates a group of pyramid-shaped rocks known as the Needles that also rise steeply from sea, while its spectacular coast includes many gulches and subterranean caves[36]. Maatsuyker Island is a marine wildlife 'jewel' that supports large populations of seals and seabirds, including Threatened species not recorded elsewhere in Tasmania. It forms the primary Tasmanian breeding site for the Rare New Zealand Fur Seal[33], a haul-out site for Australian Fur Seals[36], and produces small numbers of Endangered Southern Elephant Seal pups[94]. It therefore represents the only current Australian breeding area for the latter species outside subantarctic islands. Subtidal reefs include forests of the ecologically important Giant Kelp[104], and the sight of fur seals swimming gracefully amongst these forests provides one of the most magical diving experiences in Tasmania.

Maatsuyker Island
(Photograph: © Biodiversity Monitoring Section, DPIPWE).

Fur Seals at Maatsuyker Island
(Photograph: © Ron Mawbey)

Southern Elephant Seals (*Mirounga leonina*): this Endangered species has recently been breeding in small numbers at Maatsuyker Island
(Photograph: © Kerry Steinberner, Australian Antarctic Division).

Maatsuyker and surrounding islands support internationally significant (i.e. > 1% of total population) numbers of Short-tailed Shearwaters (about 1.5 million pairs), Fairy Prions and Black-faced Cormorants, as well as thousands of pairs of Common Diving-Petrels and Little Penguins[133]. A small breeding colony of the Endangered Soft-plumaged Petrel discovered in 2004 represents the first recorded breeding occurrence of this species in Australia[104]. Endangered Humpback and Southern Right Whales pass Maatsuyker Island during their annual migrations and can be sighted from the island, while large pods of more than 300 Common Dolphins have been observed off the Needles and southern coast[104].

Pedra Branca
(Photograph: © Biodiversity Monitoring Section, DPIPWE).

High Value Sites – Mewstone and Pedra Branca

While many of the offshore islands of the Davey Bioregion have high conservation values for seabirds and other marine life, Mewstone and Pedra Branca are unique in providing two of only three breeding colonies for our endemic and Vulnerable Shy Albatross and hence are listed nationally as Critical Habitat. Both are very remote and free of predators[68], making them safe refuges for many thousands of seabirds. Mewstone supports the largest known Shy Albatross breeding colony (7,500 breeding pairs = 60% of total species numbers), while Pedra Branca supports just 250 breeding pairs, due primarily to competition for nesting space with the 6,000-8,000 Australasian Gannets that occur there[96]. The gannet populations at Pedra Branca and the nearby Eddystone Rock represent two of only three breeding colonies for this species in Tasmania. The seabirds at Pedra Branca provide food in the form of regurgitated fishes that allows a lizard species, the Pedra Branca Skink, to survive only on this single small rocky island. Mewstone also supports an estimated 20,000 pairs of Fairy Prions, while the Rare New Zealand Fur Zeal is a visitor to Pedra Branca, and both islands provide regular haul-outs for Australian Fur Seals[36]. Limited study of subtidal marine environments around Tasmania's wild, southerly offshore islands (Pedra Branca is Tasmania's southern-most offshore island with the exception of subantarctic Macquarie Island), suggests a considerable Antarctic influence on the basis of different algal depth distributions and species composition[10]. Subtidal communities around the most southern islands of the Davey Bioregion may therefore be distinct from those at other Tasmanian sites[68].

Shy Albatross (*Thalassarche cauta*)
(Photograph: © Biodiversity Monitoring Section, DPIPWE).

Australasian Gannets (*Morus serrator*)
(Photograph: © Valeria Ruoppolo and Eric Woehler, Birds Tasmania).

6.7. BRUNY BIOREGION – NATIONAL ENDEMICS HOTSPOT

The Bruny Bioregion in south-east Tasmania is named after a major geographic feature of the region, Bruny Island, and has a particularly convoluted coastline with an abundance of islands, peninsulas, embayments and estuaries that create a huge diversity of habitats and spectacular coastal scenery. It has the highest localised level of marine endemism in Tasmania, and probably Australia[126], and is a hotspot for endemic handfishes, seastars, molluscs and algae[102,114,126]. Wave exposure is particularly variable in this bioregion, with exposed southern shores having towering sea cliffs and complex sea caves eroded by pounding seas, while the many sheltered environments contain Tasmania's widest range of sandy coastal features[24]. Clear oceanic water influences much of the exposed coast, however two large and strongly stratified drowned river valley estuaries (Derwent and Huon) have major effects on marine communities through changes in water clarity, light penetration, salinity and nutrient levels[37]. The Bruny Bioregion currently has by far the largest number of declared Marine Protected Areas (MPAs) (16)[145] although their combined area of 126 km^2 is significantly smaller than individual MPAs in the Davey and Twofold Shelf bioregions and Macquarie Island Province, and only two of the 16 include adequately protected 'no take' zones.

This bioregion supports distinctive reef and soft-sediment faunas on the basis of the high number of endemic species and inclusion of many cold-adapted species not found further north[37]. The northern boundary of the Bruny Bioregion reflects the average position of the interface between warm nutrient-poor East Australian Current waters and colder nutrient-rich subantarctic waters[24], and hence the region has distinctive cold-temperate marine communities[37].

Other distinctive features include a high reef species richness that is second only to Maria Island[6], the largest forests of the Giant Kelp and other cold-adapted algal species in Australia[37], the most significant nursery habitat in the state for the commercial School Shark[50], and also the largest beds of cool-temperate seagrasses. Endemic species include some of the most highly restricted marine animals and macroalgae in Australia; for example the Critically Endangered Spotted Handfish is found only in the Derwent Estuary[114], the Vulnerable Live-bearing Seastar is known from a total area of just 3 ha[10], and three potentially endangered species of red algae have been identified from only one or two sites[41].

Migratory and resident shorebirds utilise two major networks of mudflat sites, one including an internationally significant Ramsar wetland, while seabird populations include the largest Tasmanian population of the Fairy Prion[36] and 99% of the Tasmanian population of the Sooty Shearwater. The south-east coast provides an important migration path for two Endangered whale species, includes records for over 70% of all cetacean species recorded within Tasmania, and contains six major fur seal haul-out sites[24].

Lace bryozoan (*Triphyllozon sp.*)
(Photograph: © Neville Barrett).

Giant Spider Crab (*Leptomithrax gaimardii*)
(Photograph: © Graham Edgar).

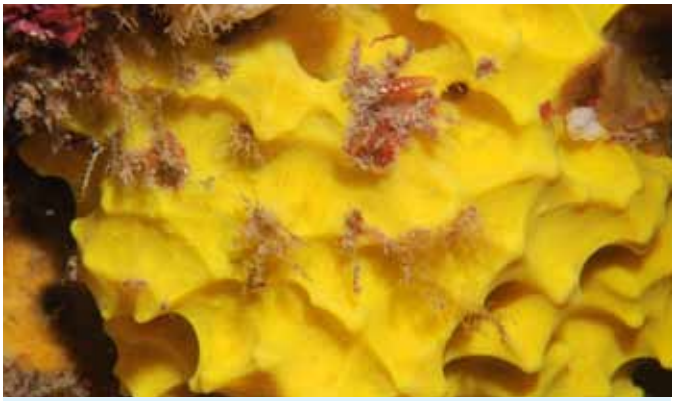
Common Gurnard Perch (*Neosebastes scorpaenoides*)
(Photograph: © Graham Edgar).

High Value Sites – Huon Estuary Entrance and Offshore Reefs (Ninepin Point, Butts Reef, Zuidipool Rock, Arch Rock)

The area where the dark tannin-stained freshwater of the Huon Estuary meets the cold, nutrient-rich seawater from the southern ocean provides a highly unusual marine environment that is distinct from other areas of the Bruny Bioregion[37]. Reduced light penetration in the water column results in species 'compression' with depth, whereby typical shallow water plant and animal species occur in very narrow bands near the surface, and are quickly replaced by species usually found in deeper water. Diversities of fish and invertebrates are high[14], including a particularly high richness of filter feeding invertebrates (e.g. sponges, gorgonians, soft corals, ascidians, bryozoans, hydroids and seawhips), a large range of unusual red algal species[37], and many fish species more typical of the deep water habitats of Tasmania's east coast[145].

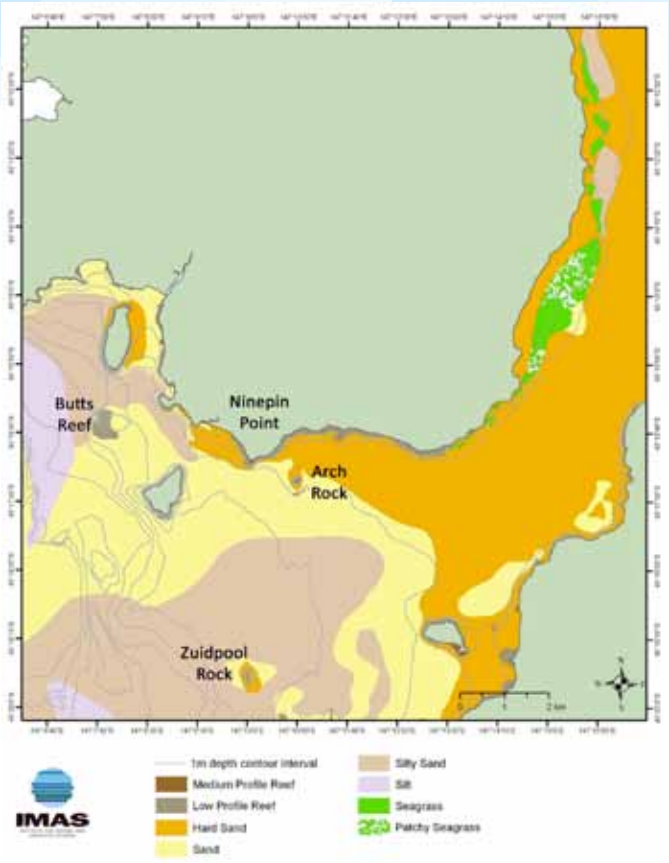
Ninepin Point at the mouth of the Huon Estuary is strongly influenced by tannin inputs, and includes a large spectacular rocky reef dissected by numerous gutters and scattered with large boulders[145]. More than 200 species of algae have been recorded, making it one of the most diverse sites for marine plants in Tasmania, and highly diverse by world standards. The community also contains more algal species classified as 'rare' than any other site in Tasmania plus several endemic red algae that are entirely confined to this area[41]. Offshore from Ninepin Point and within the Huon Estuary channel there are several isolated reefs that provide deep, tannin-influenced and frequently fast-current conditions –highly restricted habitats in Tasmania. One of the most unique sites is Butts Reef, which includes deeper reef habitat than the nearby Ninepin Point and supports diverse invertebrate communities and rare algae, including new species yet to be described. Further away from the estuary mouth, Zuidipool Rock and Arch Rock are also influenced by the stained Huon waters, and contain similarly unique communities; for example Arch Rock supports populations of at least five rare algal species, each recorded from less than five sites across their entire known ranges[41].

