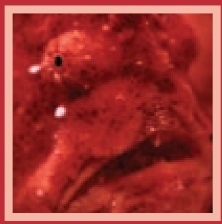
Background Paper

Key Species

A Description of Key Species Groups in the Northern Planning Area

National Oceans Office



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A Desription of Key Species Groups in the Northern Planning Area

Contents

Introduction

This report provides a description of key marine species groups – in particular their status, habitat and distribution, regional significance, threats and information gaps – in the Northern Planning Area (NPA).

This report is an important information base for the regional marine planning process for the NPA. The information contained in the report is part of the commitments of the Australian, Queensland and Northern Territory (NT) Governments for the initial scoping phase of the planning process.

The project was a coordinated approach between research agencies and scientific expertise across northern Australia to provide a description of what we know (and do not know) about the marine species across the region. By fostering this coordination the National Oceans Office, on behalf of the three governments, has collated the best available knowledge in a consistent and accessible format, to support the regional marine planning process and to inform others with an interest in the marine environment in northern Australia.

This report consists of 23 separately produced chapters, each written by researchers with expert knowledge of each species group. The information in each chapter is designed to be a stand-alone report for those who wish just to access information on a single species group. This has meant some necessary duplication in places but this has been minimised where possible without compromising the stand-alone nature of the chapters. The chapters are also structured around a template so that consistent information is provided for each species group throughout the report.

Two summary chapters support these chapters, in combining information on threats/impacts on species groups across the NPA, and summarising the key information gaps across the species groups.

Australia's Oceans Policy and Regional Marine Planning

The Australian Government's commitment to an integrated ecosystem-based approach to planning and management of all ocean uses is at the core of *Australia's Oceans Policy* (launched in December 1998). Regional marine planning is one of the tools by which this ecosystem-based approach will be delivered.

The National Oceans Office was formally established on 22 December 1999. The Office, based in Hobart, is responsible for the implementation and further development of *Australia's Oceans Policy*. Further background information on the Office, *Australia's Oceans Policy* and regional marine planning can be found at http://www.oceans.gov.au. The Office is responsible for managing the development of regional marine plans around Australia.

Northern Regional Marine Plan

In September 2001 the National Oceans Ministerial Board identified the area for Australia's second regional marine planning process. The NPA extends from the Torres Strait to include the Gulf of Carpentaria (GoC) and the eastern Arafura Sea, as far as a line coinciding with the Goulburn Islands or 133°23' E (see Figure 1.1). Due to significant ecological and institutional differences to the rest of the NPA, planning in Torres Strait is being managed through a separate but concurrent process.

The Australian, Queensland and NT Governments subsequently began a joint scoping exercise for the NPA in October 2002 to decide on priorities for regional marine planning. This region is the second to undergo regional marine planning in Australia.

During the scoping phase of the regional marine planning process, the governments have sought to:

- identify key interests and organisations in the NPA
- collate existing management, social, economic, environmental and, where appropriate, cultural knowledge
- identify important gaps in our current understanding
- identify common themes and planning objectives to be further investigated during the planning phase.

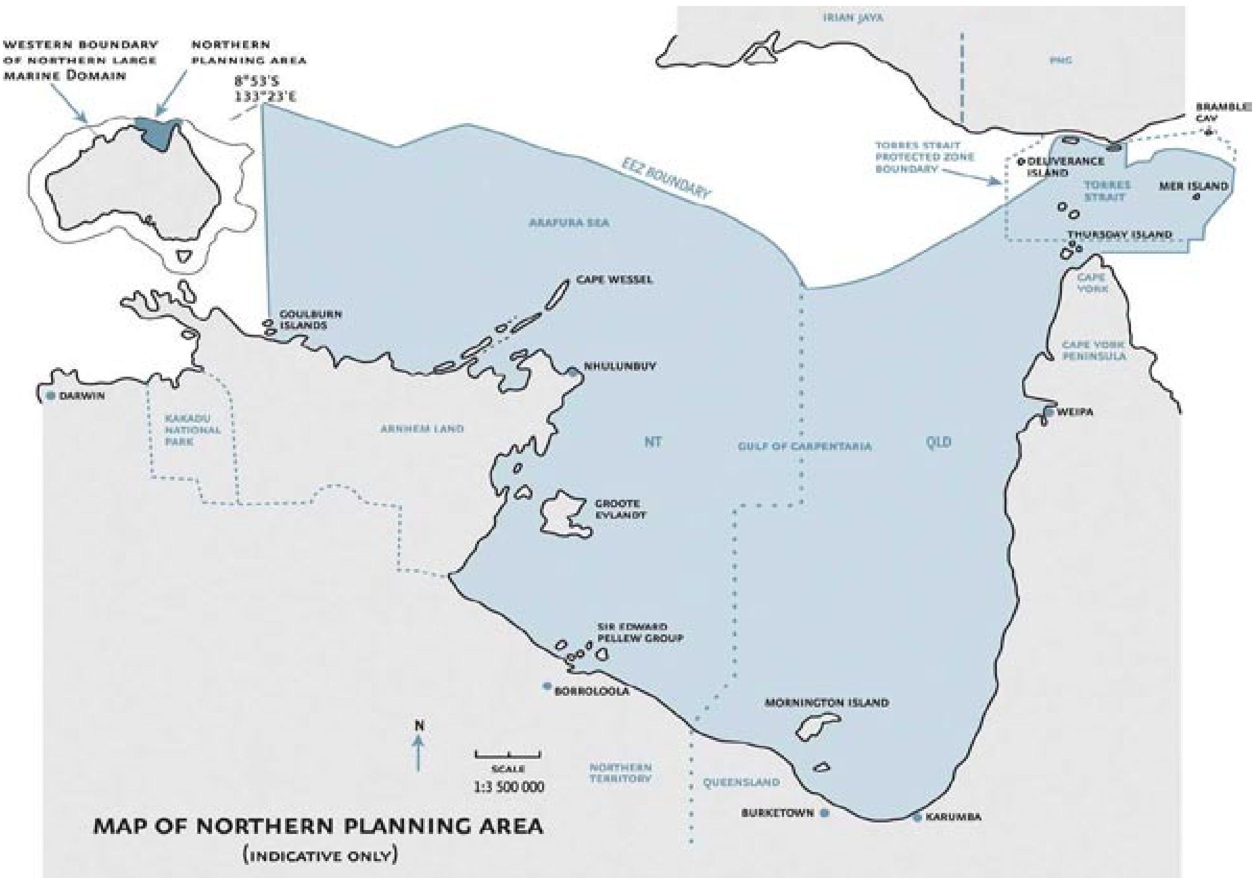
This key species group report is one of numerous reports sponsored by the National Oceans Office to address the above issues.

The NPA covers over 700 000 square kilometres and, at least initially during the scoping phase, includes inshore State/Territory waters (to 3 nautical miles offshore) and Commonwealth waters (from 3 nautical miles to Australia's international marine boundary).

The NPA's physical, biological, cultural and economic characteristics are described in the National Oceans Office publication *Snapshot of the Northern Planning Area*. This document can be found at www.oceans.gov.au or copies may be obtained by contacting the National Oceans Office. The Region's key characteristics include:

- a shallow-water tropical marine ecosystem with extensive and productive marine and estuarine habitats
- unique ecological and human cultural values
- an area of high biological diversity with internationally significant habitats for many species
- significant parts of the Area that are relatively undisturbed – relative integrity of ecological pathways and processes
- a sparse population with Indigenous people forming the majority (approximately 65%) of the population
- strong, continuous associations with Sea Country for Indigenous peoples with majority ownership of the coast (85% of the coast in the Northern Territory)
- large industrial projects (particularly mining) occurring in and just outside the region
- commercial fishing being a major economic activity with one of Australia's most valuable fisheries – the Northern Prawn Fishery – located in the region
- recreational fishing being a major leisure pursuit in the region
- the sea route across northern Australia, which is one of the nation's busiest – approximately 3000 ships in 1998 – with a growing number of cruising yachts also traversing the region.

Figure 1.1:– *The Northern Planning Area*



1. Introduction

Steering committee

An informal steering committee was formed to oversee the development of the key species group project. The committee consisted of:

Name	Agency
Dr Barry Russell	Museum and Art Gallery of the Northern Territory
Dr Rodrigo Bustamante	CSIRO
Dr Gavin Begg	CRC Reef
Dr Col Limpus	Queensland Environmental Protection Agency
Ms Zena Dinesen	Queensland Department of Primary Industries and Fisheries
Mr Steve Jackson	National Oceans Office

Dr Helen Larson assisted Dr Russell in the later stages of the project's development.

The steering committee was invaluable to the National Oceans Office by providing expert advice of the range of species groups to be considered under the project and the nature of information to be gathered under the template used for each species group. The committee also played a major role in fostering cooperation between northern Australian marine research agencies and bringing together the significant expertise that the project has been fortunate to draw upon.

The key species groups

A total of 22 species groups, plus a further group consisting of trawl bycatch species, are covered in this report. The trawl bycatch group has been included due to the information available from years of bycatch monitoring in the Northern Prawn Fishery which has identified an extremely diverse array of species with at least 366 species of teleost (fish) species from 91 families and 234 invertebrate species. Many of these are not covered under the other 22 species groups.

A full list of species groups and the agencies/researchers who contributed to the information provided for each group is provided in Table 1.1 below.

Table 1.1: *Contributors to the key species groups report*

Species group	Lead researcher (agency*)	Supporting researchers (agencies)
Seagrasses	Dr Rob Coles (QDPIF)	Neil Smit (NT DIPE), Len McKenzie & Anthony Roelofs (QDPIF), Mick Haywood & Robert Kenyon (CSIRO)
Mangroves	Glenn Wightman (NT DIPE)	Karen Danaher, Dr Malcolm Dunning & Dr John Beumer (QFS), Michael Michie (NT DIPE)
Corals	Dr JEN Veron (AIMS)	Dr Phil Alderslade (MAGNT), Dr Peter Harris (Geoscience Australia)
Seabirds	Ray Chatto (NT DIPE)	Paul O'Neill & Dr Stephen Garnett (Qld EPA), David Milton (CSIRO)
Shorebirds	Ray Chatto (NT DIPE)	Paul O'Neill & Dr Stephen Garnett (Qld EPA), David Milton (CSIRO)
Sharks and rays	Dr Helen Larson (MAGNT)	Dr Neil Gribble & Stirling Peverell (QDPIF), Dr John Salini & Dr Richard Pillans (CSIRO)
Sawfish	Stirling Peverell & Dr Neil Gribble (QDPIF)	Dr Helen Larson (MAGNT)
Cetaceans	Dr Peter Hale (Uni of Qld)	Dr Ilze Brieze (Qld EPA), Ray Chatto (NT DIPE), Guido Parra (JCU)
Dugong	Keith Saalfeld (NT DIPE) & Prof Helene Marsh (JCU)	
Turtles	Dr Colin Limpus (Qld EPA)	Ray Chatto (NT DIPE)
Marine snakes	Dr Michael Guinea (CDU)	Dr Colin Limpus (Qld EPA), Dr Scott Whiting (Biomarine International)
Groupers	Ashley Williams, Gavin Begg & Rachael Pears (CRC Reef Fishing & Fisheries Team)	Rod Garrett (QDPIF), Dr Helen Larson (MAGNT), Dr Shane Griffiths (CSIRO), Julie Lloyd (NT DBIRD)
Snappers and emperors	Ashley Williams, Gavin Begg & Ross Marriott (CRC Reef Fishing & Fisheries Team)	Rod Garrett, Dr Geoff McPherson & Wayne Sumpton (QDPIF), Dr Helen Larson (MAGNT), Dr Shane Griffiths (CSIRO)
Mackerels and tunas	Jason Stapley & Dr Neil Gribble (QDPIF)	Rik Buckworth (NT DBIRD), Dr Helen Larson (MAGNT), Dr Shane Griffiths (CSIRO), Dr Geoff McPherson (QDPIF)

*For full titles of the agencies see under Acronyms at the end of this chapter

SPECIES GROUP	LEAD RESEARCHER (AGENCY*)	SUPPORTING RESEARCHERS (AGENCIES)
Coastal fishes	Ashley Williams and Gavin Begg (CRC Reef Fishing & Fisheries Team)	Rod Garrett (QDPIF), Dr Helen Larson (MAGNT), Shane Griffiths (CSIRO)
Molluscs	Dr Richard Willan (MAGNT)	Mike Dredge (QDPIF)
Squid	Dr Malcolm Dunning (QDPIF)	Dr Richard Willan (MAGNT)
Prawns	Robert Kenyon (CSIRO)	Clive Turnbull (QDPIF), Dr Neil Smit (NT DIPE),
Crabs	Neil Smit (NT DIPE)	Dr Neil Gribble & Dr Wayne Sumpton (QDPIF), Dr Burke Hill (CSIRO)
Lobsters	Dr Darren Dennis (CSIRO)	Timothy Skewes (CSIRO), Neil Smit (NT DIPE), Annette O'Grady & Roland Griffin (NT DBIRD),
Bugs	David Vance (CSIRO)	Neil Smit (NT DIPE), Clive Turnbull (QDPIF)
Holothurians	Timothy Skewes (CSIRO)	Dr Richard Willan (MAGNT), Dr Roland Pitcher & Michael Haywood (CSIRO)
Trawl bycatch species	Dr Shane Griffiths (CSIRO)	Dr Helen Larson (MAGNT), Dr Tony Courtney (QDPIF)

Each chapter of this report draws on the most recently available information and knowledge about the key species groups in the NPA. For instance, the contributors have drawn upon recent significant reports such as Pogonoski (et al.) *Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes* and recent studies by the contributors themselves. However, contributors were asked to not rely solely on past studies but include their current knowledge, recent fieldwork and expert advice and the report benefits greatly from this. The views expressed in each of the chapters are those of the contributing researchers.

The contributors have come from a wide variety of backgrounds and expertise – ranging from taxonomists to fisheries managers. Combining such expertise has added to the breadth of information in each chapter. The lead researchers, however, have taken primary responsibility for each of the chapters and thus each chapter provides a different emphasis on the key information.

Information in this report has also been obtained by searching relevant electronic library databases, direct contact with scientist and managers whose activities have included research and management in the NPA and by searches of science committee reports and various project reports. A large proportion of the information on some species groups, such as seagrasses, in this region remains either unpublished or in a published form that is not readily available.

Although the authors of the individual chapters have made efforts to provide a summary of research and other information on the species groups in the NPA, the concise nature of each chapter means that readers interested in a species group should also seek the references provided at the end of each chapter for more detail.

The criteria used to determine whether a species group was a key group in the NPA were based on the following:

- **Economic significance:** species within the group that have existing or emerging economic value by virtue of their contribution to local, national communities through subsistence, commercial enterprise (target species, bycatch and byproduct), use by Indigenous peoples, tourism (including appreciation by tourists), etc
- **Social significance:** species within the group of known or possible value to local, national or international communities because of their heritage, historical, aesthetic, education or recreational qualities
- **Conservation significance:** species within the group that are listed, or are being considered for listing, under Northern Territory, Queensland, Australian Government, and/or international legislation, or are the subject of a regional, national or international conservation agreement
- **Ecological significance:** species within the group that contribute to essential ecological processes (eg provide essential breeding and/or feeding habitat for any species recognised under other criteria), that are representative of a habitat 'type' that has value for research or monitoring (eg 'surrogates'), or are significant due to the cross-jurisdictional management approaches required to deal with a highly mobile life-cycles (eg highly migratory species, straddling stock etc)

1. Introduction

The authors have generally used species names as specified by the United Nations Food and Agriculture Organisation (FAO). FAO names are not intended to replace local species names, but they are considered necessary by FAO to overcome the considerable confusion caused in some cases by the use of a single name for many different species or several names for one species.

Outcomes of the project

The following provides a list of the intended outcomes of the project:

- a final, aggregated report summarising current knowledge of key marine species or species groups in the NPA – in particular their status, habitat and distribution, regional significance, threats and information gaps – primarily from expert opinion supported by published research and data held
- knowledge gaps across species/species groups are identified that may be filled in a coordinated approach (eg surveys, monitoring etc)
- common impacts/threats in terms of their type/nature are identified – leading to coordinated management approaches to address them
- information is provided to assist in the development of conceptual ecosystem models of the NPA for educational and management purposes
- some common critical and other habitat requirements and locations across the range of key species/species groups are identified to direct future research and conservation planning, including the identification of possible marine protected areas and integrated conservation measures.

The information in this report is therefore intended for multiple purposes during the regional marine planning process off northern Australia, from assisting survey design and objectives[1] to management coordination and educational purposes. The report will also be used as an input to the assessment of conservation needs across the planning area, including the Torres Strait.

With respect to marine education needs, it is intended that the information will be made available for posters on key species groups, ecosystem models for the NPA (eg seagrasses) and information to support the production of school-based material.

The regional marine planning process is also seeking to initiate research to address the broad issues to be addressed during the planning phase of the regional marine planning process in the NPA. Clearly, research addressing ecosystem or biological issues in the waters of the NPA will need to consider the key information needs of species as identified in this report.

The remote and harsh environment in this part of tropical northern Australia is likely to be a primary reason why human population expansion, and subsequent development, has not (yet) occurred to any great extent compared with other parts of the Australian coast. Much of the NPA remains relatively undisturbed in terms of wildlife habitat. This, of course, may not always be the case, and is no reason to be complacent. Within this area we are in the unique position of being able to document and look after important sites and species before they begin to be detrimentally affected. Past lessons from other parts of Australia and the world can be used for future management of species and/or areas.

[1] This has already occurred with the recent Australian Institute of Marine Science (AIMS) research cruise off Arnhem Land. See the chaptert on Corals for further information.

Acronyms

AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIMS	Australian Institute of Marine Science
CDU	Charles Darwin University (Darwin)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMR	CSIRO Division of Marine Research
CPUE	Catch per Unit Effort
CRC	Co-operative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEH	Department of Environment and Heritage
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization (of the United Nations)
GBRMPA	Great Barrier Reef Marine Park Authority
GoC	Gulf of Carpentaria
IUCN	International Union for Conservation of Nature and Natural Resources
MAGNT	Museum and Art Gallery of the Northern Territory
MSY	Maximum Sustainable Yield
NPA	Northern Planning Area
NPF	Northern Prawn Fishery
NFC	Northern Fisheries Centre
NT DBIRD	Northern Territory Department of Business, Industry and Resource Development
NT DIPE	Northern Territory Department of Infrastructure, Planning and Environment
PNG NFA	Papua New Guinea National Fisheries Agency
PZJA	(Torres Strait) Protected Zone Joint Authority
QDPIF	Queensland Department of Primary Industries and Fisheries
Qld EPA	Queensland Environmental Protection Agency
QFS	Queensland Fisheries Service

Acknowledgement

The National Oceans Office would like to gratefully acknowledge Dr Peter Whitehead, Principal Research Fellow, Key Centre for Tropical Wildlife Management, Charles Darwin University, for his significant efforts in undertaking a peer review of the draft report.

2. Seagrasses

This chapter should be cited as:
Coles, R, Smit, N, McKenzie, L, Roelofs, A, Haywood, M & Kenyon, R (2004). Seagrasses. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

Monitoring seagrass ***Source:*** *Ports Corporation of Queensland*

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Species group name and description

The generic term seagrass is widely understood to include the group of flowering vascular plants that live in sea water or brackish water. They may be confused by non-specialists with some macro algae species and some freshwater vascular plants. There is debate regarding genera such as *Ruppia*. This is discussed in more detail in Short and Coles (2001). Recent taxonomic revisions of the species of *Zostera* and *Halophila* have led to some species change (Kuo 2000). The original names at the time of publication of this report have been used in this report.

Various common names are applied to species in the literature such as turtle grass, eelgrass and shoal grass. These names are not consistently applied among countries and in any case are not commonly used in northern Australia. We are not aware of any name for seagrass species used consistently by Indigenous groups. However coastal communities would almost certainly recognise the term 'dugong grass' as referring to the shallow subtidal and intertidal seagrasses.

Seagrasses are specialised marine flowering plants that have adapted to the nearshore environment of most of the world's continents. Most are entirely marine although some species cannot reproduce unless emergent at low tide or subject to fresh water inflow. Some seagrasses can survive in a range of conditions encompassing fresh water, estuarine, marine, or hypersaline. There are relatively few species globally (about 60) and these are grouped into just 13 genera and five families.

Seagrass distribution has been described for most species (den Hartog 1970, Phillips & Menez 1988, Mukai 1993, Green & Short 2003). There is now a broad understanding of the global range of species and seagrass habitats. Areas where the global distribution is less well known include the Pacific Ocean reefs and islands, South America, the southern Atlantic, the Indian Ocean islands, the west African coast, and Antarctica.

Shallow subtidal and intertidal species distributions are better recorded than seagrasses in water greater than 10 m below mean sea level. Surveying deeper water seagrass is time-consuming and expensive, and it is likely that areas of deepwater seagrass are still to be located (Lee Long et al. 1996).

Australian seagrass species distribution is well documented except for the northern tropical region (Butler & Jernakoff 1999). Recent initiatives such as the Torres Strait CRC and port monitoring programs (eg Rasheed et al. 2003) are addressing this for restricted areas but the majority of the north of Australia lacks recent seagrass distribution data.

There are 15 species of seagrass recorded in the Northern Planning Area (NPA):

Family **CYMODOCEACEAE** Taylor

- *Cymodocea rotundata* Ehrenb. & Hemp. Ex Aschers
- *Cymodocea serrulata* (R. Br.) Aschers. & Magnus
- *Halodule uninervis* (wide- & narrow-leaf) (Forsk.) Aschers.
- *Halodule pinifolia* (Miki) den Hartog
- *Syringodium isoetifolium* (Aschers.) Dandy
- *Thalassodendron ciliatum* (Forsk.) den Hartog

Family **Hydrocharitaceae** Jussieu

- *Enhalus acoroides* (L. *f*) Royle
- *Halophila decipiens* Ostenfeld
- *Halophila minor* (Zollinger) den Hartog
- *Halophila ovalis* (R. Br.) Hook f.
- *Halophila spinulosa* (R. Br.) Aschers. in Neumayer
- *Halophila tricostata* (Greenway)
- *Halophila ovata* Gaudichaud **
- *Thalassia hemprichii* (Ehrennb.) Aschers in Petermann

Family **ZOSTERACEAE** Drummortier

- *Zostera capricorni* Aschers

**Taxonomic revision now indicates this species is not present in the Torres Strait. Recent taxonomic revisions consider *H ovata* in the tropical Indo-western Pacific region to be a mis-identification of *Halophila minor*. The two species are not considered to co-occur in the same region (Kuo 2000).

In the Torres Strait the seagrass communities are a diverse array of complex assemblages with most combinations of the 11 species found recorded in the field (Long & Poiner 1997). There are large areas of reef platform seagrasses with communities consisting of the common reef associated species: *Thalassodendron ciliatum*, *Cymodocea rotundata*, and *Thalassia hemprichii*. Other species occur in small amounts with these species at some locations. These reef platform habitats are important as nursery grounds for commercial juvenile penaeid prawns (Turnbull & Mellors 1990). *Enhalus acoroides* is generally restricted to shallow subtidal and intertidal regions. It is the only seagrass species that must come to the water surface to pollinate. *Halophila spinulosa* is more common in deeper water (10 m and deeper).

2. Seagrasses

Published information on Torres Strait and Gulf of Carpentaria (GoC) seagrass is mostly in report form. The main distributional information is in Bridges et al. (1982), Long and Poiner (1997), Long and Skewes (1997), Long et al. (1997), Thomas et al. (1997), Rasheed et al. (1996; 2000; 2001; 2002; 2003) and Roelofs et al. (2001a; 2001b; 2003).

The extensive intertidal banks along the GoC coast have seagrass meadows that are a mixture of *Halodule* and *Halophila* species. *Syringodium isoetifolium* and *Cymodocea serrulata* are common subtidally and *Halophila ovalis* and *Halophila spinulosa* further offshore (Poiner et al. 1989). Published information for the GoC except in report format is now over 15 years old.

Distributional information and some ecological comment is in Coles and Lee Long (1985), Poiner et al. (1987), Rasheed et al. (1996), Kenyon et al. (1997), Loneragan et al. (1998), Kenyon et al. (1999), Sheppard et al. (2001), Rasheed et al. (2000; 2001; 2002; 2003), Roelofs et al. (2001a and 2001b) and Coles et al. (in prep). Some recent information on seagrass distribution has been collected for the Macarthur River region (south western Gulf) (Smit pers. comm. 2003).

Little information on species is available for the Northern Territory (NT) coast outside the GoC. Dugong distribution will provide some information (Elliot et al. 1979, Saalfeld 2002). Green and Short (2003) have polygon information for the NT coast that to the best of our knowledge is unverified.

Status

None of the seagrass species in the planning area is listed as threatened or endangered. *Halophila tricostata* is the least common of the 15 species and is endemic to northern Australia. *Thalassodendron ciliatum* is found almost entirely on reef platforms and exposed reef edges and so has a very limited distribution in the area.

Seagrasses are protected in Queensland waters by provisions of the *Queensland Fisheries Act 1994*. Intentional damage to seagrasses can only occur if a permit has been issued. Exemptions are available for small collections for research and for maintenance of infrastructure. The *NT Fisheries Act 1988* provides for the control of harvesting of aquatic life and for the protection of fish habitat (including seagrasses).

Marine protected areas exist under state laws but include few if any seagrass areas. Restrictions on the use of certain fishing gear (eg trawl fishing in most of the Torres Strait and from Mornington Island to Groote Eylandt, 2 nautical miles to seaward from the low tide line including embayments) would indirectly protect seagrass meadows.

