Appendix D East Marine Region Protected Species Group Report Cards

These report cards summarise information on those species that occur in the East Marine Region that are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The report cards present relevant information on species groups and are designed to be updated as new information becomes available. The report cards included in this appendix are current at September 2007. Updates of the report cards will be available on the web at <www.environment.gov.au/ coasts/mbp/east>. Protected species groups occurring in the East Marine Region for which report cards have been compiled include:

D1 Cartilaginous fish (including sharks, rays, skates and chimaeras)

D2 Bony fish (including seahorses, sea-dragons, pipefish, ghost pipefish and orange roughy)

D3 Reptiles (marine turtles and sea snakes)

D4 Seabirds

D5 Pinnipeds (fur seals, seals and sea lions)

D6 Cetaceans (whales, dolphins and porpoises)

The text for these protected species group report cards has been compiled from various sources including the following:

- South west Marine Bioregional Plan: Bioregional Profile (Department of the Environment and Water Resources 2007);
- Description of Key Species Groups in the East Marine Region (Australian Museum 2007);
- Australian Government species recovery plans including:
    - Whale Shark (*Rhincodon typus*) Recovery Plan 2005-2010 (Department of the Environment and Heritage 2005).
    - Recovery plan for the Grey Nurse Shark (*Carcharias taurus*) in Australia (Environment Australia 2002a).
    - White Shark (*Carcharodon carcharias*) Recovery Plan (Environment Australia 2002b).

Key References and Further Reading

Australian Museum, 2007, *Description of Key Species Groups in the East Marine Region*. Eds Tzioumis, V and Keable, S. Australian Museum, Sydney.

Department of the Environment and Heritage, 2005, *Whale Shark (Rhincodon typus) Recovery Plan 2005-2010*. Department of the Environment and Heritage, Canberra

Department of the Environment and Water Resources, 2007, *The South-west Marine Bioregional Plan: Bioregional Profile*. Department of the Environment and Water Resources, Canberra

Environment Australia, 2002a, *Recovery Plan for the Grey Nurse Shark (Carcharias taurus) in Australia*. Environment Australia, Canberra.

Environment Australia, 2002b, *White Shark (Carcharodon carcharias) Recovery Plan*. Environment Australia, Canberra.

D.1. East Marine Region Protected Species Group Report Card – Cartilaginous Fish

General information

Sharks, rays, skates and chimaeras (or ghost sharks) are cartilaginous fish belonging to the class Chondrichthyes. Of the 297 species that occur in Australian waters, it is estimated that approximately 200 species (125 sharks, 68 rays and 7 chimaerids) occur in the East Marine Region.

Nationally protected species

Three species of sharks found in the Region are listed under the EPBC Act (table D1). Recovery Plans for each of these three species can be found at <www.environment.gov.au/coasts/species/sharks> and white and whale sharks are also listed under international instruments. School sharks are on the priority assessment list for consideration by the Threatened Species Scientific Committee for possible listing under the EPBC Act. These three dogfish species may also be considered by the Committee.

Great white shark. Photo: Mike Ball and Rodney Fox.

Table D 1 Sharks listed as threatened or migratory under the EPBC Act that are known to occur in the East Marine Region

Species	Conservation Status	Australian Government Conservation Plans or Strategies for the Species
White shark (*Carcharodon carcharias*)	Vulnerable, Migratory Listed under CITES (Appendix II) and CMS (Appendix I)	White Shark (Carcharodon carcharias) Recovery Plan (July 2002) Recovery Plan for the Grey Nurse Shark (Carcharias taurus) in Australia (June 2002) National Plan of Action for the Conservation and Management of Sharks (2004) Whale Shark (Rhincodon typus) Recovery Plan 2005-2010 (2005)
Grey nurse shark (east coast population) (*Carcharias taurus*)	Critically endangered	
Whale shark (*Rhincodon typus*)	Vulnerable, Migratory Listed under CITES (Appendix II) and CMS (Appendix II)	

Ecology of protected sharks in the East Marine Region

White shark

The white shark is widely distributed, and located throughout temperate and sub-tropical regions in both the northern and southern hemispheres. It is most frequently encountered off South Africa, southern Australia, northern California and the northeastern United States (Last and Stevens 1994). In Australia, its range extends primarily from Moreton Bay in southern Queensland around the southern coastline to North West Cape in Western Australia (Bruce 1995). There is one record of a white shark as far north as Mackay (Paterson, 1990:154)

There are areas in the East Marine Region where encounters with white sharks are frequent. These include waters in and around seal and sea lion colonies in general, and the New South Wales coastal region between Newcastle and Port Stephens (particularly juveniles). Large white sharks were also taken in the past off Cape Moreton (once a whaling station) in Queensland (D'Ombrain 1957).

Movement patterns over the longer-term are poorly known; however, the white shark is capable of swimming long distances and for extended periods. For example, offshore tracking of a large shark with sonic tags indicated that it moved 190 kilometres in 2.5 days at an average cruising speed of 3.2 kilometres per hour (Carey et al. 1982 in Bruce 1992). One tagged shark was recorded travelling 2946km over 113 days. Other research in Australian waters has recorded shark movements mainly restricted to shelf and coastal waters and swimming depths down to 94 m (Bruce et al. 2001)

White sharks eat a variety of prey including finfish, other sharks and rays, marine mammals such as seals, sea lions, dolphins and whales, as well as squid, crustaceans and seabirds. Their diet is known to change with size – juveniles less than 2.7 m feed primarily on fish and other sharks and rays while larger sharks (reaching up to 6 m in length) are known to feed on marine mammals.

Although catch estimates for white sharks are based on incomplete information, the southern half of the East Marine Region has, historically, been a relatively significant one for white shark catch including through game fishing, incidental catch by commercial fishers, and through targeted shark control activities.

Grey nurse shark

The grey nurse shark is listed as two separate populations under the EPBC Act. The west coast population is listed as vulnerable, while the east coast population is listed as critically endangered with research suggesting that the New South Wales population is less than 1000 individuals (Otway and Burke 2004). The species is thought to occur in all waters off the Australian mainland but is considered rare in the Northern Territory and throughout the southern extent of its range (Victorian, South Australian and Tasmanian waters). It has not been found in the Great Australian Bight so it is thought that the west and east coast populations are separate.

The species is found primarily in warm-temperate (from sub-tropical to cool-temperate) inshore waters around rocky reefs and islands, and is occasionally found in the surf zone and in shallow bays. It has been recorded as far north as Cairns in the east (Pogonoski et al. 2001) although its range more recently has been confined to coastal waters off southern Queensland and along the New South Wales coast.

Grey nurse sharks have been recorded at varying depths. They are commonly found between 15 m and 40 m, but have occasionally been recorded at depths of around 200 m. The diet of grey nurse sharks is likely to consist of species such as pilchards, jewfish, tailor, bonito, moray eels, wrasses, sea mullet, flatheads, yellowtail kingfish, small sharks, squid and crustaceans.

The grey nurse shark has a relatively low growth rate and takes 4 - 6 years to mature (Branstetter and Musick 1994). The average life span of this species in the wild is unknown, although it is likely that larger specimens in the wild may be much older than 13 or 16 years (Pollard et al. 1996).

Whale shark

Whale sharks are wide-ranging species with a broad distribution. They are usually observed between latitudes 30°N and 35°S in tropical and warm temperate seas, both oceanic and coastal. The species is generally encountered close to or at the surface, as single individuals or occasionally in schools or aggregations up to hundreds.

Although it has been suggested that this species prefers waters with temperatures between 21-25°C, the whale sharks sighted at Ningaloo Reef off Western Australia (the best consistent location in Australian waters to view them) are in waters with temperatures averaging 27°C.

No areas where whale shark aggregate have been identified in the East Marine Region and no interactions with the species, such as capture in fisheries, are known to occur in the Region. Further information on whale sharks and threats to the species is available at <www.environment.gov.au/biodiversity/threatened/publications/recovery/r-typus>.

Demersal sharks and dogfish

The group of demersal sharks known as dogfish (the Centrophorus family in particular) have been greatly depleted through trawling over the last 30 years (Graham et al. 2001) with landings now very low and less than 5 per cent of the total shark catch. In response, the Australian Fisheries Management Authority has imposed limits for Harrisson's, Endeavour and southern dogfish, and has implemented a closed area to trawling on the upper slope of the continental shelf off Sydney (Mcloughlin 2006). In addition, school shark (*Galeorhinus galeus*) is on the priority assessment list for consideration by the Threatened Species Scientific Committee for possible listing under the EPBC Act, while the 3 dogfish species may also be considered by the Committee.

Known important areas for sharks in the East Marine Region and adjacent waters

In New South Wales, aggregations of grey nurse sharks can be found at reefs off the following locations: Byron Bay, Brooms Head, Solitary Islands, South West Rocks, Laurieton, Forster, Seal Rocks, Port Stephens, Sydney,

Bateman's Bay and Narooma (Otway and Parker 2000). An aggregation is considered to be 5 or more individuals present at the same site at the same time (Otway and Parker 2000). Known key aggregation sites for grey nurse sharks in Queensland include sites off Moreton and Stradbroke Islands and Rainbow Beach. In all, 19 critical habitat locations have been identified along the east coast. These sites may play an important role in pupping and/or mating activities, as grey nurse sharks form regular aggregations at these sites (Pollard et al. 1996).

Areas off Garie beach, Wattamolla and Port Stephens–Newcastle (New South Wales), and some areas off southern Queensland, appear to be seasonally important for juvenile white sharks. (Bruce et al 2001).

The upper slope of the continental shelf off central and southern New South Wales have proven to be key fishing grounds for Harrisson's, endeavour and southern dogfish. An area off the Sydney coast has recently been closed to trawling in order to protect dogfish.

Known interactions, threats and mitigation measures

Fisheries

In general, sharks are very susceptible to over-fishing. This is because their life history is characterised by relatively slow growth, late maturity, low fecundity and low natural mortality. Most reach reproductive maturity when more than three-quarters grown and either bear live young (viviparous, ovoviviparous, or oviphagous) or produce small numbers of eggs encased in a tough horny cover (oviparous).

Numbers of offspring can range from one or two every two or more years (e.g. dogfish) to 300 at one time recently produced by a whale shark. While the biology of many sharks and rays is unstudied, some general life history patterns are evident. Many coastal and shelf species have seasonal reproductive cycles with annual breeding, whereas in the majority of deepwater demersal species reproduction is non-seasonal and asynchronous, with gestation periods up to two years or more (see Kyne and Simpendorfer 2007 for review). Chondrichthyans found in the Eastern Marine Region exhibit a full range of these reproductive modes and fecundity ranges.

In addition, the demand for shark products, including fins, is relatively high, which adds to the susceptibility of some shark species to fishing pressure.

Commercial fisheries

Several state-based fisheries, and the Commonwealth-managed Eastern Tuna and Billfish Fishery (ETBF) and South East Shark and Scalefish Fishery (SESSF) exploit sharks and rays in the Eastern Marine Region waters. The Queensland East Coast Inshore Fin Fish Fishery (ECIFFF) principally targets small whaler and hammerhead sharks, with over 90 per cent of the catch taken inshore by mesh netting (Anon 2005; DPI&F 2006). Less than 20 per cent of the annual 1500 t harvest, however, is caught in the region off southern Queensland where the main target species are not reported (Gribble et al. 1998). In a recent Queensland east coast shark fishery assessment, sustainability threats were assigned to 20 species of commercially exploited sharks and rays in the ECIFFF (Gribble et al. 1998). The New South Wales catch of pelagic sharks by participants in the Offshore Trawl and Line Fishery (OTLF) is now in excess of 150 t per annum but new management plans are being formulated to put a cap on effort (and thus catch) in the fishery.

The main impact on pelagic sharks in the region is by the ETBF, both as byproduct and bycatch. While the jurisdiction of this fishery extends from Cape York to the Victoria–South Australia border, almost all fishing is in East Marine Region waters. Effort is concentrated off the northern half of New South Wales and southern half of Queensland and spans the width of the Australian Fishing Zone including waters around Lord Howe and Norfolk Islands (DAFF 2005).

With an increasing world-wide concern over the practice of finning sharks at sea and returning the injured animal to the water alive, the Australian Fisheries Management Authority (AFMA) (with complementary State legislation) banned the practice of shark finning at sea by prohibiting the possession or landing of fins separate from the carcasses and also enforcing a limit of 20 sharks per vessel per fishing trip (DAFF 2005). This measure addresses animal welfare concerns and limits the ability of fishers to take large numbers of sharks solely for their fins.

Demersal sharks in the Region are mainly exploited by the New South Wales Ocean Trawl Fishery (OTF) and Ocean Trap and Line Fishery (OTLF) fisheries, and the New South Wales trawl sector of the SESSF. Landings from the Queensland trawl fishery are now negligible since the 1999 mandatory introduction of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) (DPI&F 2006). Over 600 t of sharks and rays were reported taken from waters off New South Wales in 2000–01 (DPI 2004; DPI 2006), although this represents less than 10 per cent of the total New South Wales fishery production.

Recreational fishing – Prior to the implementation of protective State and Commonwealth legislation, game fishing for white sharks was carried out mainly in South Australia, Queensland and New South Wales, but also in

Victoria and Western Australia. Research using game fishing data for New South Wales calculated that the ratio of white sharks to all shark species caught had changed from 1:22 in the 1960s to 1:38 in the 1970s and 1:651 in the 1980s. In the 1990s, capture of White Shark by game fishers off the coast of New South Wales was 13:2103, or 1:162 (Chan 2001).

Recreational fishers still occasionally capture white sharks (for example in gill nets in Tasmanian waters) or while fishing for other sharks off the east coast states. In some cases small white sharks are mistakenly identified as other species (for example mako sharks).

Although game fishing is a potential threat to them, grey nurse sharks, are not favoured by game-fishers as they are considered to be poor fighters compared with other sharks. The extent of the impact that incidental catch by game-fishers has on grey nurse sharks is currently unknown. Until the 1980s, grey nurse sharks were wrongly perceived by the public as man-eaters, mainly because of their fierce appearance. This perception of grey nurse sharks led to intense spear-fishing pressure in eastern Australia during the 1950s and 1960s (Environment Australia 2002).

Shark Control Activities

Meshing as a protective measure for swimmers and surfers was introduced to New South Wales beaches in 1937 and to Queensland beaches in 1962. These are the only two states in Australia that employ this shark protection measure (Krogh and Reid 1996; Paterson 1990).

In New South Wales, shark nets are usually 150 m long with a mesh size of 50 to 60 cm (Krogh 1994). The nets are set parallel to the shore in around 10 to 15 m water depth with the bottom of the net resting on the ocean floor and the top supported by a series of floats (Krogh 1994). The idea of shark nets is not to stop sharks coming in to the beaches, but to intercept and catch them on their regular feeding and territorial runs (Eckersley 1996). There are currently a total of 49 meshed beaches along approximately 200 km of coastline between Newcastle and Wollongong in New South Wales. On average, approximately 4.2km of mesh net protect the beaches on any given day. The only known aggregation site in New South Wales close to protective beach meshing nets is Maroubra in Sydney.

In New South Wales during the early 1950s, up to 34 grey nurse sharks were meshed each year (Krogh and Reid 1996, Pollard et al. 1996). By the 1980s, this number had decreased to a maximum of 3 per year (Pollard et al. 1996), and over the last decade only three grey nurse sharks have been caught in the shark nets (D. Reid. unpublished data).

In Queensland, a mixture of baited drumlines and mesh nets are used. Drumlines consist of a marker buoy and float anchored to the bottom supporting a steel chain and baited hook. There has been a similar downward trend in grey nurse shark captures as seen in New South Wales, with a decrease from 90 captured between 1962 and 1972, to 21 captured over the last decade.

White sharks caught by beach meshing programs are usually small (less than 3 metres), and in many cases, are smaller than 2 metres. This suggests that these programs operate close to pupping grounds or in juvenile nursery habitats. However, while beach meshing undoubtedly is detrimental to smaller specimens, the widespread occurrence of similar small-sized white sharks in areas where beach meshing is not undertaken suggests that nursery habitats are also probably widespread in Australia (Bruce, CSIRO, pers. comm. as cited in white shark recovery plan).

Reid and Krogh (1992) observed that there has been a steady decline in numbers of white sharks caught in New South Wales meshing since 1950. Since then, up until the 1998–99 meshing season, a total of 509 white sharks have been captured in shark mesh nets in New South Wales (Dennis Reid, New South Wales Fisheries, pers. comm.). The annual average number of white sharks caught has declined from 13 for the first 20 years of recorded meshing to 4 per year caught in the last 10 years (Dennis Reid, New South Wales Fisheries, pers. comm.). New South Wales increased the meshing effort in the early 1970s and this is also reflected in the increase in shark captures around that time (Reid and Krogh 1992).

Since 1962 a total of 670 white sharks have been caught in the Queensland Shark Control Program. During the first 20 years of beach meshing in Queensland an average of about 20 white sharks per year were caught by the nets. This rate of capture has dropped to an average of 10 white sharks per year over the last 10 years. Paterson (1990) observed that nearly 90 percent of white shark captures occurred in southern Queensland off the Gold and Sunshine Coasts. The peak in captures occurred when water temperatures were low (Paterson 1990). It is interesting to note that from 1972–73 to 1989–90 the average annual catch over three major netting areas in New South Wales was about a quarter of the 1972–73 catch. A similar trend has been detected in Queensland and South Africa (Department of Primary Industries 1992).

Tourism

White shark cage diving and shark boat tours are undertaken in South Australia. There is no evidence that this activity significantly influences white shark behaviour (Bruce et al. 2005). There is no equivalent white shark tourism in the East Marine Region.

Degradation to areas of important habitat

Nineteen locations off the New South Wales and Queensland coasts have been deemed critical habitat for the grey nurse shark and are now protected under either Commonwealth or State statute. While these areas are protected from most forms of habitat damage, and, in most cases, all forms of fishing, the potential for some habitat degradation by anchors of vessels remains. Damage to the environment of inshore waters used by white sharks as nursery areas could have an effect on breeding and/or juvenile survival. In the case of school sharks and dogfish, continual trawling on substrates that support sessile organisms (e.g. sponges and gorgonians) can destroy such assemblages in a relatively short period (Pogonoski et al. 2002). The loss of these organisms can reduce habitat diversity and consequently lower species diversity.

Key References and Further Reading

Anon, 2005, *Fisheries of Queensland's East Coast : Shark*. CRC Reef Research Centre, Townsville.

Australian Museum, 2007, *Description of Key Species Groups in the East Marine Region*. Eds Tzioumis, V and Keable, S. Australian Museum, Sydney

Branstetter, S. and Musick, J.A., 1994, Age and growth estimates for the sand tiger in the Northwestern Atlantic Ocean. *Transactions of the American Fisheries Society* 123:242 -254.

Bruce, B., 1999, *Game-fish tag-release of White Sharks - an issues paper - unpublished discussion paper for the National White Shark Research Working Group*. CSIRO Marine Research, Hobart.

Bruce, B. D. and Stevens, J., 1998, *White Sharks in Australian waters*. An initial summary document.

Bruce, B.D., 1992, Preliminary observations on the biology of the White Shark, Carcharodon carcharias, in South Australian waters. *Australian Journal of Marine and Freshwater Research* 43: 1-11.

Bruce, B.D., 1995, The Protection of White Shark. A research perspective. *Southern Fisheries* 3(2):11-15. Department of Primary Industries and Fisheries.

Bruce. B.D., Malcolm H. and Stevens J.D., 2001, *A Review of the Biology and Status of White Sharks in Australian Waters*, CSIRO Marine Research, Hobart.

Chan R., 2001, *Biological studies on sharks caught off coast of New South Wales*. PhD thesis, University of New South Wales, Sydney.

D'Ombrain, A., 1957, *Game fishing off the Australian coast*. Angus and Robertson, Sydney.

Department of the Environment and Heritage, 2005, *Whale Shark (Rhincodon typus) Recovery Plan 2005-2010*. Department of the Environment and Heritage, Canberra

Department of the Environment and Water Resources, 2007, *The South-west Marine Bioregional Plan: Bioregional Profile*. Department of the Environment and Water Resources, Canberra

Department of Primary Industries, 1992, *Review of the operation and maintenance of shark meshing equipment in Queensland waters*, Department of Primary Industries, Brisbane.

Department of Primary Industries, 1998, *The Queensland Shark Control Program*. Report of the Committee of review. DPI, Brisbane.

Department of Primary Industries, 2001, *White Shark Catch Figures 1990 - 2001 Shark Control Program*, Queensland Boating and Fisheries Patrol, Brisbane.

DPI, 2004, *Environmental Impact Statement on the Ocean Trawl Fishery, volume 3*, New South Wales Department of Primary Industries.

DPI, 2006, *Environmental Impact Statement on the Ocean Trap and Line Fishery in New South Wales, volume 3*, New South Wales Department of Primary Industries.