Magnificent Hydroid (*Ralpharia magnifica*)
(Photograph: © Neville Barrett).

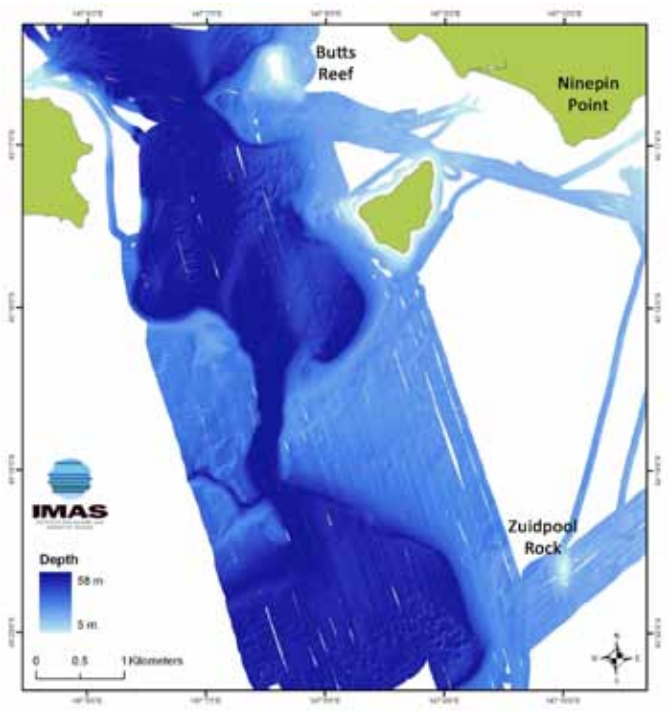


Yellow sponge (*Darwinella sp.*)
(Photograph: © Neville Barrett).

Southern Basket Star (*Conocladus australis*) attached to sea whips
(Photograph: © Sue Wragge).



Locations and habitats of unique sites near the entrance to the Huon Estuary (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).



Depth profile for the entrance to the Huon Estuary, illustrating the presence of a complex series of channels and basins that result in highly variable currents (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania; utilising multibeam sonar bathymetry data (Nichol et al. 2009[146])).

High Value Sites – Bruny Island Headlands (Roberts Point, Simpsons Point) and Tinderbox

These sites lie within the sheltered waters of the D'Entrecasteaux Channel in an area extending between the distinctive Derwent and Huon river systems. Water clarity is intermediate to the tannin-influenced waters of the Huon and the clearer oceanic waters towards the south of Bruny Island[37], providing unique environmental conditions and hence unusual marine communities. Small populations of the Wonder Cowry (*Umbilia hesitata*) – one of the largest, most ancient and beautiful of the cowries – occur in shallow depths where they can be enjoyed by divers, whilst elsewhere in Australia this species is only known from deepwater trawl samples[53].

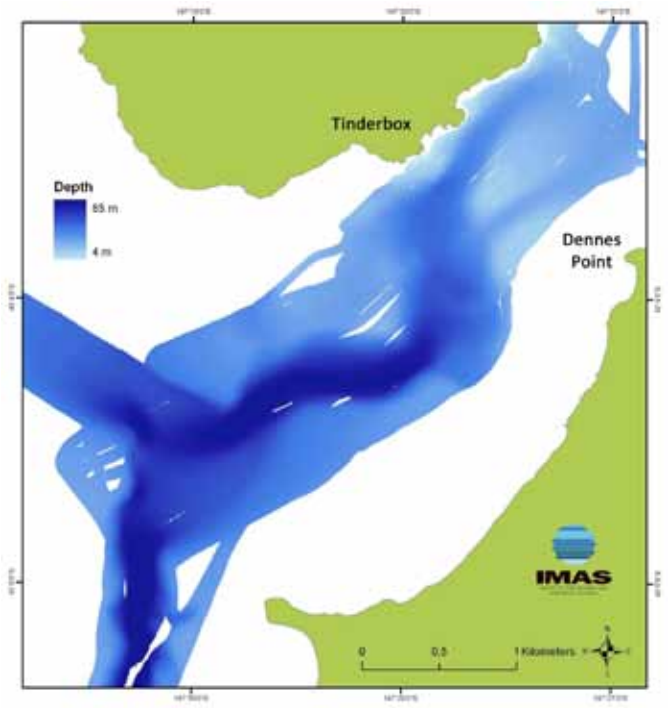
The Wonder Cowry appears to have become extinct from many other locations in Tasmania and south-east Australia, adding to the high value of local populations.

Southern White Spot Octopus (*Octopus bunurong*), Tinderbox (Photograph: © Graham Edgar).

The Wonder Cowry (*Umbilia hesitata*) occurs at unusually shallow depth at Roberts Point (Photograph: © Graham Edgar).

Further south, Simpsons Point and a rocky outcrop 500 m to its west experience high currents and reduced water clarity, resulting in the replacement of typical shallow-water kelp beds with fragile invertebrate communities and delicate red algae usually limited to much deeper waters[37]. Diverse gardens of invertebrates include seawhips, sponges, gorgonians, soft corals, bryozoans, and hydroids, while a potentially endangered endemic red alga (*Crouania brunyana*) has only been recorded at Simpsons Point and Tinderbox[41].

Tinderbox is located at the northern entrance of the D'Entrecasteaux Channel and provides a wide range of marine habitats in shallow sheltered waters, and therefore has high value as an easily accessed study area for education and research[145]. Rocky sandstone reef extends up to 100 m offshore and drops in a series of rock platforms, providing caves and other structurally complex habitats that are home to a remarkable diversity of seaweeds, iconic fishes such as the Weedy Seadragon, and a rich community of invertebrates scavenging or grazing amongst the luxuriant algal growth. The reefs extend out to sand and seagrass beds that further increase the diversity of fish and invertebrate communities.

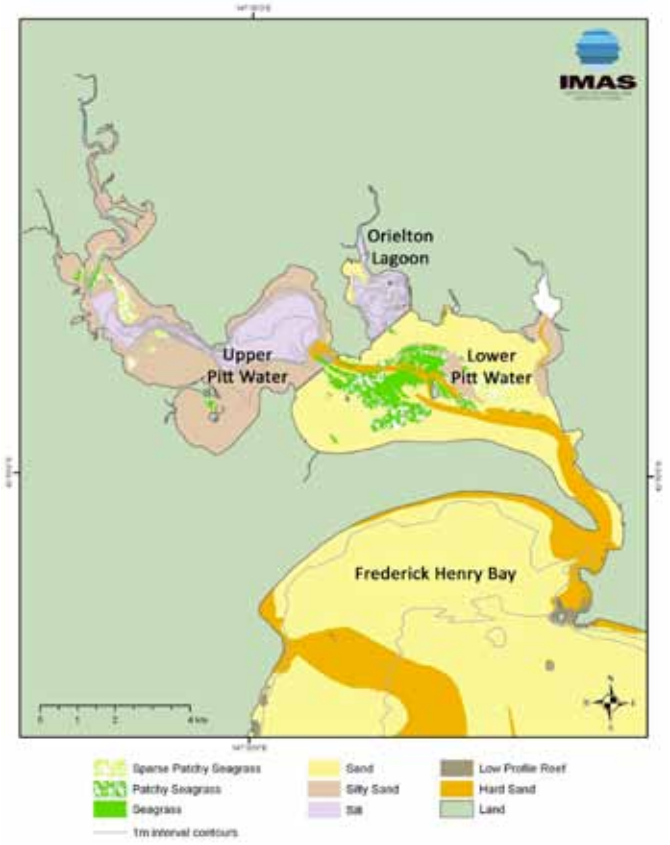


Depth profile at the northern entrance to the D'Entrecasteaux Channel, illustrating the presence of a deep narrow channel south of Tinderbox which provides habitats for a diverse range of filter feeding invertebrates (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania; utilising multibeam sonar bathymetry data (Nichol et al. 2009[146])).

High Value Site – Pitt Water / Orielton Lagoon

Pitt Water is a unique open estuary within the Bruny Bioregion that has been subject to considerable human disturbance but nevertheless has a host of important natural values that have persisted and simply cannot be overlooked. Included is an internationally significant Ramsar wetland that is particularly important for migratory shorebirds such as the Endangered Eastern Curlew, Bar-tailed Godwit, Common Greenshank, Curlew Sandpiper and Red-necked Stint[147]. The mudflats in Barilla Bay and Orielton Lagoon are primary feeding areas for resident and migratory shorebirds[147], while additional mudflats to the south at Five Mile Beach have recorded the highest densities of benthic invertebrates in south-east Tasmania, averaging at more than 11,000 animals per m^2 [79]. Pitt Water is also noted as being one of the most significant areas of saltmarsh in Tasmania and contains a range of threatened plant species[88,147].

This estuary has been designated a Shark Refuge Area, with studies revealing Upper Pitt Water to be the most significant pupping ground for commercial School Sharks in the state[50]. Extensive seagrass beds dominated by eelgrasses in Lower Pitt Water provide additional nursery habitat for sharks and other fish species[148], while rocky shores support the largest population of the endemic and Threatened Live-bearing Seastar[149]. The relatively deep and narrow entrance to this estuary is characterised by strong currents and contains beds of sponges and other filter feeding invertebrates[48].