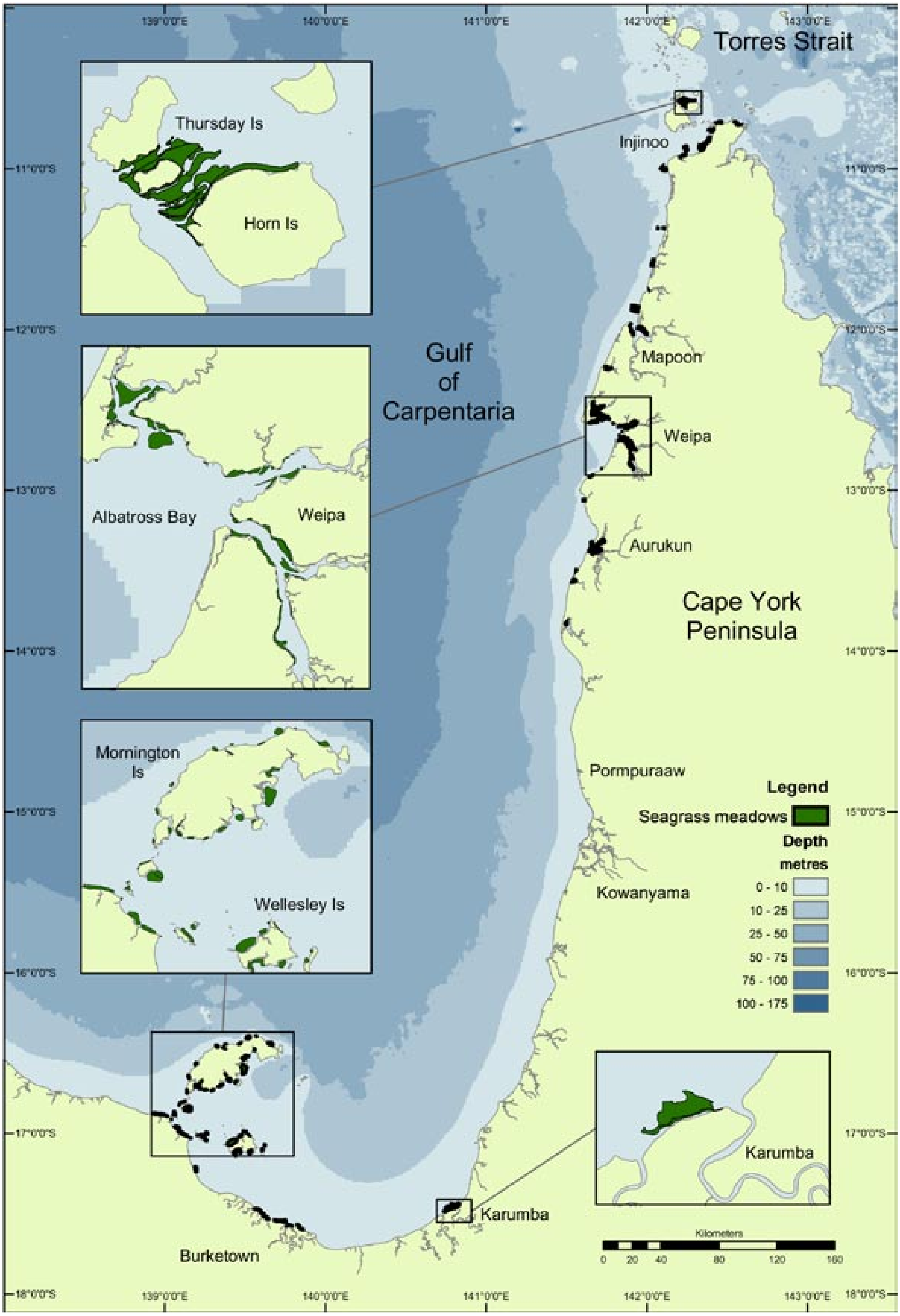
A small amount of seagrass is outside state waters and comes under Commonwealth jurisdiction. We are not aware of any specific protection given to seagrass in the NPA by Commonwealth legislation, though the *Environment Protection and Biodiversity Conservation Act 1999* requires that a person must not take in a Commonwealth marine area an action that has, will have or is likely to have a significant impact on the environment. This would include any significant impact on seagrass beds.

Habitat and distribution

Seagrasses are common in most parts of the Torres Strait and occur in dense and extensive meadows in areas such as Thursday Island Port and on some reef platforms. Surveys of the open waters of Torres Strait have estimated 13 425 km^2 of seagrass habitat. Seagrass communities occur across the open seafloor, on reef flats and subtidally adjacent to continental islands. A line of large reefs runs northwards from Cape York, including the Warrior Reefs with extensive seagrass-covered reef platforms. Mixed species occur on these platforms, most commonly of the genera *Halodule*, *Thalassia*, *Thalassodendron* and *Cymodocea*. These reef platform habitats are important as nursery grounds for commercial juvenile penaeid prawns (Turnbull & Mellors 1990).

In the Torres Strait *Enhalus acoroides* is generally restricted to shallow subtidal and intertidal regions. The large expanses of open water bottom are covered with either sparsely distributed *Halophila* or mixed species (*Halodule*, *Thalassia* and *Syringodium*) communities. Lush *Halophila ovalis* and *Halophila spinulosa* communities are also found in the deep waters (greater than 30 m) of the south-western Torres Strait. *Halophila spinulosa* is more common in deeper water (10 m and deeper).

Figure 2.1: Distribution of seagrass in the eastern Gulf of Carpentaria ***Source:*** *Marine Ecology Group, QDPIF*



2. Seagrasses

The northern tip of Cape York also has extensive coastal seagrass meadows. Seagrasses have been recorded to 15 m off Bamaga and are likely to occur deeper.

Seagrasses in the GoC are less extensive than Torres Strait, covering about 900 km² of seabed in the 1980s. They are mostly restricted to the littoral zone around the periphery of the Gulf, probably because of more turbid waters restricting light to deeper sediments. Recently, *Halophila spinulosa* and *Halophila ovalis* have been found growing in areas to the west of Mornington Island (16° 24_ S, 138° 39_ E) in about 20 m of water (Rob Kenyon pers. obs.), indicating that seagrass may grow at depths and in areas not surveyed by Poiner et al. (1987) and Coles et al. (2001). Surveys in this area are ongoing. The extent and temporal stability of such seagrass meadows throughout the region is largely unknown and requires investigation.

Moving down the western shore of Cape York, seagrasses are largely restricted to bays and inlets south as far as the Kirke and Love Rivers. The Embley and Hey Rivers at Weipa have the most extensive intertidal *Enhalus* beds in the western Gulf. No seagrass has been recorded in the coastal area between Cape Keerweer and the Norman River mouth (Karumba), over 400 km of coastline.

Seagrass bed near Karumba
Source: *Marine Ecology Group, QDPIF*

Along the exposed southern coast west of Karumba seagrass meadows are a mixture of *Halodule* and *Halophila* species. *Syringodium isoetifolium* and *Cymodocea serrulata* are common subtidally and *Halophila ovalis* and *Halophila spinulosa* further offshore (Poiner et al. 1989, Poiner & Peterken 1995, QDPIF unpublished data). These meadows occur patchily along the southern coast, becoming more extensive further westward, with substantial meadows west of the Wellesley Islands. From the Sir Edward Pellew Islands to Maria Island and adjacent to the Rose River, seagrass communities form a mostly continuous coastal meadow (Poiner et al. 1987). Shallow water areas in parts of the south-western Gulf were remapped in 2000 (Hemple & Smit 2000) and areas between the Limmen Bight and Bing Bong and the McArthur River system are considered to be among the top four important dugong sites in Australia (Smit pers. comm.). Seagrass is also found in patches up the estuaries of many rivers and creeks along the NT GoC coast and has been reported in Port Bradshaw, two hours drive south of Gove between Gove and Blue Mud Bay (mainly *Halophila* and *Halodule* species) (Smit pers. comm.).

Seagrass species dominating meadows adjacent to the mainland coast are considered to be pioneering or early colonists (*Halophila* and *Halodule* species) in intertidal areas or areas with environmental stress (eg high turbidity). Subtidally on the open coasts of the western GoC, meadows may be climax species such as *Syringodium isoetifolium* and *Cymodocea serrulata*. Very little is known of the seagrass communities in waters greater than 10 - 15 m depth. Species which are more common in deeper waters (10 m and deeper) such as *Halophila decipiens* are present in the Gulf and could at times form meadows in deeper water. *Halophila tricostata*, also a deepwater species and endemic to northern Australia, has been found in isolated patches as far south as Port Musgrave.

GoC reef flat communities are dominated by *Thalassia hemprichii*. Meadows in estuaries and sheltered bays are mostly of the genera *Halodule*, with some *Cymodocea* and *Enhalus*.

Seagrass distribution and abundance in the inlets and bays of the GoC was last mapped extensively in 1986 (Poiner et al. 1987, Coles et al. 2001). Long-term studies of change in population density and structure associated with port activities have been carried out in Weipa, Karumba and Kirke River and these studies suggest that the distribution of seagrass is still similar

to that of the 1980s but is highly seasonal with declines associated with flooding during the wet season (Roelofs et al. 2001a, Rasheed et al. 2001).

Some recent mapping has taken place in the Macarthur River region (Smit pers. comm. 2003).

Sediments throughout the southern GoC are predominately fine muds, and these are easily resuspended due to the shallow bathymetry resulting in increased turbidity, which restricts seagrass distribution and growth and may lead to seasonal and inter-annual variability in the extent of seagrass meadows.

Anecdotal evidence from the presence of Dugong populations and from unverified database entries suggests that seagrasses extend along the shallow waters of the top of the NT. A port baseline survey for introduced marine pests conducted within the Port of Gove, Nhulunbuy, did detect *Halophila decipiens* from a number of sites within Catalina Bay and adjacent to shipping berths in the Port (Neil et al. 2003).

Our understanding of seagrass flowering, asexual reproduction and timing of flowering and seed production is quite poor. Available information is summarised in Short and Coles (2001).

Significance of the species group in the Northern Planning Area

Seagrasses are a key habitat type in the NPA. They are important for stabilising coastal sediments, providing food and shelter for diverse organisms, as a nursery ground for shrimp and fish of commercial importance, and for nutrient trapping and recycling (Coles et al. 2003). The marine mammal *Dugong dugon* and the green sea turtle *Chelonia mydas* feed directly on seagrasses. Traditional Australian communities use both animals for food and ceremonies.

In the open mud flats of the GoC seagrass meadows and adjacent mangrove forests may provide the only three-dimensional habitat for fish and shrimp to shelter from predation.

Seagrass beds have been specifically identified as juvenile habitat for penaeid shrimps in the eastern Torres Strait (Turnbull & Mellors 1990) and in the GoC (Coles & Lee Long 1985; Loneragan et al. 1998; Coles et al. (in prep.)). Major trawl fisheries are based on these shrimp stocks.

The importance of seagrass meadows as structural components of coastal ecosystems has resulted in new research interest being focused on the biology and ecology of seagrasses and on the methods for mapping, monitoring and protection of critical seagrass habitats. Better camera systems, remote sensing, GPS positioning, and methods of measuring seagrass health such as PAM fluorometry, have improved our ability to map and monitor seagrass communities.

Impacts/threats

Torres Strait region

- Widespread dieback of seagrasses has been reported in the central and northern regions of the Torres Strait. More than 1400 km^2 of seagrass was lost between 1989 and 1993. There is anecdotal evidence of earlier dieback incidents in the 1970s (Long et al. 1997). It is possible this is a natural cyclical event but that has not been determined.
- Infrastructure works in the region have been permitted in seagrass areas with some small losses (eg Coles 1998).
- Seagrass exposed at low tide is likely to be threatened by climate change (*State of the Environment Report, Queensland, 2003*).
- The Torres Strait shipping lanes have been identified as high risk and port and shipping accidents could have a major impact on seagrass meadows.
- There is a risk of introduced marine pests in the Torres Strait, some of which could have an impact on coastal seagrasses.

Gulf of Carpentaria

- Major port and shipping activities at Weipa and Karumba and Macarthur River are potential threats to regional seagrasses.
- Cyclone-induced erosion has caused large loss of seagrasses (183 km^2) in the southern Gulf (Poiner et al. 1989) and an increase in cyclone activity with climate change could result in the loss of extensive intertidal meadows in this region.
- There is anecdotal evidence of seagrass dieback in the southern GoC in 2002 but insufficient data is being collected on seagrass to confirm this (Kwan & Bell 2003, Smit pers. comm. 2003).
- Minor/moderate (loss of 19 hectares) port activity at Macarthur River and Groote Eylandt may have an impact on regional seagrass meadows.
- Future land-based threats to the Gulf region seagrass may arise from increased levels of extractive mining and the development of pastoral areas

for horticulture. These activities can greatly increase the amount of sediment/turbidity and pollutants associated with runoff produced after the monsoon rains.

- Projects are being developed or extended for ecotourism, pearl leases and aquaculture and these may have an impact on coastal seagrass meadows.

Northern Territory (outside the Gulf of Carpentaria)

- Port and shipping activity at Gove and nearby may have an impact on regional seagrasses.
- There is a low level risk of introduced marine pests affecting coastal seagrasses.
- A holothurian (bêche-de-mer) aquaculture project is proposed west of Gove with a grow-out proposal for seagrass meadows.

There is insufficient information on seagrass meadows in this region from which to fully determine likely impacts and threats.

Information gaps

The only recent data collection on seagrasses in the NPA has been in ports (Thursday Island, Skardon, Weipa, Macarthur River and Karumba) or specific locations such as the Kirke River. Some information is being collected in the Torres Strait by CSIRO and QDPI and this data collection will increase with the start of the Torres Strait CRC.

Most other data for the region dates from the late 1980s or earlier and its value for input into a planning process is difficult to assess.

Detailed density, growth and reproduction data on species such as *Halodule uninervis*, *Halophila ovalis*, *Syringodium isoetifolium* and *Cymodocea serrulata* exist in CSIRO Marine Research databases. These data were collected during bi-monthly surveys at Groote Eylandt during the 1980s, but have not been analysed.

There is sufficient anecdotal evidence of seagrass losses or large time-scale cyclical change and consequent detrimental effects on large herbivore populations for this to be a matter of concern[1].

There is almost a complete lack of information in the planning area outside the Torres Strait on the distribution of seagrass deeper than about 15 m. Except for the ports monitoring program information, the shallow water information is either too old or too imprecise to be of much value for management purposes.

Proposed actions

Mapping needs

- Thursday Island to Mapoon – available data is quite old and broad-scale. The data needs to extend seaward to take in the main shipping route and include islands.
- Wellesley Islands (Mornington Island) – data are quite historic (1984) and there has been some concern over the past 12 months that the poor condition of sea turtles and dugong may be a consequence of poor habitat nutritional quality. Original maps were of low precision and re-mapping is needed.
- Western Gulf & Groote Eylandt – broad-scale mapping is mostly late-1980s and prior to accurate satellite-based position fixing and requires remapping in a consistent fashion. (Wellesley Islands to the Sir Edwin Pellew (Vanderlin Islands) were last mapped in 1984, prior to accurate satellite-based position fixing; Sir Edward Pellew Islands to Rose River was mapped in 1995 (though not published); Groote Eylandt/Blue Mud Bay was last mapped in the 1980s, prior to accurate satellite-based position fixing).
- Nhulunbuy to Goulburn Islands – little or no detailed information or consistent ground-based mapping on habitats from this area exists as far as we are aware and a baseline habitat map of seagrass would assist planning.
- Recent reports of central Gulf reefs and records of seagrass at depths of 20 m in the less turbid south-west Gulf have emphasised our lack of any data much below 15 m (and emphasise how little is really know about seagrass distribution in this region). Some deeper water surveys for seagrass habitat are required.

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[1] *See Chapter 10 'Dugon" for further dicussion on this point*

Ecological/process studies

- There have been reports from the southern GoC of turtle 'thinning' with black fat (high chlorophyll remaining in mesenteric tissue), and a high occurrence of floating turtles (this is due to obstructed digestive tract) particularly in southern Mornington Island waters. Also, there are reports of emaciated dugong with 'bubbly' fat, depleted stocks of bêche-de-mer (Holothurians) and a significant increase in filamentous algae. The Indigenous communities in the area are of the opinion that all these impacts are a consequence of Pasminco mining in the Karumba region. The concerns about these consequences of development are shared by communities in the south western Gulf (Smit pers. comm. 2003). We have little information on the quality of the seagrass as food and the relationship between the seagrass and algae communities and how this may affect grazing populations. Nutritional studies and studies of short and long-term change are required. Some ecological network analysis studies in the southern GoC would be desirable.
- Water quality information is patchy and generally specific to those estuaries used as ports. More coordinated water quality monitoring would be valuable.

Discussion

The seagrass habitats of this region are extremely valuable for endangered species and for commercial fisheries. They are a major component of the coastal habitat.

Despite this there is no coordinated ongoing monitoring and little recent published work in the scientific literature. Detailed studies are being conducted for port and fisheries monitoring but this information mostly remains in report format. Large areas of the coast have not been mapped sufficiently (or at all) and most of the potential dugong food resource in waters deeper than 15 m has not been mapped at all.

There are worrying anecdotal reports of possible dieback of seagrass in the southern GoC and effects on dugong and turtle populations but no way of verifying these at present.

This is an unsatisfactory situation from a management point of view. Data from the Torres Strait is presently being collated in a process to make all Torres Strait Fisheries Scientific Advisory Committee reports available on CD. A similar process for seagrass information/ reports in the remainder of the NPA would be highly desirable. There is potential for future catchment development and land uses to affect water quality. With the present status of information it would be difficult to assess the risk to the region's seagrasses.

Re-mapping to modern standards of precision and metadata is also essential if management or planning decisions are to be based on seagrass distribution.

Key references and current research

Most seagrass work in the NPA is undertaken by the Queensland Fisheries Service, Northern Fisheries Centre.

Species distributions for the Torres Strait and Queensland GoC are available in GIS format. Torres Strait information is held by CSIRO Marine Laboratory. The Queensland GoC maps are available on http://chrisweb.dpi.qld.gov.au/chris/ or on disk from the Northern Fisheries Centre with appropriate data contracts. Some preliminary satellite and aerial image analysis is available for the Pellew Bioregion in the NT.

More general GIS information (some unverified) is available on the IMAP system hosted by UNEP. See http:www.unep-wcmc.org.

A full list of data sets, descriptions, and references are in Table 2.1.

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2. Seagrasses

Table 2.1: Seagrasses Mapped in Northern Planning Region

Region	Location Surveyed	Scale	Date	Citation	GIS / other Status	Proprietor
Queensland Gulf of Carpentaria	Tarrant Pt – Cape York	Broad	Nov 1986	Coles et al. (in prep.)	Validated	QDPI/FRDC
	Mornington Island	Broad	Mar 1984	Coles & Lee Long 1985	In prep	QDPI
		Broad	Sept 1984	Coles et al. (in prep.)	In prep	
	Karumba	Fine	Oct 1994	Rasheed et al. 1996	Completed	QDPI/CRC/PCQ
		Fine	Mar 1995	Rasheed et al. 1996	Completed	
		Fine	Oct 1995	Rasheed et al. 2001	Completed	
		Fine	Mar 1996	Rasheed et al. 2001	Completed	
		Fine	Oct 1996	Rasheed et al. 2001	Completed	
		Fine	Mar 1997	Rasheed et al. 2001	Completed	
		Fine	Oct 1997	Rasheed et al. 2001	Completed	
		Fine	Mar 1998	Rasheed et al. 2001	Completed	
		Fine	Oct 1998	Rasheed et al. 2001	Completed	
		Fine	Mar 1999	Rasheed et al. 2001	Completed	
		Fine	Oct 1999	Rasheed et al. 2001	Completed	
		Fine	Mar 2000	Rasheed et al. 2001	Completed	
		Fine	Oct 2000	Rasheed & Thomas 2000	Completed	
		Fine	Oct 2001	Rasheed & Thomas 2002	Completed	
	Weipa	Fine	April 2000	Roelofs et al. 2001a	Completed	QDPI/CRC/PCQ
		Fine	Sept 2000	Roelofs et al. 2001a	Completed	
		Fine	April 2001	Roelofs et al. 2001b	Completed	
		Fine	Sept 2001	Roelofs et al. 2001b	Completed	
		Fine	April 2002	Roelofs et al. 2003	Completed	
		Fine	Sept 2002	Roelofs et al. 2003	Completed	
		Fine	Sept 2003	Roelofs et al. (in prep)	In prep	
	Kirke River	Fine	Aug 1999	Sheppard et al. 2001	Completed	QDPI
		Fine	Sept 2001		In prep	QDPI/PCQ
	Love River	Fine	Aug 1999	Sheppard et al. 2001	Completed	QDPI

Scale:

Broad = ground truth sites from 100s of metres to kilometres apart

Medium = ground truth sites predominantly between 100 m and 1 km apart, aerial photos 1:25000, aerial reconnaissance, satellite TM

Fine = ground truth sites predominantly <100 m apart, aerial photos 1:12000, aerial reconnaissance

Limited = medium to fine scale focused on specific areas within a location

Proprietor

QDPI = Queensland Department of Primary Industries

CRC = CRC for Great Barrier Reef World Heritage Area

PCQ = Ports Corporation of Queensland

AFMA = Australian Fisheries Management Authority

CSIRO = Commonwealth Scientific and Industrial Research Organisation

Region	Location Surveyed	Scale	Date	Citation	GIS / other Status	Proprietor
Torres Strait	Central reefs?	Broad	Feb 1988	Unpublished	Nil	QDPI
	Thursday Island – Engineers Wharf	Medium	Dec 1998	Coles 1998	Completed	QDPI
	Thursday Island Port	Fine	Mar 2002	Rasheed et al. 2003	Completed	QDPI/PCQ
	Torres Strait coverage	Broad		Long & Poiner 1997	Available	CSIRO/AFMA/QDPI
	Central Torres Strait	Broad		Long et al 1997	Available	CSIRO/AFMA/QDPI
	Warrior Reefs	Broad		Mellors/Coles/ unpublished	Nil	QDPI
	Macarthur River	Fine	1994–1996 (annually)	Kenyon et al. 1999	Nil/paper copy	CSIRO
	Sir Edward Pellew Islands to Rose River or South-west Gulf coastal distribution/ abundance surveys	Broad	1984–1995 (annually and bi-annually)	Poiner et al. 1987, 1993 & unreported	Nil/paper copy	CSIRO
	Coastal Aerial	Broad		Smit & Chatto, unpublished	Video	Biodiversity Unit/DIPE
	Port Bradshaw	Fine / point data		Smit (in prep.)	In prep	Biodiversity Unit/DIPE
	Pellews Bioregion	Broad, sat and aerial image analysis, no ground truthing		Hemple & Smit 2000	Paper with preliminary results	Biodiversity Unit/DIPE
	Groote Elyandt North West Bay	Fine	1985–1987 (bi-monthly)	Kenyon et al. 1997 & unreported	Nil/paper copy	CSIRO
	Groote/Blue Mud Bay	Fine		Loneragan et al. 1998	Nil/paper copy	CSIRO
Other Northern Territory	Coastal	Broad	Published 2003	Green & Short 2003	Available/ unverified	UNEP I map
	Bynoe Harbour / Fog Bay (west of Darwin)	Point, fine scale		Smit	In prep	Biodiversity Unit/DIPE
	Darwin	Point	Published	Kirkman 1997	Paper	CSIRO

3. Mangroves

Stilt-root Mangrove (Rhizophora stylosa), Liverpool River, Arnhem Land
Source: NT Herbarium

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Species group name and description

A broad definition of a mangrove has been used here and thus species often referred to as saltmarshes, samphires or chenopods are included, as are some species often categorised with strand or coastal plants. A total of 53 vascular plants are included in this analysis.

Information for the Northern Territory (NT) portion of the Northern Planning Area (NPA) is largely drawn from a manuscript titled *Ethnobotany* and *Floristics of Northern Territory Mangroves*, *Australia* (Wightman 2003, unpublished report). This manuscript will be published as an expanded and updated version of *Mangroves of the Northern Territory* (Wightman 1989), when data collection and collation are complete. Information for the Queensland portion of the NPA has been sourced from the Queensland Herbarium, Queensland Fisheries Service and various published reports.

Mangroves can be broadly defined as any vascular plant (a plant which possesses a well-developed system of conducting tissue to transport water, mineral salts and sugars) that regularly occurs in areas subject to tidal inundation, excluding seagrasses (Wightman 1989). This definition allows the inclusion of plant life-forms and non-obligate taxa that form important parts of mangrove communities in northern Australia that would be excluded using a strict definition that excludes all life-forms except trees and non-obligate species.

Using this broad definition of a mangrove a total of 53 vascular plant species have been identified in the mangrove communities of the NPA.

The taxa are outlined below alphabetically by genus and species name with authority, family and common name in Table 3.1.

English common names have been applied with some degree of consistency to mangrove species in the NT. However these may not be applicable on the Queensland side of the NPA. There is significant variation in the application of common names between jurisdictions and regions; this severely limits the usefulness of many common names.