DPI&F, 2006, *The Queensland East Coast Inshore Fin Fish Fishery background paper: Sharks and Rays*, Department of Primary Industries and Fisheries, Queensland.

Eckersley, Y., 1996, *Shark meshing - is the net result justifiable?* GEO Australia 18 (5): 17-26.

Environment Australia, 1999, *Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*. Environment Australia, Biodiversity Group, Canberra.

Environment Australia, 2002a, *Recovery Plan for the Grey Nurse Shark (Carcharias taurus) in Australia*. Environment Australia, Canberra.

Environment Australia, 2002b, *White Shark (Carcharodon carcharias) Recovery Plan*. Environment Australia, Canberra.

FAO, 1995, *Code of Conduct for Responsible Fisheries*. Food and Agriculture Organisation of the United Nations, Committee on Fisheries, Rome.

FAO, 1999, *International Plan of Action - Sharks*. Food and Agriculture Organisation of the United Nations, Committee on Fisheries, Rome.

Graham, KJ, 2005, 'Distribution, population structure and biological aspects of Squalus spp. (Chondrichthyes: Squaliformes) from New South Wales and adjacent Australian waters', *Marine and Freshwater Research*, 56(4): 405–416.

Graham, KJ Andrew, NL and Hodgson, KE, 2001, 'Changes in relative abundance of sharks and rays on Australian South East Fishery trawl grounds after twenty years of fishing', *Marine and Freshwater Research*, 52: 54–561.

Gribble, N., 1996, Summary of the CITES discussion paper for the Animals Committee. In: N.A. Gribble, G. McPherson and B. Lane (eds), *Shark Management and Conservation: Proceedings from the Sharks and Man Workshop of the Second World Fisheries Congress Brisbane, Australia, 2 August 1996*. Department of Primary Industries, Queensland.

Gribble, N.A., McPherson, G. and Lane, B., 1996, Shark control: a comparison of meshing with set drumlines. In Gribble, N.A., McPherson, G. and Lane, B. (1998a). *Shark Management and Conservation. Second World Fisheries Congress Workshop Proceedings, Brisbane August 1996*. QDPI Conference and Workshop series (QC98001).

Gribble, N.A., McPherson, G. and Lane, B., 1998, Effect of the Queensland Shark Control Program on non-target species: whale dugong, turtle and dolphin: a review. *Australian Journal of Marine and Freshwater Research* 49:645-651.

Krogh, M., 1994, Spatial, seasonal and biological analysis of sharks caught in the New South Wales protective beach meshing program. *Australian Journal of Marine and Freshwater Research* 45:1087 - 1106.

Krogh, M. and Reid, D., 1996, Bycatch in the protective shark meshing program off south-eastern New South Wales, Australia. *Biological Conservation* 77:219 - 226.

Kyne, P and Simpendorfer, C, 2007, *A collation and summarization of available data on deepwater chondrichthyans: biodiversity, life history and fisheries*, A report prepared by the IUCN SSC Shark Specialist Group for the Marine Conservation Biology Institute.

Larcombe, J. and McLoughlin, K. (eds), 2007, *Fishery Status Reports 2006: Status of fish stocks managed by the Australian Government*, Bureau of Rural Sciences, Canberra.

Last, P.R. and Stevens, J.D., 1994, *Sharks and Rays of Australia*. CSIRO Division of Fisheries, Australia.

Last, PR Burgess, GH and Séret, B, 2002, 'Description of six new species of lantern-sharks of the genus Etmopterus (Squaloidea: Etmopteridae) from the Australasian region', *Cybium*, 26(3): 203–223.

Last, PR White, WT and Pogonoski, J, 2007, 'Descriptions of new dogfishes of the genus Squalus (Squaloidea: Squalidae)', *CSIRO Marine and Atmospheric Research Paper*: 14.

McLoughlin, K. (ed), 2006, *Fishery Status Reports 2005: Status of fish stocks managed by the Australian Government*, Bureau of Rural Sciences, Canberra

Otway, N.M. and Parker, P.C., 1999, *A review of the biology and ecology of the Grey Nurse Shark (Carcharias taurus) Rafinesque 1810*. New South Wales Fisheries Research Report Series 1. New South Wales Fisheries, Sydney.

Otway, N.M. and Parker, P.C., 2000, *The biology, ecology, distribution, abundance and identification of Marine Protected Areas for the conservation of threatened Grey Nurse Sharks in south east Australia waters*. New South Wales Fisheries Office of Conservation, Port Stephens.

Otway, N.M., 2001, Grey Nurse Shark. *Nature Australia* - Autumn: 20-21

Otway, N.M. and Burke, A.L., 2004, Mark-recapture population estimate and movements of grey nurse sharks. New South Wales EA Project No. 30786. *New South Wales Fisheries Final Report Series No 63*. New South Wales Fisheries, Sydney.

Paterson, R.A, 1990, Effects of long-term anti-shark measures on target and non-target species in Queensland, Australia. *Biological Conservation* 52: 147 - 159.

Pogonoski, J.J., Pollard, D.A., and Paxton, J.R., 2001, *Conservation overview and action plan for Australian threatened and potentially threatened marine and estuarine fishes*. Environment Australia, Canberra.

Pollard, D.A., Lincoln Smith, M.P., and Smith, A.K., 1996, The biology and conservation status of the Grey Nurse Shark (Carcharias taurus Rafinesque 1810) in New South Wales, Australia. Aquatic Conservation: *Marine and Freshwater Ecosystems* 6:1-20.

Reid, D.D. and Krogh, M., 1992, Assessment of catches from protective shark meshing off New South Wales beaches between 1950 and 1990. *Australian Journal of Marine and Freshwater Research* 43:283 - 96.

Rose, C and McLoughlin, K, 2001, *Review of Shark Finning in Australian Fisheries*, Bureau of Rural Sciences, Canberra.

D.2. East Marine Region Protected Species Group Report Card – Bony Fish (Teleosts)

Current at September 2007. For updates see <www.environment.gov.au/coasts/mbp/east>.

General information

There are approximately 4000 species of marine fish in Australian waters (Hoese et al. 2006). A high proportion of these are found in the East Marine Region with almost 400 species of teleosts being recorded from trawl surveys off the New South Wales coast. For further information see: <www.environment.gov.au/coasts/mbp/East

Nationally protected species

Only one species of bony fish, the orange roughy (*Hoplostethus atlanticus*), is listed as threatened under the EPBC Act in the Region. Orange roughy is the first commercially harvested fish to be listed under the EPBC Act. Orange roughy is listed as conservation-dependent and is being managed subject to a conservation program to be implemented by the Australian Fisheries Management Agency (See table D2).

Ecology of protected species in the East Marine Region

Orange roughy

Outside Australian waters orange roughy live in cold, deep waters in the Atlantic, Pacific and Indian Oceans. They are most common at depths of 800-1000 m, but have occasionally been found at depths as shallow as 180 m, and as deep as 1800 m. In Australia, orange roughy are found across the southern half of the continent, from central New South Wales, through to south-western Australia, including Tasmania. They also occur on seamounts and ocean ridges south of Australia, and on the South Tasman and Lord Howe rises.

Orange roughy are believed to be one of the longest living fish species. Examinations of the otoliths (ear bones) of orange roughy suggest maximum ages of between 125 and 156 years. Its longevity means that the species is very slow growing and does not reach sexual maturity for many years. Orange roughy also have relatively low fecundity. As a result of these life history characteristics, the species has very low resilience to fishing, because the likelihood of being caught before the fish has reproduced is statistically much higher than for other species.

Syngnathids and Solenostomids (seahorses, seadragons, pipefish and ghost pipefish)

The family Syngnathidae is a group of bony fish which include seahorses, pipefish, pipehorses and sea dragons. A total of about 330 species have been described worldwide. Australia has the highest recorded diversity of syngnathids with an estimated 25–37 per cent of the world's species (Pogonoski et al. 2002). Approximately 25 per cent of syngnathid genera and 20 per cent of species are endemic to Australian waters (Kuiter 2000; Pogonoski et al. 2002; Martin-Smith and Vincent 2006).

All syngnathids and solenostomids in Australia are listed as 'marine species' under Section 248 of the EPBC Act and are protected.

In 2002, all seahorses (the entire genus of *Hippocampus*) were listed on Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973*. Permits can be granted under CITES for trade in these species, while the EPBC Act controls international trade in all wild capture and aquarium-raised Australian syngnathid and solenostomid species.

There is a paucity of knowledge on the distribution, relative abundance and habitats of species of syngnathids

Table D2 Bony fish listed as threatened under the EPBC Act that are known to occur in the East Marine Region

Species	Conservation Status	Conservation Plans and Policies
Orange roughy (*Hoplostethus atlanticus*)	Conservation dependent	Orange Roughy Conservation Programme (2006) Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes (2002)
Eastern gemfish *Rexea solandri (eastern Australian population)*	Conservation dependent	Australian Fisheries Management Authority (AFMA) (2009e). *The Eastern Gemfish Rebuilding Strategy 2008.*
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark *Galeorhinus galeus*	Conservation dependent	Australian Fisheries Management Authority (AFMA) (2009d). *The School Shark Rebuilding Strategy 2008.* Threatened Species Scientific Committee (TSSC) (2009d). *Addendum to the School Shark Rebuilding Strategy 2008.*

in the East Marine Region. They are a group with diverse characteristics, including some that are apparently rare and localised, others widely distributed and very common, and some apparently rare yet widely distributed. Many of the pipefish, seahorse and seadragon species are found in near-shore coastal environments such as seagrass beds in shallow bays, and reefs dominated by macro-algae. Some of the pipehorses are found in deeper waters of the continental shelf.

While the taxonomy of this family is contested, Australian waters appear to support the largest number of syngnathid genera in the world, and new species have been discovered in recent years. Habitats that supports syngnathid populations are generally patchy, and hence populations of syngnathid species may be dispersed and fragmented. Some groups of syngnathids, notably the seahorses, have particular microhabitat preferences, mainly occupying the edges of particular habitat types (for example, seagrass, sand or reef, or sand interfaces). Syngnathids feed in the water column, on or near the substrate. Most eat small invertebrates, such as mysids in the zooplankton and small amphipods on surfaces. A few species also eat other invertebrates (for example, shrimps), and larval fish.

Many syngnathids, particularly the seahorses, are characterised by:

- relatively low population densities;
- low mobility and small home range sizes (hence recolonisation of overexploited areas would be slow);
- possible low rates of natural mortality in adults (hence fishing may place excessive pressures on the population);
- dependency of birth and survival of offspring on the survival of the males;
- monogamous breeding (hence a 'widowed partner' may temporarily stop reproducing until another mate is found);
- small brood sizes, which limits the potential reproductive rate (although this may be offset by higher juvenile survival); and
- strong association with the preferred habitat, which can make populations vulnerable to site-specific impacts. However, some of the inshore pipefish have very high population densities and live in unstable habitats, subject to damage from storms or dramatic changes in temperature or salinity, and such species can quickly colonise even small patches of suitable habitat.

Important areas for protected bony fish in the East Marine Region

Important areas in the East Marine Region are identified for species that are listed as threatened or migratory under the EPBC Act, thus important sites are identified for the single bony fish species listed – the orange roughy.

Orange roughy are known to aggregate, particularly around underwater features such as seamounts. There are many such features in the East Marine Region although the South East Marine Region is known to contain the largest concentrations of orange roughy. In midslope depths (~800–1000 m), orange roughy aggregate at specific spawning sites; once discovered, such sites quickly become the focus of intense trawling activities e.g. St Helens Hill, a seamount off north-eastern Tasmania (Larcombe and McLoughlin 2007).

A substantial catch of spawning orange roughy was taken off Newcastle–Port Stephens in 1988 (Graham and Gorman 1988), followed by the capture of numerous orange roughy eggs in the same area in 1989 (Graham 1990). This indicates that there is also an orange roughy spawning site off central New South Wales. It is therefore likely that mature orange roughy from along much of the New South Wales coast seasonally congregate in this area for spawning as well as at the better known aggregation sites off Tasmania.

Known interactions, threats and mitigation measures

Orange roughy

Large catches of orange roughy were made during the 1980s and 1990s before stocks were given some protection. Most of the exploitation of this species occurred in the South-East Marine Region, off Tasmania.

Since the 1990s, the Australian Fisheries Management Authority, in conjunction with industry, has managed the orange roughy fishery to reduce catch levels, including the creation of management zones with associated total allowable catches set annually. In 2005, the Authority reduced several orange roughy allowable catches to negligible quantities from 2007 onwards, to enable recovery of the commercial fishery.

In addition, the *Orange Roughy Conservation Programme 2006* allowed the then Minister for the Environment and Heritage to list the orange roughy as conservation-dependent. This conservation program aims to protect orange roughy from over-fishing, in part by prohibiting targeted fishing in the management zones. The Cascade Plateau off the south-east of Tasmania (in the South-East Marine Region) is the only area where this species is currently fished with catch levels set to allow recovery of the species.

Such measures are now considered essential for long-term protection of stocks of orange roughy. In the Western Zone of the South East Fishery – an orange roughy management area adjacent to the eastern boundary of the South-west Marine Region – an important management objective of

the early 2000's was that stocks should be above 30 per cent of pre-fishing biomass by 2004. At that time, there was a 90 per cent chance that the target would not be met, and it has not been met to date. During the early 2000's, stock size was estimated to be 10–26 per cent of pre-fishing biomass (Bruce et al. 2002).

Given the long life of orange roughy, and the consequent low recruitment relative to stock size, rebuilding rates will be particularly slow, and thus the cost in foregone catch of achieving any specific rebuilding target will be high. This was evident in an assessment in 2002, which showed that even with zero fishing, rebuilding of the stocks to target biomass levels would be very slow (Caton and McLoughlin 2005, Francis and Hillborn 2002).

Although very little is known about the trophic interactions of orange roughy, it is highly likely that significant reductions in orange roughy biomass will have impacts on the species that feed on them, and on the prey of orange roughy (Bruce *et al*. 2002). For example, surveys in New Zealand have shown declines in a series of species associated with orange roughy that may be the result of orange roughy fishing, either directly through by-catch, or indirectly through trophic or habitat interactions (Clark et al. 2000).

Bottom trawling on seamounts is considered to severely affect benthic fauna by physical damage, and through by-catch. Because of the importance of seamounts to orange roughy spawning, it is considered that the damage to habitat caused by bottom trawling in such areas may also affect recruitment of orange roughy. The conservation program being implemented by the Australian Fisheries Management Authority includes a prohibition on orange roughy fishing in known aggregation areas over seamounts.

Seamount habitats can be highly productive in fishery terms, but there are growing concerns about the effects of fishing on the biodiversity and ecosystem productivity of such areas. A stark example was a description by Clark and O'Driscoll (2003) of a photographic survey in New Zealand waters that showed a reduction from almost 100 per cent coral cover on unfished seamounts to 3 per cent cover on fished seamounts. In areas adjacent to the East Marine Region, large catches of coral were reported from the Tasman Sea fisheries on the Northwest Challenger Plateau and seamounts in the South Tasman Rise (Anderson and Clark 2003). It is likely that similar habitats exist in remote areas of the Region.

Syngnathids

Syngnathids are harvested both as target species in State waters (adjacent to the Region) and as by-catch. Seahorses and pipehorses are traded in Australia and internationally for traditional medicine and for aquaria. Seahorses are currently exported for the aquarium trade, from Victoria, Queensland, South Australia, Western Australia, and the Northern Territory.

The *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes* (Environment Australia 2002) identifies over-harvesting of wild specimens for the marine aquarium fish trade and/or the traditional medicine trades as the greatest potential threat to some species of syngnathids.

Trade of seahorses is heavily regulated in Australia under international and Commonwealth law. Licences are granted under CITES II and permits are required under the EPBC Act for the export of wild capture and aquarium-raised specimens. The Department of the Environment, Water, Heritage and the Arts is the CITES management authority in Australia, relying heavily on the Australian Customs Service to implement CITES controls for the syngnathid trade at ports of exit and entry. State governments also have permit systems regulating trade in syngnathids.

The trade in dried syngnathids for traditional medicine mainly utilises tropical and sub-tropical species in Australia, which are caught as by-catch in the Queensland East Coast Otter Trawl Fishery. The by-catch and sale of syngnathids caught in this fishery is undertaken in accordance with an approved Wildlife Trade Operation issued under section 303FN of the EPBC Act.

Australia is the sole supplier of two sea dragon species, *Phycodorus eques* and *Phyllopteryx taeniolatus*, to the live aquarium trade. In a review of exports of syngnathids from Australia, Martin-Smith and Vincent (2006) conclude that trade volume is relatively low (although lucrative) and probably poses a low threat compared to habitat loss, as traders tend to capture a few brooding males and rear the young for later sale. There is no evidence of population declines for either species (Pogonoski *et al* 2002).

Seahorses are often collected for use in home aquaria but they require particular care in captivity as they usually only consume live food. Without special care many seahorses taken from the wild do not survive for very long (Kuiter 2000). A number of aquaculture organisations in Australia have developed techniques for breeding and

keeping seahorses and they are largely sold to aquarium markets in Australia, North America, Europe and Asia (Martin-Smith and Vincent 2006). Cultured specimens are not accepted in the Traditional Chinese Medicine (TCM) trade (Anna Murray pers. comm.).

More than 98 per cent of Australia's exports of dried syngnathids for use in the TCM trade are the pipehorses *Solegnathus dunckeri* and *S. hardwickii*, sourced largely from the bycatch component of the ECTF. They represent Australia's largest syngnathid export both by volume and value (Martin-Smith et al. 2003; Martin-Smith and Vincent 2006). Because *S. dunckeri* is an endemic species, Australia is the sole supplier of this pipehorse to the TCM trade (Martin-Smith and Vincent 2006).

In a recent assessment of the Queensland ECTF it was reported that over 90 per cent of the total syngnathid catch was made up of the pipehorses, *Solegnathus dunckeri* and *S. hardwickii* (Dodt 2005; Connolly et al. 2001). *Solegnathus* species have also been reported as bycatch in the New South Wales Ocean Trawl Fishery (OTF) and in trawl fishing operations off Victoria which are managed by the Australian Fisheries Management Authority (Bowles and Martin-Smith 2003). A survey of bycatch in the demersal trawl fisheries in south-eastern Australia also showed that *Solegnathus* species were the major component of the syngnathid bycatch with *Solegnathus spinosissimus* the most commonly caught species on the south coast of New South Wales and eastern Victoria, and *S. dunckeri* the most commonly caught species from the central to the far north coast of New South Wales (Bowles and Martin-Smith 2003). The volumes traded from these fisheries are largely unknown and not regulated as in the ECTF.

In an assessment of threat to bycatch species caught in the New South Wales OTF (DPI 2004) four species of syngnathids were identified as being at medium to high risk from fishing operations. These were the pipehorses *Solegnathus dunckeri*, *S. spinosissimus*, and the seahorse *Hippocampus tristis*. Many of the other species of syngnathids found along the New South Wales coast are restricted to shallow, estuarine habitats and are considered at low risk from trawling operations (DPI 2004).

Many syngnathids inhabit relatively shallow inshore areas which makes them vulnerable to human disturbance. Increasing coastal development has the potential to impact on important habitats such as seagrass, reef and soft bottom habitats through pollution, urban run-off and dredging (Vincent 1996; Kuiter 2000; Pogonoski et al. 2002; Martin-Smith unpublished manuscript).

The poaching or illegal collecting of syngnathids in southern Australia is poorly documented; however some conservation authorities and government agencies have been concerned about the potential impact of this activity on populations, particularly during the 1990s, prior to the development of syngnathid aquaculture.

Key References and Further Reading

Anderson, O.F. and Clark, M.R., 2003, 'Analysis of bycatch in the fishery for orange roughy, Hoplostethus atlanticus, on the South Tasman Rise', *Marine and Freshwater Research*, 54: 643–652.

Andrew, NL Graham, KJ Hodgson, KE and Gordon, GNG, 1997, 'Changes after twenty years in relative abundance and size composition of commercial fishes caught during fishery independent surveys on SEF trawl grounds', *New South Wales Fisheries Final Report Series* No.1, New South Wales Fisheries Research Institute, Cronulla.

Australian Fisheries Management Authority, 2009, *The School Shark Rebuilding Strategy 2008*, Australian Government, Canberra.

Australian Fisheries Management Authority, 2009, *The Eastern Gemfish Rebuilding Strategy 2008*, Australian Government, Canberra.

Australian Fisheries Management Authority, 2006, *Orange Roughy Conservation Programme*, Australian Government, Canberra.

Australian Fisheries Management Authority, 2007, *AFMA Fishing Future Volume 4(4)*, Australian Government, Canberra

Bowles, DRJ and Martin-Smith, KM, 2003, *Catch and trade of Solegnathus spp. (pipehorses) from demersal trawl fishery landing sites in New South Wales and Victoria (Australia)*, Project Seahorse/New South Wales Fisheries Scientific Committee.