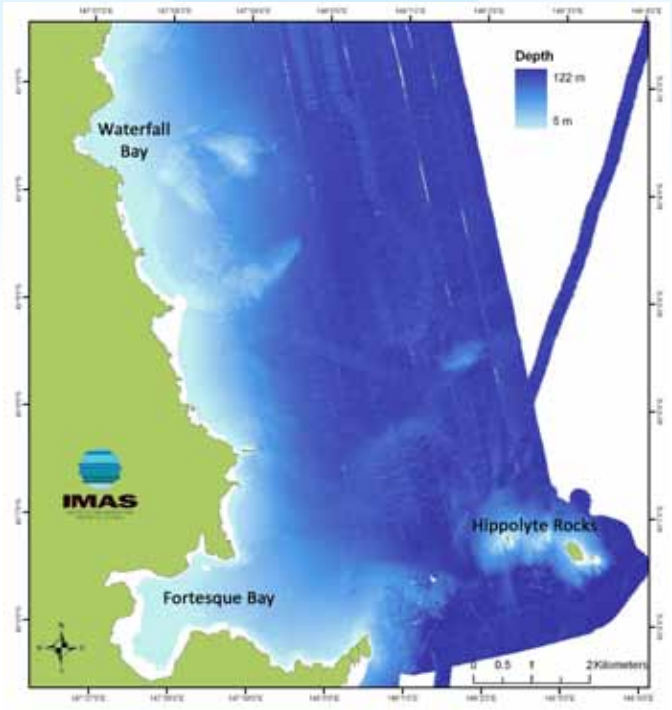


The diverse seabed habitats in Pitt Water and Orielton Lagoon (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

High Value Sites – Tasman Peninsula South and East Coasts (Fortescue Bay – Waterfall Bay, Hippolyte Rocks and Port Arthur)

The picturesque Tasman Peninsula includes magnificent coastal scenery above the water that is equally reflected below, represented by some of the largest areas of complex subtidal reef in Tasmania[42]. The coastline from Fortescue Bay to Waterfall Bay and including Hippolyte Rocks contains near pristine habitats and is renowned as a world class diving destination due to its clear waters, spectacular sea cliffs, unique cave systems, steep drop offs and diverse marine life[145]. The continental shelf break occurs unusually close to shore, providing habitat for deepwater species such as the Southern Bluefin Tuna and Albacore[15]. Some reef habitats extend to 100 m depth and are subject to high currents, resulting in rich sponge gardens that start at about 33 m in the clear waters of this region[37]. Sub-maximally exposed habitats to around 20 m support some of the most persistent and important forests of Giant Kelp in Tasmania, while this region also contains populations of Threatened endemic handfishes[114] and commercially important species including Blacklip Abalone, Southern Rock Lobster, and Striped Trumpeter. The spectacular sea caves in Waterfall Bay support complex invertebrate assemblages dominated by colourful sponges, soft corals, bryozoans, ascidians, zoanthids and anemones[145]. Offshore, the Hippolyte Rocks are surrounded by clear waters and deep reefs dominated by soft red algae below 35 m and diverse sponge gardens below 50 m[15]. They provide an important haul-out site for the Australian Fur Seal and associated hunting ground for the Vulnerable Great White Shark [145], as well as breeding habitat for numerous seabirds[36].

Within a small area, Port Arthur contains a particularly high representation of the habitats within the Bruny Bioregion, having a highly varied geology and wave exposures ranging from moderate through to very sheltered[37]. Rocky reef habitats support an estimated 219 species of algae, a diversity only known to be surpassed by the Tamar Estuary in the Boags Bioregion[41], as well as large and persistent Giant Kelp beds. Reefs are supplemented by areas of deep silty sand to 50 m depth in the middle of the port, hard shelly patches and large gravel/cobble beds which further add to the diversity of habitats available[37].



Depth profiling the Waterfall Bay–Fortescue Bay–Hippolytes area has revealed the presence of very deep waters close to the coast, and a number of interesting seabed features including massive dolerite and granite blocks 10–30 m high forming isolated mounds and ridges[146]. This region includes some of the largest areas of complex subtidal reef in Tasmania[42] (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania; utilising multibeam sonar bathymetry data[146]).

Scuba diver in Giant Kelp forest, Fortescue Bay (Photograph: © Graham Edgar).

Ziebell's (/Waterfall Bay) Handfish (*Brachiopsilus ziebelli*) (Photograph: © Karen Gowlett-Holmes).

6.8. FREYCINET BIOREGION – DAZZLING SAPPHIRE COAST

Tasmania's beautiful east coast, renowned for its contrasting orange-hued granite rocks, white sandy beaches and dazzling aquamarine waters, falls within the Freycinet Bioregion named after its most prominent coastal feature, the Freycinet Peninsula[126]. The spectacular coastal scenery of this region has received international attention, with the breathtaking Wineglass Bay and Bay of Fires voted as amongst the best beaches in the world. This bioregion is characterised by warm temperate influences, a moderate tidal range, an exposed coastline with approximately equal areas of rocky headlands and sandy beaches, and numerous coastal lagoons. Maria Island on the central coast has recorded the highest reef biodiversity in Tasmania[6], while the north-east estuaries have rich invertebrate and fish communities[14]. The geology of the region is variable, dominated by Carboniferous granite in the north and Jurassic dolerite to the south[16], with Schouten Island-Freycinet Peninsula recording the greatest proportion of 'high profile' or structurally complex reef in Tasmania[42]. The Freycinet Bioregion has two Marine Protected Areas, Governor Island at Bicheno and Maria Island, with a combined size of 15.6 km^2 – two thirds of which is fully protected as 'no take'.

This bioregion is influenced by the warm East Australian Current (EAC)[131], particularly on the north east coast. As a result, biological communities are highly variable, with many fish and other species present in the northern section but absent from the south. These include warm temperate species that are common in NSW such as the White-ear Scalyfin and Eastern Rock Blackfish, as well as the Hollow-spined Urchin (*Centrostephanus rodgersii*), Giant Rock Barnacle (*Austromegabalanus nigrescens*) and Eastern King Prawn (*Penaeus plebejus*). Some fish species found here also occur in the Furneaux Group, but cannot be seen anywhere else around the Tasmanian mainland coast[14]. The Freycinet Bioregion also contains some very rare habitats for marine species, such as the Native Flat Oyster which was very abundant in southern Australia prior to 19th century harvesting. The region is significant in supporting the most northerly forests of the Giant Kelp (*Macrocystis pyrifera*), a cold-water species that forms major beds along the Tasmanian east and south-east coasts. Barred, low salinity estuaries or 'lagoons' are highly characteristic of this region, with 14 of these sheltered waterbodies recorded along the east coast[71], including some that are intermittently closed to the sea[14]. These lagoons and adjacent beach habitats are important for migratory shorebirds, particularly Greenshank, Ruddy Turnstone, Double-banded Plover, Red-necked Stint, Pacific Golden Plover, and Sanderling[113].

Corded Siphon Shell (*Siphonaria funiculata*) (Photograph: © Graham Edgar).

Velvet Leatherjacket (*Meuschenia scaber*), Bicheno (Photograph: © Graham Edgar).

Clarrie's Hermit Crab (*Pagurixus handrecki*) (Photograph: © Graham Edgar).

High Value Site – Schouten Island and Passage

Schouten is a rugged and spectacular island surrounded by cliffs and sheltered to moderately exposed bays, and separated from the mainland by a 1.6 km wide, deep passage[42]. A high diversity of pristine marine habitats is supplemented by highly variable geology, with a north-south fault line dividing an eastern granite component, which is similar to the north-east coast, from a western dolerite section, which is more similar to the south-east of the state[36]. Structurally complex reefs include underwater extensions of sea cliffs and have highly variable wave-exposures and depths, some extending to 70 m[42]. The additional presence of seagrass beds comprised of the Black-stemmed Eelgrass (*Heterozostera nigricaulis*) in depths of 5-15 m, patchy reef intermixed with cobbles, and extensive areas of unvegetated sand add to the habitat diversity of the island. Beds of the Giant Kelp on the southern and western sides of the island are amongst the few truly persistent beds in the central-north east region[42,9], and are therefore of high conservation value. While algae dominate shallow waters, providing up to 80% cover in depths less than 30 m, sponge habitat increases below 30 m and dominates below 40 m[42] providing a diverse and brightly coloured invertebrate community.

Southern Right Whale (*Eubalaena australis*), Schouten Passage (Photograph: © Aquenal).

The island also provides breeding habitat for the Little Penguin and Short-tailed Shearwater, while offshore species such as the Australasian Gannet and Vulnerable Shy Albatross are observed in the area[36]. Australian Fur Seals haul-out on the eastern side of the island, and Southern Right Whales enter the passage during their seasonal migration[150].

High Value Site – Ile des Phoques

Ile des Phoques is a small rocky island between Maria and Schouten islands, about 20 km east of the Tasmanian mainland. It is unique in possessing numerous sea caves[36], some that run right through the island and are therefore distinct from the blind (i.e. one way) sea caves found elsewhere on the Tasmanian coastline[38]. This means that there is a high water flow through the caves, providing a rich supply of plankton that sustains a diverse community of filter feeding invertebrates. The main deep cave is pitch black in the middle, and therefore provides for deepwater emergence of a range of species usually found at greater depths, including hard and soft corals and even some deepwater crustaceans such as slipper lobsters[38,53]. Several caves have light entering through the roof creating stunning light effects that, combined with the brightly coloured jewel anemones and zoanthids (anemone-like animals) covering the cave, and frequent schools of fish, provide spectacular underwater scenery. The caves are considered to be of outstanding geological significance[36], and are quite unlike any other marine cave system in Tasmania.

The eastern side of Ile des Phoques is also a regular haul-out site for Australian Fur Seals[36], and geological evidence suggests that it once supported a large seal breeding colony. The island remains a breeding site for seabirds, including Little Penguins, Short-tailed Shearwaters, Fairy Prions and Common Diving-Petrels[36]. Ecotourism activities are centred around seal watching and spectacular cave diving.

Longsnout Boarfish (*Pentaceropsis recurvirostris*) (Photograph: © Graham Edgar).

High Value Site – Georges Bay Native Oyster Reef

The Native Flat Oyster (*Ostrea angasi*) reef in Georges Bay (Photograph: © Graham Edgar).

The Native Flat Oyster (*Ostrea angasi*) was once so abundant in southern Australian waters that it formed large reefs several metres high that dominated the seabed within estuaries and sheltered bays. In the late 19th century, these reefs provided a major food source for the population of Hobart and other parts of Tasmania; however heavy exploitation and disease destroyed all Australian reefs of this species[53], with the exception of a single reef in Georges Bay on the east coast of Tasmania. Native Flat Oysters do occur in other areas, such as the D'Entrecasteaux Channel of southern Tasmania and parts of Victoria; however in these areas the oysters only form small clumps or individuals associated with soft sediments. In Georges Bay, the oysters still form a consolidated 'biogenic' (i.e. produced by living organisms) structure elevated above the seabed – the only true native oyster reef remaining in southern Australia[28]. The reef consists of three major beds, which together have been estimated to support approximately 780,000 oysters[151], and are of critical significance for the conservation of native oyster habitat[122,123].

Southern Jewel Anemone (*Corynactis australis*) (Photograph: © Sue Wragge).