Table 3.1: *Northern Planning Area mangroves with author, family and common name*

Acanthus ebracteatus Vahl, ACANTHACEAE	Purple mangrove holly
Acanthus ilicifolius L., ACANTHACEAE	Mangrove holly
Acrostichum speciosum Willd., PTERIDACEAE	Mangrove fern
Aegialitis annulata R.Br., PLUMBAGINACEAE	Club mangrove
Aegiceras corniculatum (L.) Blanco, MYRSINACEAE	River mangrove
Amyema mackayensis (Blakely) Danser, LORANTHACEAE	Mangrove mistletoe
Amyema thalassia Barlow, LORANTHACEAE	Mangrove mistletoe
Avicennia integra N.C.Duke, VERBENACEAE	Northern Territory mangrove
Avicennia marina (Forssk.) Vierh., VERBENACEAE	Grey mangrove
Batis argillicola P.Royen, BATACEAE	Batis
Bruguiera cylindrica (L.) Blume, RHIZOPHORACEAE	Slender-fruited mangrove
Bruguiera exaristata Ding Hou, RHIZOPHORACEAE	Rib-fruited mangrove
Bruguiera gymnorrhiza (L.) Savigny, RHIZOPHORACEAE	Large-leaved mangrove
Bruguiera parviflora (Roxb.) Wight & Arn. ex Griff., RHIZOPHORACEAE	Slender-fruited mangrove
Bruguiera sexangula (Lour.) Poir., RHIZOPHORACEAE	Northern Large-leaved mangrove
Camptostemon schultzii Mast., BOMBACACEAE	Kapok mangrove
Cerbera manghas L., APOCYNACEAE	Native frangipani
Ceriops australis (C.T.White) Ballment, T.J.Sm. & J.A.Stoddart, RHIZOPHORACEAE	Smooth-fruited spur mangrove
Ceriops decandra (Griff.) Ding Hou, RHIZOPHORACEAE	Rib-fruited spur mangrove
Ceriops tagal (Perr.) C.B.Rob., RHIZOPHORACEAE	Long-fruited spur mangrove
Cynanchum carnosum (R.Br.) Schltr., ASCLEPIADACEAE	Mangrove creeper
Cynodon dactylon (L.) Pers., POACEAE	Mangrove couch-grass
Cynometra iripa Kostel., CAESALPINIACEAE	Wrinkle-pod mangrove
Dalbergia candenatensis (Dennst.) Prain, FABACEAE	Dalbergia
Derris trifoliata Lour., FABACEAE	Derris
Diospyros compacta (R.Br.) Kosterm., EBENACEAE	Ebony mangrove
Diospyros littorea (R.Br.) Kosterm., EBENACEAE	Ebony mangrove
Excoecaria agallocha L., EUPHORBIACEAE	Milky mangrove
Excoecaria ovalis Endl., EUPHORBIACEAE	Milky mangrove
Halosarcia halocnemoides (Nees) Paul Wilson, CHENOPODIACEAE	Red glasswort
Halosarcia indica (Willd.) Paul Wilson, CHENOPODIACEAE	Green glasswort
Heritiera littoralis Aiton, STERCULIACEAE	Looking-glass mangrove
Hibiscus tiliaceus L., MALVACEAE	Beach hibiscus
Lumnitzera littorea (Jack.) Voight, COMBRETACEAE	Red-flowered Black mangrove
Lumnitzera racemosa Willd., COMBRETACEAE	White-flowered Black mangrove
Lysiana maritima (Barlow) Barlow, LORANTHACEAE	Mangrove mistletoe
Nypa fruticans Wurmb, ARECACEAE	Mangrove palm

3. Mangroves

Osbornia octodonta F.Muell., MYRTACEAE .... Myrtle mangrove
Pemphis acidula J.R.Forst. et G.Forst., LYTHRACEAE .... Pemphis
Rhizophora apiculata Blume, RHIZOPHORACEAE .... Tall stilt-root mangrove
Rhizophora lamarckii Montrouz., RHIZOPHORACEAE .... Hybrid stilt-root mangrove
Rhizophora mucronata Lam., RHIZOPHORACEAE .... Long-fruited stilt-root mangrove
Rhizophora stylosa Griff., RHIZOPHORACEAE .... Stilt-root mangrove
Scyphiphora hydrophylacea C.F.Gaertn., RUBIACEAE .... Yam-stick mangrove
Sesuvium portulacastrum (L.) L., AIZOACEAE .... Sesuvium
Sonneratia alba Sm. in B.Rees, SONNERATIACEAE .... Pornupan mangrove
Sonneratia lanceolata Blume, SONNERATIACEAE .... River pornupan mangrove
Sporobolus virginicus (L.) Kunth, POACEAE .... Salt couch-grass
Suaeda arbusculoides L.S.Sm., CHENOPODIACEAE .... Suaeda
Tecticornia australasica (Moq.) Paul Wilson, CHENOPODIACEAE .... Grey samphire
Thespesia populneoides (Roxb.) Kostel., MALVACEAE .... Pacific rosewood
Xylocarpus granatum K.D.Koenig, MELIACEAE .... Cannonball mangrove
Xylocarpus moluccensis (Lam.) M.Roem, MELIACEAE .... Mangrove cedar

Status

Species conservation

Most of the mangrove plant species in the NPA are common and widespread.

Northern Territory

Of the 49 mangrove species occurring in the NT portion of the NPA, 20 species are recorded from 10 or more of the 12 coastal one-degree by one-degree grid cells encompassing the area.

Eleven species are considered to have a restricted distribution in the NT portion of the NPA, on the basis of being recorded from three or less coastal grid cells. Three are relatively widespread in the NT outside the NPA, three are considered data deficient and five are classified as near-threatened in the NT using the IUCN red list categories coding (IUCN 2001). The data-deficient and near-threatened taxa are listed in a schedule attached to the *Northern Territory Parks and Wildlife Conservation Act 1999*, which provides the threatened taxa with legislative protection.

The three species listed as **data-deficient** are: *Acanthus ebracteatus*, *Cynometra iripa* and *Lysiana maritima*.

The five species listed as **near-threatened** are: *Avicennia integra*, *Bruguiera sexangula*, *Cerbera manghas*, *Rhizophora lamarckii* and *Xylocarpus granatum*.

Species with a restricted distribution in the NT portion of the NPA are outlined below, with relevant distributional data.

Table 3.2: *Northern Territory NPA mangroves with restricted distributions*

Mangrove species	No. of NPA grid cells	No. of known NT populations	Australian distribution	Extra-Australian distribution
Acanthus ebracteatus	3	10	WA, QLD	Melanesia, Philippines
Amyema thalassia	1	8	WA	Endemic
Avicennia integra	2	11	NT Endemic	Endemic
Bruguiera sexangula	2	7	QLD	India, Asia, PNG
Cerbera manghas	1	5	QLD	Melanesia
Cynometra iripa	3	5	QLD	India, SE Asia
Dalbergia candenatensis	2	8	QLD	India, China, SE Asia
Lysiana maritima	2	5	QLD	Endemic
Rhizophora lamarckii	2	9	QLD	Sri Lanka, Melanesia
Sonneratia lanceolata	2	13	QLD	New Guinea
Xylocarpus granatum	2	12	QLD, ?WA	Old World Tropics

Queensland

Due to the lower plant-collecting intensity in the Queensland portion of the NPA it is not possible to confidently discuss the conservation status of the mangrove species. Several of the species that occur in one or two grid cells in Table 3.5, are likely to be quite common in the area but poorly collected, for example *Ceriops australis*, *Diospyros littorea* and *Halosarcia halocnemoides*. Other species that are rare in the Queensland portion of the NPA are well represented in other parts of Queensland, for example *Bruguiera cylindrica*, *Heritiera littoralis* and *Rhizophora mucronata*.

No mangrove species are listed in the extinct, endangered, vulnerable or rare categories of the *Queensland Nature Conservation (Wildlife) Regulation Act 1994*, which is the primary mechanism for the protection of threatened flora in Queensland.

As part of a program to declare Fish Habitat Areas in coastal Queensland, protection has been afforded to all fish habitats, including mangroves within the boundaries of these statutory Areas. Four such Areas have been declared in the NPA since 1990: Eight Mile Creek; Morning Inlet – Bynoe River; Staaten – Gilbert and Nassau River. A recent project has documented the fisheries resources, including mangroves, of the Kirke-Love Rivers system (Sheppard et al. 2001).

Separately mangroves are fully protected throughout Queensland, irrespective of land tenure, under the *Queensland Fisheries Act 1994*.

National

None of the NPA mangrove species or habitats are listed as extinct in the wild, critically endangered, endangered or vulnerable under the lead national environmental legislation, the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Mangrove knowledge conservation

The conservation and promotion of traditional biological knowledge are recognised internationally and nationally as important aspects of natural resource management.

Article 8(j) of the International Convention on Biological Diversity (ratified by Australia in 1993) specifically relates to the preservation of biological knowledge. The National Strategy for the Conservation of Australia's Biological Diversity (1996) Objective 1.8 relates to the recognition and conservation of ethnobiological knowledge. This objective has subsequently been implemented through the EPBC Act which seeks, amongst other things, to promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

At the regional level the NT Government has funded the Ethnobiology Project for the past 12 years. This project aims to record plant and animal knowledge in a culturally sensitive and scientifically sound manner.

Habitat and distribution

Mangrove communities

Mangrove habitats are widely distributed throughout the NPA. Recent mapping of these habitats by de Vries, Danaher and Dunning (2002) throughout the area using Landsat Enhanced Thematic Mapper Plus imagery at a scale of 1:100 000 has provided detailed distributional and dominant species spatial data at a regional scale (Figure 3.1).

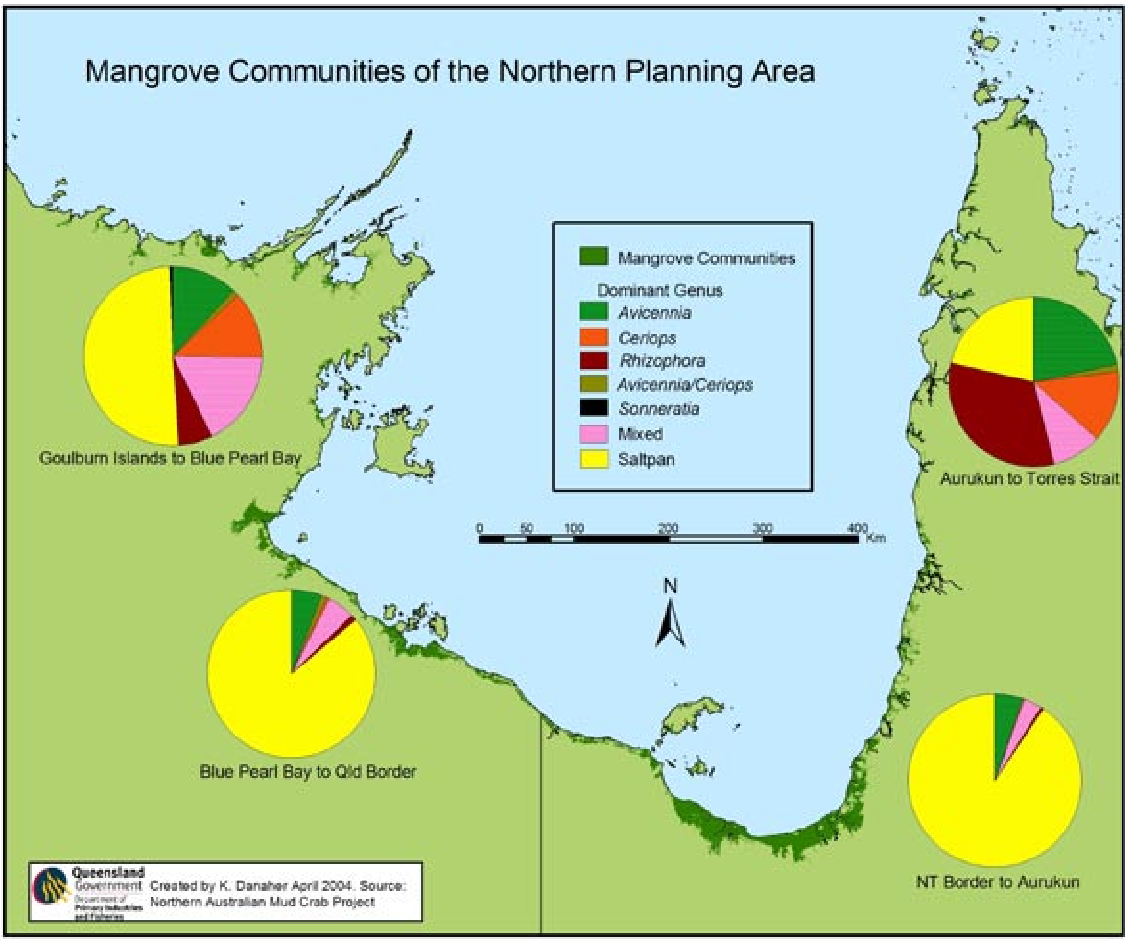
Table 3.3 outlines the mapping units and indicative geographic extent of the units in the NPA. It should be noted that these data are indicative and include the mangrove communities of Murgenella and Cobourg Peninsula in the NT, which are outside the NPA.

Table 3.3: Indicative area of coastal wetland communities in the Northern Planning Area (from de Vries et al. 2002).

Mapping unit	Area (km^2)	%
Closed Avicennia	608.26	5.60
Closed Avicennia/Ceriops	63.55	0.58
Closed Ceriops	428.25	3.94
Closed mixed	665.87	6.13
Closed Rhizophora	640.06	5.89
Closed Sonneratia	9.43	0.09
Open Avicennia	158.08	1.46
Open Avicennia/Ceriops	12.22	0.1
Open Ceriops	21.44	0.20
Open Sonneratia	5.88	0.05
Subtotal	**2613.06**	**24.05**
Saline grassland	22.64	0.21
Saltpan	8105.43	74.61
Samphire-dominated Saltpan	92.75	0.85
Sedgeland	29.64	0.27
Total	**13 476.58**	**100.00**

3. Mangroves

Figure 3.1: Distribution of mangroves in the Northern Planning Area



In the NT portion of the NPA the largest extent of mangrove habitats is found on the northern coastline and around the Sir Edward Pellew group of islands and the mouth of the Roper River (Wightman 1989, Brocklehurst & Edmeades 1996).

The above mapping displays distinct mangrove community patterns within the NPA. Arnhem Land contains high species diversity and structural complexity. *Sonneratia* communities are commonly present at the seaward edge. Heading south-east into the Gulf of Carpentaria (GoC) a combination of low relief and a seasonally dry climate creates a hypersaline environment that allows saltpans to dominate for kilometres inland with mangrove communities restricted to fringing the coastline and waterways. *Rhizophora* communities are reduced to the mouths of rivers and creeks. The species *Camptostemon schultzii* becomes rarely present. *Avicennia* communities dominate the open coastline as well as along the smaller tributaries. *Ceriops* and mixed communities are also present along the smaller tributaries.

From *Aurukun* north, *Rhizophora* replaces *Avicennia* as the most seaward community but is restricted to more sheltered inlets, rather than the open coastline. Species diversity increases in areas of higher rainfall towards Torres Strait. North of Weipa, some mangrove communities were observed growing to 35 m high. Towards Cape York the mangrove palm *Nypa fruiticans* occurs in upstream locations. The islands of the Torres Strait are dominated by *Rhizophora* communties.

Mangrove species

Distributions of individual mangrove plant species are outlined in Tables 3.4 and 3.5. The occurrence records are based on presence of species within coastal one-degree by one-degree grid cells around the NPA. The grid cell number refers to the north-west latitude and longitude reading of the area, for example the grid cell number 11/133 refers to the one degree cell that encompasses the area 11°00'00"-11°59'59"S and 133°00'00"-133°59'59"E. Figure 3.2 provides this information spatially in summary form.

Table 3.4: *Distribution of mangrove species in Northern Territory portion of the NPA*

Mangrove name/grid cell number	11/ 133	11/ 136	12/ 134	12/ 135	12/ 136	13/ 135	13/ 136	14/ 135	14/ 136	15/ 135	15/ 136	16/ 137	Total species
Acanthus ebracteatus			1	1		1							3
Acanthus ilicifolius	1		1	1	1		1	1	1		1		8
Acrostichum speciosum	1	1	1	1	1	1	1	1	1	1	1	1	12
Aegialitis annulata	1	1	1	1	1	1	1	1	1	1	1	1	12
Aegiceras corniculatum	1	1	1	1	1	1	1	1	1	1	1	1	12
Amyema mackayensis		1	1	1	1	1					1	1	7
Amyema thalassia						1							1
Avicennia integra			1	1									2
Avicennia marina	1	1	1	1	1	1	1	1	1	1	1	1	12
Batis argillicola			1	1	1		1	1			1	1	7
Bruguiera exaristata	1	1	1	1	1	1	1	1	1	1	1	1	12
Bruguiera gymnorrhiza	1	1	1	1	1	1	1	1			1		9
Bruguiera parviflora	1	1	1	1	1	1	1	1	1		1		10
Bruguiera sexangula					1				1				2
Camptostemon schultzii	1		1	1	1								4
Cerbera manghas		1											1
Ceriops australis	1	1	1	1	1	1	1	1	1	1	1	1	12
Ceriops decandra	1		1	1	1								4
Ceriops tagal	1	1	1	1	1	1	1	1	1	1	1	1	12
Cynanchum carnosum	1	1	1	1	1	1	1	1	1	1	1	1	12
Cynodon dactylon	1		1	1	1	1	1	1	1	1	1	1	11
Cynometra iripa		1			1	1							3
Dalbergia candenatensis			1		1								2
Derris trifoliata	1		1	1	1		1						5
Diospyros compacta	1	1	1	1	1	1	1	1	1				9
Diospyros littorea			1	1	1	1	1	1	1		1		8
Excoecaria agallocha	1	1			1		1	1	1				6
Excoecaria ovalis	1	1	1	1	1	1	1	1	1	1	1	1	12
Halosarcia halocnemoides			1	1	1					1	1	1	6
Halosarcia indica		1	1	1	1	1		1		1	1	1	9
Hibiscus tiliaceus	1	1	1	1	1	1	1	1	1		1	1	11
Lumnitzera littorea			1	1	1		1		1		1		6
Lumnitzera racemosa	1	1	1	1	1	1	1	1	1	1	1	1	12
Lysiana maritima						1		1					2
Osbornia octodonta	1	1	1	1	1	1	1	1	1	1	1	1	12
Pemphis acidula	1	1		1	1	1	1	1	1	1	1		10
Rhizophora apiculata	1		1	1	1								4
Rhizophora lamarckii			1		1								2
Rhizophora stylosa	1	1	1	1	1	1	1	1	1	1	1	1	12
Scyphiphora hydrophylacea	1	1	1	1	1	1	1	1					8
Sesuvium portulacastrum	1	1	1	1	1	1	1	1	1	1	1	1	12
Sonneratia alba	1	1	1	1	1	1	1						7
Sonneratia lanceolata				1	1								2
Sporobolus virginicus	1	1	1	1	1	1	1	1		1	1		10
Suaeda arbusculoides	1		1	1	1						1		5
Tecticornia australasica		1	1	1	1			1	1		1	1	8
Thespesia populneoides	1	1	1	1	1	1	1	1	1	1	1	1	12
Xylocarpus granatum		1			1								2
Xylocarpus moluccensis	1	1	1	1	1	1	1	1	1	1	1	1	12
Total species per grid cell	**31**	**30**	**40**	**40**	**44**	**31**	**30**	**30**	**26**	**20**	**30**	**22**	

3. Mangroves

Table 3.4 indicates that mangrove floristic diversity is at its peak in northern, higher rainfall areas, with the mangroves around north-east Arnhem Land having the greatest diversity. The high numbers of species from each grid cell indicates the area has been relatively well collected.

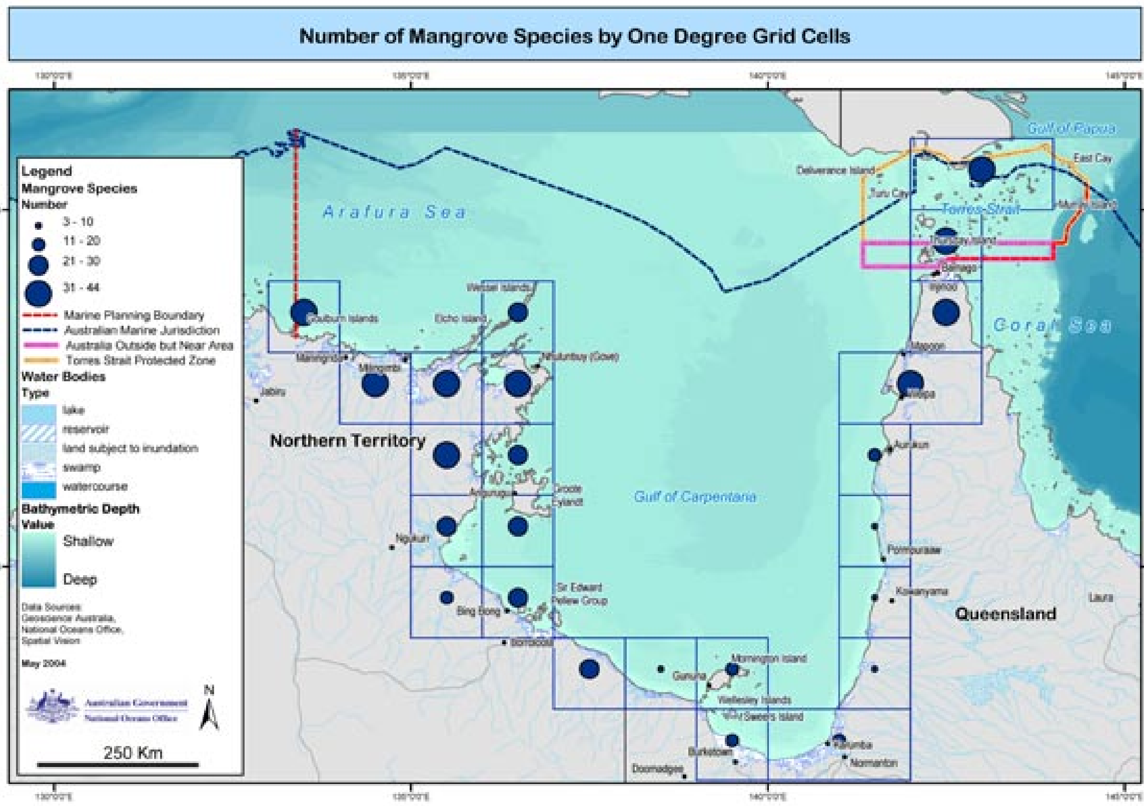
Table 3.5: *Distribution of mangrove species in the Queensland portion of the NPA.*

Mangrove name/grid cell number	16/ 138	16/ 139	17/ 139	17/ 140 141	16/ 141	15/ 141	14/ 141	13/ 141	12/ 141 142	11/ 142	10/ 142	09/ 142 143	Total species
Acanthus ebracteatus											1		1
Acanthus ilicifolius			1							1	1	1	4
Acrostichum speciosum									1	1	1	1	4
Aegialitis annulata		1	1	1			1	1	1	1	1	1	9
Aegiceras corniculatum		1	1	1		1	1	1	1	1	1	1	10
Amyema mackayensis				1									1
Avicennia marina	1	1	1	1		1	1	1	1	1	1	1	11
Batis argillicola				1		1			1		1	1	5
Bruguiera cylindrica										1	1		2
Bruguiera exaristata	1	1	1			1		1	1		1	1	8
Bruguiera gymnorrhiza			1						1	1	1	1	5
Bruguiera parviflora			1						1	1	1	1	5
Bruguiera sexangula									1	1	1		3
Camptostemon schultzii						1		1	1		1	1	5
Cerbera manghas									1	1	1	1	4
Ceriops australis		1											1
Ceriops decandra									1	1	1	1	4
Ceriops tagal	1		1		1	1	1	1	1	1	1	1	10
Cynanchum carnosum				1					1	1		1	4
Cynodon dactylon									1		1	1	3
Cynometra iripa									1	1	1		3
Dalbergia candenatensis								1	1		1		3
Derris trifoliata									1	1	1	1	4
Diospyros compacta										1	1	1	3
Diospyros littorea										1			1
Excoecaria agallocha			1					1	1		1	1	5
Excoecaria ovalis		1		1	1		1		1				5
Halosarcia halocnemoides			1	1									2
Halosarcia indica	1	1	1	1	1	1			1		1		8
Heritiera littoralis									1		1		2
Hibiscus tiliaceus	1	1	1				1	1	1	1	1	1	9
Lumnitzera littorea			1						1	1	1	1	5
Lumnitzera racemosa		1					1		1	1	1	1	6
Lysiana maritima			1	1									2
Nypa fruticans									1	1			2
Osbornia octodonta								1	1	1	1	1	5
Pemphis acidula		1								1	1	1	4
Rhizophora apiculata									1	1	1	1	4
Rhizophora lamarckii										1			1
Rhizophora mucronata									1	1			2
Rhizophora stylosa	1	1	1				1	1	1	1	1	1	9
Scyphiphora hydrophylacea								1	1	1	1	1	5
Sesuvium portulacastrum			1	1					1	1	1	1	6
Sonneratia alba									1		1	1	3
Sporobolus virginicus						1		1		1	1	1	5
Tecticornia australasica			1	1		1	1	1	1		1	1	8

Mangrove name/grid cell number	16/ 138	16/ 139	17/ 139	17/ 140 141	16/ 141	15/ 141	14/ 141	13/ 141	12/ 141 142	11/ 142	10/ 142	09/ 142 143	Total species
Thespesia populneoides	1	1	1			1		1	1	1	1		8
Xylocarpus granatum									1	1	1	1	4
Xylocarpus moluccensis									1	1	1	1	4
Total species per grid cell	7	12	18	12	3	10	9	15	37	33	39	32	

Table 3.5 indicates that the northern, higher rainfall areas of the Queensland portion of the NPA are the most species rich. The low species number for many of the grid cells, in comparison to the latitudinally equivalent NT cells, suggests the area is poorly collected floristically.

Figure 3.2: *Distribution of mangrove species in the Northern Planning Area by one-degree grids*



In the mid-1990s CSIRO mapped the distribution of mangroves in a large portion (14 122 square kilometres) of the Torres Strait using Landsat satellite imagery (Long et al. 1997). A total of 15 663 ha of mangroves was found in the study area. The low relief muddy island of Boigu near the coast of Papua New Guinea was extensively covered with mangroves, including a broad margin of mangroves 1 to 2 km wide around most of the island. Other islands in the study area with extensive mangrove cover were the small islands of Moimi and Aubussi north of Biogu, and Saibai and Turnagain Islands. In all, 49 out of a possible 174 islands and rocky outcrops had mangroves based on the satellite imagery (Long & McLeod 1997). Species compositions relied on an earlier study by Environment Science and Services (1994) and personal experience.