Bruce, B.D., Bradford, R., Daley, R.K., Green, M., and Phillips, K., 2002, *Targeted Review of Biological and Ecological Information from Fisheries Research in the South East Marine Region, Final Report*, CSIRO Marine Research report for the National Oceans Office, Canberra

Caton, A.E., and McLoughlin, K. (eds), 2005, *Fishery Status Reports 2004: Status of Fish Stocks Managed by the Australian Government*, Bureau of Rural Sciences, Canberra.

Clark, M and O'Driscoll R, 2003, 'Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand', *Journal of Northwest Atlantic Fisheries Science*, 31: 441–458.

Clark, M.R., Anderson, O.A., Francis, R.I.C.C., and Tracey, D.M., 2000, 'The Effects of Commercial Exploitation on Orange Roughy (*Hoplostethus atlanticus*) from the Continental Slope of the Chatham Rise, New Zealand, from 1979 to 1997', *Fisheries Research* 45(3): 217-238.

Connolly, RC Cronin, ER and Thomas, BE, 2001, *Trawl bycatch of syngnathids in Queensland: catch rates, distribution and population biology of Solegnathus pipehorses (seadragons), Project No. 1999/124 Report to Fisheries Research and Development Corporation*, Griffith University, Gold Coast.

Dodt, N, 2005, *Fisheries Long Term Monitoring Program —Syngnathids in the East Coast Trawl Fishery: a review and trawl survey*, Department of Primary Industries and Fisheries, Queensland.

DPI, 2004, *Environmental Impact Statement on the Ocean Trawl Fishery, Volume 3*, New South Wales Department of Primary Industries.

DPI, 2006, *Environmental Impact Statement on the Ocean Trap and Line Fishery in New South Wales, volume 3*, New South Wales Department of Primary Industries.

DPI, 2007, *Fishery Management Strategy for the Ocean Trawl Fishery*, New South Wales Department of Primary Industries.

Environment Australia, 2002, *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes*, Environment Australia, Canberra.

Foster, SJ and Vincent ACJ, 2004, 'The life history and ecology of seahorses: implications for conservation and management', *Journal of Fish Biology*, 65: 1–61.

Francis, C. and Hilborn, R., 2002, *Review of the 2002 Australian Orange Roughy Stock*, Report for Australian Fisheries Management Authority, Canberra.

Graham, KJ and Gorman, TB, 1988, Report on mid-slope trawling conducted during Cruises 88-01 to 88-18 in February–September, 1988, *Kapala Cruise Report No. 104*, New South Wales Fisheries Research Institute, Cronulla.

Graham, KJ, 1990, Report for Cruises 89-06 to 89-20 conducted on the New South Wales mid-slope between Crowdy Head and Batemans Bay during April–September, 1989, *Kapala Cruise Report No. 107*, New South Wales Fisheries Research Institute, Cronulla.

Graham, KJ Liggins, GW Wildforster, J and Wood, B, 1995, New South Wales continental shelf trawl-fish survey results for Year 1: 1993, *Kapala Cruise Report No. 114*, New South Wales Fisheries Research Institute, Cronulla.

Hoese, DF Bray, DJ Paxton, JR and Allen, GR, 2006, 'Fishes', in *The Zoological Catalogue of Australia, volume 35*, Beesley PL and Wells A (eds), ABRS and CSIRO Publishing, Australia.

Kuiter, RH, 2000, *Seahorses, pipefishes and their relatives: a guide to the syngnathiformes*, TMC Publishing, London.

Kuiter. RH, 2001, 'Revision of the Australian Seahorses of the Genus Hippocampus (Syngnathiformes: Syngnathidae) with descriptions of Nine New Species', *Records of the Australian Museum*, 50: 293 –340.

Larcombe, J and McLoughlin, K (eds), 2007, *Fishery Status Reports 2006: Status of fish stocks managed by the Australian Government*, Department of Agriculture, Fisheries and Forestry, Canberra.

Martin-Smith, KM *'Role of syngnathids in shallow coastal ecosystems of south-eastern Australia'*, Unpublished manuscript.

Martin-Smith, KM and Vincent, ACJ, 2006, 'Exploitation and trade of Australian seahorses, pipehorses, sea dragons and pipefishes (Family Syngnathidae)', *Oryx*, 40(2): 141–151.

Martin-Smith, KM Fung-ngai Lam, T and Kwok-hung Lee, S, 2003, 'Trade in pipehorses Solegnathus spp. for traditional medicine in Hong Kong', *Traffic Bulletin*, 19: 139–148.

Pogonoski, JJ Pollard, DA and Paxton, JR, 2002, *Conservation overview and action plan for threatened and potentially threatened marine and estuarine fishes*, Environment Australia, Canberra.

Rowling, KR and Makin, DL, 2001, Monitoring of the fishery for gemfish Rexea solandri, 1996–2000, *New South Wales Fisheries Final Report Series*, No. 27. New South Wales Fisheries Research Institute, Cronulla.

Rowling. KR, 1994, 'Gemfish Rexea solandri', in *The South East Fishery - a scientific review with particular reference to quota management*, Tilzey, RD (ed), Bureau of Resource Sciences, Canberra

Threatened Species Scientific Committee, 2009, *Addendum to the School Shark Rebuilding Strategy 2008*, Australian Government, Canberra.

Vincent, ACJ, 1996, *'The International Trade in Seahorses'*, TRAFFIC International, Cambridge.

D.3. East Marine Region Protected Species Group Report Card – Reptiles

Current at September 2007. For updates see <www.environment.gov.au/coasts/mbp/east >

General information

Marine turtles and sea snakes are reptiles. Both species are distantly related to land-based reptiles. They have lungs and must surface to breathe. Marine turtles and sea snakes are typically associated with tropical seas, however, some species are known to inhabit subtropical and temperate oceanic waters.

There are two extant families of marine turtles, Cheloniidae and Dermochelyidae. There are also two families of sea snakes: Hydrophiinae – aquatic species that never leave the water; and Laticaudinae – an amphibious species that can live on land and in water.

Nationally protected species

All marine turtles are listed under the EPBC Act as endangered or threatened migratory and marine species. Both these extant families of marine turtles occur in Australia and within the Eastern Marine Region including:

Cheloniidae (hard-shelled turtle)
with five species from five genera:
Loggerhead turtle (*Caretta caretta*)
Green turtle (*Chelonia mydas*)
Hawksbill turtle (*Eretmochelys imbricata*)
Olive ridley turtle (*Lepidochelys olivacea*)
Flatback turtle (*Natator depressus*)

One genus (*Natator*) is endemic to the Australian–New Guinea continental shelf. The remainder have a global distribution in tropical and temperate waters ranging from lower estuarine and inshore continental shelf to oceanic pelagic habitats. The family is characterised by non-retractable, large, paddle-like flippers, each with one or two claws and keratinised epidermal scutes (horny, scale-like structures) on the head, flippers, carapace and plastron (the underside of a turtle's shell). The ribs are fused to the overlying pleural bones which are also fused to each other to form the shield-like bony carapace of adults. The head can be partially withdrawn beneath the carapace and there are no cusps (pointed parts) on the upper jaw sheaths (Limpus and Miller 1993.

Dermochelyidae (leatherback turtle)
with a single species, *Dermochelys coriacea*.
The family has a global distribution from tropical seas to

Table D 3 Marine turtles listed as threatened or migratory under the EPBC Act that are known to occur in the East Marine Region

Species	Conservation Status	Australian Government Conservation Plans and Policies
Leatherback turtle, Leathery turtle (*Dermochelys coriacea*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	The Action Plan for Australian Reptiles (1993) Recovery Plan for Marine Turtles in Australia (2003) Sustainable Harvest of Marine Turtles and Dugongs in Australia - National Partnership Approach (2005)
Loggerhead turtle (*Caretta caretta*)	Endangered, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	
Green turtle (*Chelonia mydas*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	
Olive Ridley Lepidochelys olivacea	Endangered, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	
Flatback turtle (*Natator depressus*)	Vulnerable, Migratory, Marine Listed under CMS (Appendix I, II) and CITES (Appendix I)	Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs. Department of the Environment and Heritage (AGDEH) (2005)

sub-Arctic and sub-Antarctic waters ranging from oceanic to coastal waters but avoiding reefs. The leatherback turtle is characterised by large paddle-like flippers lacking claws, the absence of keratinised epidermal scutes except in hatchlings, separate ribs, a mosaic of small, polygonal dermal bones covering the body, a strongly ridged carapace, and pronounced cusps on the upper jaw (Limpus 1993a). The global biology of leatherback turtles has been partly reviewed by Hamann et al. (2003).

Some 25 species of marine snakes are known, or suspected, to occur in the East Marine Region. They include members of the following four major groups of snakes:

Colubrid snakes
(Family Colubridae, subfamily Homalopsinae):
1 of 4 Australian species.
These are all inshore snakes that occur mostly in the often turbid waters of protected bays and estuaries where they feed primarily on fish and crustaceans on tidal mudflats and in the intertidal zone of mangrove forests. They possess the broad ventral (belly) scales characteristic of terrestrial snakes, and their most obvious (external) marine adaptations are upwardly-directed nostrils and eyes (to allow the snakes to breathe and to see potential predators with only the tip of the snout and the eyes above water), and valvular nostrils (to prevent water entering the air passages when the snake is submerged or feeding). Members of this group possess a pair of venom glands (Duvernoy's) which can exude venom around the enlarged, grooved rear maxillary teeth when the snake bites, the venom running down the fangs largely by capillary action into the prey.

File Snakes
(Family Acrochordidae): 1 of 2 Australian species.
These snakes are entirely aquatic. They have tiny eyes and loose flabby bodies in which the skin is covered by very small keeled scales. These scales give the snakes a rough, file-or rasp-like feel and permit them to firmly grasp fish (on which they feed) between body loops prior to ingestion. They are non-venomous and harmless to humans, with only one of the three known species entering the marine environment.

Viviparous Sea Snakes
(Family Elapidae, subfamily Hydrophiinae):
16 of 29 Australian marine species.
These snakes are closely allied to Australia's proteroglyphous (fixed front-fanged) land snakes, and contain some of the most highly venomous snakes in the world. A venom gland under the skin of each cheek sends venom along a duct to the base of a hypodermic-like enlarged fang located at the front of the upper jaw. This venom can be injected into prey or predator when the snake bites. The majority of species, with the exception of a few smaller species that frequent mud and mangrove flats, never emerge voluntarily from the water. They are, however, often washed ashore, in an exhausted condition, after heavy storms and seas. The primary adaptations to a fully-aquatic life cycle are a viviparous (live-bearing) reproductive mode; a long and highly vascularised right lung (extended in length by a well-developed tracheal lung – all snakes typically have only a single functional lung) to permit submersion for extended periods; a moderate to extreme reduction in the size of the ventral (belly) scales facilitating aquatic serpentine locomotion; a large flattened, paddle-shaped tail to propel the snake through the water; and valvular nostrils that close off the air passages when the snake is under water, including when ingesting prey. The great majority of species feed on fish, with individual species specialising in particular groups of fish (e.g. eels, scorpaenids, gobeids and their eggs).

It should be noted that three additional species – *Hydrophis laboutei*, *H. gracilis* and *H. spiralis* – have been recorded from the Chesterfield Reefs and adjacent New Caledonian waters (Minton and Dunson 1985; Ineich and Rasmussen 1997; Rasmussen and Ineich 2000) and are therefore likely to occur on reef complexes within the Region (e.g. Kenn Reef). A fourth species – *Hydrophis coggeri* – is abundant in the waters of Fiji and New Caledonia, but appears to be disjunct from the only known Australian populations occurring on reefs of the North-west Shelf. However its abundance and proximity to the eastern provinces of the East Marine Region suggest that it may well occur there.

Oviparous Sea Kraits
(Family Elapidae, subfamily Laticaudinae):
2 or 3 of 8 Asian–Pacific species.
This is a small group (eight species) of semi-aquatic marine snakes in which the majority (six species) occur in the south-west Pacific region. These are mostly reef-dwelling snakes. Members of the group are sometimes carried well away from their normal ranges by storms and currents. All Australian records appear to be of waifs, and despite substantial breeding populations of at least one species in the coastal waters of southern New Guinea, no resident populations have been located within Australian waters. Sea kraits spend a substantial part of their lives on land, usually within about 100 m of the sea, and produce clutches of parchment-shelled eggs that are laid deep in rock-crevices or above the waterline in caves and overhangs, including caves with only underwater openings. Primary adaptations to a semi-marine existence in this group are enlarged ventral (belly) scales that facilitate terrestrial

locomotion, nostrils with fleshy valves to exclude water from the air passages while underwater, and a large flattened, paddle-like tail to propel the snake when swimming.

While only two species have been recognised as occurring in Australia, the scalation of two of three specimens from Australia described in Smith (1926) suggests that there may have been a third species, *Laticauda saintgironsi*, otherwise restricted to the waters of New Caledonia (Cogger and Heatwole 2006). A fourth species, *Laticauda guinea*, is also likely to occur in the far northern waters of the Cape Province bioregion. Surveys of the marine snakes of the Coral Sea (Zimmerman et al. 1994) and of New Caledonia (Ineich and Laboute 2002) are very relevant to studies of the marine snakes of the eastern limits of the East Marine Region.

For general information on the biology and ecology of marine snakes see Dunson (1975a) and Heatwole (1999) and for Australian taxa see Cogger (2000a) (keys to all taxa), Shine and Houston, (1993) (file snakes), Ehmann (1993) (colubrid snakes), Heatwole and Guinea (1993) (oviparous sea kraits) and Heatwole and Cogger (1993 1994) (viviparous sea snakes). For regional treatments within the East Marine Region see Dunson (1975b), Limpus (1975), Cogger (2000b). The phylogeny of Australian viviparous sea snakes has been recently assessed by Lukoschek and Keogh (2006).

All sea snakes are listed under Section 248 of the EPBC Act and are protected as listed marine species. No species of sea snake has been listed as threatened or migratory under the EPBC Act.

Ecology of protected reptile species in the East Marine Region

Marine turtles

On a global scale, each species of marine turtle can be subdivided into genetically separate stocks, or management units, defined by the area where they breed. Where clusters of breeding turtles of the same species occur in close proximity, they form an interbreeding population (management unit). Widely separated breeding aggregations can be expected to be genetically different and not interbreed (Dethmers et al. 2006).

Six species of marine turtles have been recorded breeding within the East Marine Region. Miller (1985) has provided a detailed account of embryological development for these species, namely the loggerhead, green, hawksbill, olive ridley, flatback and leather back turtles.

All marine turtles migrate from their dispersed foraging areas to aggregate for breeding at traditional nesting beaches (Plotkin 2003). The breeding female does not feed, or feeds at a reduced level, while offshore from the nesting beach in the inter-nesting habitat where she prepares her eggs for laying (Limpus et al. 2001; Tucker and Read 2001). Fertilisation is internal and spherical soft-shelled eggs are buried in nests on beaches above the tidal range. There is no parental care. Eggs incubate in sun-warmed sand with incubation period, incubation success, and hatchling sex ratio being a function of nest temperature (Miller 1997; Miller and Limpus 2003; Wibbels 2003). Turtles use the earth's magnetic field for navigation and hatchlings navigate across the beach using light horizons (Lohmann et al. 1997). They disperse rapidly from inshore waters without using the waters adjacent to the nesting beach for resting or foraging. When well offshore, the hatchlings cease their swimming frenzy and are then carried by ocean currents into oceanic pelagic habitats, except for flatback turtles which remain in pelagic habitats over the continental shelf (Bolten 2003). While in the pelagic habitats, all species are carnivorous, feeding on a wide range of macro-zooplankton.

The hard-shelled turtles remain in the ocean pelagic environment for a few years (hawksbill and green turtles) or up to about 16 years (loggerhead turtles) before they return to coastal waters where they change to a benthic-feeding life phase with diet varying with the species (Bjorndal 1997; Lanyon et al. 1989; Limpus and Limpus 2000; Limpus et al. 2001, 2005).

All marine turtles are slow-growing with delayed maturity (Chaloupka 1998; Chaloupka and Musick 1997; Chaloupka and Limpus 1997; Limpus and Chaloupka 1997). Green and hawksbill turtles may take about 35 years from hatchling to first breeding, Loggerhead turtles slightly less at about 30 years. Leatherback turtles are the fastest growing, reaching maturity at less than 20 years. Analyses of population genetics indicate that widely spaced clusters of breeding aggregations are genetically discrete and that the adult returns to breed at the region birth (Bowen and Karl 1997). All species lay multiple clutches of eggs in a breeding season and typically skip years between breeding seasons (Miller 1997, Hamann et al. 2003). Animals with these life history characteristics need mortality to be low throughout all their life history phases in order to maintain stable populations (Chaloupka 2002). Marine turtles are highly vulnerable to factors which cause even small increases in mortality.

Green turtle. Photo: Robert Thorne.

Green and loggerhead turtle post-hatchlings originating from nesting beaches of the southern Great Barrier Reef and mainland south Queensland and New South Wales will be carried by the East Australian Current (EAC) southward to approximately the latitude 30 °S off Coffs Harbour in New South Wales (Limpus et al. 1994c; Walker 1994) before being carried eastward to leave the Region and pass to the north of New Zealand. Post-hatchlings from the New Caledonian rookeries (figures 7.4, 7.6) can be expected to enter this same gyre and pass through the Region.

Post-hatchling loggerheads of various genetic stock are transported throughout the entire South Pacific Ocean gyre. Approximately half-grown loggerhead, originating from Coral Sea stock, are caught regularly in the longline fisheries of Peru and Chile in the eastern South Pacific (Kelez et al. 2004; Shigueto et al. 2006) (figure 7.10). They re-enter the East Marine Region oceanic waters as large immature turtles as they return to the Coral Sea area. They will leave the oceanic pelagic post-hatchling phase for the coastal benthic foraging life history phase when they are approximately 80 cm in carapace length and around 16 years of age.

Green turtles are much smaller when they leave the oceanic pelagic post-hatchling phase as recruits to coastal seagrass and algal foraging areas (Limpus et al. 2005). They presumably spend less time in the pelagic phase than loggerhead turtles, leaving it at about 8–10 years of age. It is highly likely that the green turtle post-hatchlings do not travel as extensively as loggerheads within the South Pacific. Green turtle post-hatchlings from the Coral Sea rookeries may remain entrained within the gyre of the Coral Sea. Little is known of the distribution of the green and hawksbill turtles post-hatchlings that enter the ocean currents within the northern Coral Sea.

Leatherback turtles migrate as juveniles and adults through the pelagic environment of the Coral Sea, Tasman Sea, including Bass Strait, and therefore occur throughout the oceanic areas of the Region.

Sea snakes

With the exception of the oviparous sea kraits, all other marine snakes in Australian waters are viviparous, with all phases of the reproductive cycle (mating and fertilisation, gestation, birth) and subsequent growth and sexual maturation taking place in the sea. There appear to be few, if any, modifications of the reproductive system as found in terrestrial viviparous snakes, except that copulation in many species appears to be preceded by complex courtship rituals in which males perform in front

of the female, followed by tandem swimming and head and body contact. Once copulation occurs, the snakes typically float freely, with body contact confined to the cloacal region.

Local or regional seasonal aggregations have been reported for a number of species, but in most cases there is little evidence that such aggregations have an explicit reproductive purpose rather than being for some other purpose (e.g. prey abundance). However, Limpus (2001) recorded what he presumed to be a resident breeding aggregation of the yellow-bellied sea snake (*Pelamis platurus*) in the Gulf of Carpentaria in July 1992, where he observed 84 individuals, covering all size classes, along a 99.4 km transect.

Fry et al. (2001) found that in all 13 species that they recorded from trawl bycatch in the Gulf of Carpentaria, reproduction was annual. They further suggested that the finding by Burns (1985) that reproduction in the olive sea snake (*Aipysurus laevis*) at the southern end of the Great Barrier Reef was probably on a 2-year cycle, might have been due to lower than optimum mean water temperatures.

Most viviparous sea snakes live within a fairly narrow stratum of the water column (ca. 0–100 m), with the majority restricting their normal daily activity to the 0–50 m zone. This often results in populations with very high site-fidelity, in which exchange of individuals between reefs separated by deeper bodies of water may be very low. Species occurring at deeper levels (i.e. 50–100 m) are usually those that feed on garden eels (a specialised group within the family Congridae) found on sandy substrates at these depths.

With the exception of the yellow-bellied sea snake, whose eastern Pacific populations have been studied extensively (Kropach 1975), the most studied Australian species is probably the olive sea snake (*Aipysurus laevis)* (Burns and Heatwole 1998, 2000; Lukoschek et al. 2007; Burns 1985).