High Value Site – Maria Island

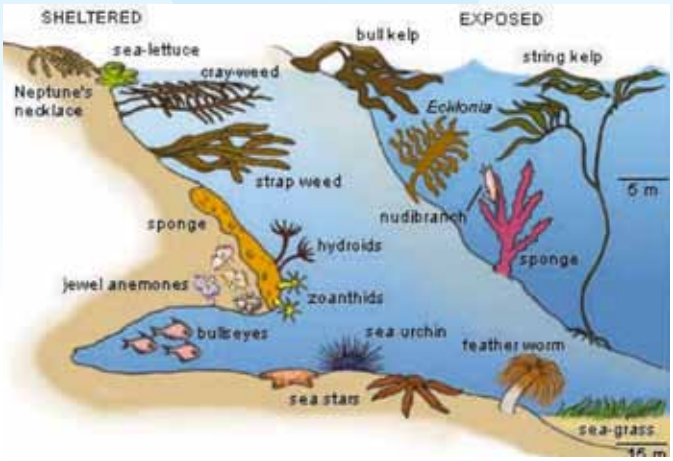
The north-west coastline of Maria Island on Tasmania's central east coast form part of the beautiful Maria Island National Park and has a remarkable diversity of marine habitats within a small area (rock, sand, seagrass, kelp forest, and dolerite, siltstone, sandstone, granite and limestone reef habitats) as well as the highest diversity of reef life in the state[6,126]. In Fossil Bay to the north, large submarine caverns and tunnels extend up to 40 m into the limestone cliffs, with Bull Kelp and other wave-loving kelps the most obvious plants, while the more sheltered western shore supports delicate algal species and consists of dolerite formations interspersed with cobbled and white sand beaches. Offshore, reefs support forests of the magnificent Giant Kelp, and expansive beds of seagrass cover the sandy seafloor extending into Mercury Passage[145].

Garden of sponges, sea whips and other sessile invertebrates (Photograph: © Sue Wragge).

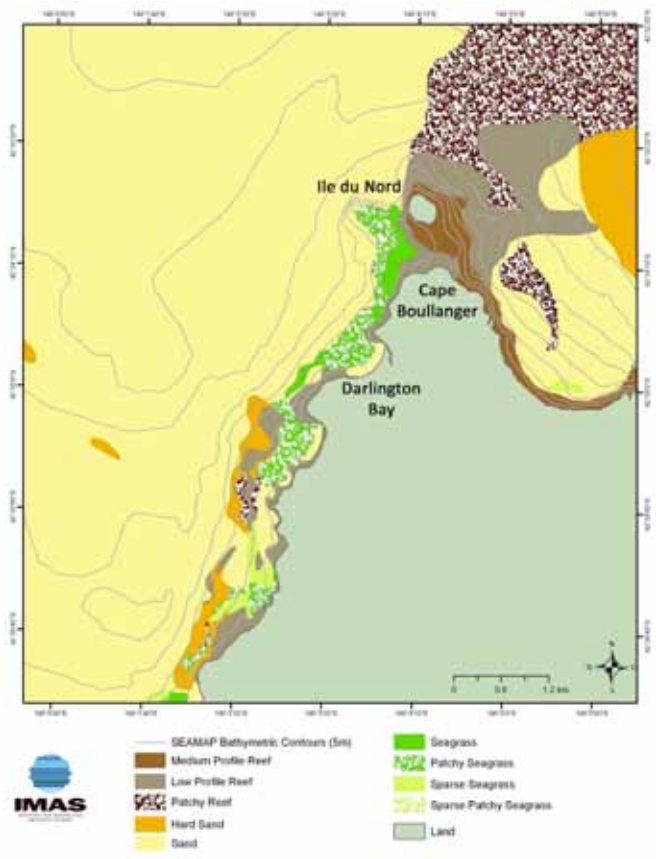
Shaw's Cowfish (*Arcana aurita*) (Photograph: © Sue Wragge)

The reefs support high abundances of Rock Lobsters and fish such as Bastard Trumpeter, Jackass and Banded morwongs, Barber Perch, and Rosy Wrasse, while fish species from the Australian mainland follow warm ocean currents to the northern end of Maria Island in summer months, and are rarely observed further south. Protected seahorses and Weedy Seadragons are commonly sighted, while fascinating species such as Warty Prowfish and Red Velvetfish are hidden amongst sponges and algae, and seagrass beds provide an important nursery for the Southern Calamary[60]. The pylons of the popular jetty dive site as well as other shaded and deeper sites support an array of colourful invertebrates including sponges, feather-like hydroids, bright zoanthids, tube worms, and jewel anemones in many different colours[145].

Rocky shore, Maria Island
(Photograph: © Karen Parsons).



The marine life of Maria Island depicting some of the species typical of sheltered and exposed habitats
(Source: Parks and Wildlife Service, Tasmania).



Diverse reef, seagrass and sandy habitats of the northeast tip of Maria Island (Source: SEAMAP Tasmania – Institute for Marine and Antarctic Studies, University of Tasmania).

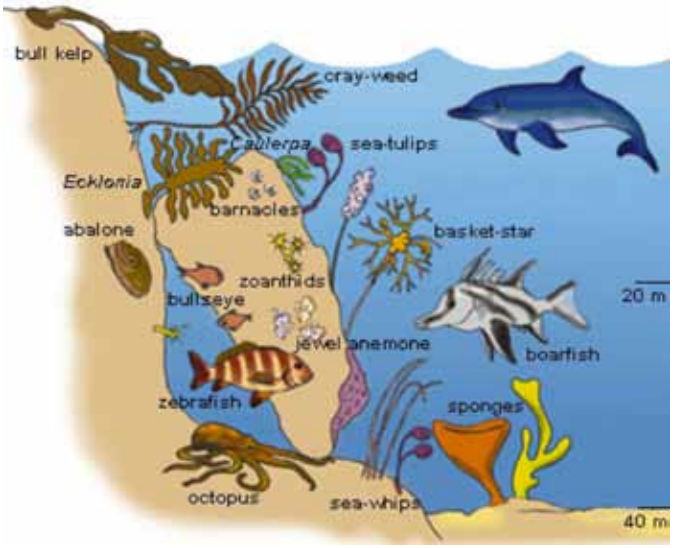
Black-lined Sea Hare (*Aplysia parvula*)
(Photograph: © Graham Edgar).

High Value Site – Governor Island

Governor Island is located less than 200 m off the coast at Bicheno. Its clear deep waters provide yet another of Australia's top diving sites, with easy access to deep reefs that extend to 45 m depth and experience strong ocean currents, characteristics that are rare so close to shore. Coarse-grained granite bedrock forms large blocks and boulders, sheer vertical walls, ledges, overhangs, and deep fissures, while small caves create spectacular underwater scenery that is best viewed in winter when reduced phytoplankton growth results in visibilities often exceeding 30 m[145].

Shallow areas of reef are dominated by kelps, while shaded and deeper areas are occupied by diverse 'sponge gardens' including sea whips, sea fans, hydroids, bryozoans, anemones, ascidians, sponges, feather stars, and basket stars. Vertical and over-hanging rock walls are covered with a brilliant mosaic of yellow zoanthids and different coloured colonies of jewel anemones. In deep sandy trenches, huge sponges crowd onto occasional boulders, while conspicuous mobile invertebrates include rock lobsters, abalone, octopus and brightly coloured sea-spiders (or 'pycnogonids') feeding amongst delicate bryozoans[145]. Fish are also abundant, including Butterfly Perch, Longsnout Boarfish and Zebrafish, while caves are crowded with bullseyes, cardinal fish, cod and Sandpaperfish. At certain times of the year, large silver schools of the Common Jack Mackerel swirl past, sometimes hunted by schools of dolphins. Governor Island is also an important seabird rookery and contains one of Tasmania's largest breeding populations of the Crested Tern[145].

This dainty pycnogonid or 'sea spider' (*Pseudopallene ambigua*) clinging to feather hydroids is a characteristic species within the waters surrounding Governor Island (Photograph: © Graham Edgar).



The marine life of Governor Island depicting some of the typical animals and plants encountered (Source: Parks and Wildlife Service, Tasmania).

6.9. MACQUARIE ISLAND PROVINCE – SUBANTARCTIC WILDLIFE JEWEL

The Macquarie Island Province forms one of only two subantarctic biological provinces in Australia, and consists only of Macquarie Island and its associated islets that represent an extremely isolated fragment of the mid-oceanic Macquarie Ridge that is raised above sea level[131]. It possesses a distinctive subantarctic flora and fauna that shares little similarity with other regions of Tasmania or Australia, and a high proportion of endemic algal and invertebrate species. Strongest shallow-water affinities are with other subantarctic areas, from which numerous plants and animals have probably arrived via the Antarctic Circumpolar Current[131]. The remarkable conservation values of this province are reflected by the attributes of the marine environment of Macquarie Island, an area fully contained within a Marine Protected Area and providing a remote wildlife refuge in the middle of the Southern Ocean.

High Value Site – Macquarie Island

Rugged coastline of Macquarie Island
(Photograph: © Kerry Steinberner, Australian Antarctic Division).

Located 1,500 km south-east of the Tasmanian mainland is Macquarie Island, our subantarctic wildlife 'jewel' which has been recognised as one of the most important sites for marine conservation in the world. This remote and dramatic island is internationally renowned for its geological, ecological and scientific values and is listed as a World Heritage Area, and a site on the National Heritage Register[1]. It is geologically significant for being the only island in the world composed entirely of oceanic crust and rocks originating from the deep mantle, up to 6 km below the earth's surface. The Macquarie Ridge Complex is one of the world's great oceanic ridges which extends underwater for 1,600 km and only rises to the surface at Macquarie Island[95,99]. As a result of its unique geological origins, the island's coastline is rugged and predominantly rocky, bounded on all sides by steep slopes that drop off quickly into deep waters a short distance from the shore.

Macquarie Island has outstanding significance for the conservation of biodiversity and is one of the world's largest subantarctic seal and bird breeding grounds[99,152]. The estimated 3.5 million breeding seabirds and 100,000 breeding seals found there include more than 40 species sustained by food resources in rich subantarctic waters[17,99].

Rugged coastline and Royal Penguins (*Eudyptes schlegeli*)
(Photograph: © Kerry Steinberner, Australian Antarctic Division).

A total of 27 seabird species and five seal species recorded at Macquarie Island are listed as Threatened at state or national levels, with 16 forming breeding colonies, including four albatrosses, six petrels, two penguins, one tern and three seals[95]. Of the extensive seabird congregations, a large proportion belong to four species of penguins, including half a million Royal Penguins[99] that represent the only breeding colony of this species in the world[35]. Four species of albatrosses breed in smaller numbers, with nesting sites for the Wandering and Grey-headed albatrosses being entirely restricted to this island within Australia, and listed as Nationally Critical Habitat. Macquarie also supports particularly impressive colonies of 70–80,000 Endangered Southern Elephant Seals and is the stronghold for this species in Australian waters[99], with conflicts between the massive bulls one of the more memorable sights on the island!