3. Mangroves

Significance of the species group in the Northern Planning Area

Aboriginal people

Mangrove communities are of major importance to Aboriginal people in the Northern Territory portion of the NPA. Mangrove plant species are used for a variety of utilitarian purposes including food, medicine, implements, dyes, fibres, fish poisons and seasonal indicators (Wightman pers. obs.).

The fauna associated with mangrove communities often form an integral part of the diet of many coastal Aboriginal groups in the NT. The most widely utilised taxa for food include mangrove worms, mud crabs, long bums, cockles, clams and a large number of fish. Some of the most common and favoured fish in mangrove habitats include barramundi, mangrove jack, small sharks and rays. These foods are often especially valued for their health-promoting qualities.

The fact that mangrove communities can provide a guaranteed food resource all year is another critically important factor for coastal Aboriginal groups. Almost all other traditional food resources are strictly seasonal.

It is highly likely that the mangrove communities of the Queensland portion of the NPA are equally important for coastal Aboriginal groups and Torres Strait Islanders, especially in areas of high population such as Mornington Island, Kowanyama and the Torres Strait. Mangrove timber from Rhizophora species has provided materials for housing on islands in Torres Strait (Beumer pers. comm.).

General

Mangrove communities provide a critical habitat in the NPA. The coastal wetland habitats that include mangroves, saltmarshes and foreshore flats are widely recognised for their value to fisheries production (Bruinsma & Duncan 2000, de Vries et al. 2002, Danaher & Stevens 1995). Estuarine habitats are critical to many commercially and recreationally important fish and crustacean species during some stage of their life cycle.

The importance of mangrove and other coastal wetland habitats is well known and widely publicised. However, some of these factors are magnified in the wet dry tropics of the NPA.

Mangrove habitats play important roles in:

- creating a buffer against coastal erosion, storm surges and flooding, especially in areas of large tidal movement
- producing detritus and energy export, which fuel food chains, especially in tropical areas
- maintaining biodiversity, with many plant and animal species dependent on mangrove habitats, especially in the species-diverse tropics.

Impacts/threats

There has been little clearing or destructive use of mangroves in the NT portion of the NPA. While mangrove communities are extensively utilised by Aboriginal people, this use appears to be sustainable and not deleterious in the long term. The mangrove communities of the NT are reported to remain intact and free from major disturbance (NT DIPE 2002). However, the NT Department of Infrastructure, Planning and Environment notes that, in accepting that further development is necessary along the NT coastline, it is important to acknowledge that some areas of mangroves may be relinquished and that it is necessary to ensure effective conservation and sustainable development (NT DIPE 2002).

In the past Macassan fisherman used mangroves in the preparation of trepang and this localised and intensive use led to destruction in some areas (MacKnight 1976); this destruction is no longer evident.

North coast of NT, Goulbourn Island to Nhulunbuy

Minor localised clearing has occurred in some areas near outstations to allow easier access to waterways for boat-launching and fishing. Occasional larger clearings for barge landings have also been undertaken near bigger communities and settlements. There has been no large scale destruction of mangrove communities.

East coast of NT, Nhulunbuy to Queensland border

Port and shipping activities established to support mining operations at Nhulunbuy, Groote Eylandt and Macarthur River have led to localised clearing of mangrove habitats in these areas. Possible future negative effects from the near-coastal 'settling ponds' and concentration plants of the Nhulunbuy and Groote Eylandt mining operations are difficult to predict. It also appears likely that these mining operations could expand in the future.

Queensland / Northern Territory border to Torres Strait

There has been no large-scale destruction of mangrove habitats in this area, but some localised clearing of mangrove habitats has occurred to allow development of local community infrastructure. Port and offloading facilities at Karumba, Weipa, Skardon River, Thursday Island and Horn Island have led to localised clearing in these locations. Mangrove timber continues to be used for the construction of traditional dwellings in Torres Strait.

There has been considerable interest in developing ponded pastures within the southern GoC which could impact on mangrove habitat and interfere with fish movement, nutrient and sediment flows. A moratorium in the construction of impoundments on tidally affected land in Queensland was declared in 1991 (Hyland 2002).

Information gaps

Traditional Aboriginal knowledge

The lack of recorded information relating to traditional Aboriginal knowledge of mangrove communities and species is the main ethnobiological information gap.

A large amount of traditional Aboriginal knowledge of mangrove plants and associated animals currently exists. There is some urgency in the need to collect this information as this complex and detailed knowledge often resides only with senior elders, many of whom will pass away within the next few years. In coastal areas of southern Australia much of this knowledge has been lost. The public aspects of this knowledge should be recorded in a culturally sensitive and scientifically sound manner where supported by Aboriginal communities.

Some of this traditional biological knowledge has been successfully recorded and published (Yunupingu et al. 1999, Groote Eylandt Linguistics-langwa 1993).

The mangrove habitat and its constituent taxa are good topics on which to collect and record associated traditional knowledge due to a number of factors:

- the relatively low number of key taxa involved (in comparison to more species-diverse habitats such as savannas, monsoon vine forests, floodplains, etc)
- the well-defined and relatively limited distribution (in relation to widespread savanna communities)
- the cultural and linguistic diversity of coastal Aboriginal groups (in comparison to larger inland groups), which is partly due to the presence of resource-rich mangrove habitats
- the desire of traditional owners to undertake joint scientific research, especially in resource-rich areas such as mangrove communities.

Biological

The biological information gap is the distributional data for mangrove plant species for the southern GoC area which is sparse in comparison to the north coast and the northern east coast. Further survey work in the area should result in new distributional records.

Floristically the mangroves are relatively well known; there have been no new species records in the NT portion of the NPA since 1987.

Other

Information relating to the effects of climate change on mangroves is lacking. The effects of changes in water temperature and sea-level rises are unknown.

Cross-jurisdictional agreement between NT and Queensland researchers and management authorities needs to be reached on the definition of a mangrove, and which species to include in a joint mangrove species list. This should also include a common English name listing for the taxa involved.

3. Mangroves

Key references and current research

This chapter and *Mangroves of the Northern Territory* (Wightman 1989) provide details of sources of data and other information for the plant communities and for individual taxa.

The NT distributional data for species were derived from several sources. This included the collection localities of mangrove specimens housed in various Australian herbaria, including the NT Herbarium (Palmerston and Alice Springs), the Australian National Herbarium (Canberra), the Queensland Herbarium (Brisbane), the Western Australian Herbarium (Perth) and the Australian Institute of Marine Sciences Herbarium (AIMS). The NT Herbarium database was searched in 2002, while the other herbarium databases were searched in 1988. It is assumed that any new NT mangrove collections in Australian herbaria post-1988 would have duplicates lodged in the NT Herbarium.

Several other datasets, with reliably identified taxon records, were also searched for locality records of NT mangrove species. These included the NT Herbarium plot database, NT Rainforest Survey, NT Melaleuca Survey, vegetation records from the Harry Messel Crocodile Survey, Groote Eylandt and Cape Arnhem Surveys (NT Government) and the NT Vegetation Map Survey.

The Queensland distributional data for species were derived from locality records in the Queensland Herbarium HERBRECS database (December 2003 and January 2004) and from several published sources (Saenger & Hopkins 1975, Woolston 1973, Messel et al. 1981). The identification to species level in these sources in the genera *Bruguiera*, *Ceriops*, *Excoecaria* and *Rhizophora* needs to be treated with caution.

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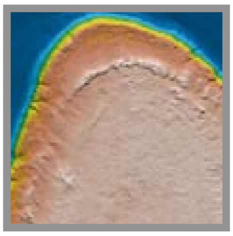

4. Corals

This chapter should be cited as:
Veron, JEN, Alderslade, P & Harris, P (2004). Corals. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

Australomussa rowleyensis at Rowley Shoals, Western Australia – also found off Arnhem Land **Source:** *Veron (2000)*

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Species group name and description

Stony corals, Scleractinia

The Scleractinia are one of approximately 25 orders of animals belonging to the phylum Coelenterata. This phylum includes corals, soft corals, hydroids, jellyfish and sea anemones, all of which have the same general body plan. They are all symmetrical about a central axis and have a sac-like body cavity with only one opening, which serves as both mouth and anus (Veron 2000).

Corals are basically anemone-like animals that secrete a skeleton. Some corals are solitary and look just like simple anemones when their tentacles are extended. Others, including most that are seen on coral reefs, are colonial (Veron 2000).

More information on corals can be found in Veron (2000) and Veron and Stafford-Smith (2002). Veron (2000) is an extensive publication providing summary descriptions and illustrations of a large number of corals. *Coral ID* (Veron & Stafford-Smith 2002) contains both field and skeletal characters and is specifically designed to support the needs of combined field and laboratory identification.

Status

All Scleractinia are listed by the Convention on International Trade in Endangered Species (CITES) as threatened by international trade. Appendices of CITES list species restricted for international trade. Any CITES-listed coral species considered endangered in the Northern Territory (NT) may be excluded by the NT Fisheries Division from any harvest allocation (NT Government 2001). The Department of Environment and Heritage regulates international trade in wildlife to and from Australia, including corals. The Department has indicated that the international trade in coral will only be permitted for one-off education purposes (NT Government 2001).

Corals have extensive protection in Queensland and Australian Government marine protected areas and National Parks including the Great Barrier Reef Marine Park. However, there are no areas under specific protection in the Northern Planning Area (NPA). Coral species are also not specifically listed under Queensland, NT or Australian Government environmental legislation.

Habitat and distribution

Global distribution maps for all zooxanthellate Scleractinia are available in Veron (2000) *Corals of the World* and Veron and Stafford-Smith (2002) *Coral ID*. Veron (2000) also gives relevant information on feeding, habitats, breeding, migratory routes, dispersal etc.

More detailed distributions relevant to Australia are in Veron (1993). It is relevant to the current activity that until recently, although the distribution of corals is well know for both the east and west coasts of Australia, there has been no detailed work on the north coast except for a single study at the Essington Peninsula, a recent survey by Geoscience Australia (see below) and studies within the Torres Strait.

In late 2003 the National Oceans Office funded a survey of corals in the NPA at sites located between Port Bradshaw and the Goulburn Islands off Arnhem Land. The survey was conducted by Dr Veron and was linked to an AIMS expedition to the coastal communities of Arnhem Land, to canvas the potential for cultivating sea sponges.

Results from the survey were that, although there was no reef development in the area surveyed, there were extensive coral communities. These were sometimes very diverse and contained coral colonies that reached maximum sizes for the species. All sites were in pristine condition (Veron 2004).

The richest sites for corals were generally partly protected from wave action. These also had high diversities of other invertebrates, especially corallimorpharians and soft corals. The corals themselves were a subset of Torres Strait species, as would be expected from prevailing currents. Results from the survey reported by Dr Veron to the National Oceans Office in April 2004 found the following points of specific interest to the NPA (Veron 2004):

- Faviids, especially the genera *Favia*, *Favites*, *Platygyra* and *Goniastrea* are overwhelmingly dominant in most sites. This would be expected in the environments encountered.
- Arnhem Land is the easternmost limit of a few western Australian species of which *Australomussa rowleyensis* and *Lithophyllon undulatum* are very conspicuous. A few additional species are awaiting detailed study.
- Arnhem Land is the westernmost limit of a few eastern Australian species (eg *Favia danae*, *Lobophyllia robusta*, *Montastrea colemani*) with some possible additional species awaiting detailed study.
- There has been little immigration from Indonesia. The very conspicuous *Euphyllia parancora* has not been previously recorded from Australia, but does occur in both eastern Papua New Guinea and Indonesia. *Mocromussa diminuta* has previously been recorded only from Indonesia.
- The region has several species which are common but which are rare elsewhere in Australia. Of these, *Hydnophora pilosa*, which is common only at Norfolk Island, is conspicuous. The conspicuous *Turbinaria bifrons* is common on the west coast but not the east.
- A *Symphyllia* was found which is similar to *S. wilsoni*, known only from far south-west Australia. This may be a new species.
- A species closely resembling *Turbinaria irregularis* may also be unique in Australia or endemic.
- At least five other species were not satisfactorily identified during the cruise and specimens have been collected for further study.
- Some genera that are common on both eastern and western Australian coasts were not recorded. Of these, Caulastrea, Cycloseris, Ctenactis and Anacropora are surprisingly missing as some species are commonly found in non-reef turbid environments.

The study off Arnhem Land has gone a long way towards completing detailed records of coral distribution around the entire Australian coastline.

The Torres Strait reefs were digitised from Landsat imagery in 1995 and the information is stored in a Geographic Information System held by CSIRO. The only classification upon the reef tops, however, was done in 1997 for an Australian Fisheries Management Authority project where the reef top habitats were classified over eastern Torres Strait (Long et al. 1997).

4. Corals

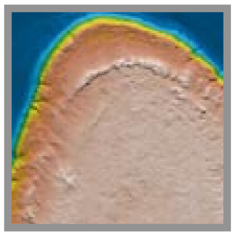
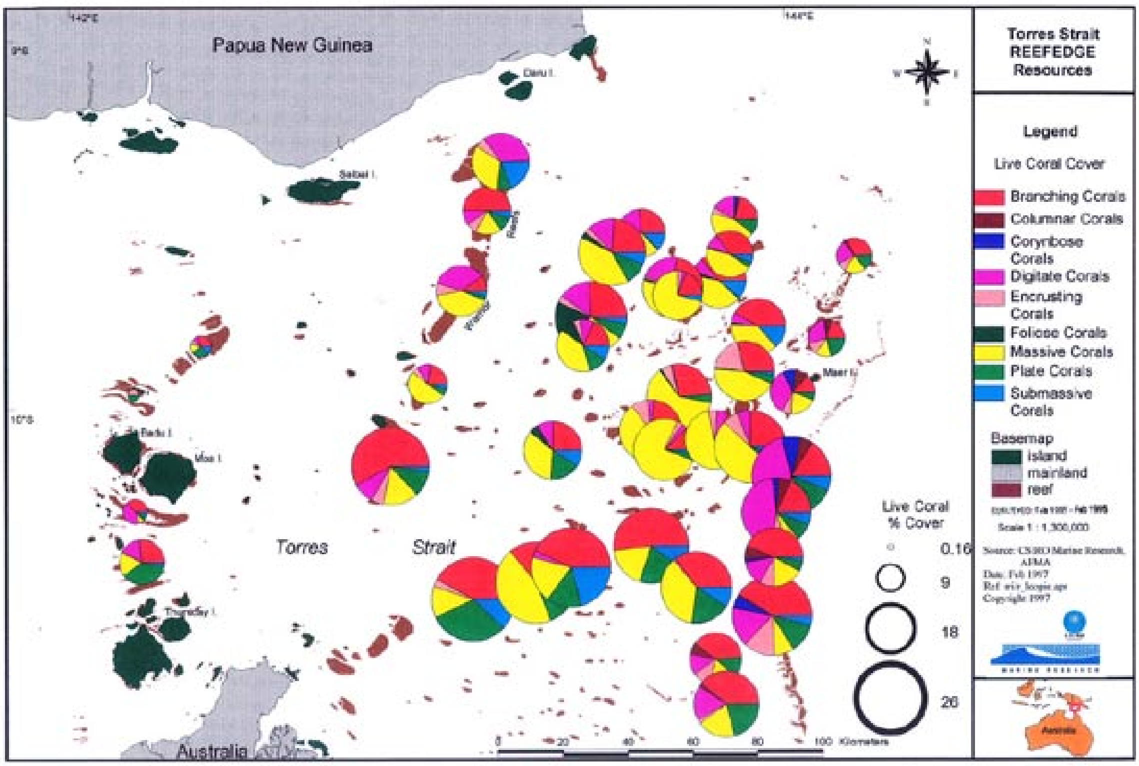


Figure 4.1: *Pie chart of live coral growth forms on the reef edges in Torres Strait, averaged by reefs.* **Source** CSIRO



The classifications were basically sand, rubble and coral zone and mixtures thereof (T Taranto CSIRO pers. comm.). This was done through field surveys during 1995 and early 1996 in which 1274 sites were sampled with a 20 m by 2 m transect line by divers on the tops of 43 reefs. Also 374 sites were sampled by divers along the edges of 41 reefs (Long et al. 1997). The study found that there was a high diversity of coral growth forms on most reefs of the Torres Strait.

Some areas of corals have been identified in shallow waters off Weipa, and fringing the Wellesley Islands, Groote Eylandt and Cape Wilberforce (north-east Arnhem Land), though overall the corals were regarded as sparse in the Gulf of Carpentaria (GoC) (Comalco 1993).

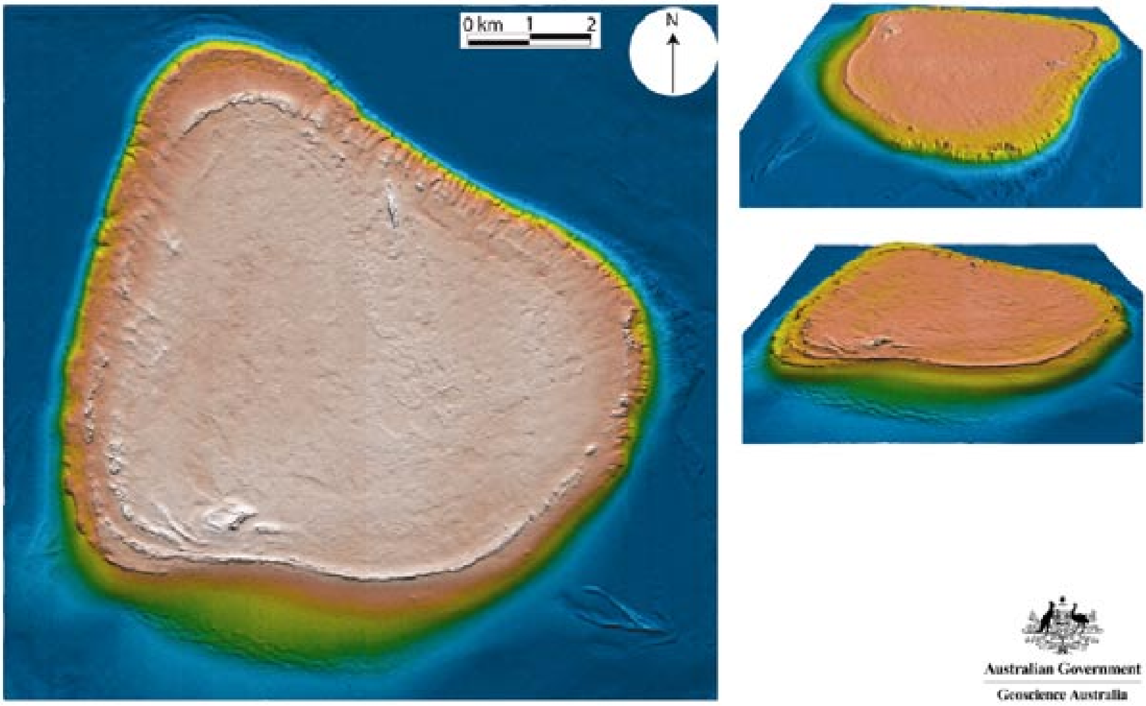
CSIRO has noted there are large areas of hard-bottomed substrata (known as 'untrawlable grounds' in the Northern Prawn Fishery) throughout the GoC. These regions have been recorded in the logbooks and electronic charts of trawl skippers. Given their considerable extent, particularly from Mornington Island around to Cape Wilberforce, these habitats could represent large hard-bottom structural reefs that are well-known areas of high diversity and provide refuges for biodiversity from the impacts of trawling (R Bustamante CSIRO pers. comm.).

The recent Geoscience Australia survey in May 2003 revealed that there are large tabletop-like coral reef structures around 40 to 50 m deep in the southern part of the Gulf. These structures include Big Reef, a 100 km^2 reef north of Mornington Island, which was found to have luxuriant growth similar to the Great Barrier Reef on platforms 30 m deep. This discovery also points to the possibility that other similar reefs may occur in this area (Harris et al. submitted).

The Fisheries Branch of the NT Government notes that there is limited recorded information on the extent of the marine habitats in the NT. However, anecdotal information from fishers and others with experience of the NT coastline indicates that there may be extensive reef systems that are not officially recorded. Available information on the extent of harvestable coral reefs is not adequate to make informed decisions on significantly increasing the harvest level (NT Government 2001).

There has been no stock assessment within the NPA.

Map of Big Reef, Gulf of Carpentaria **Source:** Geoscience Australia



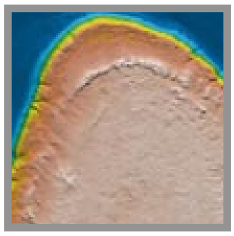
Australian Government
Geoscience Australia

Significance of the species group in the Northern Planning Area

As corals are the main components of coral reefs, they have major relevance to all activities where there are coral reefs. Reefs were believed to be only sporadically distributed in the western GoC and the northern coast of the NT. However, it is now known that 'coral carpets' are widely distributed in the Gulf region, in mangrove channels and on the coast of Arnhem Land where they are used as a food and recreational resource by Aboriginal people.

In the NT there is an Aquarium Fishery in which licences have been granted for the harvesting of a wide range of fish species from freshwater and marine environments, as well as plants and coral, for the purpose of display. Up until 1994 all aquarium collecting licences permitted the collection of coral. In 1994, a prohibition on coral harvesting was imposed. In response to submissions from a number of licensees, aquarium collectors were permitted to take restricted quantities of coral. In 2002, 18 aquarium Fish/Display licences were issued. Three licensees can each harvest up to 10 kg of live coral per month. Two of these licences have a limit on the type of corals harvested and one has no limit (NT Government 2003). Harvest areas include all NT marine waters to the outer boundary of the Exclusive Economic Zone of the NPA.

There is no commercial coral harvesting in either Queensland or offshore waters under Australian Government jurisdiction.



Impacts/threats

Global warming and El Niño events pose major long-term threats to shallow water corals. The recent cruise by AIMS off Arnhem Land, however, found a relative lack of coral bleaching which is of interest as maximum sea surface temperatures would be expected to be higher in this region than for those reefs on both the east and west coasts of Australia where extensive bleaching has taken place (Veron 2004). The cruise also found that all sites studied were in pristine condition (Veron 2004).

Human impact in the region, including direct impact through commercial coral harvest in the NT, may be small although this has not been assessed.

The Torres Strait is a major shipping route and impacts on coral may be from oil spills and localised damage from groundings and bottom scouring.

Information gaps

In contrast to both the east and west coasts, until the recent coral survey off Arnhem Land there was an almost total lack of information about the corals of the planning area. Little is still known, however, on the nature of the deeper water coral structures in the GoC, though there are plans by CSIRO and Geoscience Australia to explore areas of 'untrawlable ground' in the Gulf of Carpentaria in the near future. It is possible that these grounds could represent large hard-bottom structural reefs.

Analysis of the results from the Arnhem Land cruise will indicate affinities between the corals of Australia and its northern neighbours. If undertaken, the analysis would need to be GIS-based. The main significance of this is that such an analysis would reveal (for the first time for any major marine invertebrate group) the potential for Australia to fulfill a custodial role should diversity in the Indonesian/Philippines global centre of diversity continue to decline.

Key references and current research

Coral Geographic, a website of coral biogeography is highly relevant to the present activity and is currently being built at AIMS.

The CSIRO Marine Laboratories in Cleveland, Queensland, has information on reefs in the Torres Strait in GIS format. This information is presented in Long et al. (1997).

The final report from the AIMS survey across northern Arnhem Land is due in April 2004 and will include:

- a table of species by site for corals and sponges (at least those sponges of potential commercial value)
- site descriptions involving an estimate of percentage cover of coral and other benthos
- some description of site condition – including indication of damage by human (eg trawling) or natural events, disease and/or predation and the presence of debris
- interpretation of the data collected on the cruise to set this region into context with known coral distribution and abundance.

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Websites

www.aims.gov.au/corals
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5. Seabirds

This chapter should be cited as:
Chatto, R, O'Neill, P, Garnett, S & Milton, D (2004). Seabirds. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

One of the large breeding colonies of crested terns found off northern Australia. ***Source:*** *Ray Chatto*

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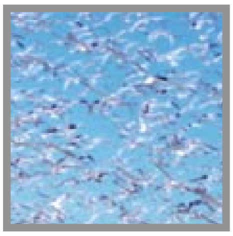
Species group name and description

Birds that have been traditionally referred to as seabirds in Australia include all, or representatives of: albatrosses, boobies, cormorants, egrets, frigatebirds, gannets, gulls, herons, jaegers, noddies, pelicans, penguins, petrels, phalaropes, prions, raptors, shearwaters, skuas, storm-petrels, terns and tropicbirds. Although some species are regularly regarded as seabirds, there is no set list. A number of species referred to as seabirds by some authors are listed as shorebirds or waterbirds by others. The reports for the Northern Planning Area (NPA) scoping study include one on shorebirds and one on seabirds, but there is not one specifically reporting on waterbirds. A number of birds traditionally referred to as waterbirds use the marine environments of the NPA for feeding and breeding. Some of the largest waterbird breeding colonies in Australia, for example, are in mangroves along the coast of the Northern Territory (NT) (Chatto 2000).

This chapter on seabirds, in combination with the following chapter on shorebirds, will consider all 'aquatic' birds for which the tidally affected coastal wetlands and rivers, estuaries, intertidal zones, or waters seaward of the low water mark in the NPA are a significant part of their life cycles. Those species traditionally referred to as waterbirds will be considered in the most appropriate of each of these two reports. In order to put all species into one of the reports they have been separated on the basis of those that feed primarily in marine waters by flying or swimming (seabirds) and those that primarily feed by wading (shorebirds). This is somewhat arbitrary but it allows all aquatic birds to be covered using only two groupings. On this basis there are in



excess of 40 species classified here as seabirds that have been recorded within the NPA. There is little or no representation of some of the large groups of seabirds such as penguins, petrels, prions, shearwaters, albatrosses and storm-petrels, but good representation of groups such as terns and cormorants within the NPA.