There are currently no confirmed occurrences of migration events on a large geographic scale for any marine snake. Whether the breeding aggregations cited above represent migratory or merely local events is unknown. Older reports (Heatwole 1999) of great masses of intertwined sea snakes extending over many kilometres on the surface of the open ocean have long suggested the occurrence of mass migrations of sea snakes converging on particular oceanic sites to breed, but despite the great increase in shipping over the past century such aggregations (though they may occasionally occur for reproductive or other purposes) have so rarely been reported that they are unlikely to represent regular or typical breeding behaviours.

Important areas for marine reptiles in the East Marine Region

Marine turtles

The loggerhead turtles that breed in the South Pacific Ocean basin are from one interbreeding genetic stock (Dutton et al. 2002; Bowen 2003; Limpus and Limpus 2003a; Limpus et al. 2006). These turtles come ashore to nest on beaches of eastern Australia from the southern Great Barrier Reef and along the adjacent mainland coast to as far south as northern New South Wales, and in New Caledonia. The largest of the five major nesting concentrations for this stock (several hundred females annually) occurs at Mon Repos and adjacent beaches of the Woongarra Coast near Bundaberg adjacent to the East Marine Region. Smaller and decreasing numbers of loggerheads breed on beaches south from Bundaberg. A few tens nest on the Sunshine Coast annually, mostly near Caloundra. About 10 individuals per year breed on the beaches of the islands that enclose Moreton Bay, mostly on Moreton and North Stradbroke Islands. Nesting is rare on the Gold Coast. Isolated individuals nest annually on the northern beaches to as far south as about Ballina. On rare occasions, nesting may occur as far south as Newcastle (Limpus 1985).

Breeding adults migrate through the Region to their traditional nesting beaches in eastern Australia from dispersed foraging areas scattered within a 2,500 km radius of the beaches (from Eastern Indonesia, Papua New Guinea, Solomon Islands, New Caledonia, Northern Territory, Queensland and New South Wales (Limpus et al. 1992).

There are currently eight recognised genetic stocks of the green turtle (*Chelonia mydas)* breeding in separate areas in north-eastern Australia and the adjacent western Pacific Ocean (Dethmers et al. 2006; FitzSimmons 1997). One of these, the Coral Sea stock (many hundreds to low thousands of females breeding annually) is restricted to breeding on the islets within the Coringa–Herald National Nature Reserve.

Low density rookeries at the southern extremity of the distribution of southern Great Barrier Reef stock (Bundaberg coast – low tens of females annually; Fraser Island – high tens to low hundreds annually; Sunshine Coast – less than ten females annually) also occur within the East Marine Region. The main breeding population for this latter stock occurs in the southern Great Barrier Reef with some 5 – 8 thousand females breeding annually. Nesting numbers may fluctuate across three orders of magnitude in successive years in response to El Nino Southern Oscillation climate change events (Limpus and Nicholls 2000). Isolated individuals may nest as far south as northern New South

Wales in seasons of high density nesting. Adult turtles remain in their respective foraging areas in years that they do not breed.

Hawksbill turtle nesting within the Region is a rare event, restricted to the coral cays of the Coral Sea Nature Reserve. The principal nesting areas for the species in the Coral Sea region lie outside the region in the northern Great Barrier Reef–Torres Strait and Solomon Islands. Different genetic stocks are recognised for this species as well (Broderick et al. 1994)

Breeding by the flatback turtle is restricted to Australia and occurs from the Ningaloo area off Western Australia across northern Australia to Bundaberg in eastern Australia (figure 7.8). The nesting population on the central Queensland coast from Townsville to Bundaberg (adjacent to the waters of the Region) represents a discrete genetic stock for the species (Dutton et al. 2002). This east coast breeding population nests in mid-summer in contrast to the winter peak of nesting for the northern Australia nesting population (Limpus et al. 1993). Only a few tens of flatbacks nest annually on nesting beaches of mainland south Queensland between Baffle Creek and Hervey Bay within the Region. This contrasts with approximately 1,000 females nesting annually just to the north within the Great Barrier Reef.

Breeding adults migrate to their traditional nesting beaches in eastern Australian from dispersed foraging areas scattered over a 1300 km length of the lagoonal non-reef habitats inside the Great Barrier Reef between Torres Strait and Hervey Bay.

When nesting Letherback turtles were discovered in eastern Australia in the 1970s there were less than ten females nesting annually (Limpus and McLachlan 1979 1994). Nesting occurred mainly on Wreck Rock and Rules Beaches (~24.3 °S) immediately north of Baffle Creek within the Great Barrier Reef area. However, scattered nesting occurred on most mainland beaches adjacent to the Region north from Bundaberg. Further to the south, successful nesting and incubation was reported from an isolated female at Ballina (~28.8 °S) in northern New South Wales (Tarvey 1994). In contrast, a solitary nesting was reported from Forster (~32.2 °S) in New South Wales and, although embryonic development commenced within the eggs, no hatchlings were produced because the beach temperature at nest depth was below the lethal minimum for successful incubation. Nesting has declined since that time and the last record of leatherback nesting in eastern Australia occurred at Moore Park (~24.7 °S) near Bundaberg in 1996. The Australian east coast leatherback turtle nesting population appears to be approaching extinction.

This decline in eastern Australia nesting parallels the major decline in leatherback nesting reported during the same period in the eastern Pacific and attributed to bycatch mortality in oceanic gillnet and longline fisheries (Spotilla et al. 1996).

The olive ridley turtle does not breed in eastern Australia, nor is there significant nesting by the species within the Pacific Island nations of the western Pacific. The origin of the individuals that forage along the eastern Australian continental shelf is undetermined.

Sea snakes

The regular sighting of sea snakes in the south-east waters of the East Marine Region in mid- to late-summer is most likely to reflect waif individuals being caught up in the seasonally-active East Australian Current (Cogger 2000b). Whether such summer waifs are able to return to their source populations is unknown, but there currently is no evidence that they make the reverse journey.

Known interactions, threats and mitigation measures

Marine turtles

Indigenous harvest

Under Section 211 of the *Native Title Act 1993*, Indigenous people with a native title right can legitimately hunt marine turtles in Australia for communal, non-commercial purposes. In January 2004, the Marine and Coastal Committee, a body of the Natural Resource Management Ministerial Council, established a Taskforce on Marine Turtle and Dugong Populations (MACC Taskforce). The purpose of the MACC Taskforce was to develop a national partnership approach to help Indigenous communities achieve sustainable harvests of turtles and dugongs (Australian Government 2005). In 2005 a 'National Partnership Approach' for the sustainable harvest of turtles and dugongs in Australia was endorsed by the Natural Resource Management Ministerial Council.

The 'National Partnership Approach' has five key goals, which broadly aim to ensure that Indigenous harvest of turtles and dugongs is sustainable by outlining how Governments and Indigenous communities can work more closely together to increase the effectiveness of the protection and conservation of dugongs and marine turtles. Importantly, the Approach also aims to contribute to the conservation of turtles and dugongs while ensuring that the important economic, spiritual and cultural relationships Indigenous people have with these animals are maintained for future generations.

The loggerhead, green and hawksbill turtle populations that breed in eastern Australia are derived from foraging populations spread throughout eastern Indonesia, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia and Fiji as well as in the Northern Territory, Queensland and New South Wales. Similarly, Green turtles that breed in Papua New Guinea, Solomon Islands, Vanuatu and New Caledonia have part of their dispersed populations foraging in eastern Australia. Throughout these countries, green, hawksbill and loggerhead turtles are hunted for food. Indeed, the largest collective take of green and hawksbill turtles for human consumption globally occurs in the area of eastern Indonesia, Papua New Guinea, northern Australia and the western Pacific island nations. There are serious concerns that the collective harvest of these species within this area is not sustainable. The impact of the combined harvesting of turtles within the south-western Pacific region is seen as a threat to maintaining sustainable populations of marine turtles in the Region for the above three species.

Commercial fishery interactions

Marine turtles are caught as by-catch in a range of fisheries operating in Australian waters, including trawl, longline and pot fisheries.

By catch mortality within the pelagic longline fisheries of the South Pacific has been identified as a serious threat, particularly to leatherback and loggerhead turtles (Spotila et al. 2000, Lewison et al. 2004). While the mortality of marine turtles in the longline fisheries operating within eastern Australian waters, and hence the East Marine Region, may be low (Robins et al. 2002) it is the pooled mortality from all the longline fleets operating across the entire south Pacific (for loggerheads) and within the entire Pacific Ocean (for leatherbacks) that is the issue. Even with low bycatch mortality, Australian longline fisheries are contributing to the problem.

In coastal waters, bycatch mortality in prawn trawl fisheries in eastern and northern Australia has been the major contributing factor to the decline of the loggerhead nesting population of eastern Australia since the 1970s (Limpus and Limpus 2003a). This decline has been stopped by the mandatory use of turtle exclusion devices within these prawn trawl fisheries introduced in 2001. In the past two decades there has been increasing recognition of the entanglement and mortality of green and loggerhead turtles in the floatlines of crabpots with some tens of large individuals for each species being killed annually in Hervey Bay and Moreton Bay (Greenland et al. 2004). In the broader area of Bass Strait, appreciable numbers of leatherbacks are drowned annually through entanglement in the floatlines of crayfish traps (Bone 1998). The mortality of marine turtles in coastal gillnet fisheries has been poorly documented in eastern Australia. In addition, many tens of green, loggerhead and hawksbill turtles are estimated to die annually from ingestion of hooks and ingestion or entanglement in lost/discarded fishing line (presumed to originate from recreational fishers) within Hervey Bay, Moreton Bay and the estuaries of northern New South Wales

Habitat Loss

Human alteration of catchments with the associated change in the quality of the water flowing into coastal habitats, especially with floods, is probably the most pervasive cause of habitat loss impacting marine turtles within the Region. Land clearing for agricultural and pastoral industries and for urban development can result in increased sediment outflow from rivers which can cause significant losses of marine seagrass and algal pastures (Preen et al. 1995). Associated with human activities within the catchments, a great range of chemicals find their way into our waterways and subsequently flow into coastal habitats. For example, chlorinated hydrocarbons derived from land-based activities are now widespread in the sediments of coastal estuaries and bays adjacent to the East Marine Region and are concentrated as they pass up the food web from sediments to seagrass to turtles (Gaus et al. 2001; Hermanussen et al. 2004 2006). In some cases these pollutants can be passed across generations from adult female turtles to their hatchlings via the yolk of eggs (Muusse et al. 2006). The implications of these pollutants on the food resources and health of marine turtle populations is still under investigation.

At the nesting beaches, light pollution from coastal development has the most profound impact on the use of beaches by the nesting females and the survivorship of hatchlings. In the extreme, Kelly's Beach near Bundaberg has changed from supporting the second highest nesting density of loggerhead turtles within the district prior to the mid 1970s to now supporting a trivial nesting population as a result of changed light horizons associated with motel and housing developments on the dunes. The turtle are choosing not to use this beach with its altered light horizons while they continue to nest in large numbers on dark beaches a few kilometres away.

Boatstrike and propeller cuts

In recent decades there has been an increasing incidence of turtles killed by collision with vessels and chops from propellers (Greenland et al. 2002). It is estimated that many tens of large green and loggerhead turtles are killed annually in the Hervey Bay–Moreton Bay area. With increasing numbers of vessels being used in our coastal

waters, this problem is expected to increase. There has been some success in reducing boatstrike at localised sites using "go-slow" zoning within the Moreton Bay Marine Park.

Marine debris

Plastic rubbish washed or blown from land into the sea, fishing gear abandoned by recreational and commercial fishers, and solid non-biodegradable floating materials are all considered harmful marine debris. Marine debris was listed as a key threatening process under the EPBC Act in 2003 because of the threat it posed to all marine life. It is an additional threat to the survival of species already listed as threatened under the EPBC Act.

All marine turtles nesting in Australia are considered to be at risk from marine debris (Department of the Environment and Heritage 2003). Marine turtles can be harmed by marine debris in two ways: by entanglement in discarded fishing gear or by ingestion of plastics. Some species of marine turtles, particularly leatherbacks and loggerheads are known to mistake plastic bags for jellyfish.

While small numbers of turtles from the foraging populations within coastal habitats are recorded dead each year from gut blockages resulting from ingestion of synthetic debris including plastic sheeting, plastic bags, balloons and fragmented plastic containers, it appears to be a much more significant issue for the post-hatchling turtles foraging in the pelagic waters off shore. The high incidence of appreciable amounts of synthetic debris in the guts of turtles being examined from the pelagic life history phase within the Region and the difficulty in quantifying mortality from this ingestion in offshore habitats is of concern.

The majority of strandings of post-hatchling green turtles in south Queensland – identified as recently derived from pelagic habitats – have gut blockages of synthetic debris. While some of this ingested marine debris may be derived from vessel operations, a high proportion is almost certainly land-based debris, not necessarily from Australia, which has drifted into oceanic habitats.

The Australian Government is currently developing a threat abatement plan that aims to minimise the impacts of marine debris on threatened marine species. Further information is available at <www.environment.gov.au/biodiversity/threatened/publications/marine-debris.html>.

Sea snakes

Commercial fisheries

The paucity of data on marine snake numbers and species richness in the Region, including meaningful information on bycatch numbers, prevents any reliable assessment of species at risk. The greatest long-term threat to marine snakes is probably the degradation of reef systems through siltation, eutrophication (excessive input of nutrients) or pollution from agricultural run-off and from the impacts of projected climatic shifts.

The most immediate threat to marine snakes in the East Marine Region is likely to be the mortality of those snakes taken as bycatch in commercial trawl fisheries (Ward 2000, Fry et al. 2001). There is some information to show that a high proportion of sea snakes survive following release from trawl capture (Department of the Environment and Heritage 2005) so the implications of bycatch of snakes are not clear.

Another significant threat, but one with longer-term implications, is the damage wrought by trawling on the benthic ecology (involving snake feeding grounds). Clearly, the overall impacts of trawling on marine snake populations will depend on the geographic extent of trawled snake habitat. There are few data available to determine this, but with the exclusion of the Great Barrier Reef Marine Park from the East Marine Region, impacts of trawling will be largely confined to the coastal zone between Fraser Island and the border between New South Wales and Queensland.

Trade in sea snake skins

The Australian Government has not yet issued commercial export permits for Australian sea snakes, but sea snake skin goods are already sold widely in northern Australia. This trade requires careful monitoring to ensure that populations of individual species do not decline to a level that threatens their survival.

Habitat Loss

While the role of marine snakes in reef ecosystems is virtually unknown and their responses to perturbations in those systems difficult to predict, as top order predators they are integral components of tropical shallow-water reef ecosystems. It is reasonable to assume then that loss or degradation of any part of these systems will result in the decline or loss of the snakes living within them. It is known that some marine snakes are quite sensitive to subtle changes in reef ecosystems so absence of evidence of macrodegradation should not be taken to imply that snake populations are secure.

Five species of *Aipysurus* (including three endemics) are recorded from the Northwest Shelf's Ashmore Reef. Together with a further 12 species in other genera, these sea snakes were in great abundance in 1972 (Dunson 1975a) but numbers have declined dramatically in recent

years, with few species and few individuals observed in recent surveys (Guinea 2007 pers.comm.). More than 500 individuals were collected or observed by a team of biologists during one week of surveying in 1972 but Guinea (2007) recorded continuing declines in the period 1992–2007, culminating in the observation of only seven snakes in 10 survey days in March 2007. Only two of these could be accurately identified, both being the olive sea snake, *Aipysurus laevis*. The causes of these declines in what were considered pristine oceanic reef habitats are unknown, but ecosystem degradation is implicated.

Other interactions/threats – There is evidence from northern Australian waters of interactions between sea snakes and marine debris, specifically discarded trawl nets. The yellow-bellied sea snake is also vulnerable to the adverse effects of oil spills at sea.

Key References and Further Readings

Bjorndal, KA, 1997, 'Foraging ecology and nutrition of sea turtles', in *The Biology of Sea Turtles*, PL Lutz and JA Musick (eds), CRC Press, Boca Raton, pp. 199 –232.

Bolten, A, 2003, 'Variation in sea turtle life history patterns: Neritic vs. Oceanic developmental stages', in *The Biology of Sea Turtles*, Vol. II, PL Lutz, JA Musick and J. Wyneken (eds), CRC Press, Boca Raton, pp. 243 – 258.

Bolten, AB and Witherington, BE, 2003, *Loggerhead Sea Turtles*, Smithsonian Institution, Washington D.C.

Bone, C, 1998, *Preliminary investigation into leatherback turtle, Dermochelys coriacea (L.) distribution, abundance and interactions with fisheries in Tasmanian waters*, Unpublished Report by Tasmanian Parks and Wildlife Service, pp. 1–25.

Bowen, BW and Karl, SA, 1997, 'Population genetics, phylogeography and molecular evolution', in *The Biology of Sea Turtles*, PL Lutz and JA Musick (eds), CRC Press, Boca Raton.

Bowen, BW, 2003, 'What is a loggerhead turtle? The genetic perspective', in *Loggerhead Sea Turtles*, AB Bolten and BE Witherington (eds), Smithsonian Institution, Washington, D.C.

Broderick, D Moritz, C Miller, JD Guinea, M Prince, RIT and Limpus, CJ, 1994, 'Genetic studies of the hawksbill turtle Eretmochelys imbricata: evidence for multiple stocks in Australian waters', *Pacific Conservation Biology*, 1(2): 123–131.

Burns, G and Heatwole, H, 1998, 'Home range and habitat use of the olive sea snake, Aipysurus laevis, on the Great Barrier Reef', *Journal of Herpetology*, 32(3): 350–358.

Burns, G and Heatwole, H, 2000, 'Growth, sexual dimorphism, and population biology of the olive sea snake, Aipysurus laevis, on the Great Barrier Reef of Australia', *Amphibia-Reptilia*, 21(3): 289–300.

Burns, GW, 1985, 'The female reproductive cycle of the olive sea snake, Aipysurus laevis (Hydrophiidae)', in *The Biology of Australasian Frogs and Reptiles*, GC Grigg, R Shine and HFW Ehmann (eds), Surrey Beatty and Sons with Royal Zoological Society of New South Wales, Sydney.

Chaloupka, M, 1998, 'Polyphasic growth apparent in pelagic loggerhead sea turtles', *Copeia*, 1998(2): 516–518.

Chaloupka, M, 2002, 'Stochastic simulation modelling of southern Great Barrier Reef green turtle population dynamics', *Ecological Modelling*, 148: 79–109.

Chaloupka, M Y Limpus, CJ and Miller, JD, 2004, 'Green turtle somatic growth dynamics in a spatially disjunct Great Barrier Reef metapopulation', *Coral Reefs*, 23: 325–335.

Chaloupka, MY and Limpus, CJ, 1997, 'Robust statistical modelling of hawksbill sea-turtle growth rates (southern Great Barrier Reef)', *Marine Ecology Progress Series*, 146: 1–8.

Chaloupka, MY and Musick, JA, 1997, 'Age, growth and population dynamics', in *The Biology of Sea Turtles*, PL Lutz and JA Musick (eds), CRC Press, Boca Raton, pp. 233–276

Cogger, HG and Heatwole, HF, 2006, 'Laticauda frontalis (de Vis, 1905) and Laticauda saintgironsi n.sp. from Vanuatu and New Caledonia (Serpentes: Elapidae: Laticaudinae)—a new lineage of sea kraits?' *Records of the Australian Museum*, 58(2): 245–256.

Cogger, HG, 2000a, *Reptiles and Amphibians of Australia*, Reed New Holland, Sydney.

Cogger, HG, 2000b, *The Status of Marine Reptiles in New South Wales*, Unpublished Report, New South Wales National Parks and Wildlife Service, pp. 1–65.

Dethmers, KM Broderick, D Moritz, C FitzSimmons, NN Limpus, CJ Lavery, S Whiting, S Guinea, M Prince, RIT and Kennett, R, 2006, 'The genetic structure of Australasian green turtles (Chelonia mydas): exploring the geographical scale of genetic exchange', *Molecular Ecology*, 15(13): 3931–3946.

Dunson, WA (ed), 1975a, *The Biology of Sea Snakes*, University Park Press, Baltimore.

Dunson, WA, 1975b, 'Sea snakes of tropical Queensland between 18 degrees and 20 degrees south latitude', in *The Biology of Sea Snakes*, W Dunson (ed), University Park Press, Baltimore.

Dutton, P Broderick, D and FitzSimmons, N, 2002, 'Defining management units: molecular genetics', in *Proceedings of the Western Pacific Sea Turtle* Cooperative Research and Management Workshop, I Kinan (ed), Western Pacific Regional Fishery Management Council, Honolulu.

Ehmann, H, 1993, 'Family Colubridae', in *Fauna of Australia Vol. 2A*, Amphibia and Reptilia, CJ Glasby, GJB Ross and PL Beesley (eds), Australian Government Publishing Service, Canberra.

FitzSimmons, NN Moritz, C Limpus, CJ Pope, L and Prince, R, 1997, 'Geographical structure of mitochondrial and nuclear gene polymorphisms in Australian green turtle populations and male-biased gene flow', *Genetics*, 147: 1843–1854.