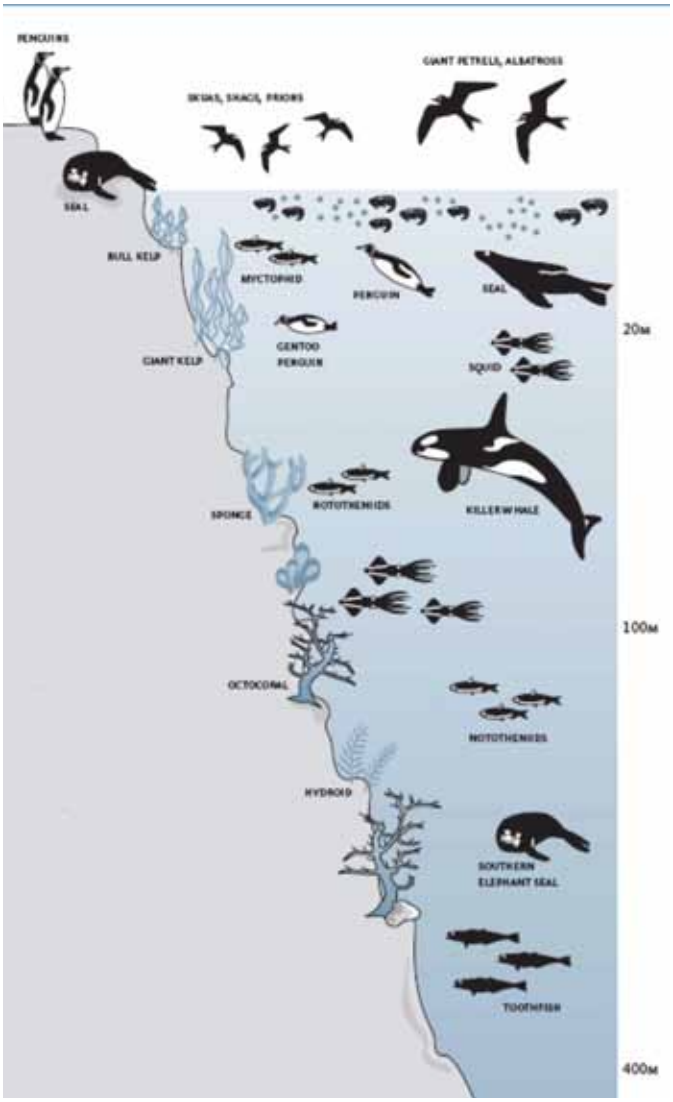
The beautiful and Endangered Grey-headed Albatross (*Thalassarche chysostoma*) at Macquarie Island, individual and with chick
(Photographs: © Christo Baars, Australian Antarctic Division).

Endangered Antarctic Tern (*Sterna vittata*)
(Photograph: © Evan Jones, Australian Antarctic Division).

Hookers Sea Lion (*Phocarctos hookeri*), back, and Southern Elephant Seal (*Mirounga leonina*) at Macquarie Island (Photograph: © Gavin Johnstone, Australian Antarctic Division).

Colony of King Penguins (*Aptenodytes patagonicus*)
(Photograph: © Kerry Steinberner, Australian Antarctic Division).

The seals and majority of seabirds derive all of their food directly from the sea, with krill, squid and fish particularly important in the food chain[99,153]. The fish fauna at Macquarie Island includes at least 33 cold water species, including the 'myctophids' that comprise the second largest biological resource (after Antarctic Krill) in the Southern Ocean. A high diversity of squid is reflected by identification of nearly 20 species in the stomachs of breeding albatrosses and Southern Elephant Seals[99]. The rocky intertidal and shallow subtidal areas of the coast support extensive and luxuriant growth of algae (seaweeds), with the 103 recorded species reflecting a very high diversity compared with other subantarctic islands. These algae, including the conspicuous Giant Antarctic Kelp that covers intertidal rocks and grows in dense offshore beds, provide habitat for invertebrate communities characterised by high levels of endemism and species diversity. The molluscs are the best known group, with many of the 74 species identified not known to occur anywhere else. The uniqueness of nearshore communities is not surprising given that they occur in one of very few shallow habitats in thousands of square kilometres of ocean[99].



The marine life of Macquarie Island depicting a range of organisms found at different depths (Source: National Oceans Office 2002[153]).

Southern Elephant Seals fighting (Photograph: © Kerry Steinberner, Australian Antarctic Division).

7. CONCLUSIONS

Tasmania's marine environment is truly unique and contains a diversity of ecosystems and temperate marine life forms that is amongst the highest in the world. From magnificent Giant Kelp forests to luxuriant seagrass meadows, globally unique tannin-stained estuaries, ancient relic species, Critically Endangered fish, pristine seabird islands and a myriad of other productive habitats and rare species, our small island state is a hotspot for diverse marine communities and important conservation values.

The unique ecological attributes of Tasmanian marine environments are evident at various spatial scales, as demonstrated by statewide, bioregional and site descriptions in this report, while significant species and rare features of particular ecosystems may be widely dispersed or cross bioregional boundaries. The physical attributes of the sea and seabed around Tasmania make it unique within Australia, as summarised below, with this physical rarity reflected in the unique structure of biological communities:

- A disproportionately long and highly complex coast, with Tasmania accounting for only 0.9% of Australia's area and yet 8.2% of its coastline, and including numerous estuaries and embayments and more than 6,000 islands and smaller rocky islets;
- A very wide diversity of coastal landforms and submarine topography, and a complex geology that is exceptionally well exposed on the coast, includes the oldest rock types in eastern Australia and is more similar to Antarctica than other parts of Australia;
- Extreme variation in wave exposure due to a highly indented coast, with waves impacting from every direction unlike in other states in Australia, and incorporating the only section of Australian coast lying in the path of the Roaring 40s gales;
- A high level of tidal variation due to the Bass Strait shelf and associated islands creating a larger tidal range in the north than experienced in the south;

- A diverse range of oceanographic influences, with Tasmania located at the meeting point of three major oceanographic currents that result in mixing of waters and marine species from warm nutrient poor areas to the north and west with cold nutrient rich areas to the south; and therefore representing the northern geographical limits for species of subantarctic origin, and at the same time the southern limits for a range of warm temperate species;

- Upwellings of cold, nutrient-rich subantarctic water in the vicinity of Tasmania resulting in higher nutrient levels than in more northern parts of Australia, a key contributor to our high marine productivity, distinctive 'cool temperate'assemblages, and presence of subantarctic influences absent from mainland Australia;

- A temperate marine location that has been geographically and climatically isolated from other temperate systems for around 65 million years, leading to levels of marine diversity and 'endemism' (i.e. species unique to the region) that are amongst the highest in the world; and including some of the most highly localised marine species in the world – with some only recorded at one site or limited to one or two estuaries;

- Unusually large areas of pristine habitat around the mainland coast (west, south-west), as well as undisturbed estuaries and islands that provide refuges for wildlife and globally unique marine communities;

- Exceptionally wide diversity of estuarine habitat types, due to a steep south-west to north-east rainfall gradient and high geological diversity, with all major geomorphological types of estuaries other than fjords represented;

- A higher diversity and number of wetlands and internationally important bird sites relative to its size than any other Australian state, and unique location at the most southerly extremity of the East Asian-Australasian Flyway for migratory shorebirds;

- A remarkable hotspot for seabird activity that includes the only nationally listed Critical Habitats for marine species (albatross species), and stronghold populations of Endangered seals.

As a result of the above factors and associated outstanding diversity of marine habitats and communities, Tasmania has a very high number of bioregions relative to its size, based on major changes in marine species composition around our coast. The most distinctive features of each bioregion have been reported elsewhere[17,126,131] and hence are not summarised again here, however this paper describes additional common characteristics within each that further illustrate their unique characters and values. The attributes of specific high conservation value sites with each bioregion are variable and include features such as: complex cave systems; a high diversity of habitats within a small area; close proximity of the continental shelf and hence representation of deepwater fauna; high diversity of migratory shorebirds; extensive sponge gardens at unusually shallow depths; breeding habitat for Endangered species, and so the list goes on.

Sites described in this paper were identified as having high natural values on the basis of various criteria such as uniqueness, representativeness, ecological importance, productivity and naturalness. The sites listed include some 'stand out' examples of high ecological values, but do not consider additional factors such as social and economic values, and are not intended to provide an exhaustive or rigorously assessed list of important areas.

Identification of habitats that denote a high natural value by virtue of their rarity can be summarised from examples of unique ecosystems in this report, while descriptions of significant species contribute to the identification of areas of high ecological importance and national/international significance. Together, these provide a general guide to hotspots for high ecological values in Tasmania's marine environment, as outlined below:

- Structurally complex reefs with unique geology (e.g. outcrops of rare rock types);
- High current habitats supporting shallow water 'sponge gardens' (e.g. protruding headlands, restricted channels);
- Deep reefs located unusually close to shore;
- Large and persistent Giant Kelp beds;
- Large and persistent seagrass beds;
- Unusually deep seagrass beds;
- Native oyster reef habitat;
- Tannin estuaries that provide for species 'compression' or 'deepwater emergence' whereby marine species occur in shallower waters than normally encountered;
- Combinations of the above may be of particularly high value (e.g. a tannin estuary with high currents and deep reefs);
- Marine environments surrounding Australian Fur Seal breeding habitats;
- Sites supporting internationally significant numbers of shorebirds or seabirds;
- Habitats that support discrete populations of Threatened species, or are of current or growing importance as sites for Threatened migratory species (e.g. Endangered Southern Right Whale).

The above is certainly not intended as a 'completed' list of unique and high value marine habitats in Tasmania. However, in conjunction with the examples of high ecological value sites within each bioregion, it does attempt to identify some of the very special areas that are worthy of representation within our MPA system as it grows to meet national and international targets. Further work to define the specific attributes of the rare marine habitats identified in this report may also enable their consideration in supplementary legislative instruments focussed on protection of particular habitats at a statewide level.