Status

All species, or parts of, and their eggs are protected under NT and Queensland legislation within three nautical miles of the coast, and under Australian Government legislation from there to the EEZ line. Seabird species of conservation significance (25 species) and their listings by various assessments, are shown in Table 5.1.

Table 5.1: *Seabird species of conservation significance in the Northern Planning Area*

Species	Common Name	Jamba	Camba	Bonn	CITES	NT	QLD
Tadorna radjah	Radjah shelduck	-	-	II	-	LC	Rare
Anus gracillis	Grey teal	-	-	II	-	LC	-
Calonectris leucomelas	Streaked shearwater	+	+	-	-	DD	-
Oceanites oceanicus	Wilson's storm petrel	+	-	-	-	DD	-
Phaetheo rubicauda	Red-tailed tropicbird	-	-	-	-	NE	Vul.
Phaetheo lepturus	White-tailed tropicbird	+	-	-	-	NE	-
Sula dactylatra	Masked booby	+	-	-	-	NE	-
Sula sula	Red-footed booby	+	-	-	-	NE	-
Sula leucogaster	Brown booby	+	-	-	-	LC	-
Fregata minor	Great frigatebird	+	-	-	-	NE	-
Fregata ariel	Lesser frigatebird	+	-	-	-	LC	-
Pandion haliaetus	Osprey	-	-	II	II	LC	-
Milvus indus	Brahminy kite	-	-	II	II	LC	-
Haliaeetus leucogaster	White-bellied sea-eagle	-	+	II	II	LC	-
Stercorarius pomarinus	Pomarine jaeger	+	+	-	-	DD	-
Stercorarius parasiticus	Artic jaeger	+	+	-	-	DD	-
Sterna caspia	Caspian tern	-	+	-	-	LC	-
Sterna bengalensis	Lesser crested tern	-	+	-	-	LC	-
Sterna bergii	Crested tern	+	-	-	-	LC	-
Sterna sumatrana	Black-naped tern	+	+	-	-	LC	-
Sterna hirundo	Common tern	+	+	-	-	LC	-
Sterna albifrons	Little tern	+	+	-	-	LC	End.
Sterna anaethetus	Bridled tern	+	+	-	-	LC	-
Chlidonias leucopterus	White-winged tern	+	+	-	-	LC	-
Anous stolidus	Common noddy	+	+	-	-	NE	-

Jamba = Listed under the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment.

Camba = Listed under the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment.

Bonn = Listed under the Convention on the Conservation of Migratory Species of Wild Animals. (All are listed under Appendix II).

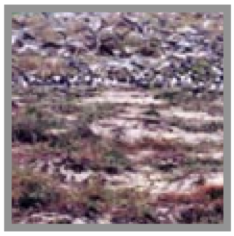
NT = Listing under the NT Threatened Species List (NE= not evaluated, LC = least concern, DD = data deficient).

QLD = Listing under the Queensland Threatened Species List (Rare, Vulnerable or Endangered).

No species are listed under either the 2002 International Union for the Conservation of Nature Red List of Threatened Species or the *Environmental Protection and Biodiversity Conservation Act* 1999.

Species names follow Christidis and Boles (1994).

5. Seabirds



Although several species are listed on JAMBA and CAMBA, none are listed as vulnerable or endangered under NT legislation. Within Queensland the little tern is listed as endangered and the red-tailed tropicbird is listed as vulnerable. Although the general status and distribution of most species considered in this report has been quite thoroughly surveyed in recent years within the inshore part of the NT, none of the species been studied to the extent of has species overviews or management/monitoring plans being written for them for the NPA.

Several species are listed as threatened and given a taxonomy summary or recovery outline in Garnett and Crowley (2000). The white-tailed tropicbird (Indian Ocean) is listed as endangered; the Australian breeding population of the masked booby (east Indian Ocean) as vulnerable; red-tailed tropicbird as near threatened; and the rajah shelduck, sooty oystercatcher (northern), little tern (west Pacific) and the white tern (Indo-Pacific) are all listed as of least concern.

There are no Ramsar sites, nor current plans to list any, within the NPA. However, several sites would qualify on the basis of numbers of birds. On the NT side of the NPA there is one National Park – the Barranyi (North Island) National Park which is part of the Sir Edward Pellew Islands. On the Queensland side there are no seabird sites listed as National Parks. Manowar, Rocky and Bountiful Islands in the Wellesley Group have been identified as meeting the BirdLife International criteria as Important Bird Areas.

Habitat and distribution

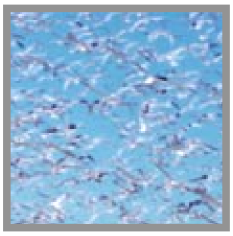
As such a wide diversity of species is covered in this chapter, comments on their habitat and distribution are divided into groups of ecologically and/or taxonomically similar species. All species present in the NT section of the NPA have been, or will be, reported on in detail in a series of Parks and Wildlife Service technical reports (Chatto 2000, 2001, 2003, in prep.). These reports are based on extensive coastal and coastal wetland fauna surveys conducted throughout the 1990s. Unless otherwise referenced the species group information detailed below is taken from these reports. In the Queensland section, surveys have only been conducted for the Manowar, Rocky and Bountiful Islands. Opportunistic information has been collected for the other sites.

Ducks and Grebes

Two species of duck, the rajah shelduck and grey teal, and one species of grebe, the Great-crested Grebe, have been considered as seabirds for the purposes of this report. Each of these species, unlike other species within their groups, spends some time in coastal or saline wetland habitats. Both duck species are very common in these habitats within the NPA. Rajah shelduck are a resident breeding species while most, but not all, grey teal are dry season visitors, sometimes in flocks of many thousands. The great-crested grebe is a fairly rare visitor to the Top End of the NT and, in Queensland, occurs primarily in freshwaters along the eastern seaboard.

Shearwaters and Petrels

Limited surveys have been done in the offshore waters of the NPA so it is possible that the number and status of species in this area is under-recorded. For example, species, such as the Wilson's storm-petrel, may be a more common visitor than has been so far recorded. Nevertheless, it is likely that these species and other tube-nosed seabirds are poorly represented in NPA waters. The only oceanic species that does not come into inshore waters and that has been recorded in reasonable numbers is the streaked shearwater (Carter 1983, Blaber & Milton 1994). Prior to surveys by these authors, streaked shearwaters were thought to be vagrants, but it now appears they may well be a regular and common non-breeding summer visitor. Hutton's shearwaters, considered globally endangered on the basis of threats at its breeding grounds, also sometimes occur in the NPA. It has been suggested that this species has a circumpolar migration route but this has not been verified.



Tropicbirds and boobies

Within, the tropicbird and booby group only the brown booby is regularly recorded in the NPA. The others have only occasionally been recorded, although Red-tailed Tropicbirds breed on Raine Island, just to the east of the NPA (King 1993). Brown boobies have been regularly reported from all around the coast of the NT and Queensland, and in the offshore waters of the Gulf of Carpentaria (GoC) (Blaber & Milton 1994). They do not breed anywhere around the NT coast. The only recorded breeding locations within the NPA are Rocky and Manowar Islands within the Wellesley Islands (Garnett & Crowley 1987 a & b, Walker 1992b, Chatto pers. obs.) where both eggs and fledglings were present in July. Birds banded on these islands have been recovered along the west coast of Cape York Peninsula and near Mossman on the east coast. Brown boobies are found throughout the NPA all year round although records are less frequent away from the Wellesley s between May and August.

Darter, cormorants and Australian pelicans

The great cormorant is fairly uncommon within the NPA. However, the darter and other species of cormorants found in northern Australia are all common and widely distributed resident species around the coast and coastal wetlands of the NPA. All four species also breed in mangroves along the coast or along the downstream areas of rivers, as well as in freshwater wetlands inland from the coast. All except the pied cormorant spend most of their feeding time in freshwater wetlands inland from the coast. Cormorant species and darters breed either in single or mixed species colonies. Twenty-one have been recorded within the NT section of the NPA. Most breeding within the NPA occurs between February and August. Breeding numbers of individual species within these colonies vary from a few pairs to over 2500 pairs.

The Australian pelican is also commonly found in the habitats mentioned above throughout the NPA. Numbers vary greatly with large influxes after successful breeding in inland Australia is followed by dry conditions, as happened in 1978 and 2002. The only breeding within the NPA is in the Queensland section. Three sites have been recorded here; one on Rocky Island (King 1993), one on Austin Island at the mouth of the Smithburne River in the south-east of the GoC (Driscoll 2001) and the third between the mouths of the Bynoe and Flinders Rivers (Garnett pers. obs.). The number of breeding birds in any season varies from none to several thousand (B. Cropp pers. comm., Driscoll 2001). The only NT coastal breeding colony is on North Peron Island on the western side of the coast. Consequently, pelicans must move out of the NT part of the NPA to breed.

Frigatebirds

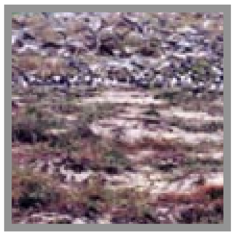
Of the two species that occur in Australia, only the lesser frigatebird is recorded regularly within the NPA. The only recorded breeding site within the NPA is on Manowar Island where a single greater frigatebird was observed breeding among several thousand lesser frigatebirds (Garnett & Crowley 1987a). Lesser frigatebirds are seen in both inshore and offshore waters throughout the NPA. They are more frequently seen closer to the coast in times of rough weather or at dusk when they may come in to roost on islands. There is one large permanent roost in tall forest near Weipa.

Raptors

Although a number of raptors hunt and breed along the coast, only three species are included here – the osprey, white-bellied sea-eagle and Brahminy kite. All three are resident species that are commonly recorded hunting, roosting and breeding around the coast and adjacent wetlands of the NPA. Many nesting sites have been located around the NT coastal part of the NPA, with some areas (for example, the smaller islands around Groote Eylandt) having particularly high densities of each species. Queensland has not been checked as thoroughly.

Jaegers and silver gulls

The small number of records of both the Pomarine and Arctic jaeger (Higgins & Davies 1996) suggest both species are uncommon within waters of the NPA. However, the very few surveys of pelagic water seabirds may be part of the reason for the small number of records. Silver gulls, on the other hand, are common and widespread in coastal and inshore waters of the NPA. About 20 breeding colonies have been located around the coast in the NT part of the NPA, but only the one has been reported from the Queensland part of the NPA. This is in the Wellesley Islands (Walker 1992b). These colonies tend to be smaller than those in the southern and eastern parts of Australia, but they appear to be increasing in numbers. Silver gulls are also clearly increasing in numbers around Darwin, to the west of the NPA.



Terns and noddies

Thirteen species of tern and two species of noddy have been recorded from within the NPA. The species within this group use the offshore and coastal waters and the coastal wetlands in a number of different ways. Some species are vagrants or have only occasionally been recorded in the area, but most species are numerous - at least at certain times of the year. Some species are resident and present all year in the area, while others migrate to breed – some into the area, others out of the area. Within this last group are some that breed elsewhere in the world and some that breed elsewhere in Australia. Common terns, for example, breed in the Northern Hemisphere, but can be seen in groups of many thousands in the NPA. Some species, for example, Caspian terns even have some individuals that breed in the NPA while others move out of the NPA to breed.

Over 100 tern and noddy breeding colonies have been located around the NT coastal section of the NPA. Some of these are, and others are among, the largest in the world. In the Queensland section of the NPA, the only colonies reported for these species are in the Wellesley Islands (King 1993) and the Cape York Peninsula mainland (Garnett 1985, Garnett & Bredl 1985). Some of the Wellesley colonies are also very significant. The number of colonies for each species varies between one and more than 30. With the exception of the little tern, which will also breed on mainland beaches, all colonies are on offshore islands. Breeding occurs from the beginning of March to the end of December. Some species breed in one set season, others in two distinct seasons or spread throughout a large part of the year. Breeding numbers of individual species within these colonies vary from a few pairs to over 25 000 pairs. As colonies have between one and five species, total colony sizes can be much larger. Details of two important NT seabird breeding islands can be found in Chatto (1998, 1999).

Other species

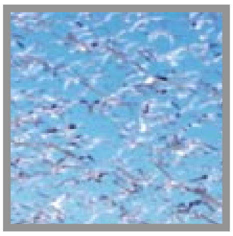
A number of other birds spend all, or at least most, of their time in mangrove habitats. These are not considered in this report but include representatives of species such as kingfishers, whistlers, flycatchers, gerygones, fantails and butcherbirds.

Significance of the species group in the Northern Planning Area

The NPA is an extremely important area for a number of the bird species considered in this report. The remoteness of the area and relative absence of human disturbance or development in the NPA are probably two of the main reasons for the large number of nationally and internationally significant colonial breeding sites for a number of species of terns. Some of these are the largest recorded breeding sites not only within Australia, but also in the world. Breeding colonies of roseate and crested terns involving more than 7500 and 50 000 birds respectively are probably the largest in the world for these species. Both species have at least two sites with close to this number of breeding birds. The more than 30 relatively undisturbed breeding sites for little tern (involving up to 200 birds at a single site) within the NT part of the NPA alone, is highly significant to a species that was formerly nationally endangered, and is still listed as such in some states. Further, it is almost certain that there are more breeding colonies along the Queensland coastal part of the NPA, judging by habitat observed during aerial surveys of the southern part of the GoC (Chatto pers. obs.).

The breeding site on the NT side of the GoC, which is regularly used by 5000 or more pied cormorants (easily the largest in the NT) is also of significance. There is also a high density of coastal raptors and their nests in the coastal mangroves and on a number of islands within the NT part of the NPA.

Traditional harvesting of tern eggs, particularly those of the crested tern, is culturally significant.



Impacts/threats

Most of the frequently documented impacts/threats to seabirds and their habitats around Australia apply to the NPA. In many cases, though, they are still minimal compared to other more populated coastal areas of Australia.

Potential and/or real impacts/threats to seabirds in the NPA include:

Climate change

Naturally occurring inclement weather conditions can adversely affect seabirds and their breeding sites throughout their range. In the far south or north of the world it is the cold and storms that cause problems, in the NPA it is the heat and cyclones. These things are natural and largely out of our control, but are generally not a long-term problem to seabird populations unless they occur in combination with other threats. Climate change with accompanying sea level rise is also another potential issue.

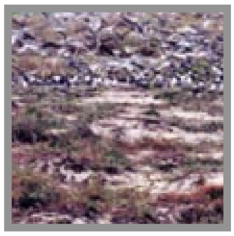
Human disturbance of breeding sites

Disturbing seabirds nesting on open ground in this region and thus causing them to leave eggs or small young exposed to the very hot weather can cause considerable losses. This can be a problem even in remote areas when boat/yacht travellers (or researchers) come ashore onto islands for a short time. They may not even know there are nesting seabirds present or, if they do, may not realise they are causing harm by keeping the adults from their nests. This only needs to occur once during the breeding cycle to do major harm to a colony. With so little of the area being monitored or patrolled, and what appears to be a steady increase in the number of boats (both sailing and fishing) in northern waters, this may be a more significant issue than we realise, and something that needs investigation.

At present, there are few registered tourist ventures taking people out to islands or other important seabird sites, unlike the situation along the eastern coast of Queensland. Most of the marine-type tourism in the NPA involves fishing and/or diving charters, although it is possible that these people may go ashore from time to time. There are also several larger cruise vessels such as the *Coral Princess* and *True North* working the coast between Broome and Cairns. These vessels all have tender boats to ferry people ashore at various places. *True North* also has a helicopter, which then introduces low flying over sensitive wildlife sites as a threat as well as landing at these sites. Most of these shore visits are to Aboriginal communities but some may be to small islands to look at scenery and/or wildlife.

It is important that these cruise companies be educated about the harm that can be done by going ashore at sensitive wildlife sites such as seabird breeding colonies. Cruise ventures should be instructed not to approach certain sites. Such cruise activity is showing signs of increasing across northern waters. For example, *True North* is fairly new on the scene and taking advantage of a market with growing potential in the north of Australia. There are long waiting lists for clients on these cruises. It is important that the tour schedules of these cruise ships are obtained and checked for landing sites. As virtually all islands in the NPA are Aboriginal-owned, permits are required to land on them. Tourist ventures are unlikely to repeatedly risk their businesses by illegal trespass, so the permit system is one means of controlling future access to significant seabird islands. Government wildlife agencies and Aboriginal land councils need to work together to achieve protection of significant seabird breeding or roosting sites.

The driving of 4WD vehicles along beaches, particularly by Aboriginal people looking for turtle nests, is a frequent occurrence on the mainland and on larger islands. There is also some tourist beach-driving near larger towns such as Nhulunbuy. Although driving on beaches is probably a threat to more species of shorebirds, it is certainly a potential threat to some little tern colonies.



Fishing lines and hooks, discarded or lost nets and other rubbish

The problem of seabirds taking baited fishing hooks or getting tangled in fishing line, net or other rubbish is probably not as large over most of the NPA as it is around more heavily populated parts of coastal Australia. At the same time, it is also less likely to be found and/or reported in such remote areas. Large amounts of discarded net (much of it foreign and floating in from outside Australian waters) and a range of rubbish washes ashore along the mainland coast and islands of the eastern GoC. This is particularly so in the early dry when the south-easterly winds commence. This has not been shown to be a major problem for direct mortality of seabirds but it certainly has for a number of other species of wildlife, particularly marine turtles. The risk of long-line fishing killing brown boobies should also be assessed.

Introduced species

Introduced animals such as cats, dogs, pigs and rats can cause considerable damage to seabird nesting sites. Although some or all of these animals are present on some of the larger islands within the NPA, they have not yet been found on the smaller seabird nesting islands, except Rocky Island which has black rats. Truant Island off north-east Arnhem Land also has rats but no seabird breeding. It is doubtful that these introduced animals would survive for long on many seabird islands, mostly because of a lack of fresh water, but seabird colonies on some of the larger islands need to be monitored to prevent short-term intrusions by such predators.

Cane toads are moving fast through the Top End of the NT and have made it out onto some islands already. Cane toads eat anything they can swallow. Although it has not been shown that they eat young seabird chicks, it is likely they will, and so this threat needs to be monitored. A lack of water on most of these islands should help limit their spread. Nevertheless, the need for education about accidental transport, and monitoring sites such as barge loading areas, are important.

Virtually no work has been done to assess the potential impact of introduced (or native) vegetation over-growing seabird breeding sites. Whereas this is an issue and needs to be monitored it has not been seen to be a major threat at this stage.

Pollution

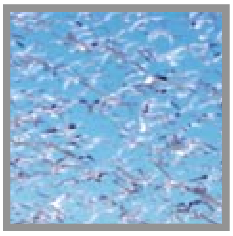
Pollution has not been a major issue in the NPA to date, but it is something that needs to be closely monitored as new farming and mining ventures arise that may discharge pollutants into the waterways flowing out to sea. The small size of most towns or outstations in the NPA means that smaller amounts of domestic or industrial wastes need to be disposed of. Monitoring these potential forms of pollution is important in remote areas where out of sight can sometimes mean out of mind.

Oil spills are always a potential source of major problems for seabirds but no major oil spills have been reported in the NPA to date. National and State/Territory contingency plans have been drawn up to reduce the chances of this happening and to minimise impacts on wildlife should a spill occur.

Shipping/aircraft

Although many small fixed-wing aircraft and helicopters regularly fly around the coast of the NPA, most flights are from town to town and in and out of regularly used strips. Even though this involves low-level flying over the coast in some places, it is not seen as a major threat (other than the occasional bird strike) because it has been happening for a long time in most locations and birds are used to it. There are not yet many tourist flights flying out and circling low over breeding islands or major roosts, but this activity may develop more in the future and needs to be monitored.

Similarly, ships with large amounts of lighting, or the potential to leak fuel or dispose rubbish near seabird islands is also unlikely to be a major issue in the NPA at this stage.



Mining

No mining is carried within the area of the NPA. However, there are several mines inland from the coast. These have the potential to cause problems for seabirds through spillages in the upper catchment of rivers that make their way to the sea or at coastal loading ports. Major mining activities currently occur at Gove, Groote Eylandt, McArthur River, Nicholson River and Weipa but no major effects on seabirds have been noticed at this stage. As with many of the potential threats in the NPA, the remoteness of much of the area means problems may go undetected unless strict monitoring programs are put in place. These programs need to be monitored by government agencies or groups independent from the mine operators to ensure compliance.

Fishing

The large amount of trawl discard from the Northern Prawn Fishery has certainly increased the amount of food available to species such as silver gulls, boobies, frigatebirds, raptors and a few species of tern. This has probably led to a population increase for some species. This may then in turn be detrimental to other species through breeding site competition or direct predation. This latter problem particularly applies to increasing numbers of silver gulls. It should also be remembered that such large kills of small fish, squid etc may reduce the food available for those species that do not pick up trawl discards.

Traditional hunting and burning

The hunting of adult seabirds does not seem to be a common practice, either now or in the past. However, the traditional take of seabird eggs from some islands has been occurring for a long time. Although there has been no scientific study of the long-term effect, it does not seem, on its own, to be an unsustainable practice. Although all eggs might be taken from some of the smaller colonies, eggs taken from some of the larger crested tern colonies, usually represent only a small proportion of the colony. Anecdotal information from Aboriginal people and monitoring some of these long-harvested, regularly used sites over a number of years, does not indicate any obvious shrinking of colony size. In the years since prawn trawling began, effects on a species like the crested tern are more difficult to assess because of its preference for feeding on trawl discard (Blaber et. al. 1995).

The regular Aboriginal practice of burning islands (probably more for access than to help seabird breeding) may have positive and negative effects. Burning while birds are still breeding (Chatto 1995) is obviously detrimental, but burning between nesting seasons may keep the nesting sites open and prevent them becoming overgrown with vegetation – native or introduced.

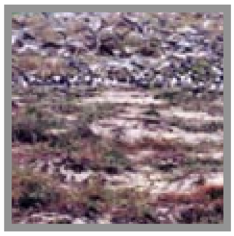
Aquaculture

Aquaculture is not yet a major industry within the NPA. However, it is increasing, particularly with the setting up of oyster leases in remote areas. So far no obvious problems for seabirds have been observed. This could be due to the lack of observation of operations in such remote areas. Again, because aquaculture operations have the potential to cause problems if poorly managed, non-operator monitoring of these sites is essential. Even issues such as staff visiting surrounding islands in their time off need to be monitored/controlled, and this can be difficult in such remote areas. Acid sulphate soils have been identified as a potential problem for aquaculture ventures in the GoC (Parish & Garnett 1990).

Information gaps

Three of the more important gaps in information are primarily a consequence of the remoteness of the NPA. Firstly the difficulty and cost of surveying such areas in the past has led to a lack of base-line knowledge of which seabirds are present, let alone whether they are under any threat. The other key issues associated with remote, unpopulated areas are the lack of reporting of potential problems and the difficulty/cost of organising monitoring programs to detect threatening processes.

In the last 14 years a large amount of baseline fauna surveying has been done around the inshore waters and adjacent coastal wetlands of the NT section of the NPA. This information is progressively being published in a series of detailed reports relating to a range of different species groups. It has also provided substantial information on the status and distribution of seabirds in an area for which very little had been previously recorded. From this baseline data it is now proposed, within the NT, to select certain sites/species for future monitoring to assess their ongoing status. Similar surveys are required along the equally remote Queensland coastal section of the NPA where data have been collected less systematically.



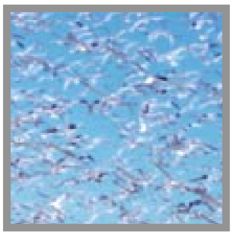
Much more survey work in the offshore waters of the entire NPA is also needed. Few surveys have been undertaken in the past. Should plans be approved for the NT Parks and Wildlife Service to extend the previous coastal surveys further offshore to cover a range of fauna species, this should help increase knowledge of the status and distribution of seabirds in these areas. However, all such future survey needs for the NPA should involve cooperation between the NT, Queensland and the Australian Governments rather than each working independently, as has often happened in the past. Similarly a coordinated approach to producing area or species management plans/actions is needed, because wildlife is distributed widely among jurisdictions.

Such coordination and cooperation should extend not just across the Parks and Wildlife sections of each of these governments, but also to other government departments, non-government organisations and other stakeholders. This is even more important in remote areas. One of many simple examples would be to train fisheries department observers who go out on fishing boats to record fish catches to also record wildlife observations. This would be an effective way to increase wildlife baseline data from remote areas. Promoting and assisting bird interest groups, either to undertake observational surveys or banding programs, should also be encouraged. Working with traditional inhabitants can give access to many years of knowledge and provide assistance with monitoring programs. There is a risk of traditional local knowledge being lost as older Aboriginal people die without passing this information on to the next generation.

Key references and current research

Key databases for the NT are held by the Parks and Wildlife Service. These databases contain over 70 000 fauna records from around the coast and Top End wetlands of the NT. Between half and two-thirds of this information comes from the NPA section of the NT. These records cover a number of wildlife species groups, several thousand would relate to seabirds. These basic databases are being progressively edited and corrected as individual reports are written on selected species groups. To date, most seabird and shorebird species records have been checked. However, the waterbird report is still in preparation so data on a number of species of aquatic birds using the NPA are yet to be finalised. Completed reports, and those currently being written, have been previously referred to in the 'Habitat and distribution' section of this chapter.

The Museum and Art Gallery of the NT, the Queensland Museum and probably other state museums, hold specimens and their associated information. These data will become more easily accessible when OZCAM (Online Zoological Collections of Australian Museums) comes online to the public from the NT section of the NPA (H. Larson pers. comm.).