Fry, GC Milton, DA and Wassenberg, TJ, 2001, 'The reproductive biology and diet of sea snake bycatch of prawn trawling in northern Australia: characteristics important for assessing the impact on populations', *Pacific Conservation Biology*, 7(1): 55–73.

Gaus, C Papke, O Blanchard, W Haynes, D Connell, DW and Muller, JF, 2001, 'Bioaccumulation and pathways of PCDDs in the lower trophic marine system', *Organohalogen Compounds*, 52: 95–98.

Greenland, JA Limpus, CJ and Currie, KJ, 2004, Queensland marine wildlife stranding and mortality database annual report, 2001–2002, III: *Marine turtles*, *Conservation Technical and Data Report 2002*.

Guinea, M, 2007, *Final report on Survey March 16–April 2 2007: Sea Snakes of Ashmore reef, Hibernia reef and Cartier Island with comments on Scott Reef*, Unpublished Report to the Department of the Environment and Water Resources, Canberra.

Guinea, ML Limpus, CJ andWhiting, SD, 2004, 'Marine Snakes' in National Oceans office: *Description of Key Species Groups in the Northern Planning Area*, National Oceans Office, Hobart.

Hamann, M Limpus, CJ and Owens, DW, 2003, 'Reproductive cycles of males and females', in *The Biology of Sea Turtles*, Vol, II, PL Lutz, JA Musick and J. Wyneken (eds), CRC Press, Boca Raton.

Heatwole, H and Cogger, HG, 1993, 'Family Hydrophiidae', in *Fauna of Australia Vol. 2A* Amphibia and Reptilia, CJ Glasby, GJB Ross, andPL Beesley (eds), Australian Government Publishing Service, Canberra.

Heatwole, H and Cogger, HG, 1994, 'Sea snakes of Australia', in *Sea snake toxinology*, P Gopalakrishnakone (ed), Singapore University Press, Singapore.

Heatwole, H and Guinea ML, 1993, 'Family Laticaudidae', in *Fauna of Australia Vol. 2A*, Amphibia and Reptilia, CJ Glasby, GJB Ross and PL Beesley (eds), Australian Government Publishing Service, Canberra.

Heatwole, H, 1999, *Sea Snakes*, University of New South Wales Press, Sydney.

Hermanussen, S Limpus, CJ Papke, O Blanchard, W Connell, D and Gaus, C, 2004, 'Evaluating spatial patterns of dioxin in sediments to aid determination of potential implications for marine reptiles', *Organohalogen Compounds*, 66: 1861–1867.

Hermanussen, S Limpus, CJ Papke, O Connell, DW and Gaus, C, 2006, 'Foraging habitat contamination influences green turtle PCDD/F exposure', *Organohalogen Compounds*, 68: 592–595.

Ineich, I and Laboute, P, 2002, Les serpents marins de Nouvelle-Calédonie/Sea snakes of New Caledonia, IRD Éditions, Institut de Recherche pour le Dévelopment, *Muséum National d'histoire Naturelle*, Paris, pp. 1–302.

Ineich, I and Rasmussen, AR, 1997, 'Sea snakes from New Caledonia and the Loyalty Islands (Elapidae, Laticaudinae and Hydrophiinae)', *Zoosystema*, 19(2–3): 185–192.

Kelez, S Velez-Zuazo, X and Mamrique, C, 2004, *Conservation of sea turtles along the coast of Peru*, *Grupo de Tortugas Marinas* - Peru and Associasion Peruana para la Conservacion de la Naturaleza: Unpublished report to UNEP/CMS.

Kropach, C, 1975, 'The Yellow-bellied Sea Snake, Pelamis, in the Eastern Pacific', in *The Biology of Sea Snakes*, W. Dunson (ed), University Park Press, Baltimore.

Lanyon, J Limpus, CJ and Marsh, H, 1989, 'Dugongs and turtles: grazers in the seagrass system', in *Biology of Seagrasses*, AWD Larkum, AJ McComb, and SA Shepherd (eds), Elsevier, Amsterdam.

Lewison, RL Freeman, SA and Crowder, LB, 2004, 'Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles', *Ecology Letters*, 7: 221–231.

Limpus, C and Nicholls, N, 2000, 'ENSO regulation of Indo-Pacific green turtle populations', in *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*, G Hammer, N Nicholls and C Mitchell (eds), Kluwer Academic Publishers, Dordrecht.

Limpus, CJ and Chaloupka, M, 1997, 'Nonparametric regression modelling of green sea turtle growth rates (southern Great Barrier Reef)', *Marine Ecology Progress Series*, 149: 23–34.

Limpus, CJ and Limpus, DJ, 2000, 'Mangroves in the diet of Chelonia mydas in Queensland, Australia', *Marine Turtle Newsletter*, 89: 13–15.

Limpus, CJ and Limpus, DJ, 2003a, 'Loggerhead turtles in the Equatorial and Southern Pacific Ocean: a species in decline' in *Loggerhead Sea Turtles*, AB Bolten and BE Witherington (eds), Smithsonian Institution, Washington, D.C.

Limpus, CJ and Limpus, DJ, 2003b, 'The biology of the loggerhead turtle, Caretta caretta, in southwest Pacific Ocean foraging areas', in *Loggerhead Sea Turtles*, AB Bolten and BE Witherington (eds), Smithsonian Institution, Washington, D.C.

Limpus, CJ and McLachlan, N, 1994, 'The conservation status of the leatherback turtle, Dermochelys coriacea, in Australia', in *Proceedings of the Marine Turtle Conservation Workshop, Seaworld Nara Resort, Gold Coast, 14–17 November 1990*, R James (compiler), Australian National Parks Service, Canberra.

Limpus, CJ and McLachlan, NC, 1979, 'Observations on the leatherback turtle, Dermochelys coriacea, in Australia', *Australian Wildlife Research*, 6: 105–116.

Limpus, CJ and Miller, JD, 1993, 'Family Cheloniidae', in *Fauna of Australia, Vol.2A*, Amphibia and Reptilia, CJ Glasby, GJB Ross and PL Beesley (eds), Australian Government Publishing Service, Canberra.

Limpus, CJ and Miller, JD, 2000, *Australian hawksbill turtle population dynamics project, Final Report*, Queensland Parks and Wildlife Service, Brisbane.

Limpus, CJ, 1971, 'The flatback turtle, Chelonia depressa Garman, in southeast Queensland, Australia', *Herpetologica*, 27: 431–436.

Limpus, CJ, 1975, 'Coastal sea snakes of subtropical Queensland waters (23° to 28° south latitude)', in *The Biology of Sea Snakes*, W. Dunson (ed), University Park Press, Baltimore.

Limpus, CJ, 1978, 'The Reef', in *Exploration North*, H Lavery (ed), Richmond Hill Press, Melbourne.

Limpus, CJ, 1985, *A study of the loggerhead turtle, Caretta caretta, in eastern Australia*, Unpublished PhD Thesis, Zoology Department, University of Queensland, Brisbane.

Limpus, CJ, 1993a, 'Family Dermochelyidae', in *Fauna of Australia, Vol. 2A*, Amphibia and Reptilia, CJ Glasby, GJB Ross and PL Beesley (eds), Australian Government Publishing Service, Canberra.

Limpus, CJ, 2001, 'A breeding population of the yellow-bellied sea-snake Pelamis platurus in the Gulf of Carpentaria, *Memoirs of the Queensland Museum*, 46 (2): 629–630.

Limpus, CJ Boyle, M and Sunderland, T, 2006, 'New Caledonian loggerhead turtle population assessment: 2005 pilot study', in *Proceedings of Second Western Pacific Sea Turtle Cooperative research and Management workshop, Vol. II, North Pacific Loggerhead sea turtles*, I Kinan (ed), Western Pacific Regional Fisheries Management Council: Honolulu.

Limpus, CJ Carter, D and Hamann, M, 2001, 'The green turtle, Chelonia mydas, in Queensland: the Bramble Cay rookery in the 1979–1980 breeding season', *Chelonian Conservation and Biology*, 4(1): 34–46.

Limpus, CJ Couper, PJ and Couper, KLD, 1993, 'Crab Island revisited: reassessment of the world's largest flatback turtle rookery after twelve years', *Memoirs of the Queensland Museum*, 33(1): 277–289.

Limpus, CJ Couper, PJ and Read, MA, 1994a, 'The green turtle, Chelonia mydas, in Queensland: population structure in a warm temperate feeding area', *Memoirs of the Queensland Museum*, 35: 139–154.

Limpus, CJ Couper, PJ and Read, MA, 1994b, 'The loggerhead turtle, Caretta caretta, in Queensland: Population structure in a warm temperate feeding area', *Memoirs of the Queensland Museum*, 37: 195–204.

Limpus, CJ de Villiers, DL de Villiers, MA Limpus, DJ and Read, MA, 2001, 'The loggerhead turtle, Caretta caretta, in Queensland: observations on feeding ecology in warm temperate waters', *Memoirs of the Queensland Museum*, 46(2): 631–645.

Limpus, CJ Eggler, P and Miller, JD, 1994, 'Long interval remigration in eastern Australian Chelonia', *National Oceanographic and Atmospheric Administration Technical Memorandum*, National Marine Fisheries Service Southeast Fisheries Science Center, 341: 85–88.

Limpus, CJ Fleay, A and Baker, V, 1984a, 'The flatback turtle, Chelonia depressa in Queensland: reproductive periodicity, philopatry and recruitment', *Australian Wildlife Research*, 11: 579–587.

Limpus, CJ Fleay, AF and Guinea, M, 1984b, 'Sea turtles of the Capricorn Section, Great Barrier Reef', in *The Capricornia Section of the Great Barrier Reef: Past Present and Future*, WT Ward and P Saenger (eds), Royal Society of Queensland and Australian Coral Reef Society, Brisbane.

Limpus, CJ Miller, JD Parmenter, CJ and Limpus, DJ, 2003, 'The green turtle, Chelonia mydas, population of Raine Island and the northern Great Barrier Reef: 1843–2001', *Memoirs of the Queensland Museum*, 49(1): 349–440.

Limpus, CJ Miller, JD Parmenter, CJ Reimer, D McLachlan, N and Webb, R, 1992, 'Migration of green (Chelonia mydas) and loggerhead (Caretta caretta) turtles to and from eastern Australian rookeries', *Australian Wildlife Research*, 19: 347–358.

Limpus, CJ Parmenter, CJ Baker, V and Fleay, A, 1983a, 'The flatback turtle Chelonia depressa in Queensland: post-nesting migration and feeding ground distribution', *Australian Wildlife Research*, 10: 557–561.

Limpus, CJ Parmenter, J and Limpus, DJ, 2002, 'The status of the flatback turtle, Natator depressus, in Eastern Australia', *NOAA Technical Memorandum* NMFS-SEFSC, 477:140–142.

Limpus, CJ Reed, P and Miller, JD, 1983b, 'Islands and turtles: the influence of choice of nesting beach on sex ratio', in *Proceedings of Inaugural Great Barrier Reef Conference, Townsville, 28 Aug. – 2 Sept.* 1983, JT Baker, RM Carter, PW Sammarco and KP Stark (eds), JCU Press, Townsville.

Limpus, CJ Reed, PC and Miller, JD, 1985, 'Temperature dependent sex determination in Queensland sea turtles: intraspecific variation in Caretta caretta', in *Biology of Australian Frogs and Reptiles* ,G Grigg, R Shine and H Ehmann (eds), Surrey Beatty and Sons, Sydney.

Limpus, CJ Walker, TA and West, J, 1994, 'Post-hatchling sea turtle specimens and records from the Australian Region', in *Proceedings of the Marine Turtle Conservation Workshop, Seaworld Nara Resort, Gold Coast, 14–17 November 1990*, R James (compiler), Australian National Parks Service, Canberra.

Lohmann, KJ Witherington, BE Lohmannm, CMF and Salmon, M, 1997, 'Orientation, navigation, and natal beach homing in sea turtles' in *The Biology of Sea Turtles*, PL Lutz and JA Musick (eds), CRC Press, Boca Raton.

Lukoschek, V and Keogh, JS, 2006, 'Molecular phylogeny of sea snakes reveals a rapidly diverged adaptive radiation', *Biological Journal of the Linnean Society*, 89: 523–539.

Lukoschek, V Heatwole, H Grech, A Burns, G and Marsh, H, 2007, 'Distribution of two species of sea snakes, Aipysurus laevis and Emydocephalus annulatus, in the southern Great Barrier Reef: metapopulation dynamics, Marine Protected Areas and conservation', *Coral Reefs*, 26(2): 291–307.

Miller, JD and Limpus, CJ, 2003, 'Ontogeny of marine turtle gonads', in *The Biology of Sea Turtles*, Vol. II, PL Lutz, JA Musick and J Wyneken (eds), CRC Press, Boca Raton, pp. 199–224.

Miller, JD, 1985, 'Embryology of Marine Turtles', in *Biology of the Reptilia, Vol. 14*, Development A, C Gans, F Billett and P Maderson (eds), John Wiley and Sons, Sydney.

Miller, JD, 1997, 'Reproduction in marine turtles', in *The Biology of Sea Turtles*, PL Lutz and JA Musick (eds), CRC Press, Boca Raton.

Miller, JD Dobbs, KA Mattocks, N Limpus, CJ and Landry, AM, 1998, 'Long distance migrations by the hawksbill turtle, Eretmochelys imbricata, from north-eastern Australia', *Wildlife Research*, 25: 89–95.

Minton, SA and Dunson, WW, 1985, 'Sea snakes collected at Chesterfield Reefs, Coral Sea', *Atoll Research Bulletin*, 292: 101–107.

Muusse, M Hermanussen, S Limpus, CJ Papke, O and Gaus, C, 2006, 'Maternal transfer of PCDD/Fs and PCBs in marine turtles', *Organohalogen compounds*, 68: 596–599.

Plotkin, P, 2003, 'Adult migrations and habitat use', in *The Biology of Sea Turtles*, Vol. II, PL Lutz, JA Musick and J Wyneken (eds), CRC Press, Boca Raton,.

Preen, AR Long, WJL and Coles, RG, 1995, 'Flood and cyclone related loss, and partial recovery, of more than 1000 km² of seagrass in Hervey Bay, Queensland, Australia', *Aquatic Biology*, 52: 3–17.

Rasmussen, AR and Ineich I, 2000, *'Sea snakes of New Caledonia and surrounding waters (Serpentes: Elapidae): first report on the occurrence of Lapemis curtus and description of a new species from the genus Hydrophis, Hamadryad*, 25: 91–99.

Robins, CM Bache, SJ and Kalish, SR, 2002, *Bycatch of sea turtles in pelagic longline fisheries – Australia*, Fisheries Research and Development Corporation, Canberra.

Shigueto, JA Mangel, J and Dutton, J, 2006, 'Loggerhead turtle bycatch in Peru', in *Proceedings of Second Western Pacific Sea Turtle Cooperative research and Management workshop*, Vol. II, North Pacific Loggerhead sea turtles, I Kinan (ed), Western Pacific Regional Fisheries Management Council, Honolulu.

Shine, R and Houston, D, 1993, 'Family Acrochordidae', in *Fauna of Australia Vol. 2A*, Amphibia and Reptilia, CJ Glasby, GJB Ross and PL Beesley (eds), Australian Government Publishing Service, Canberra.

Shuntov, VP, 1971, 'Sea snakes of the north Australian shelf', (in Russian), Ekologiya, 2(4): 65–72 (*Soviet Journal of Ecology*, New York, 1972, 2: 338–344).

Smith, MA, 1926, *Monograph on the Sea Snakes (Hydrophiidae)*, British Museum, London, xvii + 130 pp.

Spotila, JR Reina, RD Steyermark, AC Plotkin, PT and Paladino, FV, 2000, 'Pacific leatherback turtles face extinction', *Nature*, 405 (June 1): 529–530.

Tarvey, L, 1994, 'First nesting records for the leatherback turtle Dermochelys coriacea in northern New South Wales Australia, and field management of nest sites', in *Herpetology in Australia: A Diverse Discipline*, D Lunney and D Ayers (eds), Royal Zoological Society of New South Wales, Chipping Norton.

Tucker, AD and Read, M, 2001, 'Frequency of foraging by gravid green turtles (Chelonia mydas) at Raine Island, Great Barrier Reef', *Journal of Herpetology*, 35(3): 500–503.

Walker, TA, 1994, 'Post-hatchling dispersal of sea turtles'. in *Proceedings of the Marine Turtle Conservation Workshop, Seaworld Nara Resort, Gold Coast, 14–17 November 1990*, R James (compiler), Australian National Parks Service, Canberra.

Wibbels, T, 2003, 'Critical approaches to sex determination in sea turtles', in *The Biology of Sea Turtles*, Vol. II, PL Lutz, JA Musick and J Wyneken (eds), CRC Press, Boca Raton.

Zimmerman, KD Heatwole, H and Menez, A, 1994, 'Sea snakes in the Coral Sea: an expedition for the collection of animals and venom', *Herpetofauna*, 24(1): 25–29.

D.4. East Marine Region Protected Species Group Report Card – Seabirds

Current at May 2007. For updates see <www.environment.gov.au/coasts/mbp/east>.

General information

The term 'seabird' is used informally for a range of birds that inhabit the marine environment to some degree, for breeding and/or feeding. The extent of such use is highly variable, with some species moving into marine, estuarine or coastal environments for short term, opportunistic periods, whereas others are obligatorily tied to these situations for all aspects of their life cycle. Taxonomically, seabirds encompass members from several avian orders.

The species considered for this report are constrained by the geographical limits that have been set. The limits of the East Marine Region exclude most of the coastal breeding islands of southeastern Australia (e.g. Five Islands, etc.) and those of the Great Barrier Reef. It also excludes birds that use estuarine environments along the coast. Islands within the Region are the Lord Howe Island group (including Ball's Pyramid, and Roach, Muttonbird and other satellite islands and rock stacks) surrounded by the Lord Howe Island Marine Park; Norfolk Island group (including Phillip and Nepean Islands); Solitary Islands (Solitary Islands Marine Reserve); and small reefs and atolls of the Coral Sea, such as Willis Reef and three national nature reserves (Coringa–Herald, Elizabeth and Middleton Reefs, and Lihou Reef). There are a number of species that breed close to the mainland but forage away from the coast and potentially move into the East Marine Region. Species generally staying within a few kilometres of the coast are of limited direct relevance for consideration here.

For the purposes of this review, the following taxa are considered further: penguins, petrels and shearwaters, albatrosses, storm-petrels, frigatebirds, tropicbirds, gannets and boobies, gulls, terns and skuas. Shorebirds and herons are addressed as a single group. These taxa include a number of species that have been recorded only as vagrants. These stragglers are not specifically addressed here, but would be affected by the same threats as related species.

There are also north-south components in the distribution of seabirds. Penguins, albatrosses, many petrels and shearwaters, and gannets are generally limited to the temperate and/or subtropical parts of the Region. Although a few nest on islands along the south-eastern coast, most breed in the New Zealand region or on sub-Antarctic islands and move into the Region to forage. Boobies, frigatebirds and several species of terns that nest on islands in the Great Barrier Reef and Coral Sea are largely restricted to the tropical northern part for their foraging. A small number of species, such as the wedge-tailed shearwater (*Puffinus pacificus*) occur widely along the entire length of eastern Australia.

Nationally protected species

Of the 130 seabirds known to occur in the Region, 64 are listed as threatened and/or migratory under the EPBC Act (table D 4). These species include: albatrosses, petrels, shearwaters, noddies and terns. The protected seabird species found within the Region are described in further detail below.

Australia is a signatory to four international agreements for the conservation of migratory birds, namely.

- the *Agreement on the Conservation of Albatrosses and Petrels* (ACAP), a multilateral agreement that seeks to conserve albatrosses and petrels by coordinating international activity to mitigate known threats to albatross and petrel populations. ACAP has been developed under the auspices of the *Convention on the Conservation of Migratory Species of Wild Animals (CMS) 1979*;
- the *Agreement for the Protection of Migratory Birds and their Environment between the Government of Australia and the Government of Japan 1974* (JAMBA);
- the *Agreement for the Protection of Migratory Birds and their Environment between the Government of Australia and the People's Republic of China 1986* (CAMBA); and
- the *Republic of Korea–Australia Migratory Bird Agreement 2007* (ROKAMBA).

Ecology of protected seabird species in the East Marine Region

Penguins

Although a number of penguin species have been recorded in Australian waters as stragglers or vagrants, only one species breeds here. Within the East Marine Region, the little penguin (*Eudyptula minor*) nests on islands along the coast of New South Wales and Victoria and a few mainland sites. Occurrence of this species extends northwards into subtropical waters but it is uncertain how far beyond coastal areas little penguins move.