8. REFERENCES

1. DPIPWE (2010) Vulnerability of Tasmania's natural environment to climate change: an overview. Resource Management and Conservation Division, Department of Primary Industries, Parks, Water and Environment, Tasmania.
2. Edmunds, M., Mustoe, S., Stewart, K., Sheedy, E. and Ong, J. (2009) VNPA Nature Conservation Review: marine conservation priorities and issues for Victoria. Report to Victorian National Parks Association. Australian Marine Ecology Report 405, Melbourne.
3. Mount, R. (2001) Tasmania's coastline and coastal waters. Resource Planning and Development Commission, Tasmania.
4. RPDC (2003) State of the Environment (SoE) Tasmania 2003. Resource Planning and Development Commission, Tasmania.
5. Parks and Wildlife Service (2008) Geoheritage: biogeography of Tasmania. Available at: http://www.parks.tas.gov.au/index.aspx?id=2893. Accessed 6th April 2011.
6. Edgar, G. J., Moverley, J., Barrett, N. S., Peters, D. and Reed, C. (1997) The conservation-related benefits of a systematic marine biological sampling program: the Tasmanian reef bioregionalisation as a case study. Biological Conservation 79(2-3): 227-24
7. Tasmanian Planning Commission (2009) State of the Environment Report: Tasmania 2009. Tasmanian Planning Commission, Tasmania.
8. Poore, G.C.B. (2001) Biogeography and diversity of Australia's marine biota. In: Zann, L.P. and Kailola, P. (eds) The State of the Marine Environment Report for Australia Technical Annex: 1. The Marine Environment, Department of the Environment, Sport and and Territories, Ocean Rescue 2000 Program. pp 75-84. Townsville, Queensland, Australia: Great Barrier Reef Marine Park Authority.
9. Edyvane, K. S. (2003) Conservation, monitoring and recovery of threatened giant kelp (Macrocystis pyrifera) beds in Tasmania. Department of Primary Industries, Water and Environment, Hobart, Tasmania.
10. Edgar, G. J. (1984) Marine life and potential marine reserves in Tasmania. Part 2. National Parks and Wildlife Service of Tasmania. Occasional Papers 7: 1-102.
11. Edgar, G., Last, P., Barrett, N., Gowlett-Holmes, K., Driessen, M. and Mooney, P. (2007) Marine and estuarine ecosystems in the Port Davey-Bathurst Harbour region: biodiversity, threats and management options. Report for the Department of Primary Industries and Water, Tasmania. Aquenal Pty Ltd.
12. Poloczanska, E. S., Babcock, R. C., Butler, A., Hobday, A. J., Hoegh-Guldberg, O., Kunz, T. J., Matear, R., Milton, D. A., Okey, T. A. and Richardson, A. J. (2007) Climate change and Australian marine life. Oceanography and Marine Biology 45: 407-478.
13. Bryant, S. (2002) Conservation assessment of beach nesting and migratory shorebirds in Tasmania, Nature Conservation Branch, Department of Primary Industries, Water and Environment, Tasmania.
14. Edgar, G. J., Barrett, N. S., Graddon, D. J. and Last, P. R. (2000) The conservation significance of estuaries: a classification of Tasmanian estuaries using ecological, physical and demographic attributes as a case study. *Biological Conservation* **92(3)**: 3
15. Last, P. R. (1989) Nearshore habitats. In: Smith, S.J. (ed.) Tasman Peninsula - is history enough? Past, present and future use of the resources of the Tasman Peninsula. pp 71-80. Royal Society of Tasmania.
16. Short, A. D. (2006) Beaches of the Tasmanian coast and islands: a guide to their nature, characteristics, surf and safety. Coastal Studies Unit, School of Geosciences. Sydney University Press.
17. DPIWE (2000) Tasmanian Marine Protected Areas Strategy: Background Report. Department of Primary Industries, Water and Environment, Tasmania.
18. Redmap (2011) Redmap website. Institute for Marine and Antarctic Studies, University of Tasmania. Available at: http://www.redmap.org.au/. Accessed 2nd February 2011.
19. Gill, P. C., Evans, K.J. and Wapstra, H. (1998) Feeding by humpback whales in Tasmanian waters. Records of the Queen Victoria Museum, No. 107. Launceston, Tasmania.
20. Johnson, C., Ling, S. Ross, J., Shepherd, S. and Miller, K. (2005) Establishment of the long-spined sea urchin (*Centrostephanus rodgersii*) in Tasmania: first assessment of potential threats to fisheries. Report for Fisheries Research and Development Corporation, FRDC Project No. 2001/044. Tasmanian Aquaculture and Fisheries Institute, School of Zoology, University of Tasmania.
21. Ling, S. D., Johnson, C. R., Ridgway, K., Hobday, A. J. and Haddon, M. (2009) Climate-driven range extension of a sea urchin: inferring future trends by analysis of recent population dynamics. *Global Change Biology* **15**: 719-731.
22. Hallegraeff, G. (2011) Personal communication. Department of Plant Science, University of Tasmania.
23. Edgar, G.J. (2001) Australian marine habitats in temperate waters. New Holland Publishers, Australia.
24. RPDC (2006) Inquiry into the establishment of marine protected areas within the Bruny Bioregion. Background report. Resource Planning and Development Commission, Tasmania.
25. Hallegraeff, G. M., Bolch, C.J.S., Hill, D.R.A, Jameson, I., LeRoi, J-M., McMinn, A., Murray, S., Salas, M.F. and Saunders, K. (2010) Algae of Australia: phytoplankton of temperate coastal waters, CSIRO Publishing/ABRS, Australia.

26. Swadling, K. M., Slotwinski, A.S., Ritz, D.A., Gibson, J.A.E. and Hosie, G.W. (2008) Guide to the marine zooplankton of south eastern Australia. Version 1.0 June 2008 www.tafi.org.au/zooplankton. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

27. Taw, N. and Ritz, D. A. (1978) Zooplankton distribution in relation to the hydrology of the Derwent River estuary. *Australian Journal of Marine and Freshwater Research* **29**: 763-775.

28. Edgar, G.J. (2011) Personal communication. Aquenal Pty Ltd.

29. Sharples, C. and Mowling, F. (2006) Southern Natural Resource Management Region coastal geomorphic mapping and management decision support tools. Interpretation report and manual. Report to the Southern Tasmanian Regional NRM Coastal Management Committee

30. Richardson, A.M.M., Swain, R. and Shepherd, C. (1997) The fauna of rock platforms on the east coast of Tasmania and Flinders Island. Zoology Department, University of Tasmania.

31. Bennett, I. (1987) Australian seashores; W.J. Dakin's classic study. A guide to the temperate shores for the beach-lover, the naturalist, the shore-fisherman and the student. Angus and Robertson Publishers, Australia.

32. Bennett, I. and Pope, E. C. (1960) Intertidal zonation of the exposed rocky shores of Tasmania and its relationship with the rest of Australia. *Australian Journal of Marine and Freshwater Research* **11(2)**: 182-221.

33. Bryant, S. and Jackson, J. (1999) Tasmania's threatened fauna handbook: what, where and how to protect Tasmania's threatened animals. Parks and Wildlife Service, Tasmania.

34. Smith, S. D. A. and Simpson, R. D. (2002) Spatial variation in the community structure of intertidal habitats at Macquarie Island (sub-Antarctic). *Antarctic Science* **14**: 374-384.

35. Dutson, G., Garnett, S. and Gole, C. (2009) Australia's Important Bird Areas: key sites for bird conservation. Birds Australia (RAOU) Conservation Statement No. 15.

36. Brothers, N., Pemberton, D., Pryor, H. and Halley, V. (2001) Tasmania's offshore islands: seabirds and other natural features. Nature Conservation Branch of the Department of Primary Industries, Water and Environment. Tasmanian Museum and Art Gallery, Hob

37. Barrett, N., Sanderson J. C., Lawler, M., Halley, V. and Jordan, A. (2001) Mapping of inshore marine habitats in south-eastern Tasmania for marine protected area planning and marine management. Technical Report Series No. 7. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

38. Barrett, N.S. (2010) Personal communication. Institute for Marine and Antarctic Studies, University of Tasmania.

39. Jordan, A. R., Lawler, M. and Halley, V. (2001) Estuarine habitat mapping in the Derwent - integrating science and management. NHT Final Report, Project No. CMP22338. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

40. DPIPWE (2011) Department of Primary Industries, Parks, Water and Environment website, Tasmania. Available at: http://www.dpiw.tas.gov.au. Accessed December 2010 to May 2011.

41. Scott, F. (2011) Personal communication. Institute for Marine and Antarctic Studies, University of Tasmania.

42. Lucieer, V., Lawler, M., Morffew, M. and Pender, A. (2007) Mapping of inshore marine habitats from Schouten Island to Bicheno on the east coast of Tasmania. Natural Heritage Trust project. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

43. Ling, S. D. (2008) Range expansion of a habitat-modifying species leads to loss of taxonomic diversity: a new and impoverished reef state. *Oecologia* **156**: 883-894.

44. Warman, R. and Bryan, J. (2004) Beneath the waves: an introduction to the unique marine life around Low Head, Launceston Environment Centre, Tasmania.

45. Jordan, A. R., Mills, D. M., Ewing, G. and Lyle, J. M. (1998) Assessment of inshore habitats around Tasmania for life-history stages of commercial finfish species, Report for the Fisheries Research and Development Corporation. FRDC Project No. 94/037. Tasmanian Aquaculture and Fisheries Institute, Hobart, Tasmania.

46. Last, P. R. and Gledhill, D.C. (2007) The Maugean Skate, *Zearaja maugeana* sp. nov. (Rajiformes: Rajidae) – a micro-endemic, Gondwanan relict from Tasmanian estuaries. *Zootaxa* **1494**: 45-65.

47. Aquenal (2007) Marine ecological monitoring program: second pre-commissioning monitoring survey, spring 2007. Gunns Ltd Pulp Mill outfall Report for Gunns Ltd.

48. Aquenal (2007) Marine ecology assessment; a strategic land use and development study for the Seven Mile Peninsula. Report for Robert Luxmoore Pty Ltd.

49. Jordan, A. (1997) Demersal trawl surveys of the continental shelf of southern and eastern Tasmania 1993-1995. Technical Report No. 50. Marine Research Laboratories, Taroona. Marine Resources Division, Department of Primary Industry and Fisheries, Tasmania

50. CSIRO (1993) Investigation of school and gummy shark nursery areas in southeast Tasmania. CSIRO Division of Fisheries, Project 91/23.

51. Stevens, J.D. and West, G.J (1997) Investigation of school and gummy shark nursery areas in south eastern Tasmania. CSIRO Marine Research, FRDC Project 93/061.

52. Last, P.R. (2011) Personal communication. CSIRO Marine and Atmospheric Research, Hobart.

53. Edgar, G. J. (2008) Australian marine life: the plants and animals of temperate waters. Second edition. Reed New Holland, Melbourne, Australia.

54. Rees, C.G. (1994) Tasmanian seagrass communities. Unpublished Masters Thesis. Centre for Environmental Studies, University of Tasmania.