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6. Shorebirds

This chapter should be cited as:
Chatto, R, O'Neill, P, Garnett, S & Milton, D (2004). Shorebirds. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office. Hobart, Australia.

Red-capped plover: a shorebird which can be found on offshore islands, the coast and both saline and freshwater wetlands inland from the coast. ***Source:*** *Ray Chatto*

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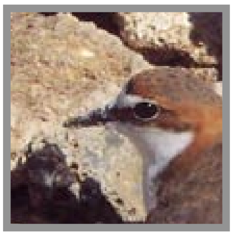
Species group name and description

Birds that have been traditionally referred to as shorebirds in Australia include all, or representatives of: avocets, curlews, dotterels, godwits, gulls, jacanas, jaegers, lapwings, oystercatchers, plovers, pratincoles, sandpipers, skuas, snipe, stilts, terns and thick-knees. Although some species are regularly regarded as shorebirds, there is no set list. A number of species referred to as shorebirds by some authors are listed as seabirds or waterbirds by other authors.

The reports being done for the Northern Planning Area (NPA) scoping study include one on shorebirds and one on seabirds, but there is not one specifically reporting on waterbirds. A number of birds traditionally referred to as 'waterbirds' use the marine environments of the NPA for feeding, roosting and breeding. Some of the largest waterbird breeding colonies in Australia, for example, are in mangroves along the coast of the Northern Territory (Chatto 2000b).

This chapter on shorebirds, in combination with the previous chapter on seabirds, will consider all 'aquatic' birds for which the tidally effected coastal wetlands and rivers, estuaries, intertidal zones, or waters seaward of the low water mark in the NPA are a significant part of their life cycles. Those species traditionally



referred to as waterbirds will be considered in the most appropriate of each of these two reports. In order to put all species into one of the reports they have been separated on the basis of those that feed primarily in marine waters by wading (shorebirds) and those that feed by flying or swimming (seabirds). This is somewhat arbitrary but it allows all aquatic birds to be covered using only two groupings. On this basis there are in excess of 40 species classified here as shorebirds, that have been recorded within the NPA.

Status

All species, or parts of, and their eggs are protected under Northern Territory (NT) and Queensland legislation within three nautical miles of the coast, and under Australian Government legislation from there to the EEZ line. Shorebird species of conservation significance (35 species) and their listings by various assessments, are shown in Table 6.1.

Table 6.1: *Seabird species of conservation significance in the Northern Planning Area.*

Species	Common Name	Jamba	Camba	Bonn	IUCN	CITES	NT	QLD
Ardea garzetta	Little egret	-	-	-	-	III	LC	-
Ardea sacra	Eastern-reef egret	-	+	-	-	-	LC	-
Ardea alba	Great egret	+	+	-	-	III	LC	-
Ardea intermedia	Intermediate egret	-	-	-	-	-	LC	-
Ardea ibis	Cattle egret	+	+	-	-	III	LC	-
Plegadis falcinellus	Glossy ibis	-	+	II	-	-	LC	-
Ephippiorhynchus asiaticus	Black-necked stork	-	-	-	LR/nt	-	LC	-
Limosa limosa	Black-tailed godwit	+	+	II	-	-	LC	-
Limosa lapponica	Bar-tailed godwit	+	+	II	-	-	LC	-
Numenius phaeopus	Whimbrel	+	+	II	-	-	LC	-
Numenius madagascariensis	Eastern curlew	+	+	II	-	-	LC	Rare
Tringa totanus	Common redshank	-	+	-	-	-	NE	-
Tringa stagnatilis	Marsh sandpiper	-	+	II	-	-	LC	-
Tringa nebularia	Common greenshank	+	+	II	-	-	LC	-
Xenus cinereus	Terek sandpiper	+	+	II	-	-	LC	-
Actitis hypoleucos	Common sandpiper	+	+	II	-	-	LC	-
Tringa brevipes	Grey-tailed tattler	+	+	II	-	-	LC	-
Tringa incanus	Wandering tattler	+	-	II	-	-	NE	-
Arenaria interpres	Ruddy turnstone	+	+	II	-	-	LC	-
Limnodromus semipalmatus	Asian dowitcher	-	+	II	-	-	NE	-
Calidris tenuirostris	Great knot	+	+	II	-	-	LC	-
Calidris canutus	Red knot	+	+	II	-	-	LC	-
Calidris alba	Sanderling	+	+	II	-	-	LC	-
Calidris ruficollis	Red-necked stint	+	+	II	-	-	LC	-
Calidris acuminata	Sharp-tailed sandpiper	+	+	II	-	-	LC	-
Calidris ferruginea	Curlew sandpiper	+	+	II	-	-	LC	-
Limicola falcinellus	Broad-billed sandpiper	+	+	II	-	-	NE	-
Esacus magnirostris	Beach thick-knee	-	-	-	LR/nt	-	LC	Vul
Haematopus fuliginosus	Sooty oystercatcher	-	-	-	-	-	LC	Rare
Himantopus himantopus	Black-winged stilt	-	-	II	-	-	LC	-
Recurvirostra novaehollandiae	Red-necked avocet	-	-	II	-	-	LC	-
Pluvialis squatarola	Grey plover	+	+	II	-	-	LC	-
Charadrius ruficapillus	Red-capped plover	-	-	II	-	-	LC	-
Charadrius mongolus	Lesser sand plover	+	+	II	-	-	LC	-
Charadrius leschenaultii	Large sand plover	+	+	II	-	-	LC	-

Jamba = Listed under the Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment.

Camba = Listed under the Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment.

Bonn = Listed under the Convention on the Conservation of Migratory Species of Wild Animals. (All are listed under Appendix II).

IUCN = 2002 International Union for the Conservation of Nature Red List of Threatened Species.

NT = Listing under the Northern Territory Threatened Species List (NE= not evaluated, LC = least concern, DD = data-deficient).

QLD = Listing under the Queensland Threatened Species List (Rare or vulnerable).

No species are listed under the Environmental Protection and Biodiversity Conservation Act 1999.

Species names follow Christidis and Boles (1994).

Although a number of the species are listed on JAMBA and CAMBA, none are listed as vulnerable or endangered under NT legislation. Within Queensland the beach thick-knee is listed as vulnerable and the eastern curlew and sooty oystercatcher are listed as rare. Although the general status and distribution of most species considered in this report has been quite thoroughly surveyed in recent years within the inshore part of the NT, none of the species has been studied to the extent of species overviews or management/monitoring plans being written for them.

Three species are listed in Garnett and Crowley (2000) as threatened and given a taxonomy summary. All are listed as of least concern. They include the great-billed heron, black-necked stork and beach thick-knee.

There are currently no Ramsar or East Asian-Australasian Shorebird Reserve Network sites within the NPA. However, several sites would qualify on the basis of numbers of birds. Some examples from within the NT can be seen in Chatto (2000a). On the NT side of the NPA there is one National Park – the Barranyi (North Island) National Park which is part of the Sir Edward Pellew Islands. On the Queensland side the wetlands of the south-east Gulf of Carpentaria (GoC) have been identified as important sites. The area also meets the BirdLife International criteria as an internationally Important Bird Area.

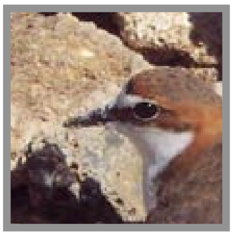
The Department of Environment and Heritage is currently developing a Wildlife Conservation Plan for migratory shorebirds in Australia. The plan will set out the research and management actions necessary to support survival of migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999*. The plan is a statutory document and is also intended to describe the actions required in Australia to implement the Action Plan for the Conservation of Shorebirds in the East Asian – Australasian Flyway.

Habitat and distribution

As such a wide diversity of species is covered in this chapter, comments on their habitat and distribution are divided into groups of ecologically and/or taxonomically similar species. In terms of the NT, all species have been, or will be, reported on in detail in a series of Parks and Wildlife Service technical reports (Chatto 2000b, 2001, 2003, in prep.). These reports are based on extensive coastal and coastal wetland fauna surveys conducted throughout the 1990s. Fewer shorebird surveys have been done within the Queensland section of the NPA. The only surveys done in Queensland were a series of aerial shorebird surveys along the coast during the early 1980s by Stephen Garnett and others, and some more detailed surveys in the of the southeastern GoC by the Queensland wader studies group in 1998/9 (Driscoll 2001). Unless otherwise referenced, most of the species group information detailed below is taken from these works.

Herons, egrets and ibis

For the purposes of this chapter 12 species from the herons, egrets and ibis groups are considered as shorebirds found in the NPA. The species from this group feed, roost and/or breed around the coast or adjacent saline wetlands within the NPA. Some species are also regularly found on islands. Eleven of the 12 species are common and widespread resident species. The great-billed heron is also a resident species but less commonly seen. As well as breeding in freshwater wetlands inland from the coast, a number of species also breed in large mixed species colonies in mangroves along the coast or along the downstream banks of rivers. Some of the species from these breeding colonies spend some of their time feeding along the coast or in coastal saline wetlands, whereas others move to freshwater wetlands inland to feed. Most colonial breeding within the NPA occurs between February and August. Numbers of individuals breeding within these colonies vary from a few pairs to several thousand



pairs. The largest colony around the NPA coast is near the mouth of the Roper River in the NT. It regularly contains nearly 10 000 breeding birds. In Queensland there are substantial colonies on the Coleman, Mitchell, Nassau, Norman, Bynoe and Flinders Rivers (Garnett 1985, Driscoll 2001, Garnett, S pers. obs.).

Black-necked storks and chestnut rails

The black-necked stork and chestnut rail are both widespread, breeding residents. The black-necked stork is commonly seen feeding and nesting in coastal and freshwater areas. The chestnut rail is a secretive species that is still quite common in the NT but has not been reliably recorded in Queensland for over a century. Although it is usually thought of as a mangrove bird, it is also often seen on vegetated, rocky islands, with few or no mangroves.

Sandpipers, curlews and godwits

Around 20 species of sandpipers, curlews and godwits occur regularly within the NPA and feed and roost around the coast or adjacent saline wetlands. Suitable islands are also used, but more by some species than others. All are Northern Hemisphere breeding migrants that migrate into the area around September and leave around March. Over-wintering numbers can also be very high, indicating that many birds do not migrate north to breed each year. Most of those birds staying behind would be very young or very old birds. Many birds remain in the NPA after migrating from the north, but others use the NPA as a refueling stopover en route to another location. Most species are extremely numerous, obviously more so at some times in the year. Some of these species spend some of their time feeding along the coast or in coastal saline wetlands, whereas others also use freshwater wetlands further inland from the coast.

Beach thick-knees, pied and sooty oystercatchers

Beach thick-knees, pied and sooty oystercatchers are all common and widespread breeding residents of the NPA, although the sooty oystercatcher is less common in most of Queensland as most of the coast lacks the rocky habitat it requires. However, it is a common resident in the Wellesley Islands. Within the NPA these are mostly seen as single birds, pairs or small roosting groups, although larger roosting groups of oystercatchers are sometimes seen. All species are rarely found away from the coast of either the mainland or islands. Sooty oystercatchers tend to prefer islands but the other two are equally common on the mainland. They are all solitary ground-nesting birds that usually lay their eggs on sand, shell or coral rubble areas.

Black-wing stilts and red-necked avocets

Black-wing stilts and red-necked avocets can both be found throughout the year, though numbers tend to be higher in the dry season. The stilts are more widespread and more often recorded than avocets. However, many thousands of the latter can still be found on some of the bare saline wetlands just inland from the coast at certain times. Both species mainly feed and roost on wetlands, both saline and fresh, although stilts will sometimes be seen roosting along the coast, and very occasionally on islands. Apart from rare records of breeding stilts, all birds move out of the NPA to breed. Data collected on these species for the NT side has yet to be fully analysed, but if birds move to intermittently flooded inland wetlands to breed, then their movements in and out of the NPA maybe irregular.

Plovers and lapwings

Five species of plover and lapwing occur within the NPA. They contain a mix of migratory and breeding resident species, all of which are common and widespread throughout the NPA. The species within this group use offshore islands, the coast and both saline and freshwater wetlands inland from the coast. Masked lapwings are also very common on short grass areas in towns and communities.

Other species

A number of other species spend all, or at least most, of their time in mangrove habitats. These are not considered in this report but include representatives of species such as kingfishers, whistlers, flycatchers, gerygones, fantails and butcherbirds.

Significance of the species group in the Northern Planning Area

Large sections of the NPA coast and adjacent wetlands are extremely important for shorebirds. The remoteness of the area and relative absence of human disturbance or development in the NPA are probably two of the main reasons for the large number of nationally and internationally significant sites in this area. The significance of shorebirds in the NPA relates not to the presence of threatened species but to the large numbers of most species. This is partly due to the large amount of relatively undisturbed shorebird habitat still present in the NPA and the large number of rivers that nourish the extensive intertidal flats.

Within the NPA there are at least 20 large mixed heron/egret breeding colonies on or close to the coast in the NT and five in Queensland. Some of these

are of national significance. There are numerous sites along the coast in the western (NT) part of the NPA and around the southern half of the GoC that support feeding and roosting groups of migratory shorebirds that number in excess of 10 000 birds at each site. Populations of many of the more solitary shorebirds such as black-necked storks, beach thick-knees and pied oystercatchers, are larger than in many other coastal areas of Australia. For example, single roosts of over 300 pied oystercatchers are significantly larger than have been recorded elsewhere in Australia.

Impacts/threats

Most of the frequently documented impacts/threats to shorebirds and their habitats around Australia apply to the NPA. However, in many cases they are still minimal compared to other more populated coastal areas of Australia. It should also be kept in mind that, in managing species that migrate between Australia and elsewhere, consideration should be given where possible to potential threats in parts of their range outside Australia.

Potential and/or real impacts/threats to shorebirds in the NPA include:

Climate change

Naturally occurring inclement weather conditions can adversely affect feeding habitats, breeding sites and flight movements throughout their range. In the far south or north of the world it is the cold and storms that cause problems, in the NPA it is the heat and cyclones. (Northern Hemisphere migrants often have to deal with both.) These things are natural and largely out of our control, but are generally not a long-term problem for shorebird populations unless they occur in combination with other threats. Climate change with associated sea level rise is another potential issue, although this may in fact be an advantage to shorebirds.

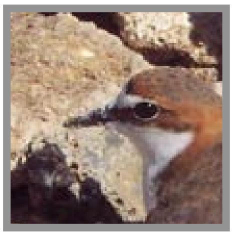
Human disturbance

Disturbing shorebirds nesting on open ground in this region and thus causing them to leave eggs or small young exposed to the very hot weather can cause considerable losses. This can be a problem even in remote areas when boat/yacht travellers (or researchers) come ashore onto islands for a short time. They may not even know there are nesting birds presentor, if they do, may not realise they are causing harm by keeping the adults from their nests. With so little of the area being monitored/patrolled, and what appears to be a steady increase in the number boats (both sailing and fishing) in northern waters, this may be a more significant issue than we realise, and something that needs investigation.

Migratory species are also subject to disturbance by people at their high-tide roosting sites. Putting such birds to flight can cause two major problems. First, as most need to spend a lot of their day feeding, disturbing their valuable resting time is a problem. Second, constantly being put to flight causes birds to lose body condition. This is particularly crucial before, during and just after long migration flights.

At present there are few registered tourist ventures taking people to important shorebird sites, such as occurs along the eastern coast of Queensland. Most of the marine-type tourism in the NPA involves fishing and/or diving charters, although it is possible that these people may go ashore from time to time. There are also several larger cruise vessels such as the *Coral Princess* and *True North* working the coast between Broome and Cairns. These vessels all have tender boats to ferry people ashore at various places. *True North* also has a helicopter, which then introduces low flying over sensitive wildlife sites as a threat as well as landing at these sites. Most of these shore visits are to Aboriginal communities but some may be to small islands to look at scenery and/or wildlife. It is important that cruise companies be educated about the harm that can be done by going ashore at sensitive sites, and instructed about sites that they should not go near. Such cruise activity is showing signs of increasing across our northern waters. *True North*, for example, is fairly new on the scene and tapping in on a market with growing potential in the north of Australia. There are long waiting lists for clients on these cruises. It is important that the tour schedules of these cruise ships are obtained and checked for landing sites. As virtually all islands in the NPA and much of the coast is owned by Aboriginal people, permits are required to land or go ashore. Tourist ventures are unlikely to repeatedly risk their businesses by illegal trespass, so the permit system is one means of controlling future entry onto significant sites. Government wildlife agencies and Aboriginal land councils need to work together to achieve protection of significant shorebird sites.

The driving of 4WD vehicles along beaches, particularly by Aboriginal people looking for turtle nests, is a frequent occurrence on the mainland and larger islands. There is some amount of tourist beach-driving near larger towns such as Nhulunbuy. This can have considerable local detrimental effect on ground-nesting or high-tide roosting shorebirds.



Fishing lines and hooks, discarded or lost nets and other rubbish

Unlike seabirds, most species of shorebird are unlikely to take baited fishing hooks, but they can certainly suffer from entanglement in fishing line, net or other rubbish. This is perhaps not as big an issue over most of the NPA as it is around more heavily populated parts of coastal Australia. However, it needs to be monitored in the NPA, particularly because in this large and remote area much of this may go unnoticed or unreported. One problem area that is known about is the eastern GoC coast. Here, large amounts of discarded net (much of it foreign and floating in from outside Australian waters) and a range of rubbish washes ashore, particularly in the early dry season when the south-easterly winds commence. This has not been shown to be a major problem for direct mortality of shorebirds but it certainly has been for a number of other species of wildlife, particularly marine turtles.

Introduced species

Introduced animals such as cats, dogs, pigs and rats can cause problems for ground-nesting shorebirds, although the dispersed nature of their nesting means that the problem is less intense than for colonial nesting seabirds. It is doubtful that these introduced animals would survive on many of the smaller islands, mostly because of a lack of fresh water. However, such introduced predatory animals are present around much of the coastal mainland and larger islands. Important sites in these areas need to be monitored. Dogs chasing roosting or feeding shorebirds, particularly prior to, or just after migration, can be a problem.

Cane toads are continuing their movement north and west and are now found throughout most of the mainland part of the NPA, as well as on some of the islands. Predation by cane toads of young ground nesting shorebirds chicks could be a problem. A bigger threat will be posed to those species of shorebirds, such as egrets and herons, which will prey on the poisonous cane toads, their tadpoles or their eggs. Until a means of controlling cane toads is found it is likely that they will eventually reach most of the mainland habitats used by shorebirds. However, their arrival on islands can perhaps be controlled. Education about accidental transport and monitoring of sites such as barge loading areas are important.

The spread of certain species of introduced vegetation onto freshwater wetlands is becoming one of the more serious threats to freshwater wetlands in the NPA. Species such as olive hymenachne or mimosa are turning open wetlands into monocultures of thick, closed vegetation. Whether or not a similar problem may be occurring on the saline wetlands included as part of the NPA or coastal beach habitats is unknown.

Pollution

Pollution has not yet been seen to be a major issue in the NPA, but it is something that needs to be closely monitored as new farming and mining ventures arise that may discharge pollutants into the waterways flowing out to sea. The small size of most towns or outstations in the NPA means that there are smaller amounts of domestic or industrial wastes for disposal. Monitoring these potential forms of pollution is important in remote areas where out of sight can sometimes mean out of mind.

Oil spills are always a potential source of major problems for shorebirds but no major oil spills have been reported in the NPA to date. National and State/Territory contingency plans have been drawn up to reduce the chances of this happening and to minimise the effects on wildlife should a spill occur.

Shipping/aircraft

Although many small fixed-wing aircraft and helicopters regularly fly around the coast of the NPA, most flights are from town to town and in and out of regularly used strips. Even though this involves low-level flying in and out over the coast in some places, it is not seen as a major threat (other than the occasional bird strike) because it has been happening for a long time in most locations and birds are used to it. There are not yet many tourist flights flying out and circling low over significant shorebird sites, but this may develop more in the future and needs to be monitored.

Similarly, the occurrence of ships with large amounts of lighting, or the potential to leak fuel or dispose rubbish near important shorebird sites is also unlikely to be a major issue at this stage in the NPA.

Mining

No mining is carried out within the area of the NPA. However, there are several mines inland from the coast. These have the potential to cause problems for shorebirds through spillages in the upper catchment that make their way to the sea or at coastal loading ports. Major mining activities currently occur at Gove, Groote Eylandt, McArthur River, Nicholson River and Weipa but no major effects on shorebirds have been noticed at this stage. As with many of the potential threats in the NPA, the remoteness of much of the area means

problems may go undetected unless strict monitoring programs are put in place. These programs need to be monitored by government agencies or groups independent from the mine operators to ensure compliance.

Traditional hunting and burning

None of the species of shorebird considered in this chapter is likely to be hunted or have their eggs collected by Aboriginal people to any great extent. However, the burning of wetlands and their buffer area affects some of the saline wetlands considered as part of the NPA. Whether this is good or bad for the area is not well understood and needs to be studied further. In some cases it may actually be beneficial in opening up areas that have become covered with introduced weeds such as olive hymenachne.

Aquaculture

There is an increasing number of oyster leases being set up in remote areas, but in general aquaculture is not yet a major industry within the NPA. Nevertheless, much of the coastline has been identified as having some level of suitability and this could have a devastating effect on the suitability of supratidal wetlands for waders. As yet no obvious problems have been observed for shorebirds, but this could be due to a lack of observation of operations in such remote areas. Again, with aquaculture operations having the potential to cause problems if poorly managed, monitoring of these sites by an independent party is essential. Even issues such as staff visiting surrounding islands in their time off need to be monitored/controlled, and this can also be difficult in such remote areas.

Information gaps

Three of the more important gaps in information are primarily a consequence of the remoteness of the NPA. Firstly, the difficulty and cost of surveying such areas in the past has led to a lack of baseline knowledge of which shorebirds are present, let alone whether they are under any threat. The other key issues associated with remote, unpopulated areas are the lack of reporting of potential problems and the difficulty/cost of organising monitoring programs to detect threatening processes.

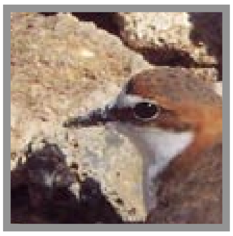
In the last 14 years a large amount of baseline fauna surveying has been done around the inshore waters and adjacent coastal wetlands of the NT section of the NPA. This information is progressively being published in a series of detailed reports relating to a range of different species groups. It has also provided substantial information on the status and distribution of shorebirds in an area for which very little had been previously recorded. From this baseline data it is now proposed, within the NT, to select certain sites/species for future monitoring to assess their ongoing status. Similar surveys are required along the equally remote Queensland coastal section of the NPA where data have been collected less systematically.

Much more survey work in the offshore waters of the entire NPA is also needed. Few surveys have been undertaken in the past. Should plans suggested to the NT Parks and Wildlife Service to extend the previous coastal surveys further offshore to cover a range of fauna species be approved, this should help increase our knowledge of the status and distribution of shorebirds migrating over these areas. However, all such future survey needs for the NPA should involve cooperation between the NT, Queensland and Australian Governments and research agencies rather than each working in isolation, as has largely been the case in the past. Similarly a coordinated approach to producing area or species management plans/actions is needed, because wildlife is distributed widely among jurisdictions.

Such coordination and cooperation should extend not just across the Parks and Wildlife sections of each of these governments, but also to other government departments, NGOs and other stakeholders. This is even more important in remote areas. One of many simple examples would be to train fisheries department observers who go out on fishing boats to record fish catches to also record wildlife observations. This would be an effective way to increase wildlife baseline data from remote areas. Promoting and assisting bird interest groups, either to undertake observational surveys or banding programs, should also be encouraged. Working with traditional inhabitants can give access to many years of knowledge and provide assistance with monitoring programs. There is a risk of traditional local knowledge being lost as older Aboriginal people die without passing this information on to the next generation.

Key references and current research

Key databases for the NT are held by the Parks and Wildlife Service. These databases contain over 70 000 fauna records from around the coast and Top End wetlands of the NT. Between half and two-thirds of these records would be from the NPA section of the NT. Although these records cover a number of



wildlife species groups, several thousand records would relate to shorebirds. These basic databases are being progressively edited and corrected as individual reports are written on selected species groups. To date, most shorebird and seabird species records have been checked. However, the waterbird report is still in preparation so data on a number of species of aquatic birds using the NT are yet to be finalised. Completed reports, and those currently being written, have been previously referred to in the 'Habitat and distribution' section of this chapter.

The most detailed surveys for the Queensland side of the NPA for shorebirds are those reported in Driscoll (2001).

The Museum and Art Gallery of the NT, the Queensland Museum and probably other state museums, hold specimens and their associated information. These data will become more easily available when OZCAM (Online Zoological Collections of Australian Museums) comes online to the public from the NT section of the NPA (H. Larson pers. comm.).