Petrels and shearwaters

Around 30 petrels, shearwaters, prions and diving-petrels are found in the Region on a regular basis. A number of other species have been recorded as vagrants. Several species breed on islands along the coast, or in the Great Barrier Reef and Coral Sea. There are also some that nest

Table D 4. Seabirds listed as threatened or migratory under the EPBC Act that are known to occur in the Region

Common name	Species	Conservation status	Australian Government Conservation Plans and Policies
little tern	*Sterna albifrons*	Migratory, Marine Listed under CAMBA & JAMBA & CMS (Appendix II)	Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (2006) National Recovery Plan for Ten Species of Seabirds (2005) National Recovery Plan for Ten Species of Seabirds – Issues Paper (2005) Recovery Plan for Albatrosses and Giant-petrels (2001) The Action Plan for Australian Birds (2000) Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (1998)
lesser frigatebird	*Fregata ariel*	Migratory, Marine Listed under CAMBA & JAMBA	
great frigatebird	*Fregata minor*	Migratory, Marine Listed under CAMBA & JAMBA	
red-footed booby	*Sula sula*	Migratory, Marine Listed under CAMBA & JAMBA	
brown booby	*Sula leucogaster*	Migratory, Marine Listed under CAMBA & JAMBA	
sooty shearwater	*Puffinus griseus*	Migratory, Marine Listed under CAMBA & JAMBA	
streaked shearwater	*Calonectris leucomelas*	Migratory, Marine Listed under CAMBA & JAMBA	
pacific golden plover	*Pluvialis fulva*	Migratory, Marine Listed under CAMBA & JAMBA	
lesser sand plover	*Charadrius mongolus*	Migratory, Marine Listed under CAMBA & JAMBA	
bar-tailed godwit	*Limosa lapponica*	Migratory, Marine Listed under CAMBA & JAMBA	
whimbrel	*Numenius phaeopus*	Migratory, Marine Listed under CAMBA & JAMBA	
little whimbrel	*Numenius minutus*	Migratory, Marine Listed under CAMBA & JAMBA	
terek sandpiper	*Xenus cinereus*	Migratory, Marine Listed under CAMBA & JAMBA	
common sandpiper	*Actitis hypoleucos*	Migratory, Marine Listed under CAMBA & JAMBA	
grey-tailed tattler	*Tringa brevipes*	Migratory, Marine Listed under CAMBA & JAMBA	
wandering tattler	*Tringa incana*	Migratory, Marine Listed under CAMBA & JAMBA	
common greenshank	*Tringa nebularia*	Migratory, Marine Listed under CAMBA & JAMBA	
marsh sandpiper	*Tringa stagnatilis*	Migratory, Marine Listed under CAMBA & JAMBA	
ruddy turnstone	*Arenaria interpres*	Migratory, Marine Listed under CAMBA & JAMBA	
red knot	*Calidris canutus*	Migratory, Marine Listed under CAMBA & JAMBA	
sanderling	*Calidris alba*	Migratory, Marine Listed under CAMBA & JAMBA	
red-necked stint	*Calidris ruficollis*	Migratory, Marine Listed under CAMBA & JAMBA	
sharp-tailed sandpiper	*Calidris acuminata*	Migratory, Marine Listed under CAMBA & JAMBA	
curlew sandpiper	*Calidris ferruginea*	Migratory, Marine Listed under CAMBA & JAMBA	

Table D 4. Seabirds listed as threatened or migratory under the EPBC Act that are known to occur in the Region

Common name	Species	Conservation status	Australian Government Conservation Plans and Policies
pomarine jaeger	*Stercorarius pomarinus*	Migratory, Marine Listed under CAMBA & JAMBA	Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (2006) National Recovery Plan for Ten Species of Seabirds (2005) National Recovery Plan for Ten Species of Seabirds – Issues Paper (2005) Recovery Plan for Albatrosses and Giant-petrels (2001) The Action Plan for Australian Birds (2000) Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (1998)
common noddy	*Anous stolidus*	Migratory, Marine Listed under CAMBA & JAMBA	
bridled tern	*Sterna anaetheta*	Migratory, Marine Listed under CAMBA & JAMBA	
black-naped tern	*Sterna sumatrana*	Migratory, Marine Listed under CAMBA & JAMBA	
common tern	*Sterna hirundo*	Migratory, Marine Listed under CAMBA & JAMBA	
lesser crested tern	*Sterna bengalensis*	Migratory, Marine Listed under CAMBA	
Wilson's storm-petrel	*Oceanites oceanicus*	Migratory, Marine Listed under JAMBA	
brown skua	*Stercorarius antarcticus*	Migratory, Marine Listed under JAMBA	
masked booby	*Sula dactylatra*	Migratory, Marine Listed under JAMBA	
white-tailed tropicbird	*Phaethon lepturus*	Migratory, Marine Listed under JAMBA	
wedge-tailed shearwater	*Puffinus pacificus*	Migratory, Marine Listed under JAMBA	
flesh-footed shearwater	*Puffinus carneipes*	Migratory, Marine Listed under JAMBA	
short-tailed shearwater	*Puffinus tenuirostris*	Migratory, Marine Listed under JAMBA	
cattle egret	*Ardea ibis*	Migratory, Marine Listed under JAMBA	
pectoral sandpiper	*Calidris melanotos*	Migratory, Marine Listed under JAMBA	
arctic jaeger	*Stercorarius parasiticus*	Migratory, Marine Listed under JAMBA	
crested tern	*Sterna bergii*	Migratory, Marine Listed under JAMBA	
amsterdam albatross	*Diomedea amsterdamensis*	Endangered, Migratory, Marine Listed under CMS (Appendix I)	
chatham albatross	*Thalassarche eremita*	Endangered, Migratory, Marine Listed under CMS (Appendix II)	
herald petrel	*Pterodroma heraldica*	Critically Endangered	
wandering (snowy) albatross	*Diomedea exulans*	Vulnerable, Migratory, Marine Listed under JAMBA, CMS (Appendix II)	
Tristan albatross	*Diomedea dabbenena*	Endangered, Migratory, Marine Listed under CMS (Appendix II)	
northern royal albatross	*Diomedea sanfordi*	Endangered, Migratory, Marine Listed under CMS (Appendix II)	
black-browed albatross	*Thalassarche melanophrys*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
grey-headed albatross	*Thalassarche chrysostoma*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	

Table D 4. Seabirds listed as threatened or migratory under the EPBC Act that are known to occur in the Region

Common name	Species	Conservation status	Australian Government Conservation Plans and Policies
northern giant-petrel	*Macronectes halli*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (2006) National Recovery Plan for Ten Species of Seabirds (2005) National Recovery Plan for Ten Species of Seabirds – Issues Paper (2005) Recovery Plan for Albatrosses and Giant-petrels (2001) The Action Plan for Australian Birds (2000) Threat Abatement Plan for the Incidental Catch (or bycatch) of Seabirds During Oceanic Longline Fishing Operations (1998)
southern royal albatross	*Diomedea epomophora*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
shy albatross	*Thalassarche cauta*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
white-capped albatross	*Thalassarche steadi*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Salvin's albatross	*Thalassarche salvini*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Buller's albatross	*Thalassarche bulleri*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Pacific albatross	*Thalassarche sp. nov. (plateni)*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Campbell albatross	*Thalassarche impavida*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Indian yellow-nosed albatross	*Thalassarche carteri*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
Atlantic yellow-nosed albatross	*Thalassarche chlororhynchos*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
sooty albatross	*Phoebetria fusca*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
southern giant-petrel	*Macronectes giganteus*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
providence petrel	*Pterodroma solandri*	Migratory, Marine Listed under JAMBA	
antipodean albatross	*Diomedea antipodensis*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	
light-mantled sooty albatross	*Phoebetria palpebrata*	Vulnerable, Migratory, Marine Listed under CMS (Appendix II)	

in the Lord Howe or Norfolk Island groups. In some cases, species are extinct on the main islands and now breed only on satellite islands.

Albatrosses

No albatrosses breed in or near the Region, instead nesting mainly on islands in the sub-Antarctic and near mainland Tasmania. A number of species of albatrosses have been recorded in temperate waters along eastern Australia during non-breeding periods. The number of species recognised varies depending on the taxonomy adopted, ranging from 8 to more than 20. Albatross are long-lived, slow-breeding birds. These characteristics mean that they are unlikely to recover quickly from significant threats.

Storm-petrels

Five species of storm-petrels occur regularly in eastern Australian waters, mainly in temperate and subtropical zones. The white-faced storm-petrel (*Pelagodroma marina*) breeds on islands along the southeast coast. The white-bellied storm-petrel (*Fregetta grallaria*) formerly bred on Lord Howe Island, but is now restricted to smaller islands in that vicinity.

Frigatebirds

Two species, the great frigatebird (*Fregata minor*) and lesser frigatebird (*F. ariel*) nest on islands in the Great Barrier Reef and Coral Sea and move into the tropical sections of the Region when foraging.

Tropicbirds

The red-tailed tropicbird (*Phaethon rubricauda*) nests on islands in the Great Barrier Reef and Coral Sea, as well as on Lord Howe and Norfolk Islands. A second species, the white-tailed tropicbird (*P. lepturus*), does not breed in the vicinity but, like the other species, forages throughout the northern (tropical) part of the East Marine Region.

Gannets and boobies

Within Australia, the Australasian gannet (*Morus serrator*) breeds in a few Victorian sites adjacent to the Region, as well as having many nesting sites around New Zealand. There is extensive movement across the Tasman Sea and through the southern half of the Region. The red-footed booby (*Sula sula*) and brown booby (*S. leucogaster*) breed on islands in the Great Barrier Reef and Coral Sea, and forage widely through the tropical northern section of this Region.

Osprey

The single species of osprey, *Pandion haliaetus*, occurs around almost the entire mainland coast. It occasionally extends to the Solitary Islands.

Gulls

Australia has three breeding species of gulls. All seem confined to coastal areas, with little movement into pelagic waters.

Terns

Of the 15 species of terns that occur regularly along eastern Australia, nine breed on islands along the coast, or in the Great Barrier Reef or Coral Sea. Three breed in both the Lord Howe and Norfolk Island groups, and two widespread species are found throughout. Two species are restricted to coastal areas, while the others occur widely in the East Marine Region.

Skuas and jaegers

The four species that are found regularly in the East Marine Region do not breed near the Australian mainland, but forage widely through temperate and subtropical waters.

Shorebirds, egrets and herons

About 14 sandpiper and 3 plover species occur in small but regular numbers on the coasts of the Lord Howe and Norfolk Islands groups. Several species are non-breeding visitors, usually as migrants but occasionally as vagrants. Only the masked lapwing (*Vanellus miles*) breeds in the Region (at Lord Howe Island). The white-faced heron (*Egretta novaehollandiae*) breeds in small numbers. The cattle egret (*Ardea ibis*) is a regular, non-breeding visitor. On the Solitary Islands, two species of oystercatcher, usually confined to the mainland coast, also occur. Because all these species spend much of their time feeding along the water's edge, they are potentially at risk from oil or other pollution.

Important areas for seabirds in the East Marine Region

Breeding and roosting seabirds are an important component of the natural heritage values of areas in the Region that have been set aside for special protection. Surrounded by the Lord Howe Island Marine Park, the island itself has been recognised as a World Heritage Area in part for its biodiversity. Similarly, the Solitary Islands Marine Reserve, off New South Wales, the Coral Sea National Nature Reserves (Coringa–Herald, Lihou Reef) and Elizabeth and Middleton Reefs Marine National Park have been established because of their biodiversity, including birds.

Known interactions, threats and mitigation measures

Threats to seabirds cited in the Action Plan for Australian Birds (2000) primarily involved either mortality through longline and other fishing activities or disturbance to nesting birds and predation by feral animals. The EPBC Act specifically identifies three major threatening processes: (1) longline fishing, (2) feral cats and (3) competition with, and environmental damage caused by, rabbits. The latter two are of relevance on breeding islands, notably on sub-Antarctic Macquarie Island outside the Region.

Fishing-related impacts and disturbance/predation on breeding islands are the most relevant to seabirds within the East Marine Region. Other threats to seabirds, such as pollution, are of major concern. Discarded plastics are a global threat to both adults and chicks, and can be encountered anywhere in the Region. Some forms of pollution are more likely to be confined to areas within near proximity of coastal Australia but could occur near the Lord Howe and Norfolk Islands groups in the Region. These threats and others are discussed in detail below

Human disturbance

Historically, human impact on breeding seabirds has been substantial. Settlers on Norfolk Island harvested breeding providence petrels for food, starting in 1790. The bird was extirpated from the island within a few years. The providence petrel survived on Lord Howe Island and in recent years the species has recolonised Philip Island, off Norfolk Island. Several species of petrels once bred on the main island of those island groups, but now persist only on satellite islands (e.g. white-bellied storm petrel (*Fregata grallaria)* in the Lord Howe Island group). The sooty tern (*Sterna fuscata*) nests on Lord Howe Island and on smaller islands adjacent to Norfolk Island.

Human disturbance to sea birds on Lord Howe Island is now greatly reduced because much of the island's breeding habitat is protected. On Norfolk Island, some breeding areas are difficult to access, being on cliff faces or offshore stacks, but others rely on the protection of private landowners. Several other islands are specially protected, but a combination of difficult access and remoteness contributes as least as much to their security. Human-related disturbance to nesting

seabirds in the Great Barrier Reef has been studied, and findings are applicable to the Coral Sea also. While human intrusion does have an impact on seabirds, detrimental effects are minor if properly managed. Considerably more work is required to protect various groups of birds in different situations (e.g. burrows or surface nesting, roosting or breeding).

Introduced predators and domestic animals

Introduced species pose a considerable threat to seabird populations on the islands in the East Marine Region. For example, rats were inadvertently introduced to Lord Howe Island in 1918 by a shipwreck. Within a few years, several of the native breeding birds had become extinct. Masked owls (*Tyto novaehollandiae*), a species native to mainland Australia, were released on Lord Howe Island to control the rats but these preyed extensively on white terns (*Gygis alba*) and other native island species. Despite efforts to remove these owls, a few individuals remain. The release of predators near colonies on smaller, uninhabited Coral Sea atolls could be devastating for breeding birds.

Domestic pets, particularly cats, have caused considerable mortality in some petrel colonies on Norfolk Island.

Boats and planes

Birds become accustomed to the presence of boats and planes and associated noise, provided a minimum distance is maintained. As long as people stay within craft and collisions with birds are avoided, these are minor threats.

Mining

At present, mining activities are of minimal concern for the East Marine Region; however, these activities have been shown to have significant impact on birds elsewhere. Spillages from mainland-based mining activities could wash into feeding areas or in the vicinity of breeding sites.

Oil and pollution

Oil spills are devastating to seabirds. Oil can coat the birds, reducing insulation and waterproofing, and resulting in problems with foraging. If ingested during preening, the oil can be toxic. If not fatal to the bird, it can contaminate their young. Winds can move spilt oil towards the shore and in the vicinity of breeding areas and feeding sites. In the East Marine Region, shorelines in the Norfolk and Lord Howe island groups would be the most likely affected through oil spills, presenting a major threat to non-breeding, migrant shorebirds.

Heavy metals and organic compounds (e.g. organochlorines) also have the potential to be major threats. These can be ingested by the birds directly or bio-accumulated from further down the food chain. Contamination by organic chemicals is widespread and has been found in almost all procellariiforms tested for their presence. Individuals that are older or higher up the food chain, exhibit more elevated levels of chemicals as shown in wandering albatrosses by Hindell et al. (1999). Direct mortality may not be as pervasive as more indirect effects. For instance, higher levels of ingested contaminants can manifest themselves in faulty calcium deposition in eggshells or abnormal embryos. Effects of this nature have been documented in giant petrels by Luke et al. (1989).

Marine debris

Discarded debris at sea has been shown to be a threat to seabirds. Fish lines and nets can entangle birds, impeding their ability to forage to the point of starvation if not killing them outright. Of other substances jettisoned, plastic is by far the most hazardous. This is frequently ingested. While it can be toxic, it is more of a problem by becoming an obstruction in the digestive tract. Plastic debris has been recorded in the stomachs of a number of species and has been observed being regurgitated by adults in food for their young.

Loss of food stock

Breeding cycles of many species have evolved to exploit seasonal occurrence of food sources. Fish stocks in many areas are already known to be depleted. Combined with natural fluctuations in population densities, these decreases in available food, particularly at critical times, could cause extensive mortality in seabirds. For example, a high adult mortality and a poor breeding season for little penguins immediately followed the widespread mortality of pilchards (*Sardinops sagax*) in the autumn–winter of 1995 (Dann et al. 2000).

Commercial Fishing

Incidental bycatch of seabirds, particularly albatrosses, has been explicitly identified as a threatening process. The major fishing techniques posing threats are the use of longlines and trawling.

Longline fishing has been described as the single most pervasive threat to seabirds, and is listed in the EPBC Act as a major threatening process. Although the extent of mortality associated with longline fishing is poorly known worldwide, it is recognised that tens of thousands of birds are killed annually in licensed fisheries and even more in illegal, unreported and unregulated fishing. Longline fishing uses a weighted main line sporting side branches with baited hooks. Given that a typical single line may be up to 10 km long and have 10,000 hooks, it is not surprising that millions of hooks are set annually in the Region. Each hook is baited, and as a line is set, this remains on or near

the surface for a period before sinking. Birds attempt to take the bait while it is still on or near the surface. In doing so, they may ingest hooks and subsequently be dragged underwater and drowned as the line sinks.

There are regional differences in the effects on seabirds depending on the techniques and equipment used, as well as seasonal and geographical variations. A range of measures have been implemented to reduce seabird mortality from fishing in Australian waters. The target level is 0.05 birds killed per 1000 hooks set (Department of the Environment and Heritage 2006). However, much of the fishing occurring in the high seas adjacent to the Region, where seabirds forage, have ineffective or no seabird bycatch mitigation measures in use.

During trawl fishing, birds may be injured or killed when nets are being set or hauled. Birds can collide with trawl wires, become entangled in the nets or caught in the mechanisms withdrawing the nets as they attempt to take captured items. They have also been recorded striking ships or protruding structures when flying about awaiting an opportunity for a feeding attempt. There is growing evidence that mortality related to trawl fishing can be important, but this mostly comes from outside the review area in other Australian waters or globally. Information on domestic trawl seabird bycatch is minimal; some reports suggesting that trawl bycatch in southeastern Australian waters is low. There are probably insufficient data to make a meaningful assessment.

Seabird bycatch appears low in the longline billfish and tuna fishery, which is concentrated along the entire east coast of Australia. Monitoring of seabird mortality has increased on domestic longline boats since experience globally indicates that a dedicated observer regime during longline and trawl fishing is the only reliable method of assessing the level of seabird mortality.

Gill nets can capture and kill birds, but these are essentially used in coastal areas. Ghostfishing by discarded or lost nets is problematic; however, there are few, if any, data to assess its significance in the East Marine Region.

Birds have learnt to follow fishing boats, taking discarded fish remains. While this can have local beneficial effects if it occurs near nesting sites, by increasing food available to parents and offspring, it also increases the likelihood of mortality and injury as it brings birds into closer contact with ships, nets and lines, and is overall an undesirable situation.

Climate change

The range of impacts that climate change will have is uncertain. It is likely that warming of ocean waters will affect aspects of the food chain. For example, warming water will hold reduced levels of oxygen, which, in turn, could cause reductions in primary production and a subsequent decrease in the amount of krill. This would have ramifications up the food chain for birds that feed directly on krill or those dependent on prey species that do. Changes in water temperatures could also shift preferred feeding areas. Breeding patterns might change, with birds breeding earlier (Hobday et al. 2006). In little penguins, breeding success and chick weight can be affected by ocean temperatures at a local scale (Chambers 2004). Changes in severity of storms could affect breeding sites. Control of these factors is not amenable to direct human intervention.

Key References and Further Reading

Chambers, LE, 2004, *The impact of climate on Little Penguin breeding success*, BMRC Research Report 100.

Dann, P Norman, FI Cullen, JM Neira, FJ & Chiaradia, A, 2000, 'Mortality and breeding failure of little penguins, *Eudyptula minor*, in Victoria, 1995–96, following a widespread mortality of pilchard, *Sardinops sagax*', *Marine and Freshwater Research*, 51: 355–362.

Department of the Environment and Heritage, 2006, *Threat abatement plan 2006 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*, Australian Antarctic Division, Department of the Environment and Heritage, Kingston.

Garnett, ST and Crowley, GM, 2000, '*The action plan for Australian birds*', Environment Australia, Canberra.

Hindell, MA Brothers, N and Gales, R, 1999, 'Mercury and cadmium concentrations in the tissues of three species of southern albatrosses', *Polar Biology* 22: 102–108.

Hobday, AJ Okey, TA Poloczanska, ES Kunz, TJ and Richardson, AJ (eds), 2006, *Impacts of Climate Change on Australian Marine Life*, CSIRO Marine and Atmospheric Research, Report to the Australian Greenhouse Office, Department of the Environment and Heritage.