55. Lucieer, V. (2011) Personal communication. Institute for Marine and Antarctic Studies, University of Tasmania.

56. Kirkman, H. (2011) Personal communication.

57. Larkum, A. W. D., Orth, R.J. and Duarte, C.M. (2006) Seagrasses: biology, ecology and conservation. Springer, Netherlands.

58. Aquenal and DTAE (2008) State of the Tamar Estuary 2006. Aquenal Pty Ltd and the Department of Environment, Parks, Heritage and the Arts, Tasmania.

59. Edgar, G. J. and Shaw, C. (1995) The production and trophic ecology of shallow-water fish assemblages in southern Australia. III. General relationships between sediments, seagrasses, invertebrates and fishes. *Journal of Experimental Marine Biology and and Ecology* **194(1)**: 107-131.

60. Moltschaniwskyj, N., Steer, M., Pecl, G.T. and Doubleday, Z. (2011) Southern calamary, individual species assessment. In: Pecl G.T, Ward, T., Doubleday, Z., Clarke, S., Day, J., Dixon, C., Frusher, S., Gibbs, P., Hobday, A., Hutchinson, N., Jennings, S., Jones, K., Li, X., Spooner, D., and Stocklosa, R (eds.) Risk assessment of impacts of climate change for key marine species in south eastern Australia. pp 255-267. Fisheries Research and Development Corporation, Project 2009/070.

61. Pecl, G. T., Tracey, S.R., Danyushevsky, L., Wotherspoon, S. and Moltschaniwskyj, N.A. (unpublished manuscript) Elemental fingerprints of southern calamary reveal local recruitment sources and allow assessment of the importance of closed areas.

62. Pecl, G.T. (unpublished) Southern calamary in Great Oyster Bay. Tasmanian Aquaculture and Fisheries Institute.

63. Pecl, G. T., Tracey, S.R., Semmens, J.M. and Jackson, G.D. (2006) Use of acoustic telemetry for spatial management of southern calamary *Sepioteuthis australis*, a highly mobile inshore squid species. *Marine Ecology Progress Series* **328**: 1-15.

64. Jordan, A., Halley, V., Lawler, M. and Barrett, N. (2002) Habitat mapping in the Kent Group of Islands. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

65. Barrett, N.S. and Edgar, G. J. (1992) A survey of potential marine reserve locations in Bass Strait. Final Report for Ocean Rescue Project D701. For Australian National Parks and Wildlife Service.

66. Barrett, N. and Wilcox, S. (2001) Biological surveys and habitat mapping of proposed marine protected areas on the Tasmanian north and north-eastern coasts. Technical Report Series No. 6. Tasmanian Aquaculture and Fisheries Institute, University of Tasman

67. Richardson, A. M. M., Swain, R. and Shepherd, C. (1998) The strandline fauna of beaches on the north and west coasts of Tasmania, Flinders and King Islands. Zoology Department, University of Tasmania.

68. Harris, S., Brothers, N., Coates, F., Edgar, G.J., Last, P.R., Richardson, A.M.M. and Wells, P. (1993) The biological significance of a coastline in the roaring forties latitudes. In: Smith, S.J. and Banks, M.R. (eds.) Tasmanian wilderness - world heritage values. pp 123-128. Royal Society of Tasmania, Hobart, Tasmania.

69. Oldland, J., Rogers, D., Clemens, R., Berry, L., Maguire, G. and Kosbell, G. (2009) Shorebird conservation in Australia. Birds Australia Conservation Statement, No. 14, 2009.

70. Watkins, D. (1993) A national plan for shorebird conservation in Australia. RAOU Report No. 90. Australasian Wader Studies Group, Royal Australasian Ornithologists Union and World Wide Fund for Nature.

71. DPIW (2008) Conservation of Freshwater Ecosystem Values (CFEV) Project Technical Report. Conservation of Freshwater Ecosystem Values Project. Department of Primary Industries and Water, Hobart, Tasmania.

72. Parks and Wildlife Service (2008) Port Davey Marine Reserve, visitor's guide. Parks and Wildlife Service, Tasmania.

73. Edgar, G. (1989) Hydrological and ecological survey of the Port Davey/Bathurst Harbour Estuary 1988-1989. Zoology Department, University of Tasmania.

74. Edgar, G. J., Last, P R, Barrett, N. S., Gowlett-Holmes, K, Driessen, M and Mooney, P. (2010) Conservation of natural wilderness values in the Port Davey marine and estuarine protected area, south-western Tasmania. *Aquatic Conservation: Marine and Freshwater Ecosystems* **20**: 297-311.

75. Last, P. R. and Edgar, G. J. (1994) Wilderness Ecosystems Baseline Studies Interim Report 1994: Invertebrate community delineation and mapping of Bathurst Harbour. Project funded by a Wilderness Ecosystems Baseline Studies Grant. Hobart, Tasmania.

76. Edgar, G. J. and Barrett N. S. (2010) Biotic affinities of rocky reef fishes, invertebrates and macroalgae in different zones of the Port Davey marine protected area, south-western Tasmania. *Aquatic Conservation: Marine and Freshwater Ecosystems* **20**: 282-2

77. Whitehead, J., Coughanowr, C., Agius, J., Chrispijn, J., Taylor, U. and Wells, F. (2010) State of the Derwent Estuary 2009: a review of pollution sources, loads and environmental quality data from 2003 – 2009. Derwent Estuary Program, Department of Primary Industries, Parks, Water and Environment, Tasmania.

78. Aquenal (2002) Exotic marine pests survey, Port of Hobart, Tasmania. Prepared for the Hobart Ports Corporation Pty Ltd to meet the requirements of the AQIS Decision Support System (DSS) for Ballast Water Management.

79. Aquenal (2008) Marine and estuarine ecology literature review and field survey program, Lauderdale Quay Proposal. Report for Cardno Pty Ltd and Walker Corporation Pty Ltd. Aquenal Pty Ltd.

80. Cook, S. S., Roberts, J.L., Hallegraeff, G.M. and McMinn, A. (2007) Impact of canal development on intertidal microalgal productivity: Comparative assessment of Patterson Lakes and Ralphs Bay, South East Australia. *Journal of Coastal Conservation* **11**: 171-181.

81. DPIWE (2004) A wetlands strategy for Tasmania. Natural Heritage Trust Project. Resource Management and Conservation Division, Department of Primary Industries, Water and Environment, Tasmania.

82. Aquenal (2008) Wader utilisation surveys in and around Lauderdale. Report for Cardno Pty Ltd and Walker Corporation Pty Ltd. Aquenal Pty Ltd.

83. Lord, M. K. (1992) Wader counts in the Derwent Region 1992, unpublished data. Birds Tasmania.

84. Atkinson, P.W. and Stillman, R.A. (2008) Carrying capacity modelling for the pied oystercatcher at Lauderdale and surrounding sites. Lauderdale Quay Proposal. BTO Research Report No. 515. British Trust for Ornithology and Bournemouth University. Report prepared for Aquenal Pty Ltd.

85. Blackhall, S. A., McEntee, A. C. and Rollins, E. (2001) Tasmania. In: Environment Australia (ed.) A directory of important wetlands in Australia, Third Edition. Environment Australia, Canberra.

86. Glasby, J. (1975) Distribution of salt marsh communities in the Hobart area. BA (Hons.) Thesis, School of Geography and Environmental Studies, University of Tasmania, Hobart.

87. Wetlands International (2007) Ramsar information sheets. Available at: http://ramsar.wetlands.org/Database/Searchforsites/tabid/765/language/en-US/Default.aspx. Accessed 16th March 2011.

88. Kirkpatrick, J. and Glasby, J. (1981) Saltmarshes in Tasmania. Department of Geography, University of Tasmania. *Occasional Paper* **8**.

89. Richardson, A.M.M., Swain, R. and Wong, V. (1997) The crustacean and molluscan fauna of Tasmanian saltmarshes. *Papers and Proceedings of the Royal Society of Tasmania* **131**: 21-30.

90. Marsh, J.A. (1982) Aspects of the ecology of three saltmarshes of the Derwent region and an investigation into the role of the burrowing crab Heliograpsus haswelliams. Hons. Thesis, Zoology Department, University of Tasmania, Hobart.

91. DPIPWE (2009) Managing natural resources: saltmarsh. Department of Primary Industries, Parks, Water and Environment, Tasmania. Available at: http://www.dpiw.tas.gov.au/inter.nsf/WebPages/ALIR-4Z52SN?open. Accessed 4th May 2011.

92. Adam, P. (1990) Saltmarsh ecology. Cambridge University Press, Cambridge.

93. Kirkwood, R., Gales, R., Terauds, A., Arnould, J.P.Y., Pemberton, D., Shaughnessy, P.D., Mitchell, A.T. and Gibbens, J. (2005) Pup production and population trends of the Australian fur seal (*Arctocephalus pusillus doriferus*). *Marine Mammal Science* **21**: 26

94. DPIPWE (2010) Princess Melikoff Trust Marine Mammal Conservation Program, Annual Report 2009-2010. Department of Primary Industries, Parks, Water and Environment, Tasmania.

95. Environment Australia (2001) Macquarie Island Marine Park. Management Plan 2001, Environment Australia, Canberra.

96. ACAP (2009) ACAP Species assessment: Shy Albatross *Thalassarche cauta*. Agreement on the Conservation of Albatrosses and Petrels. Downloaded from http://www.acap.aq on 31st January 2011.

97. Vine, S. (2010) The national context. In: Kirkwood, J. and O'Conner J. (eds.) The state of Australia's birds 2010: islands and birds. Supplement to Wingspan, vol. 20, no. 4. Birds Australia.

98. Woehler, E. J. and Ruoppolo, V. (2010) Shorebirds and seabirds of Flinders and King Islands. In: Kirkwood, J. and O'Conner J. (eds.) The state of Australia's birds 2010: islands and birds. Supplement to Wingspan, vol. 20, no. 4. Birds Australia.

99. Parks and Wildlife Service (2006) Macquarie Island Nature Reserve and World Heritage Area. Management Plan 2006. Parks and Wildlife Service, Tasmania.

100. DEH (2004) Biology, threats and conservation status of the sub-antarctic fur seal and southern elephant seal in Australian waters. Department of the Environment and Heritage, Commonwealth of Australia, Canberra.

101. Edgar, G. J., Samson, C. R. and Barrett, N.S. (2005) Species extinction in the marine environment: Tasmania as a regional example of overlooked losses in biodiversity. *Conservation Biology* **19(4)**: 1294-1300.

102. Edgar, G. J. and Samson, C. R. (2004) Catastrophic decline in mollusc diversity in eastern Tasmania and its concurrence with shellfish fisheries. *Conservation Biology* **18(6)**: 1579-1588.