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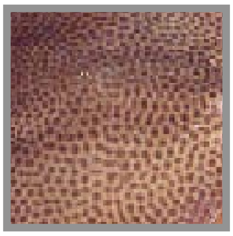

7. Sharks and Rays

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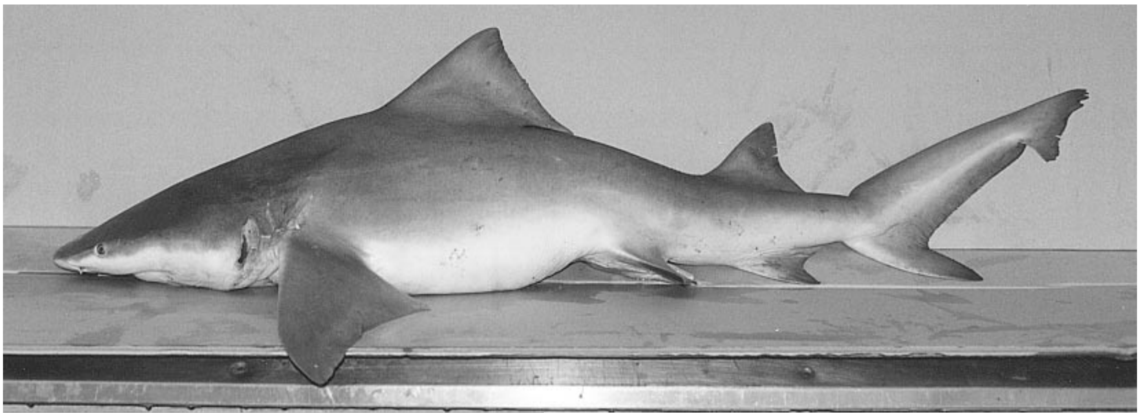
Speartooth shark, Glyphis sp. A ***Source:*** *Museum and Art Gallery of the Northern Territory*



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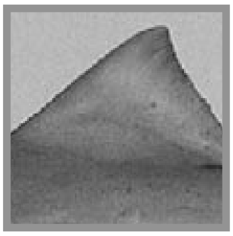
Sharks

Species group name and description

Sharks are cartilaginous fishes of the class Chondrichthyes, subclass Elasmobranchii, which includes all the living sharks, rays and sawfish (Compagno 1973). The shark fauna of Australia is extremely rich, with the most recent taxonomic review estimating that, of the about 1025 species of sharks and rays worldwide (Shark Advisory Group 2002), at least 297 species occur in Australian waters (Last & Stevens 1994). Of the 49 shark species found so far in the Northern Planning Area (NPA), 10 are endemic to Australia (Last & Stevens 1994). Current research indicates that a number of unidentified taxa exist, confused with presently recognised species (P Last pers. comm. 2003).

Sharks generally inhabit marine waters over a wide depth range, and a number of Australian sharks are found in estuaries and the lower freshwater reaches of rivers (Last & Stevens 1994). However, only three species in the NPA (*Carcharhinus leucas*, *Glyphis* sp. A and *Glyphis* sp. C) occur in the upper reaches of rivers well inland from the coast (Thorburn et al. 2003), with *Carcharhinus leucas* often found in pure fresh water.

Sharks are known by a range of common names which may vary regionally (there exists no 'standard' of names for fish), and some may have a marketing name (eg tropical shark, blacktip). Species presently known to be found in the NPA are shown in Table 7.1; the Australian scientific and common names mostly follow those in Last and Stevens (1994). Some alternative names are in use by other authors (eg Compagno & Niem 1998, Compagno 2001).



Status

The true status of most shark populations of the NPA is not known, with most of the present research effort being expended on commercially caught species. Shark species of conservation significance, and their listings by various assessments, are shown in Table 7.2. Sharks could be afforded some protection by specific listings such as these, but habitat protection is essential, in fish reserves or National Parks. The two species of *Glyphis* (speartooth sharks) are the least-known within the area, and it is suspected that their distribution is patchy and limited by specific habitat requirements not yet understood.

In the Northern Territory (NT) portion of the NPA, only one marine protected area exists: the 5381 hectare (ha) Barranyi (North Island) National Park in the Sir Edward Pellew Group. Gazetted in 1991, it is managed by the Parks and Wildlife Commission of the NT as a National Park on Aboriginal land. The 100 000 ha Dhimurru Indigenous Protected Area (gazetted in 2000) in north-east Arnhem Land includes 8913 'marine' hectares down to the low water mark. Other areas that may afford some protection to both sharks (and rays) include coastal Aboriginal lands such as the Milingimbi Crocodile Island and Glyde River area, and the Castlereagh Bay/ Howard Island area.

In Queensland, there are no national parks within the NPA, but there are four Management 'A' Fish Habitat Areas (declared under the *Fisheries Act 1994*) from the Nassau River to Eight Mile Creek in the Gulf of Carpentaria (GoC).

Habitat and distribution

The life histories of most sharks within the NPA are either poorly known or not known at all. Available information on habitats, depth range and mode of reproduction is broadly summarised in Table 7.3 (adapted and revised from data in Table 7.1 in the Australian Shark Assessment Report and museum sources). Specific habitat preferences are not known for most species. Additional data and references are in Cavanagh et al. (2003). Habitats for sharks in the NPA include the turbid waters of the shallow (2-55 m) GoC, the fringing coral reefs around the coast and offshore rocky islands, the wide estuaries and seasonally flooding rivers to isolated shoals in the Arafura Sea, which is a relatively shallow (50–210 m) sea between Papua New Guinea and northern Australia (Russell & Houston 1989) and forms the major offshore shark habitat in the region.

The shallow inshore and estuarine coastal waters of the NPA form significant habitat for a wide range of shark species.

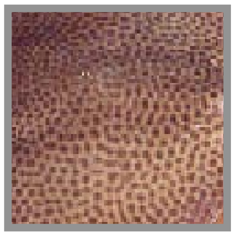
Most of the NPA shark fishery is coastal, carried out within 12 nautical miles of the coast or just off the coast (especially in the GoC). The total catch for 2002 in the Queensland GoC shark fishery was 180 t (caught by line and gill-net). The total commercial catch of sharks in the entire NT fishery in 2002 was 670 t (Coleman 2003). Since 1983 the catch of sharks in this fishery has been highly variable, fluctuating between 100 and 900 t. Sharks are also an incidental catch in commercial fisheries targeting other species, with NT landings from these fisheries ranging between 32 t and 64 t since 1994.

Recreational fishers in the NT catch sharks while fishing for other species, mostly around Darwin, Cobourg Peninsula and the McArthur River. In 1995, over 80 000 individuals were caught, but only 18% were retained, giving a harvest of 15 000 individuals (Coleman 2003). Reef fishing accounted for most (74%) of the total shark catch. In contrast, Henry and Lyle (2003) estimate the annual harvest of Queensland and NT sharks and rays (not distinguished) by recreational fishers as 43 841 individuals.

Indigenous fishing mostly takes place close to communities and outstations, in inland or near coastal waters. Sharks and rays are one of the more important groups of fish caught by indigenous coastal-dwelling people in the NT. In 2000, over 12 000 sharks and rays (not distinguished) were harvested, comprising just over 3% of the total finfish harvest (Coleman 2003). Henry and Lyle (2003) give an estimated harvest of 16 283 sharks and rays by indigenous fishers in Queensland and the NT.

The joint NT Fisheries-CSIRO Pelagic Fish Stock Assessment Program (in the 1980s) estimated that, in NT and neighbouring waters, the maximum sustainable yield for the blacktip sharks, *Carcharhinus tilstoni* and *C. sorrah*, was 3400 t annually (Coleman 2003). CSIRO tagging studies indicated that blacktip sharks form a single large stock throughout northern Australia, with relatively restricted movements between the Bonaparte Gulf and the GoC. A more recent assessment suggests a potential yield for the region of at least 2000 t per year (Coleman 2003).

Research, through age-structure modelling, indicates that the overall stock should have been increasing since the mid 1980s, when foreign gill-netter catches were greatly reduced, but data on catch per unit effort from the NT gill net fishery indicate a substantial decline in relative abundance since then, probably due to a range



of factors (Coleman 2003). Given these problems, the reliability for shark fishery stock assessment appears to be low, and the fishery is probably fully exploited.

Significance of the species group in the Northern Planning Area

Sharks were first documented in the NPA in rock art paintings by Aboriginal artists 8000 to 1500 years ago (Chaloupka 1993). Sharks are significant to Aboriginal coastal and estuarine dwelling groups on many levels. Sharks are highly prized food, and Aboriginal people look to seasonal markers to indicate the best time to hunt and gather them, using a range of techniques (Meehan 1982, Davis 1984, Waddy 1988). Shark livers are delicacies, and for some cultural groups the shark's liver has been elevated to the highest level of sacred object, reflecting the significant religious association of the shark and other animals as ancestral beings, responsible for the creation of various sites. For example, the shark ancestor of the Djambarrpingu group, Maarna, gouged out the track of rivers in their land then turned into a freshwater shark. Indigenous people derive their social identities from such totemic beings, and where these beings traversed the land of other groups of people, this forges an enduring bond between them. Clan groups associated with the shark in north-east Arnhem Land perform a shark dance during their Dhuwa Nara ceremonies and in the past the shark dance was also performed prior to a fight - to highlight its angry and dangerous nature. The power of this being and its potentially dangerous character is also emphasised by the Kunwinjku people in western Arnhem Land who associate it with the ambivalent force of the powerful rainbow serpent (M West, MAGNT, pers. comm. 2003).

Sharks are predators, regardless of shape or size, and are therefore of considerable ecological significance. Many species are top predators, taking large bony fishes as well as other vertebrates such as marine mammals and turtles.

There are a number of species of conservation significance in the NPA, including the two IUCN-listed Endangered species of *Glyphis* (Table 7.2). *Glyphis* are particularly problematic large sharks as both species appear to be undescribed and their true distribution and basic ecology is unknown. A number of *Carcharhinus* species are IUCN-listed as Near Threatened (based on fishing pressure elsewhere), but which have apparently healthy populations in the NPA.

The NT commercial shark fishery is of considerable economic significance, with a total of 19 licences in the NT fishery (most vessels employ a skipper and two or three crew members) (Coleman 2003). At the point of first sale in 2002, the commercial shark fishery was valued at $6.9 million. The blacktip shark (*Carcharhinus sorrah* and *C. tilstoni*) catch was valued at $1.6 million (in 2001, $1.5 million), with other sharks valued at $2.7 million (in 2001, $0.7 million).

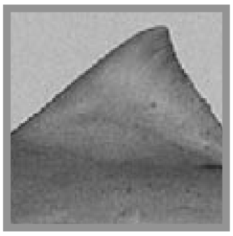
Recreational fishers in the NT catch sharks while fishing for other species. The NT recreational fishery is estimated to spend $267 033 695 annually. In 2002, there were 142 licensed fishing tour operators in the NT, but there has been no research carried out on their catches (Coleman 2003).

Impacts/threats

Fishing pressure, especially the commercial catch, is significant for some sharks such as *Carcharhinus leucas*, *C. sorrah*, *C. tilstoni* and other species of *Carcharhinus* and *Rhizoprionodon*. Stock assessments of the main target species, independent of the fishery, should be carried out, in collaboration with the foreign fisheries operating in the Arafura Sea outside the Australian waters. Shark resources in the NPA are presently shared by Australia, New Guinea, Indonesia and East Timor. A limit on the shark bycatch was agreed for the NT barramundi and coastal line fisheries in 2002, and a ban on possession of sharks and shark product was also agreed for the Timor Reef, demersal, finfish trawl and Spanish mackerel fisheries (Coleman 2003).

Deliberate post-capture mortality (eg finning) is a potential threat to populations under pressure. Shark finning is not specifically prohibited in the NT, but if any shark fins are taken, a set percentage of trunks or fillets must be kept on board. In Queensland the fins may only be removed if the shark body is retained. There is now a ban on all shark products (eg fins, jaws, fillets) in the Commonwealth-administered Northern Prawn Fishery, in which sharks may occur as bycatch. Overseas market demand for shark fin remains high.

Thorburn et al. (2003) found low catches of their target species (*Carcharhinus leucas* and *Glyphis* species) in northern Australian estuaries, and identified the potential threat of gill-netting and line fishing to the future sustainability of these species. Small sharks may be incidentally captured for mudcrab (*Scylla serrata*) bait in estuaries and brackish rivers by professional crabbers in the NT; several specimens of young *Glyphis* sp. A have been caught this way. The amount of shark harvested by crabbers is unknown (but is probably low).



Habitat changes, which possibly affect shark populations, that have been observed in the NPA are nearly always linked to cyclonic activity, such as that documented for Cyclone Kathy which affected the southern GoC region (Marsh et al. 1986). Substrate is reworked and buried, corals are killed, seagrass and algal beds disappear. Some areas of the southern Gulf are presently showing apparent signs of stress, maybe due to wide-scale reduction in seagrass beds (Kiessling & Josif, in litt. 2003).

Information gaps

Sharks occur over a wide range of habitats in the NPA, from offshore open waters to over 100 km inland in freshwater rivers. However, information on the occurrence of sharks and rays in the NPA is still scanty.

Basic biological information is lacking for almost all species of sharks in the NPA. The information summarised in Table 7.3 is from best guesses based on work mostly done elsewhere. It is acknowledged that what is true for one population or locality may be different for species in the NPA. Knowledge of habitat preferences and other ecological requirements, such as details of their breeding biology, distributional and migration patterns, is mostly lacking.

Fishery observer work is needed across the region, as logbooks are insufficient for the needed data collection (Coleman 2003); but this depends upon resources being available. It is possible that information on populations and their movements may be obtained by adopting the gene-tagging methodology developed for Spanish mackerel by NTDPIF (Buckworth & Martell 2003).

Knowledge of Aboriginal usage and the amount and species of sharks that they utilise needs to be understood. It is not known if the numbers and species taken are stable or have changed. Henry and Lyle's (2003) work shows the lack of basic data for Indigenous communities; although they do state that relevant data acquired during the 2000–2001 recreational fishing survey still remain to be worked up. Meehan (1982) documented traditional fishing around the Blyth River of the NT, where 500 kg of fish (including five species of sharks and rays in addition to 16 species of other fish) were obtained from a fish trap over a one-month period. Was this typical? Has fishing effort increased and have the methods used changed (eg more emphasis on gill nets and less on hand-spears or traps)? Anthropological studies are continuing in coastal Arnhem Land, but these works are generally hampered by lack of proper identification of species involved.

Key references and current research

Current work relevant to the NPA

FRDC project - Northern Australian sharks and rays: the sustainability of target and bycatch species, phase 2. Participants include WA, NT, Qld Fisheries, CSIRO Cleveland, and VIMS; project managed by John Salini.

Objectives of the project are to:

- collect catch composition data from target shark fisheries in northern Australia
- determine the management scale for target species (stocks)*
- evaluate effect of gillnet fishing (bycatch composition)
- derive biological parameters to assess the status of sawfish populations; age structure, reproduction and growth
- re-evaluate the risk assessment of northern chondrichthyans

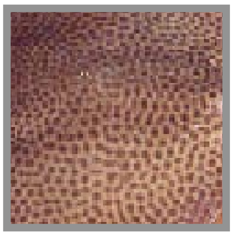
ACIAR Sharks & Rays Projects, Phase 1. Project managed by Steve Blaber.

Overall objective is to develop an understanding of the socioeconomic characteristics of the artisanal shark and ray fishery and to provide a preliminary assessment of the status of the fishery. Some specific objectives include to:

- evaluate the socioeconomic status of the artisanal fishery and to describe the main biological, catch and gear characteristics of the fishery
- develop a preliminary assessment of the status of the stocks and the extent to which they may be shared with Australia
- provide training and advice to Indonesian scientists with respect to issues that may be important with regard to possible alternative management options for the fishery

Key datasets are held at state museums in the form of specimens and their intrinsic information; this data will become more easily available when OZCAM (Online Zoological Collections of Australian Museums) comes online to the public. An FRDC-funded project on sharks and rays of northern Australia is ongoing (leader, John Salini, CSIRO).

References are listed in full after the section on Rays.



Rays

Leopard whipray tagged and released in north Queensland 2002 ***Source:*** *Stirling Peverell*

Species group name and description

Rays are cartilaginous fishes of the class Chondrichthyes, subclass Elasmobranchii, which includes all the living sharks, rays and sawfish (Compagno 1973). Australia has a rich ray fauna, with the most recent taxonomic review estimating that, of the about 1025 species of sharks and rays worldwide (Shark Advisory Group 2002), at least 117 ray species occur in Australian waters (Last & Stevens 1994). Of the 36 ray species found so far in the NPA, 10 are endemic to Australia. Species presently known to be found in the NPA are shown in Table 7.4; the scientific and common names mostly follow those in Last and Stevens (1994).

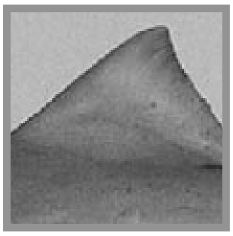
Rays generally inhabit marine waters (coastal and offshore), although a few Australian rays are found in estuaries and the lower freshwater reaches of rivers (Last & Stevens 1994). However, in the NPA only two rays (*Dasyatis fluviorum* and *Himantura chaophraya*) occur in oligohaline (range of low salinity) environments of the upper reaches of rivers, and may be found far from the coast.

Status

Ray species of conservation significance, and their listings by a range of agencies, are shown in Table 7.5. Rays are afforded some protection by specific listings such as these, but also by habitat protection in fish reserves or National Parks. Two rays of concern, *Dasyatis fluviorum* and Himantura chaophraya, are dependent upon estuarine to fresh water habitats, and their true distributions and populations are poorly understood.

Habitat and distribution

Almost nothing is known of the natural histories of rays within the NPA. They inhabit a wide depth range, although most species could be considered coastal. Rays are found among coral reefs, in mangrove creeks and estuaries as well as offshore. Rays appear to be long-lived, take a number of years to reach sexual maturity, have low fecundity and reach a large size as adults. Rays are carnivorous, but take mostly small prey items and many species have small crushing teeth.



Available information on habitats, depth range and mode of reproduction (mostly ovoviviparous or viviparous) is broadly summarised in Table 7.6 (data from Carpenter and Niem 1999 and museum sources). The table demonstrates the paucity of information on habitat preferences and basic life history of these fishes, and how few offspring are born. Gestation period and frequency of breeding is largely unknown. The skates (a largely deep-water group with only two species known so far from the NPA) are oviparous, placing their eggs, concealed in a horny pouch, on the substrate.

Significance of the species group in the Northern Planning Area

Rays were first documented in the NPA in rock art paintings by Aboriginal artists 8000 to 1500 years ago (Chaloupka 1993). Marine animals including stingrays are significant to Aboriginal coastal and estuarine dwelling groups on many levels. Aboriginal coastal people highly prize rays as food, and these fish play a role as seasonal indicators (Meehan 1982, Davis 1984, Waddy 1988). Economically rays continue to be an important source of food, even in urban areas, and people look to seasonal markers to indicate the best time to hunt and gather them.

Ray livers are delicacies and for some groups the livers have been elevated to the highest level of sacred object. This reflects the significant religious association of animals as ancestral beings, responsible for the creation of various sites. On Groote Eylandt, it is said that the Angurugu River was carved out by sawfish after the stingray was having trouble cutting though the land. People here derive their social identities from such totemic beings, and where the beings traversed through the land of other groups, this forges an enduring bond between them (M West, MAGNT, pers. comm. 2003).

Rays are carnivorous, but most species have crushing teeth, feeding on invertebrates such as molluscs and crustacea as well as fishes and small plankton organisms. Many shallow-dwelling rays make characteristic feeding depressions in soft sand or mud.

There are a number of ray species of conservation significance in the NPA, with the freshwater whipray (*Himantura chaophrya*) being the best-known. This species is listed as Vulnerable by the IUCN but is unlisted by the EPBC (in fact, no rays are EPBC-listed, probably due to lack of information). One of the difficulties with *Himantura chaophrya* is the uncertainty as to its identity, as the rays in Thailand (where the species was first described) are much larger than specimens presently known from northern Australia.

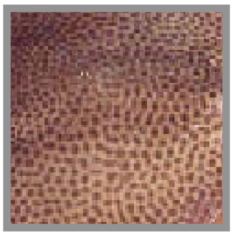
It is probable that the main non-commercial catch of rays is by indigenous coastal communities, for subsistence, using hand-spears and fish-traps. Meehan (1982) documented traditional fishing practices around the Blyth River, where 82 kg of stingrays (four species) were obtained over one month. It was not clear if these were all obtained by hand-spears or by a fish-trap, in which 500 kg of fish (including five species of sharks and rays) were obtained over a one-month period. Rays are caught by spears, hook and line, a variety of nets including community gill nets, and fish traps (stone and woven). The barbed spines from stingrays are often used to make fishing spear tips. Large rays such as *Manta*, *Mobula* and *Aetobatus* have spiritual significance for some Tiwi people from Bathurst and Melville Island and are not eaten (Puruntatameri et al. 2001) (this may be true for some other coastal communities).

Rays are of minimal economic significance in the NPA, although they are common in fishery catches. Rays are prized in South-east Asian fish markets, with ray species with large pectoral flaps ('wings') such as dasyatids mostly targeted. Shark-like species with large fins such as *Rhynchobatus* and *Rhina* may contribute to the shark-fin trade, although most rays lack sufficient ceratotrichia (the cartilaginous fin rays) to be used in this way. The level of 'finning' such rays in the NPA is unknown. Information on catches and bycatch is lacking (Carpenter & Niem 1999).

Impacts/threats

There are few reliable data available on population structures, fishery catch and bycatch of rays, and commercial and Indigenous fishing impacts are unknown. Foreign fishing impacts from outside the AEEZ are unknown. Many rays are of great commercial significance throughout Indonesia and Malaysia.

Freshwater stingrays with limited distributions are vulnerable to exploitation and habitat degradation, such as inappropriate agricultural practices in river catchments. Species dependent upon reefs and corals, such as *Taeniura lymma*, may be threatened by habitat loss (eg coral bleaching).



Information gaps

Adult rays may be quite large (and broad) and thus, because of their sheer size and difficulty with storage, are poorly represented in museum collections. Because of the lack of specimens, knowledge of the taxonomy and basic biology of rays is poor. Species identification is a major problem in managing rays (Pogonoski et al. 2002). The confusion over the large and conspicuous *Rhynchobatus* species is a case in point (generally considered to be *R. djiddensis*, but there are probably three species present in the NPA, none of which is *R. djiddensis*) (Carpenter & Niem 1998, Cavanagh et al. 2003).

Basic biological information and knowledge of habitat requirements is lacking for nearly all rays. Reliable catch data is required to assess populations and any declines. The Indigenous fishery is significant from community, economic and cultural viewpoints, but this remains relatively unstudied. Henry and Lyle's (2003) work shows the lack of basic data on Indigenous communities' fishing activities.

Key references and current research

Key datasets are held at state museums in the form of specimens and their intrinsic information; this data will become more easily available when OZCAM (Online Zoological Collections of Australian Museums) comes online to the public.

Current work relevant to the NPA

FRDC project - Northern Australian sharks and rays: the sustainability of target and bycatch species, phase 2. Participants include WA, NT, Qld Fisheries, CSIRO Cleveland, and VIMS; project managed by John Salini.