Klaer, N and Polacheck, T, 1997, 'By-catch of albatrosses and other seabirds by Japanese longline fishing vessels in the Australian Fishing Zone from April 1992 to March 1995', *Emu*, 97: 150–167.

Luke, BG Johnstone, GW and Woehler, EJ, 1989, 'Organochlorine pesticides, PCBs and mercury in antarctic and subantarctic seabirds', *Chemosphere*, 19: 2007–2021.

Tuck, GN Polacheck, T and Bulman, CM, 2003, 'Spatio-temporal trends of longline fishing effort in the Southern Ocean and implications for seabird bycatch', *Biological Conservation*, 114: 1–27.

D.5. East Marine Region Protected Species Group Report Card – Pinnipeds

Current at September 2007. For updates see <www.environment.gov.au/coasts/mbp/East>

General information

There are ten species of seals recorded in Australian waters. This report focuses on the only two species breeding in continental Australia that are likely to be encountered in the East Marine Region. These are the Australian fur seal (*Arctocephalus pusillus doriferus*) and New Zealand fur seal (*Arctocephalus forsteri*).

The weight of scientific evidence suggests that although the seal population is probably still lower than before commercial hunting began, the New Zealand fur seal and Australian fur seal have been increasing their population size and range for some time (Marine and Marine Industries Council 2002; Kirkwood et al. 1992; Shaughnessy 1999). Moreover, based on current trends, seal population growth may continue into the future (Marine and Marine Industries Council 2002) with a possible trebling of the population by 2035 (Goldsworthy et al. cited in Kearney et al. 2003).

There are no known breeding colonies of either seal species in the East Marine Region; however, there are historical records of Australian fur seals breeding at Seal Rocks, near Port Stephens and Montague Island in southern New South Wales. At present Montague Island is the major haul-out site along the coast of New South Wales for both species (Shaughnessy 1999). Although there have been a number of reports of fur seal pups on Montague Island it is considered as supporting haul-out sites rather than breeding sites (Shaughnessy et al. 2001).

New Zealand fur seals can be distinguished from the Australian fur seal by their uniformly darker coat colour, high pitched call (Australian fur seals have a deep bark), and relatively long pointed nose. They also move differently on land. New Zealand fur seals "hop" with fore-flippers moving together whereas Australian fur seals "waddle" from side to side as they move one fore flipper after the other (Goldsworthy et al. 1997).

Nationally protected species

Under the EPBC Act, the Australian fur seal and New Zealand fur seal are listed marine species (see Table D5.1). It is an offence to kill, injure, take, trade, keep or move any member of either species in Commonwealth waters without a permit.

The Australian fur seal and the New Zealand fur seal are listed under Appendix II of the *Convention on International Trade in Endangered Species* (CITES). This means they are not necessarily threatened with extinction now but that may be the case unless trade is closely controlled.

Ecology of pinnipeds in the East Marine Region

The life history characteristics of the Australian and New Zealand fur seals are summarised in table D5.2.

There are no records of large seal numbers in the East Marine Region. Movements of tagged fur seals have been recorded occasionally along the New South Wales coastline which indicates that they travel large distances. Tagging studies have shown that the Australian fur seals at Montague Island come from several of the breeding colonies in Bass Strait. Tagged New Zealand fur seals from colonies in South Australia and New Zealand have been recorded on the coast of New South Wales (Shaughnessy et al. 2001).

Important areas in the East Marine Region

Although there are no breeding colonies of Australian or New Zealand fur seals in the Region and the haul-out sites for both species fall within State waters, it is likely

Table D 5.1 Pinnipeds listed as threatened under the EPBC Act that are known to occur in the Region

Species	Conservation Status	Australian Government Conservation Plans and Strategies for the Species
Australian fur seal (*Arctocephalus pusillus*)	Listed Marine	The Action Plan for Australian Seals (1999)
New Zealand fur seal (*Arctocephalus forsteri*)	Listed Marine	National Strategy to Address Interactions between Humans and Seals: Fisheries, Aquaculture and Tourism (November 2006) National Assessment of Interactions between Humans and Seals: Fisheries, Aquaculture and Tourism (2007)

Table D5.2 Summary of life history, feeding and population information for Australian and New Zealand fur seals (sources: Shaughnessy 1999; DAFF 2007).

	Australian Fur Seal	New Zealand Fur seal
Scientific name	Arctocephalus pusillus doriferus	Arctocephalus forsteri
Abundance	92 000	57 400
Feeding	Feed primarily on fish and cephalopods, also seabirds	Feed primarily on fish and cephalopods, also seabirds (incl. little penguins)
Longevity	Male: 19 years; female: 21 years	Male: 15 years; female: 26 years
Age at sexual maturity	Females: 3–6 years; males – hold territories at 8 to 13 years	Females: 6 years; males – hold territories at about 9 years
Pupping interval	1 year	1 year
Gestation	8–9 months	8–9 months
Pupping season	late October to late December	Late November to mid-January
Mating season	November–January	Mid-November–mid-January

that they traverse both State and Commonwealth waters, and that they have feeding areas in Commonwealth waters of the Region. Montague Island and Steamers Head should be considered as key areas as they are the only haul-out sites in New South Wales, are used by many animals for resting, and are far removed from breeding grounds. There are likely to be key feeding areas nearby but further research is required to identify these areas.

The major haul-out site at Montague Island is only 8 km from the continental shelf margin, an area typically high in primary production supporting relatively high concentrations of fish and seabirds on which the seals feed (Irvine et al. 1997). These feeding grounds are mostly in Commonwealth waters.

Fur seals in the Region interact with the fishing industry and are the focus of tourist operations at Montague Island and Steamers Head (see below).

Although Australian fur seals currently breed at a small number of islands in Bass Strait, this range was previously more widespread. Adjacent to the East Marine Region Australian fur seals are reported to have bred at Seal Rocks, near Port Stephens and Montague Island, off Narooma in New South Wales (Shaughnessy 1999). Shaughnessy recommended that long-term planning for conservation should not overlook the possibility that this species may re-colonise some of its former breeding sites.

Known interactions, threats and mitigation measures

Seals may be affected by several human activities including: conflict with commercial fishing; entanglement in fishing gear and other marine debris; reduction in food supply; human disturbance, including tourism, aircraft and vessels; oil spills and chemical contaminants; and diseases.

The three most important of these occurring in the East Marine Region are considered below. To ensure the conservation of seal species, management plans put in place by State authorities need to be considered in order to protect animals traversing and feeding in Commonwealth waters of the Region.

Fishing

The main concern for fur seals in the waters of mainland Australia result from interactions with fishing operations. Australian fur seal populations are still recovering from over-exploitation during past commercial sealing operations and despite recent increases in numbers are estimated to be about half of pre-harvesting levels (Kirkwood in Shaughnessy et al. 2003a). Similarly the New Zealand fur seal is recovering from earlier harvesting (Shaughnessy et al. 1995). As fur seal numbers increase there is potential for an increase in operational interactions between these marine mammals and fisheries in Australian waters (Shaughnessy et al. 2003b).

Interactions of seals with fisheries in the East Marine Region are most likely to occur with the Ocean Trawl Fishery. This fishery is managed by the New South Wales Department of Primary Industries (DPI) which is undertaking a project to identify the broad-scale interactions that occur between fishing operations and mammals, reptiles and birds in New South Wales waters (DPI 2004). A scientific observer program is being introduced across all commercial fisheries in New South Wales. The purpose of this program is to document the interactions of fishing

operations with non-retained and threatened species (including seals), and to collect information on the use and effectiveness of bycatch reduction devices (DAFF 2007). The data collected from the observer program will be used to assess the need to introduce seal-excluder devices and other measures to minimise impacts between seals and fishing operations (DAFF 2007). Methods for decreasing bycatch of seals in the trawling sector are set out in the 'Code of Fishing Practice to Minimise Seal Bycatch' (AFMA 2001). The code also includes suggestions on how to avoid attracting seals to the fishery grounds. These are voluntary guidelines and standards of behaviour for responsible fishing practices.

There is currently limited observer data but anecdotal reports indicate that fur seals take fish from nets and interrupt fishing operations in the Ocean Trawl Fishery. The Australian fur seal may interact with the fishery in a number of ways: capture or contact with fishing gear; entanglement in discarded or lost fishing gear; competition; and illegal shooting by fishers. However, the risk to both the Australian and the New Zealand fur seal is currently considered low-medium with only a small proportion of the population affected by operations of the fishery (DPI 2004).

Seal interactions with the Ocean Trap and Line Fishery operations in the Region are also likely, particularly south of Jervis Bay (DPI 2004). As in the Ocean Trawl Fishery, there is limited observer data; however there are anecdotal reports of fur seals interacting with fishing operations (DAFF 2007). In interviews conducted in 1999 with fishers from the drop-line, trawl and hand-line fisheries on the south coast of New South Wales, between Jervis Bay and Eden, drop-liners, hand-liners and trappers reported most problems with seals. Trawlers reported fewer interactions and long-liners even less. Interactions with seals occurred more often in winter (when they were more abundant in the area) than in summer. More interactions were reported around Montague Island than north or south of it. The two main causes of interactions appeared to be seals preying on target fish in fishing operations, and seals becoming entangled in gear (Hickman 1999). The Lobster Fishery operating off the New South Wales coast has no recorded interactions with fur seals and the potential impact is currently considered low (Department of the Environment and Heritage 2006).

Seals also interact with the operations of the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF). Although this fishery extends southwards from Sandy Cape in Queensland to Cape Jervis in South Australia the majority of operators fish in southern Australia—mainly off Tasmania, Victoria and South Australia. Observer programs in these regions have documented female fur seal interactions with sectors of this fishery (DAFF 2007).

A study of the seasonal overlap between the foraging areas of female Australian fur seals and fishing activity in the Commonwealth Trawl Sector found that considerable overlap occurs between the South East Trawl Fishery and the areas used by fur seals from colonies at Lady Julia Percy, The Skerries and Kanowna Island (off Victoria). This overlap does not, however, coincide with areas of the highest fishing activity.

Interactions in the Region (mainly the southern coast of New South Wales) are more likely to occur in spring when female fur seals undertake more dispersed foraging trips unencumbered by dependent pups (Arnould 2004).

Little is known of the interactions of seals and the recreational fishing sector in the Region but in a comprehensive review of marine mammal interactions with fisheries it was concluded that interactions which lead to the death and entanglement of some marine mammals and economic losses for the fishing industry are inevitable (Shaughnessy et al. 2003b).

Marine debris

Apart from direct interactions with fishing operations seals can become entangled in discarded or lost fishing equipment (classed as harmful marine debris). Marine debris is considered a Key Threatening Process under the EPBC Act 1999 (see: http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl). In the listing of harmful marine debris as a Key Threatening Process, six endangered species, fourteen vulnerable species, and one critically endangered population of grey nurse shark were identified as being adversely affected by harmful marine debris.

Entanglement of fur seals in discarded fishing gear usually results in death (Shaughnessy et al. 2003b). Although impacts of this mortality on Australian fur seals in the East Marine Region have not been evaluated, it is likely that fur seals in the region will become entangled based on data collected elsewhere in their range. For Australian fur seals, Pemberton et al. (1992) recorded that 1.9 per cent of animals at haul-out sites in southern Tasmania were entangled in marine debris: the highest incidence of entanglement recorded for a marine mammal. A number of juvenile Australian fur seals were observed with man-made debris around their necks at Montague Island (Shaughnessy et al. 2001) showing that fur seals are vulnerable to fishing-related marine debris throughout their foraging range.

Page et al. (2004) collated data on entanglements of Australian sea lions and New Zealand fur seals on Kangaroo Island for each year between 1988 and 2002. The incidence of entanglement for fur seals was 0.9 per cent in 2002, the fourth highest rate reported for a seal species. This rate did not decrease after government and fishing industry associations introduced guidelines in 2000 to reduce the impact of fishing on non-target species (Page et al. 2004). Loops of packing tape from the rock lobster fishery and trawl net fragments from the trawl fishery were found on seals most frequently. Page et al. (2004) estimated 295 New Zealand and 1119 Australian fur seals die as a consequence of entanglement each year in southern Australia. At present, rates of entanglement and mortality of seals in lost or discarded fishing gear in waters of the Region are not systematically assessed and are likely to be underestimated (DAFF 2007).

Tourism

In southern New South Wales there are several haul-out sites for fur seals, most of which are Australian fur seals, but some New Zealand fur seals are included. Tourist operators provide seal viewing opportunities at two of these, Montague Island, off Narooma, and Steamers Head, near Jervis Bay.

The effects of tour boat operations on fur seals at Montague Island were investigated by Shaughnessy et al. (2007). As a result a minimum approach distance to fur seal colonies of 40 m has now been gazetted as a regulation (NSW Government 2006). It has also been recommended that visitors and staff should not walk to seal colonies because the seals are likely to flee to the water when approached on shore (Shaughnessy et al. 2007).

Monitoring of the fur seal colony at Steamers Head, near Jervis Bay has shown that seals at this haul-out site are affected by a range of disturbances such as landslides, tourist boats and bombardment at a nearby weapons range. The authors recommended that researchers and tourists should remain at least 75 m from the colony when animals number less than 50 and at least 100 m when there are more than 100 seals present at the haul-out site.

In reviewing the effects of seal-focussed tourism in the southern hemisphere, Kirkwood et al. (2003) concluded that guidelines and regulations need to be implemented to ensure the protection and conservation of these animals, and the sustainability of the tourist industry.

Key References and Further Reading

AFMA, 2001, *Background Paper: Bycatch Action Plan, South East Trawl Fishery*, Australian Fisheries Management Authority, Canberra.

Arnould, JPY, 2004, *Reducing interactions between female Australian fur seals and commercial fisheries*, ARF R02/1702, Final report to the Australian Fisheries Management Authority <http://www.afma.gov.au/research/reports/2004/r02_1702.pdf > accessed 20/6/07

DAFF, 2007, *National Assessment of Interactions between Humans and Seals: Fisheries, Aquaculture and Tourism*, Australian Government Department of Agriculture Fisheries and Forestry, < http://www.daff.gov.au/fisheries/environment/bycatch/seals> accessed 15/6/07.

Department of the Environment and Heritage, 2006, *Assessment of the New South Wales Lobster Share Management Fishery*, <http://www.environment.gov.au/coasts/fisheries/nsw/lobster/pubs/nsw-lobster-assessment.pdf >

DPI, 2004, *Environmental Impact Statement on the Ocean Trawl Fishery*, Vol. 3, New South Wales Department of Primary Industries.

Goldsworthy, SD, Bulman, C, Xi, H, Larcome, J and Littman, C, 2002. Trophic interactions between marine mammals and Australian fisheries: An ecosystem approach. Draft Chapter for book "*Trophic Interactions Between Fisheries and Marine Mammals*".

Goldsworthy, SD Bulman, C He, X Larcombe, J and Littnan, C, 2003, 'Trophic interactions between marine mammals and Australian fisheries: an ecosystem approach', in *Marine Mammals: Fisheries, Tourism and Management Issues*, N Gales, M Hindell and R Kirkwood (eds), CSIRO Publishing: Collingwood.

Goldsworthy, SD, Pemberton D and Warneke, RM, 1997, 'Field identification of Australian and New Zealand fur seals *Arctocephalus* spp. based on external characters', in *Marine Mammal Research in the Southern Hemisphere*, M Hindell and C Kemper (eds), Surrey Beatty and Sons, Chipping Norton, Sydney.

Hickman, LJ, 1999, '*Effects of fur seals on fishing operations along the New South Wales south coast*', B.A. (Hons.) Thesis, University of New South Wales, Sydney

Irvine, A Bryden, MM Corkeron, PJ and Warneke, RM, 1997, 'A census of fur seals at Montague Island, New South Wales', in *Marine Mammal Research in the Southern Hemisphere*, M Hindell and C Kemper (eds), Surrey Beatty and Sons, Chipping Norton, Sydney.

Kearney, B. Foran, B, Poldy, F and Lowe, D, 2003, *Modelling Australia's Fisheries to 2050: Policy and Management Implications*. Final Report. Fisheries Research and Development Corporation, Canberra.

Kirkwood, R., Pemberton, D. and Copson, G., 1992. *The conservation and management of seals in Tasmania*. Unpublished report, Department of Parks, Wildlife and Heritage, Hobart

Kirkwood, R Boren, L Shaughnessy, P Szteren, D Mawson, P Hückstädt, L Hofmeyr, G Oosthuizen, H Schiavini, A Campagna, C and Berris, M, 2003, 'Pinniped focussed tourism in the southern hemisphere: A review of the industry', in *Marine Mammals: Fisheries, Tourism and Management Issues*, N Gales, M Hindell and R Kirkwood (eds), CSIRO Publishing: Collingwood.

Kirkwood, R Gales, R Terauds, A Arnould, JPY Pemberton, D Shaughnessy, PD Mitchell, AT and Gibbens, J, 2005, 'Pup production and population trends of the Australian fur seal (Arctocephalus pusillus doriferus)', *Marine Mammal Science*, 21(2): 260–282.

Marine and Marine Industries Council, 2002, *A seal/fishery interaction management strategy: Background report*. Department of Primary Industries, Water and Environment, Tasmania

New South Wales Government, 2006, National Parks and Wildlife Amendment (Marine Mammals) Regulation 2006, *Government Gazette of the State of New South Wales*, 72: 3739–3749.

Page, B McKenzie, J Sumner, MD Coyne, M and Goldsworthy, SD, 2006, 'Spatial separation of foraging habitats among New Zealand fur seals', *Marine Ecology Progress Series*, 323: 263–279.

Page, B McKenzie, J McIntosh, R Baylis, A Morrissey, A Calvert, N Haase, T Berris, M Dowie, D Shaughnessy, PD and Goldsworthy, SD, 2004, 'Entanglement of Australian sea lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem', *Marine Pollution Bulletin*, 49: 33–42.

Pemberton, D and Gales, R, 2004, 'Australian fur seals (*Arctocephalus pusillus doriferus*) breeding in Tasmania: population size and status', *Wildlife Research*, 31: 301–309.

Pemberton, D Brothers, NP and Kirkwood R, 1992, 'Entanglement of Australian fur seals in man-made debris in Tasmanian waters', *Wildlife Research*, 19: 151–159.

Shaughnessy, PD 1999, *The Action Plan for Australian Seals*, Environment Australia, Canberra.

Shaughnessy, PD Briggs, SV and Constable, R, 2001, 'Observations on seals at Montague Island, New South Wales', *Australian Mammalogy*, 23: 1–7.

Shaughnessy, PD Goldsworthy, SD and Libke, JA, 1995, 'Changes in the abundance of New Zealand fur seals, *Arctocephalus forsteri*, on Kangaroo Island, South Australia', *Wildlife Research*, 22: 201–215.

Shaughnessy, P Kirkwood, R and Goldsworthy, S, 2003a, 'Distribution and abundance of seals in southern Australia – an overview', in *Reducing seal interactions and mortalities in the trawl sector*, compiled by C Stewardson, Discussion paper for the meeting of the Southern and Eastern Scalefish and Shark Fishery Ecological Advisory Group (SESSFEAG), Canberra.

Shaughnessy, P Kirkwood, R Cawthorn, M Kemper, C and Pemberton, D, 2003b, 'Pinnipeds, cetaceans and Fisheries in Australia: a review of operational interactions', in *Marine Mammals: Fisheries, Tourism and Management Issues*, Gales, N Hindell, M and R Kirkwood (eds), CSIRO Publishing: Collingwood, Victoria, pp. 132–152.

Shaughnessy, PD Nicholls, AO and Briggs, SV, 2007, '*Responses of fur seals to visitation by tourist boats at Montague Island, New South Wales*', Tourism in Marine Environments, 4 (3): In press.

D.6. East Marine Region Protected Species Group Report Card – Cetaceans

Current at December 2007. For updates see <www.environment.gov.au/coasts/mbp/East>.

Dolphins/Porpoises

Description

There are 21 species of dolphins and porpoises recorded in Australian waters, with 12 of these known to occur in the East Marine Region. These are the Australian snubfin dolphin (*Orcaella heinsohni*), Indo–Pacific humpback dolphin (*Sousa chinensis*), rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), Fraser's dolphin (*Lagenodelphis hosei*), pantropical spotted dolphin (*Stenella attenuate*), spinner dolphin (*Stenella longirostris*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), and Indo–Pacific bottlenose dolphin (*Tursiops aduncus*) (Menkhorst and Knight 2001, and Ross 2006). The 12 species of dolphins or porpoises can be divided into near shore and oceanic species. There are two near shore species, the Australian snubfin and Indo–Pacific humpback dolphins which are primarily found in State waters. As they do not occur in the Region per se, they are not considered as key species for the purposes of this report. The significance of oceanic species in the Region is not well known.