103. DEWHA (2007) Seals and sea-lions. Department of the Environment, Water, Heritage and the Arts, Australian Government. Available at: http://www.environment.gov.au/coasts/species/seals/index.html#seals. Accessed 2nd February 2011.

104. Friends of Maatsuyker Island (2010) Maatsuyker Island, Tasmania. Friends of Maatsuyker Island.

105. Parks and Wildlife Service (2003) Seals of Tasmania. Parks and Wildlife Service, Tasmania. Available at: http://www.parks.tas.gov.au/file.aspx?id=6916. Accessed 6th April 2011.

106. DSEWPC (2011) EPBC Act Protected Matters Report, Tasmania. Department of Sustainability, Environment, Water, Population and Communities, Australian Government. Available at: http://www.environment.gov.au/epbc/pmst/index.html. Generated 10th January 2011

107. Alderman, R. (2011) Personal communication. Department of Primary Industries, Parks, Water and Environment, Tasmania.

108. DEWR (2011) National whale and dolphin sightings and strandings database. Department of the Environment and Water Resources, Australian Government. Available at: http://data.aad.gov.au/aadc/whales/. Accessed 2nd March 2011.

109. DSEWPC (2010) Dermochelys coriacea – Leatherback Turtle. SPRAT Profile. Department of Sustainability, Environment, Water, Population and Communities, Australian Government. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768. Accessed 13th April 2011.

110. Watts, D. (1999) Field guide to Tasmanian birds. New Holland Publishers, Sydney, Australia.

111. Parks and Wildlife Service (2010a) Birds of Tasmania. Parks and Wildlife Service, Tasmania. Available at: http://www.parks.tas.gov.au/index.aspx?base=3049. Accessed 31st January 2011.

112. Bamford, M., Watkins, D., Bancroft, W., Tischler, G. and Wahl, J. (2008) Migratory shorebirds of the East Asian - Australasian Flyway; population estimates and internationally important sites. Wetlands International – Oceania. Canberra, Australia.

113. Woehler, E. J. and Park, P. (2006) Inventory of nationally important shorebird sites in Tasmania, Unpublished manuscript. Birds Tasmania.

114. Last, P. R. and Gledhill, D.C. (2009) A revision of the Australian handfishes (Lophiiformes: Brachionichthyidae), with descriptions of three new genera and nine new species. *Zootaxa* **2252**: 1-77.

115. Green, M. A. (2005) Marine habitat rehabilitation and threatened fish investigation. Report to Tasmanian Department of Primary Industry, Water and Environment - Nature Conservation Branch. CSIRO Marine and Atmospheric Research, Hobart.

116. Green, M. (2007) Implementing the handfish Recovery Plan 2006/07. Report to the Tasmanian Department of Primary Industry and Water, Threatened Species Section, Biodiversity Conservation Branch. CSIRO Division of Marine and Atmospheric Research, Hobart.

117. DSEWPC (2011) Raja sp. L (Maugean Skate). Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on a public nomination for a species listing on the Environment Protection and Biodiversity Conserva

118. Zann LP. (1995) Our Sea, Our Future. Major findings of the State of the Marine Environment Report for Australia. Department of the Environment, Sport and Territories, Ocean Rescue 2000 Program, Canberra.

119. Fulton, W. and Pavuk, N. (1988) The Tasmanian whitebait fishery: Summary of present knowledge and outline of future management plans. Unpublished report, Inland Fisheries Commission, Hobart, Australia.

120. Materia, C.J. (1994) A study of the native asteroids in south eastern Tasmania. Wildlife Report 94/9. Parks and Wildlife Service, Tasmania.

121. Byrne, M. (2005) Viviparity in the sea star *Cryptasterina hystera* (Asterinidae) – conserved and modified features in reproduction and development. *Biological Bulletin* **208**: 81-91.

122. Beck, M.W., Brumbaugh, R.D., Airoldi, L., Carranza, A., Coen, L.D., Crawford, C., Defeo, O., Edgar, G.J., Hancock, B., Kay, M., Lenihan, H., Luckenbach, M.W., Toropova, C.L. and Zhang, G. (2009) Shellfish reefs at risk: a global analysis of problems and solutions. The Nature Conservancy, Arlington VA.

123. Beck, M. W., Brumbaugh, R.D., Airoldi, L., Carranza, A., Coen, L.D., Crawford, C., Defeo, O., Edgar, G.J., Hancock, B., Kay, M., Lenihan, H., Luckenbach, M.W., Toropova, C.L., Zhang, G. and Guo, X. (2011) Oyster reefs at risk and recommendations for conservation, restoration, and management. *BioScience* **61**: 107-116.

124. Edgar, G.J. (1999) Tasmania. In: Andrew, N. (ed.) Under southern seas: the ecology of Australia's rocky reefs, pp. 30-39.

125. Sanderson, J.C. and Balmer, J. (unpublished) (eds.) A census of the marine benthic flora of Tasmania. Nature Conservation Report 2000/2. Resource Management and Conservation Division, Department of Primary Industries, Water and Environment, Tasmania.

126. Edgar, G. J., Moverley, J., Peters, D. and Reed, C. (1995) Regional classification of Tasmanian coastal waters and preliminary identification of representative marine protected area sites, Ocean Rescue 2000 Project D705. Parks and Wildlife Service, Tasmania.

127. Edgar, G. J. (1984) General features of the ecology and biogeography of Tasmanian subtidal rocky shore communities. *Papers and Proceedings of the Royal Society of Tasmania* **118**: 173-186.

128. Nicol, J. (2007) Current ecological knowledge of the flora of coastal lagoon estuary systems in south-eastern Australia: a literature review. SARDI Research Report Series No: 210. South Australian Research and Development Institute.

129. Commonwealth of Australia (2006) A guide to the Integrated Marine and Coastal Regionalisation of Australia. IMCRA version 4.0, Department of the Environment and Heritage, Canberra, Australia.

130. The Ecology Centre, The University of Queensland (2009) Scientific principles for design of marine protected areas in Australia: a guidance statement. The Ecology Centre, The University of Queensland.

131. IMCRA (1998) Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments. Version 3.3. Interim Marine and Coastal Regionalisation for Australia Technical Group. Environment Australia, Commonwealth Department of the Environment, Canberra.

132. Woehler, E. J. (2007) Inventory of shorebird sites in the Cradle-Coast NRM Region, including King Island, 2006/07. Report to CC-NRM and DPIW. Birds Tasmania.

133. Birds Australia (2005-2007) Bird data, Birdlife IBA Important Bird Areas. Available at: http://www.birdsaustralia.com.au/our-projects/important-bird-areas.html. Accessed 17th January 2011.

134. Lucieer, V., Lawler, M., Pender, A. and Morffew, M. (2009) Seamap Tasmania - mapping the gaps. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

135. Everard, J. L., Calver, C.R., Pemberton, J., Taheri, J. and Dixon, G. (1997) Geology of the islands of southwestern Bass Strait. A contribution to the National Geoscience Mapping Accord, Tasmanian Geological Survey, Record 1997/03. Mineral Resources Tasmania.

136. Woehler, E. J. (2009) Shorebirds and small terns on King Island, Report to King Island NRM. Birds Tasmania.

137. Woehler, E. J. (2008) Report on coastal shorebird and tern survey, Flinders Island, 3-9 November 2008. Report to Parks and Wildlife Service. Birds Tasmania.

138. Barrett, N. S., Edgar, G. J. and Polacheck, A. (2007) Baseline surveys of the subtidal reef biota of the Kent Group Marine Nature Reserve 2004-2006. Internal Report, Tasmanian Aquaculture and Fisheries, University of Tasmania.

139. RPDC (2003) Inquiry into the establishment of marine protected areas within the Davey and Twofold Shelf Bioregions. Final recommendations report. Resource Planning and Development Commission, Tasmania.

140. RPDC (2002) Inquiry into the establishment of a marine protected area within the Davey and Twofold Shelf Bioregions. Background report. Resource Planning and Development Commission, Tasmania.

141. Creswell, G.R., Edwards, R.J. and Barker, B.A. (1989) Macquarie Harbour, Tasmania – seasonal oceanographic surveys in 1985. *Papers and Proceedings of the Royal Society of Tasmania* **123**: 63-66.

142. Hirst, A., Barrett, N., Meyer, L. and Reid, C. (2007) A detailed benthic faunal and introduced marine species survey of Port Davey, Bathurst Channel and Bathurst Harbour in south west Tasmania. NRM Project No. WPD3. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

143. Edgar, G. J. and Cresswell, G. R. (1991) Seasonal changes in hydrology and the distribution of plankton in the Bathurst Harbour Estuary, southwestern Tasmania, 1988-89. *Papers and Proceedings of the Royal Society of Tasmania* **125**: 61-72.

144. Barrett, N. S., Edgar, G. J., and Mooney, P. (1998) A preliminary investigation of the distribution, range and extent of reef habitats and communities in Port Davey, March 1998. Report to the Tasmanian Parks and Wildlife Service, Hobart.

145. Parks and Wildlife Service (2009) Visitors guide to Tasmania's marine reserves. Parks and Wildlife Service, Tasmania. Available at: http://www.parks.tas.gov.au/index.aspx?base=397. Accessed 6th April 2011.

146. Nichol, S. L., Anderson, T.J., McArthur, M., Barrett, N., Heap, A. D., Siwabessy, P.J.W. and Brooke, B. (2009) Southeast Tasmania temperate reef survey: post survey report. Geoscience Australia Record 2009/43.

147. Parks and Wildlife Service (2010) Pitt Water Nature Reserve Draft Management Plan. Department of Primary Industries, Parks, Water and Environment, Hobart.

148. Aquenal (2000) Marine biota survey – Sorell Causeway Bridge Replacement. Report pepared for Pitt and Sherry Engineering Consultants and the Department of Infrastructure, Energy and Resources, Tasmania.

149. Prestedge (1998) The distribution and biology of *Patiriella vivipara* (Echinodermata: Asteroidea: Asterinidae): a seastar endemic to southeast Tasmania. *Records of the Australian Museum* **50**: 161-170.

150. Parsons, K. (2007) Personal observation.

151. DEWR (2007) Assessment of the harvest of native oysters (*Ostrea angasi*) from the Tasmanian shellfish fishery. Department of the Environment and Water Resources, Australian Government.

152. National Oceans Office (2002) Resources: Macquarie Island's picture. The South-east Regional Marine Plan, National Oceans Office.

153. National Oceans Office (2002) Ecosystems: nature's diversity. The South-east Regional Marine Plan, National Oceans Office.