Conservation Status

All cetaceans, which include dolphins and porpoises, are protected under the EPBC Act. This means that they are protected in Commonwealth waters and it is an offence to kill, injure, treat or interfere with them. To 'treat' a cetacean means to divide, cut-up, or extract any product from a cetacean, and to "interfere" means to harass, chase, herd, tag, mark or brand a cetacean. An approval is required for any actions that are likely to have a significant impact on these species.

The Australian snubfin and Indo–Pacific humpback dolphins are scheduled in Queensland as 'rare wildlife' under the *Nature Conservation (Wildlife) Regulation 1994* which means that their conservation status is regularly monitored and reviewed, and they are provided with protection under an assessment and approval processes for any actions that may adversely impact them. Neither species is listed in New South Wales. None of the oceanic species of dolphins or porpoises are listed in Queensland or New South Wales.

All cetacean species other than those listed in Appendix I, are listed in Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). Species in this list are not necessarily threatened with extinction, but trade must be controlled in order to avoid utilisation incompatible with their survival. The Indo–Pacific humpback and Australian snubfin (under the scientific name *Orcaella brevirostris*) dolphins are listed under Appendix I of CITES. This means these species are threatened with extinction and trade is permitted only in exceptional circumstances.

Habitat and Distribution

Important habitats for dolphins include those which support feeding and calving areas.

Significance of Dolphins in the East Marine Region

The bottlenose dolphin is usually found in colder, deeper waters in southern Queensland and New South Wales. The Indo-Pacific bottlenose dolphin is usually found in warmer inshore waters in northern New South Wales and Queensland. Accurate population estimates are not available for bottlenose dolphins in Australia, but they are common in inshore waters and bays such as Moreton Bay and Port Stephens. Local population numbers indicate that the total population of bottlenose dolphins is in the order of thousands rather than hundreds. Dolphins in the East Marine Region are important to a number of tourist operations and are known to interact with the fishing industry.

Known Interactions, threat and mitigation measures

Dolphins may be affected by human activities including: harassment, accidental collision, habitat loss or degradation and food stock reduction, incidental catch, capture for live display, hunting, wild feeding programs, swim programs, and strandings.

Habitat loss or degradation and food stock reduction

Indo-Pacific humpback and Australian snubfin dolphins depend on coastal and riverine habitats that may be affected by developments and pollution. Higher levels of polychlorinated biphenyls (PCBs) have been found in dolphins from the Gold Coast than anywhere else in Australia. High levels of PCBs have been linked to severely impaired reproductive capacity. Some dolphins are thought to feed regularly around sewage outlets and port facilities and could be vulnerable to contamination from poor water quality. Some studies have found significant levels of mercury in the respiratory tracts of dolphins, raising the possibility that air quality adjacent to major centres may affect dolphins. The degradation of dolphin habitat and the overfishing of dolphin prey species are potential threats to dolphins (Queensland Department of Environment 1997).

Incidental catch

The barramundi fishery and gillnet fishery for shark and mackerel may be associated with significant incidental catches of oceanic species of dolphins in the Region. Indo–Pacific humpback and Australian snubfin dolphins could be particularly at risk from barramundi and threadfin bream nets in northern Australia. Beach meshing (nets) and drum lines used in shark control programs on the east coast of Australia capture both target shark species, such as tiger sharks and bull whalers, and non-target marine species, such as turtles, rays and cetaceans (including dolphins).

Five hundred and twenty dolphins, an average of 26 a year, were caught in mesh nets along the Queensland coast from 1967 to 1987. The Australian snubfin dolphin was the most common species caught in nets north of Mackay, while the Indo–Pacific humpback dolphin was one of the main species caught in southern Queensland. From 1993 to 2003, eight Australian snubfin dolphins were caught in mesh nets, five animals dying and three animals released alive. Between 1996 and 2003, 16 Indo–Pacific humpback dolphins were caught and all died. The incidental catch of dolphins may be a significant threat due to the long lifespan, likely low breeding rate and low population densities of Indo–Pacific humpback dolphins (Queensland Department of Environment 1997). From 1996 to 2003 in Queensland, 25 bottlenose dolphins were caught in mesh nets and 19 died, while an average of 3.3 common dolphins died each year in the same way. In New South Wales, 23 common and bottlenose dolphins died in mesh nets between 1996 and 2003 (Department of the Environment and Water 2005).

Wild feeding programs

Issues associated with deliberately developed and/or maintained feeding programs for wild dolphins include the water quality at feeding areas, food quality and quantity, the risk of promoting a dependence of wild dolphins on supplied food, the possibility of dolphins seeking food from all humans, inappropriate human activities in the vicinity of feeding areas (such as boat operation and fishing), human safety issues, the risk of transmission of pathogens to dolphins, either from contaminated food or through direct contact between humans and dolphins, and the ability to control human access. The effects of feeding practices has also been associated with high calf mortalities in some dolphin populations.

There is a commercial feeding program at Tangalooma Resort on Moreton Island, 'quasi-commercial' feeding of resident Indo–Pacific humpback dolphins at Tin Can Bay, southern Queensland, and 'non-commercial' feeding of dolphins from disposal of by-catch and offal from fishing vessels (Queensland Department of Environment 1997). The Australian Government has also developed the Australian National Guidelines for Whale and Dolphin Watching. The Guidelines set standards that allow people to observe and interact with whales and dolphins in a way that ensures these animals are not harmed.

Whales

Description

There are 30 species of whales recorded in Australian waters, all of them found in the East Marine Region (Menkhorst and Knight 2001).

Humpback whales grow to a maximum length of 18 metres and can weigh 45 tonnes. They have very large, often white, pectoral fins up to 5 metres long, a prominent dorsal fin, scalloped and irregular trailing edges to flukes, and prominent knobbly protuberances on the head and pectoral fins. Southern hemisphere humpbacks usually have white undersides and male humpbacks are known for their long, complex 'songs' (Queensland Department of Environment 1997).

Dwarf minke whales are an, as yet, un-named subspecies of the Northern Hemisphere minke whales (*Balaenoptera acutorostrata*), and are only known from the Southern Hemisphere. They can grow to nearly 8 metres in length and weigh 5-6 tonnes. They have a white shoulder and flipper base, with a dark-grey tip on the flipper, and a large dark patch extending onto the throat (CRC Reef Research Centre 2002).

Humpback and dwarf minke whales are important to the whale watching and swim-with-whales industries.

Conservation Status

All cetaceans are protected by the EPBC Act. Humpback whales are listed under the EPBC Act in the Cetacean, Vulnerable, and Listed migratory species categories. These listings categorise Humpbacks as a matter of national environmental significance and ensure that their recovery is promoted through a recovery plan (describing key threats and identifying specific recovery actions) under the EPBC Act. Dwarf minke whales are listed under the EPBC Act under the category of Cetacean.

The humpback whale is scheduled in Queensland as 'vulnerable wildlife' under the *Nature Conservation (Wildlife) Regulation 1994* which provides protection and requires the promotion of its recovery using a recovery plan or conservation plan and an assessment and approval process

Table D6.1 Cetaceans listed as threatened or migratory under the EPBC Act that are known to occur in the East Marine Region

Species	Conservation Status	Australian Government Conservation Plans and Policies
killer whale (*Orcinus orca*)	All cetaceans are protected under the EPBC Act Migratory CITES Appendix II CMS Appendix II	
long-finned pilot whale (*Globicephala melas*)	CITES Appendix II	
short-finned pilot whale (*Globicephala macrorhynchus*)	CITES Appendix II	
melon-headed whale (*Peponocephala electra*)	CITES Appendix II IUCN Lower Risk/Least Concern	
pygmy killer whale (*Feresa attenuate*)	CMS Appendix II	
false killer whale (*Pseudorca crassidens*)	CITES Appendix II	
pygmy sperm whale (*Kogia breviceps*)	CITES Appendix II	
dwarf sperm whale (*Kogia simus*)	CITES Appendix II	
sperm whale (*Physeter macrocephalus*)	Migratory CITES Appendix I CMS Appendix I	
humpback whale (*Megaptera novaeangliae*)	Vulnerable Migratory CITES Appendix I CMS Appendix I	Humpback Whale Recovery Plan 2005 - 2010 (Department of the Environment and Heritage 2005)
southern right whale (*Eubalaena australis*)	Endangered Migratory CITES Appendix I CMS Appendix I	Southern Right Whale National Recovery Plan 2005-2010 (Department of the Environment and Heritage 2005c)
pygmy right whale (*Caperea marginata*)	Migratory CITES Appendix I CMS Appendix II	
dwarf minke whale (*Balaenoptera acutorostrata*)	CITES Appendix I	
Antarctic minke whale (*Balaenoptera bonaerensis*)	Migratory CITES Appendix I CMS Appendix II	
sei whale (*Balaenoptera borealis*)	Vulnerable Migratory CITES Appendix I CMS Appendix I	Blue, Fin and Sei Whale Recovery Plan 2005 - 2010 (Department of the Environment and Heritage 2005)

Table D6.1 Cetaceans listed as threatened or migratory under the EPBC Act that are known to occur in the East Marine Region

Species	Conservation Status	Australian Government Conservation Plans and Policies
Bryde's whale (*Balaenoptera edeni*)	Migratory CITES Appendix I CMS Appendix II	
fin whale (*Balaenoptera physalus*)	Vulnerable Migratory CITES Appendix I	Blue, Fin and Sei Whale Recovery Plan 2005 - 2010 (Department of the Environment and Heritage 2005)
blue whale (*Balaenoptera musculus*)	Endangered Migratory CITES Appendix I CMS Appendix I	Blue, Fin and Sei Whale Whale Recovery Plan 2005 - 2010 (Department of the Environment and Heritage 2005)
Andrew's beaked whale (*Mesoplodon bowdoini*)	CITES Appendix I	
Blainville's beaked whale (*Mesoplodon densirostris*)	CITES Appendix II	
ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*)	CITES Appendix II	
strap-toothed beaked whale (*Mesoplodon layardi*)	CITES Appendix II	
True's beaked whale (*Mesoplodon mirus*)	CITES Appendix II	
Hector's beaked whale (*Mesoplodon hectori*)	CITES Appendix II	
Gray's beaked whale (*Mesoplodon grayi*)	CITES Appendix I	
goose-beaked whale (*Ziphius cavirostris*)	CITES Appendix I	
Shepherd's beaked whale (*Tasmacetus shepherdi*)	CITES Appendix II	
Arnoux's beaked whale (*Beradius arnuxii*)	CITES Appendix I	
southern bottlenose whale (*Hyperoodon planifrons*)	CITES Appendix I	
Longman's beaked whale (*Indopacetus pacificus*)	CITES Appendix I	

Humpback whale. Photo: Dave Paton.

for any actions that are likely to have an adverse impact on the whales.

The humpback whale is listed in New South Wales as "vulnerable" under the *Threatened Species Conservation Act 1995* which provides protection and requires an assessment and approval process for any actions that are likely to have an adverse impact on the whales.

The humpback and dwarf minke whales are listed under Appendix I of CITES. This means these species are threatened with extinction and trade is permitted only in exceptional circumstances.

Habitat and Distribution

Important habitats for whales include those which support resting areas, feeding areas, calving and breeding grounds.

Humpback whale

Humpback whales are found in all State and Commonwealth waters of Australia. The International Whaling Commission recognises at least six southern hemisphere populations of humpback whales based on their Antarctic feeding distribution and location of breeding grounds, but notes that the level of confidence associated with defining different populations of humpback whales varies considerably across the southern hemisphere (Bannister et al. 1996). During the southern migration of humpback whales through the East Marine Region, large numbers of whales are known to aggregate in Hervey Bay and the Whitsundays, which have been identified as resting areas. Resting areas may allow mother-calf pairs to maximise the growth of calves before swimming to Antarctic waters. Mothers with calves are often found close to shore and using sheltered bays to rest. Humpback whales are generally regarded as Antarctic krill specialists (Kawamura 1994), normally feeding in Antarctic waters south of 55° S but some opportunistic feeding has been observed off Eden in New South Wales (Stamation et al. 2007).

Calving occurs in tropical waters. Although exact locations of calving grounds are not known, breeding activity has been observed in the central Great Barrier Reef area (see the Australian Government Species and Threats Database at <www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>).

In 2004, the east population of humpback whales was estimated to be approximately 7,000 individuals increasing approximately 10 per cent per year (Noad et al. 2006). It is not known to what extent this population may mix with animals from other breeding stocks further east in the Pacific Islands.

Dwarf minke whale

Dwarf minke whales have been recorded in all state waters (except the Northern Territory) and in Commonwealth waters up to north Queensland. They spend summer in sub-Antarctic waters and are found in far north

Queensland in winter, often close inshore, and will enter bays and estuaries. They are mostly found alone or in pairs, and will approach people and ships. Dwarf minke whales feed on krill, open-ocean lantern fish and small shoaling fish, herding them into compact shoals before cruising through with open mouths (Menkhorst and Knight 2001; CRC Reef Research Centre 2002).

The size of the population in Australian waters is not known but up to 200 dwarf minke whales have been recorded over a season in Great Barrier Reef waters (CRC Reef Research Centre 2002).

Life History and Ecology

Table D6.2 Summary of life history, feeding and population information for Australian humpback and dwarf minke whales (sources: Menkhorst and Knight 2001; Australian Government Species and Threats Database 2007; GBRMPA 2007; Bannister et al. 1996; Queensland Department of Environment 1997; CRC Reef Research Centre 2002)

Movements/migration

Humpback whales migrate through the East Marine Region from June to August to northern tropical breeding grounds and return south to Southern Ocean feeding areas between September and November. Humpback whales migrating through the Region have wintering grounds in the Great Barrier Reef, New Caledonia, Tonga and other South Pacific islands. There are links between animals in these areas but these links are not well understood. Humpbacks migrate in groups segregated by sex and age (Bannister and Hedley 2001). In the Southern Ocean, humpback whales occur over a wide range of latitudes, but are mostly encountered between 62°S and 66°S (Kasamatsu et al. 1996).

Dwarf minke whales are found in sub-Antarctic waters (58°S – 60°S) to the south of Australia and New Zealand between December and March, and in the northern Great Barrier Reef between June and July. The migration of dwarf minke whales is not well understood.

Significance of Whales in the East Marine Region

Each year between April and November humpback whales can be seen migrating along the east coast of Australia. These animals undertake an annual migration of 10 000 kilometres between the waters of the Southern ocean where they feed on krill and the warmer waters of their calving grounds in the Great Barrier Reef.

The Whitsunday islands, Hervey Bay, Stradbroke Island, Cape Byron, Coffs Harbour, and the southern coast of New South Wales are key localities for humpback whales as aggregation and resting areas along their migration route. The northern Great Barrier Reef is a key locality where dwarf minke whales aggregate in winter.

Humpback whales in the East Marine Region interact with the fishing and shipping industries, and whale-watching tourist operations in the Great Barrier Reef, Whitsunday Islands, Hervey Bay, Stradbroke Island, Cape Byron, Port Stephens, Botany Bay, Jervis Bay and Eden. Dwarf minke whales interact with swim-with-whale tourist operations in the Great Barrier Reef.

Known Interactions, threat and mitigation measures

Whales may be affected by human activities including: harassment, accidental collision, habitat loss or degradation and food stock reduction, hunting, swim programs, and strandings (Department of the Environment and Heritage 2005, Queensland Department of Environment 1997).

Table D6.2 Summary of life history, feeding and population information for Humpback and Dwarf minke whales (sources: Menkhorst and Knight 2001; Australian Government Species and Threats Database 2007; GRMPA 2007; Bannister et al. 1996; Queensland Department of Environment 1997; CRC Reef Research Centre 2002)

	Humpback whale	Dwarf minke whale
Scientific name	Megaptera novaeangliae	Balaenoptera acutorostrata
Abundance	Approximately 7000 (Ei population)	Not known
Feeding	Krill	Krill and small fish
Longevity	50 years	Not known
Age at sexual maturity	4-10 years	6-8 years
Calving interval	2-3 years	1 year
Gestation	11 -11.5 months	10 months
Calving season	June – October	May – June
Calving areas	Tropical coastal waters near the Great Barrier Reef, and possibly other areas	Temperate - tropical waters
Mating season	June – October	Not known

Harassment

Unregulated recreational and commercial whale watching, and movements of general boating traffic have the potential to cause disruption to the normal behaviour or activity patterns of whales. Evidence of disrupted behaviour can include prolonged diving, evasive swimming with rapid changes in direction or speed, and interruptions to breeding or nursing activity. High levels of boating traffic have been found to cause lactating female humpback whales and calves to leave traditional inshore resting areas in favour of offshore waters. Lactation imposes the greatest energy drain on female humpback whales and they may be most vulnerable to harassment at that stage. Low aircraft operations have been found to cause extreme avoidance behaviour in humpback whales (Queensland Department of Environment 1997). Swimming, snorkelling or diving with whales has the potential to place both people and animals at risk. Direct contact with whales could transfer disease, scare away the whale or cause injury to both people and whales (CRC Reef Research Centre 2002).

Habitat loss/degradation and food stock reduction

Declining water quality along the migratory route of humpback whales may reduce occupancy and/or exclude whales from traditional inshore areas, compromise reproductive success and increase risk of mortality (Department of the Environment and Heritage 2005).

Key References and Further Reading

Bannister, JL Hedley, SL, 2001, Southern Hemisphere Group IV humpback whales: their status from recent aerial surveys. *Memoirs of Queensland Museum* 47(2): 587-598.

Bannister, JL Kemper, CM Warneke, RM, 1996, *The Action Plan for Australian Cetaceans*, Final Report to the Australian Nature Conservation Agency, http://www.environment.gov.au/coasts/publications/cetaceans-action-plan/pubs/whaleplan.pdf accessed 22/11/07.

CRC Reef Research Centre, 2002, *Dwarf minke whales in the Great Barrier Reef*, Current State of Knowledge, CRC Reef Research Centre, http://www.reef.crc.org.au/publications/brochures/minke_2002_www.pdf accessed 22/11/07.

Department of the Environment and Heritage, 2005, *Humpback Whale Recovery Plan 2005-2010*, Australian Government Department of the Environment and Heritage, http://www.environment.gov.au/biodiversity/threatened/publications/recovery/m-novaeangliae/index.html accessed 22/11/07.

Department of the Environment and Water Resources, 2005, *Death or injury to marine species following capture in beach meshing (nets) and drum lines used in Shark Control Program*. Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on Amendments to the List of Key Threatening Processes under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Department of the Environment and Water Resources, 2007, *Species Profile and Threats Database*, Australian Government Department of the Environment and Water Resources, http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl accessed 23/11/07.

GBRMPA, 2007, *Operational Policy on Whale and Dolphin Conservation in the Great Barrier Reef Marine Park*, Australian Government Great Barrier Reef Marine Park Authority, http://www.gbrmpa.gov.au/__data/assets/pdf_file/0008/20132/whale__dolphin_operational_policy_mpa.pdf accessed 23/11/07.

Kasamatsu, F Joyce, GG Ensor, P Mermoz, J, 1996. Current occurrence of baleen whales in Antarctic waters. *Report of the International Whaling Commission* 46: 293-304.

Kawamura, A, 1994. A review of baleen whale feeding in the Southern Ocean. 1267 *Report of the 1268 International Whaling Commission* 44: 261-271.

Menkhorst, P and Knight, F, 2001, *A Field Guide to the Mammals of Australia*, Oxford University Press, South Melbourne.

Noad, MJ Cato, DH Paton, D, 2006 *Absolute and relative abundance estimates of Australian east coast humpback whales (Megaptera novaeangliae)*. Paper SC/A06/HW27 presented to the IWC Scientific Committee Workshop on the Comprehensive Assessment of Southern Hemisphere Humpback whales, April 2006 unpublished.

Ross, G, 2006, *Review of the Conservation Status of Australia's Smaller Whales and Dolphins, Final Report to the Australian Government*, http://www.environment.gov.au/coasts/publications/pubs/conservation-smaller-whales-dolphins.pdf accessed 23/11/07.

Ross, GJB, 2002. Humpback dolphins. In *Encyclopaedia of Marine Mammals* (eds Perrin, WF Wursig, B Thewissen, JGM), pp. 585-589. Academic Press, San Diego.

Stamation, KA Croft, DB Shaughnessy, PD Waples, KA, 2007. Observations of humpback whales (Megaptera novaeangliae) feeding during their southward migration along the coast of southeastern New South Wales, Australia: Identification of a possible supplemental feeding ground. *Aquatic Mammals* 33(2), 165-174.

Queensland Government, 1997, *Conservation and management of whales and dolphins in Queensland 1997-2001*, Queensland Government Department of Environment, http://www.epa.Queensland.gov.au/publications/p00524aa.pdf/Conservation_and_management_of_whales_and_dolphins_in_Queensland_19972001.pdf accessed 22/11/07.

Lord Howe Island Group. Photo: Ian Hutton and the Department ofthe Environment, Water, Heritage and the Arts.