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- derive biological parameters to assess the status of sawfish populations; age structure, reproduction and growth
- re-evaluate the risk assessment of northern chondrichthyans

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- develop a preliminary assessment of the status of the stocks and the extent to which they may be shared with Australia
- provide training and advice to Indonesian scientists with respect to issues that may be important with regard to possible alternative management options for the fishery

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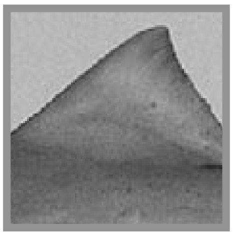

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7. Sharks and Rays

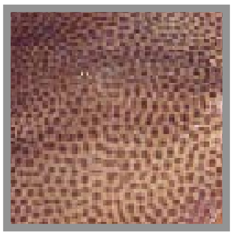
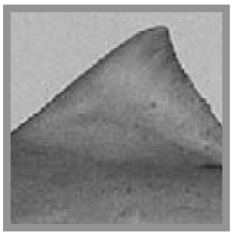


Table 7.1: *List of shark species known so far from the Northern Planning Area*

Scientific Name	Common Name	NPA Distribution	Status
Atelomycterus fasciatus (Compagno & Stevens 1993)	banded catshark	NT, Qld	Common; Australian endemic
Atelomycterus macleayi (Whitley 1939)	marbled catshark	NT	Probably common; Australian endemic
Brachaelurus colcloughi (Ogilby 1908)	blue-grey carpet shark	Qld	Uncommon; eastern Australian endemic
Carcharhinus albimarginatus (Rüppell 1837)	silvertip shark	NT, Qld	Poorly known, widespread in Indo-west Pacific
Carcharhinus amblyrhynchoides (Whitley 1934)	graceful shark	NT, Qld	Poorly known, widespread in Indo-west Pacific
Carcharhinus amblyrhynchos (Bleeker 1856)	grey reef shark	NT, Qld	Common, widespread in Indo-west Pacific
Carcharhinus amboinensis (Muller & Henle 1839)	pig-eye shark	NT, Qld	Common; eastern Atlantic to Indo-west Pacific
Carcharhinus brevipinna (Muller & Henle 1839)	spinner shark	NT, Qld	Common; eastern Atlantic and Mediterranean to Indo-west Pacific
Carcharhinus cautus (Whitley 1945)	nervous shark	NT, Qld	Poorly known; northern Australia; New Guinea and Solomon Islands
Carcharhinus dussumieri (Muller & Henle 1841)	white-cheek shark	NT, Qld	Common; Indo-west Pacific
Carcharhinus falciformis (Bibron 1839)	silky shark	NT, Qld	Common; circumglobal
Carcharhinus fitzroyensis (Whitley 1943)	creek whaler	NT, Qld	Not common; Australian endemic
Carcharhinus leucas (Valenciennes 1839)	bull shark	NT, Qld	Common; circumglobal
Carcharhinus limbatus (Valenciennes 1839)	blacktip shark	NT, Qld	Common; circumglobal
Carcharhinus macloti (Muller & Henle 1839)	hard-nose shark	NT, Qld	Common; Indo-west Pacific
Carcharhinus melanopterus (Quoy & Gaimard 1824)	black-tip reef shark	NT, Qld	Common; Indo-Pacific
Carcharhinus obscurus (LeSueur 1818)	dusky shark	NT, Qld	Common; circumglobal
Carcharhinus plumbeus (Nardo 1827)	sand-bar shark	NT, Qld	Common; circumglobal
Carcharhinus sorrah (Valenciennes 1839)	spot-tail shark	NT, Qld	Common; Indo-west Pacific
Carcharhinus tilstoni (Whitley 1950)	Australian black-tip shark	NT, Qld	Common; Australian endemic
Carcharias taurus (Rafinesque 1810)	grey nurse shark	NT, Qld	Common; circumglobal
Chiloscyllium punctatum (Muller & Henle 1838)	brown-banded catshark	NT, Qld	Common; Indo-west Pacific
Eucrossorhinus dasypogon (Bleeker 1867)	tasselled wobbegong	NT, Qld	Poorly known, locally common; Austral ia, New Guinea
Eusphyra blochii (Cuvier 1816)	winghead shark	NT, Qld	Common; Indo-west Pacific
Galeocerdo cuvieri (Peron & LeSueur 1822)	tiger shark	NT, Qld	Common; circumglobal
Galeus gracilis (Compagno & Stevens 1993)	slender saw-tail shark	NT, Qld	Not common; Australian endemic
Glyphis sp. A	speartooth shark	NT, Qld	Not common; Australian endemic
Glyphis sp. C	northern river shark	NT	Not common; may be Australian endemic
Hemigaleus microstoma (Bleeker 1852)	weasel shark	NT, Qld	Common; Indo-west Pacific
Hemipristis elongatus (Klunzinger 1871)	fossil shark	NT, Qld	Locally common; Indo-west Pacific
Hemiscyllium ocellatum (Bonnaterre 1788)	epaulette shark	NT, Qld	Common; Australia and New Guinea
Hemiscyllium trispeculare (Richardson 1843)	speckled carpet shark	NT, Qld	Common; Australia
Iago garricki (Fourmanoir & Rivaton 1979)	long-nose hound shark	NT, Qld	Uncommon; Australia and New Hebrides
Loxodon macrorhinus (Muller & Henle 1839)	slit-eye shark	NT, Qld	Common; Indo-west Pacific
Mustelus sp. A	grey gummy shark	NT	Uncommon; Australia
Nebrius ferrugineus (Lesson 1830)	tawny nurse shark	NT, Qld	Common; Indo-Pacific
Negaprion acutidens (Ruppell 1837)	lemon shark	NT, Qld	Common; Indo-west Pacific
Orectolobus ornatus (De Vis 1883)	banded wobbegong	Qld	Common; western Pacific



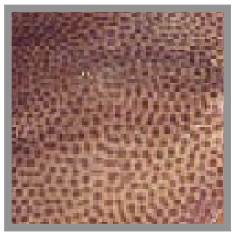
Scientific Name	Common Name	NPA Distribution	Status
Orectolobus wardi (Whitley 1939)	northern wobbegong	NT, Qld	Uncommon; Australian endemic
Pseudocarcharias kamoharai (Matsubara 1936)	crocodile shark	NT, Qld	Rare to locally common; Indo-Pacific
Rhincodon typus (Smith 1828)	whale shark	NT, Qld	Uncommon; circumglobal
Rhizoprionodon acutus (Ruppell 1837)	milk shark	NT, Qld	Common; Indo-west Pacific
Rhizoprionodon oligolinx (Springer 1964)	grey sharpnose shark	NT, Qld	Common; eastern Atlantic and Indo-west Pacific
Rhizoprionodon taylori (Ogilby 1915)	Australian sharp-nose shark	NT, Qld	Common; Australia and New Guinea
Sphyrna lewini (Griffith & Smith 1834)	scalloped hammerhead	NT, Qld	Common; circumglobal
Sphyrna mokarran (Ruppell 1837)	great hammerhead	NT, Qld	Common; circumglobal
Squalus megalops (Macleay 1881)	piked dogfish	NT, Qld	Poorly known complex; Indo-west Pacific
Stegostoma varium (Seba 1759)	zebra shark	NT, Qld	Common; Indo-west Pacific
Triaenodon obesus (Ruppell 1837)	reef white-tip	NT, Qld	Common; Indo-Pacific

Table 7.2: *Shark species of conservation significance in the Northern Planning Area.*

IUCN = 2002 International Union for the Conservation of Nature Red List of Threatenened Species
EPBC = *Environmental Protection and Biodiversity Conservation Act 1999*

Pogon. et al. = Pogonoski et al. (2002)
Cavanagh et al. = Cavanagh et al. 2003.
* indicates species not specifically listed by IUCN, but included under the listing for Glyphis glyphis.
CE = critically endangered, EN = endangered, VU = vulnerable, NT= lower risk (near threatened), LC = lower risk (least concern), DD = data deficient.

Family	Name	Common Name	IUCN	EPBC	Pogon. et al.	Cavanagh et al.
Brachaeluridae	*Brachaelurus colcloughi*	blue-grey carpet shark	VU	-	VU	VU
Carcharhinidae	*Carcharhinus albimarginatus*	silvertip shark	-	-	-	LC
Carcharhinidae	*Carcharhinus amblyrhynchoides*	graceful shark	-	-	-	NT
Carcharhinidae	*Carcharhinus amblyrhynchos*	grey reef shark	NT	-	LC	NT
Carcharhinidae	*Carcharhinus amboinensis*	pig-eye shark	-	-	-	DD
Carcharhinidae	*Carcharhinus brevipinna*	spinner shark	NT	-	LC	NT
Carcharhinidae	*Carcharhinus cautus*	nervous shark	-	-	-	LC
Carcharhinidae	*Carcharhinus dussumieri*	white-cheek shark	-	-	-	LC
Carcharhinidae	*Carcharhinus falciformis*	silky shark	LC	-	LC	LC
Carcharhinidae	*Carcharhinus fitzroyensis*	creek whaler	-	-	-	LC
Carcharhinidae	*Carcharhinus leucas*	bull shark	NT	-	LC	NT
Carcharhinidae	*Carcharhinus limbatus*	blacktip shark	NT	-	DD	NT
Carcharhinidae	*Carcharhinus macloti*	hard-nose shark	-	-	-	LC
Carcharhinidae	*Carcharhinus melanopterus*	black-tip reef shark	-	-	-	NT
Carcharhinidae	*Carcharhinus obscurus*	dusky shark	NT	-	NT	NT
Carcharhinidae	*Carcharhinus plumbeus*	sandbar shark	NT	-	NT	NT
Carcharhinidae	*Carcharhinus sorrah*	spot-tail shark	-	-	-	LC
Carcharhinidae	*Carcharhinus tilstoni*	Australian black-tip shark	-	-	-	LC
Carcharhinidae	*Galeocerdo cuvier*	tiger shark	NT	-	LC	NT
Carcharhinidae	*Glyphis* sp. A	speartooth shark	EN *	CE	CR	CE
Carcharhinidae	*Glyphis* sp. C	northern river shark	EN *	EN	EN	CE
Carcharhinidae	*Loxodon macrorhinus*	slit-eye shark	-	-	-	LC
Carcharhinidae	*Negaprion acutidens*	lemon shark	-	-	-	LC
Carcharhinidae	*Rhizoprionodon acutus*	milk shark	-	-	-	LC
Carcharhinidae	*Rhizoprionodon oligolinx*	grey sharpnose shark	-	-	-	LC
Carcharhinidae	*Rhizoprionodon taylori*	Australian sharp-nose shark	-	-	-	LC
Carcharhinidae	*Triaenodon obesus*	reef white-tip shark	NT	-	LC	NT
Ginglymostomatidae	*Nebrius ferrugineus*	tawny nurse shark	-	-	-	LC
Hemigaleidae	*Hemigaleus microstoma*	weasel shark	-	-	-	LC
Hemigaleidae	*Hemipristis elongatus*	fossil shark	-	-	-	LC
Hemiscylliidae	*Chiloscyllium punctatum*	brown-banded catshark	-	-	-	LC
Hemiscylliidae	*Hemiscyllium ocellatum*	epaulette shark	-	-	-	LC
Hemiscylliidae	*Hemiscyllium trispeculare*	speckled carpet shark	-	-	-	LC
Odontaspidae	*Carcharias taurus*	grey nurse shark	VU	CE (E), VU (W)	EN	VU
Orectolobidae	*Eucrossorhinus dasypogon*	tasselled wobbegong	-	-	-	LC
Orectolobidae	*Orectolobus ornatus*	banded wobbegong	LC	-	DD	NT

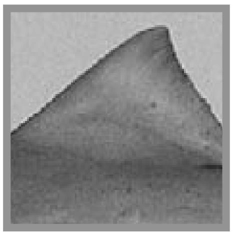


Family	Name	Common Name	IUCN	EPBC	Pogon. et al.	Cavanagh et al.
Orectolobidae	*Orectolobus wardi*	northern wobbegong	-	-	-	LC
Pseudocarcharhiidae	*Pseudocarcharias kamoharai*	crocodile shark	NT	-	LC	NT
Rhincodontidae	*Rhincodon typus*	whale shark	VU	VU	DD	VU
Scyliorhinidae	*Atelomycterus fasciatus*	banded catshark	-	-	-	LC
Scyliorhinidae	*Atelomycterus macleayi*	marbled catshark	-	-	-	LC
Scyliorhinidae	*Galeus gracilis*	slender saw-tail shark	-	-	-	DD
Sphyrnidae	*Eusphyra blochii*	winghead shark	-	-	-	LC
Sphyrnidae	*Sphryna lewini*	scalloped hammerhead	NT	-	LC	LC
Sphyrnidae	*Sphyrna mokarran*	great hammerhead	DD	-	LC	LC
Squalidae	*Squalus megalops*	piked dogfish	-	-	-	LC
Stegostomatidae	*Stegostoma varium*	zebra shark	-	-	-	LC
Triakidae	*Iago garricki*	long-nose hound shark	-	-	-	LC
Triakidae	*Mustelus* sp. A	grey gummy shark	-	-	-	LC

Table 7.3: *Broad habitat preferences and life history data for sharks within the NPA*

D = demersal, P = pelagic; Co = coastal, inshore, Sh = offshore, shelf; Ovo = ovoviviparous (eggs hatch internally), Oph = oviphagous (eggs hatch internally and embryos feed on other eggs and embryos), Ovi = oviparous (lay eggs), Viv = viviparous (live-bearing).

Species	Common name	Habitat	Habitat	Area	Depth (m)	Reproductive mode	Litter size	Gestation (months)
Atelomycterus fasciatus (Compagno & Stevens 1993)	banded catshark	D, Sh	D	Sh	27–122	Ovi	?	?
Atelomycterus macleayi (Whitley 1939)	marbled catshark	D, Co, Sh	D	Co, Sh	4–98	Ovi	?	?
Brachaelurus colcloughi (Ogilby 1908)	blue-grey carpet shark	D, Sh	D	Sh	20–217	Ovo	6–8	?
Carcharhinus albimarginatus (Rüppell 1837)	silvertip shark	P, Co, Sh	P	Co, Sh	88–800	Viv	1–11	12
Carcharhinus amblyrhynchoides (Whitley 1934)	graceful shark	P, Co, Sh	P	Co, Sh	2–50	Viv	3	9–10
Carcharhinus amblyrhynchos (Bleeker 1856)	grey reef shark	P, Co, Sh	P	Co, Sh	2–280	Viv	1–6	12
Carcharhinus amboinensis (Muller & Henle 1839)	pig-eye shark	D, P, Co, Sh	D, P	Co, Sh	1–100	Viv	6–13	?
Carcharhinus brevipinna (Muller & Henle 1839)	spinner shark	P, Co, Sh	P	Co, Sh	3–75	Viv	3–15	?
Carcharhinus cautus (Whitley 1945)	nervous shark	D, P, Co, Sh	D, P	Co, Sh	2–100	Viv	1–5	8–9
Carcharhinus dussumieri (Muller & Henle 1841)	white-cheek shark	D, P, Co, Sh	D, P	Co, Sh	3–170	Viv	2	?
Carcharhinus falciformis (Bibron 1839)	silky shark	P, Co, Sh	P	Co, Sh	18–500	Viv	2–15	?
Carcharhinus fitzroyensis (Whitley 1943)	creek whaler	D, P, Co, Sh	D, P	Co, Sh	3–40	Viv	1–7	?
Carcharhinus leucas (Valenciennes 1839)	bull shark	D, P, Co, Sh	D, P	Co, Sh	2–150	Viv	1–13	10–11
Carcharhinus limbatus (Valenciennes 1839)	blacktip shark	P, Co, Sh	P	Co, Sh	3–94	Viv	4–11	11–12
Carcharhinus macloti (Muller & Henle 1839)	hard-nose shark	P, Co, Sh	P	Co, Sh	50–170	Viv	2	12
Carcharhinus melanopterus (Quoy & Gaimard 1824)	black-tip reef shark	D, P, Co, Sh	D, P	Co, Sh	1–26	Viv	3–4	8–9
Carcharhinus obscurus (LeSueur 1818)	dusky shark	D, P, Co, Sh	D, P	Co, Sh	2–400	Viv	3–14	22–24
Carcharhinus plumbeus (Nardo 1827)	sand-bar shark	D, P, Co, Sh	D, P	Co, Sh	2–-280	Viv	1–14	9–12
Carcharhinus sorrah (Valenciennes 1839)	spot-tail shark	P, Co, Sh	P	Co, Sh	3–80	Viv	1–8	10
Carcharhinus tilstoni (Whitley 1950)	Australian black-tip shark	P, Co, Sh	P	Co, Sh	2–150	Viv	1–6	10
Carcharias taurus (Rafinesque 1810)	grey nurse shark	D, P, Sh	D, P	Sh	2–200	Oph	2	9–12



Species	Common name	Habitat	Habitat	Area	Depth (m)	Reproductive mode	Litter size	Gestation (months)
Chiloscyllium punctatum (Muller & Henle 1838)	brown-banded catshark	D, Co	D	Co	1–85	Ovi	20	?
Eucrossorhinus dasypogon (Bleeker 1867)	tasselled wobbegong	D, Co	D	Co	20–60	Ovo	?	?
Eusphyra blochii (Cuvier 1816)	winghead shark	D, P, Co, Sh	D, P	Co, Sh	2–7	Viv	6–25	10–11
Galeocerdo cuvieri (Peron & LeSueur 1822)	tiger shark	D, P, Co, Sh	D, P	Co, Sh	1–150	Ovo	10–80	12
Galeus gracilis (Compagno & Stevens 1993)	slender saw-tail shark	D, Sh	D	Sh	290–470	?	?	?
Glyphis sp. A	speartooth shark	D, P, Co	D, P	Co	1–-8	?	?	?
Glyphis sp. C	northern river shark	D, P, Co	D, P	Co	4–8	?	?	?
Hemigaleus microstoma (Bleeker 1852)	weasel shark	D, Co, Sh	D	Co, Sh	51–170	Viv	1–19	6
Hemipristis elongatus (Klunzinger 1871)	fossil shark	D, Co, Sh	D	Co, Sh	13–130	Viv	2–11	7–8
Hemiscyllium ocellatum (Bonnaterre 1788)	epaulette shark	D, Co	D	Co	1–10	Ovi	20	?
Hemiscyllium trispeculare (Richardson 1843)	speckled carpet shark	D, Co	D	Co	1–10	Ovi	2–50	?
Iago garricki (Fourmanoir & Rivaton 1979)	long-nose hound shark	P, Sh	P	Sh	250–475	Viv	4–5	?
Loxodon macrorhinus (Muller & Henle 1839)	slit-eye shark	D, P, Co, Sh	D, P	Co, Sh	7–100	Viv	2	?
Mustelus sp. A	grey gummy shark	D, Sh	D	Sh	20–205	Viv	6–24	?
Nebrius ferrugineus (Lesson 1830)	tawny nurse shark	D, Co, Sh	D	Co, Sh	5–70	Ovo	2–8	?
Negaprion acutidens (Ruppell 1837)	lemon shark	D, Co, Sh	D	Co, Sh	1–30	Viv	1–14	10–11
Orectolobus ornatus (De Vis 1883)	banded wobbegong	D, Co, Sh	D	Co, Sh	1–117	Ovo	12–20	?
Orectolobus wardi (Whitley 1939)	northern wobbegong	D, Co	D	Co	1–20	Ovo	?	?
Pseudocarcharias kamoharai (Matsubara 1936)	crocodile shark	P, Sh	P	Sh	5–590	Oph	4	?
Rhincodon typus (Smith 1828)	whale shark	P, Sh	P	Sh	10–5,000	Ovo	300	?
Rhizoprionodon acutus (Ruppell 1837)	milk shark	D, P, Co, Sh	D, P	Co, Sh	2–200	Viv	1–8	?
Rhizoprionodon oligolinx (Springer 1964)	grey sharpnose shark	D, P, Co, Sh	D, P	Co, Sh	?	?	?	?
Rhizoprionodon taylori (Ogilby 1915)	Australian sharp-nose shark	D, P, Co, Sh	D, P	Co, Sh	2–110	Viv	1–8	12
Sphyrna lewini (Griffith & Smith 1834)	scalloped hammerhead	D, P, Co, Sh	D, P	Co, Sh	5–275	Viv	13–23	9–10
Sphyrna mokarran (Ruppell 1837)	great hammerhead	D, P, Co, Sh	D, P	Co, Sh	10–-80	Viv	6–33	11
Squalus megalops (Macleay 1881)	piked dogfish	D, Sh	D	Sh	152–510	Ovi	2–4	24
Stegostoma varium (Seba 1759)	zebra shark	D, P, Co, Sh	D, P	Co, Sh	10–50	Ovi	?	?
Triaenodon obesus (Ruppell 1837)	reef white-tip	D, P, Co, Sh	D, P	Co, Sh	5–300	Viv	6–25	10–11

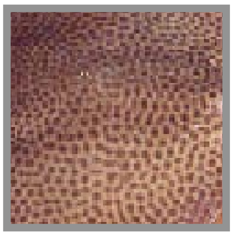


Table 7.4: *List of ray species known so far from the Northern Planning Area*

Scientific Name	Common Name	NPA Distribution	Status
Aetobatus narinari (Euphrasen 1790)	white-spotted eagle ray	NT, Qld	Common; circumglobal
Aetomylaeus vespertilio (Bleeker 1852)	ornate eagle ray	NT, Qld	Poorly known; Indo-west Pacific
Aetomyleus nichofii (Bloch & Schneider 1801)	banded eagle ray	NT, Qld	Common; Indo-Pacific
Aetoplatea zonura (Bleeker 1852)	zone-tail butterfly ray	NT	Locally common; South-east Asia to NT
Aptychotrema sp. A	spotted shovel-nose ray	NT	Rare; Australian endemic
Dasyatis annotata (Last 1987)	plain maskray	NT, Qld	Uncommon; Australian endemic
Dasyatis fluviorum (Ogilby 1908)	estuary stingray	NT, Qld	Uncommon; Australia and New Guinea
Dasyatis kuhlii (Muller & Henle 1841)	blue-spotted maskray	NT, Qld	Common; Indo-west Pacific
Dasyatis leylandi (Last 1987)	painted maskray	NT, Qld	Uncommon; Australia and New Guinea
Gymnura australis (Ramsay & Ogilby 1886)	Australian butterfly ray	NT, Qld	Locally common; Australia and New Guinea
Himantura chaophraya (Monkolprasit & Roberts 1990)	freshwater whipray	NT, Qld	Uncommon; Australia, New Guinea and South-east Asia
Himantura fai (Jordan & Seale 1906)	pink whipray	NT, Qld	Uncommon; Australia and western Pacific
Himantura granulata (Macleay 1883)	mangrove whipray	NT, Qld	Poorly known; Australia and western Pacific
Himantura jenkinsii (Annandale 1909)	Jenkins' whipray	NT, Qld	Locally common; Indo-west Pacific
Himantura sp. A	brown whipray	NT, Qld	Locally common; Australia
Himantura toshi (Whitley 1939)	black-spotted whipray	NT, Qld	Locally common; Australia and New Guinea
Himantura uarnak (Forsskal 1775)	reticulate whipray	NT, Qld	Common; Indo-west Pacific
Himantura undulata (Bleeker 1852)	leopard whipray	NT, Qld	Common; South-east Asia to western Pacific
Irolita sp. A	western round skate	NT	Poorly known; Australia endemic
Manta birostris (Donndorff 1798)	manta ray	NT, Qld	Locally common; circumglobal
Mobula eregoodootenkee (Bleeker 1859)	pygmy devilray	NT	Locally common; Indo-west Pacific
Myliobatis hamlyni (Ogilby 1911)	purple eagle ray	NT	Poorly known; Australian endemic
Narcine lasti (Carvalho & Séret 2002)	western numbfish	NT	Poorly known; Australian endemic
Narcine westraliensis (McKay 1966)	banded numbfish	NT	Locally common; Australian endemic
Narcine sp. A	ornate numbfish	NT, Qld	Poorly known; Australian endemic
Pastinachus sephen (Forsskal 1775)	cow-tail stingray	NT, Qld	Common; Indo-west Pacific
Dipturus sp. D	false Argus skate	NT	Uncommon; Australia
Rhina ancylostoma (Bloch & Schneider 1801)	shark ray	NT, Qld	Common; Indo-west Pacific
Rhinobatos typus (Bennett 1830)	giant shovel-nose ray	NT, Qld	Locally common; Indo-west Pacific
Rhinoptera javanica (Muller & Henle 1841)	Javanese cownose ray	NT	Common; Indo-west Pacific
Rhynchobatus australiae (Whitley 1939)	white-spotted shovel-nose ray	NT, Qld	Locally common; South-east Asia and Australia
Taeniura lymma (Forsskal 1775)	blue-spotted fantail ray	NT, Qld	Common; Indo-west Pacific
Taeniura meyeni (Muller & Henle 1841)	blotched fantail ray	NT, Qld	Locally common; Indo-Pacific
Urogymnus asperrimus (Bloch & Schneider 1801)	porcupine ray	NT, Qld	Poorly known; Indo-Pacific
Urolophus mitosis (Last & Gomon 1987)	mitotic stingaree	NT	Uncommon; Australian endemic
Urolophus westraliensis (Last & Gomon 1987)	brown stingaree	NT	Uncommon; Australian endemic

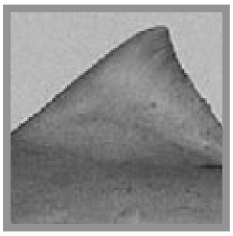


Table 7.5: *Ray species of conservation significance in the Northern Planning Area*

IUCN = 2002 International Union for the Conservation of Nature Red List of Threatened Species
EPBC = *Environmental Protection and Biodiversity Conservation Act 1999*
Pogon. et al. = Pogonoski et al. (2002)
Cavan. et al. = Cavanagh et al. (2003). VU = vulnerable, NT = lower risk (near threatened), LC = lower risk (least concern), DD = data deficient.

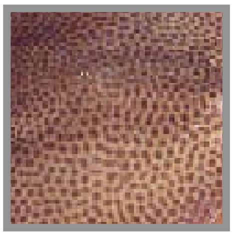
Family	Name	Common Name	IUCN	EPBC	Pogon. et al.	Cavan. et al.
Dasyatidae	*Dasyatis fluviorum*	estuary stingray	-	-	NT	VU
Dasyatidae	*Himantura chaophraya*	freshwater whipray	VU	-	VU	VU
Dasyatidae	*Taeniura lymma*	blue-spotted fantail ray	NT	-	LC	NT
Dasyatidae	*Urogymnus asperrimus*	porcupine ray	VU	-	NT	VU
Mobulidae	*Manta birostris*	manta ray	DD	-	LC	DD
Mobulidae	*Mobula eregoodootenkee*	pygmy devilray	-	-	-	LC
Myliobatidae	*Aetobatus narinari*	white-spotted eagle ray	DD	-	LC	DD
Myliobatidae	*Aetomylaeus nichofii*	banded eagle ray	-	-	-	VU
Rhinidae	*Rhynchobatus australiae*	white-spotted shovel-nose ray	VU	-	LC	VU
Rhinobatidae	*Aptychotrema sp. A*	spotted shovel-nose ray	-	-	-	LC
Rhinobatidae	*Rhinobatos typus*	giant shovel-nose ray	-	-	-	NT

Table 7.6: *Broad habitat preferences and life history data for rays within the NPA*

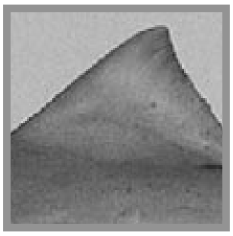
D = demersal, P = pelagic; Co = coastal, inshore, Sh = offshore, shelf; Ovo = ovoviviparous (eggs hatch internally), Ovi = oviparous (lay eggs), Viv = viviparous (live-bearing).

Species	Common name	Habitat	Habitat	Area	Depth (m)	Reproductive mode	Litter size
Aetobatus narinari (Euphrasen 1790)	white-spotted eagle ray	P, Co, Sh	P	Co, Sh	5–100	Ovo	4
Aetomylaeus vespertilio (Bleeker 1852)	ornate eagle ray	P, Sh	P	Sh	20–110	Ovo	-
Aetomyleus nichofii (Bloch & Schneider 1801)	banded eagle ray	P, Co, Sh	P	Co, Sh	5–70	Ovo	Up to 4
Aetoplatea zonura (Bleeker 1852)	zone-tail butterfly ray	P, Sh	P	Sh	15–57	Ovo	-
Aptychotrema sp. A	spotted shovel-nose ray	D, Sh	D	Sh	2–120	Ovo	-
Dasyatis annotata (Last 1987)	plain maskray	D, Sh	D	Sh	10–75	Viv	2–6
Dasyatis fluviorum (Ogilby 1908)	estuary stingray	D, Co	D	Co	1–28	Viv	2–6
Dasyatis kuhlii (Muller & Henle 1841)	blue-spotted maskray	D, Co	D	Co	1–90	Viv	2–6
Dasyatis leylandi (Last 1987)	painted maskray	D, Sh	D	Sh	5–150	Viv	2–6
Gymnura australis (Ramsay & Ogilby 1886)	Australian butterfly ray	P, Co, Sh	P	Co, Sh	15–900	Ovo	-
Himantura chaophraya (Monkolprasit & Roberts 1990)	freshwater whipray	D, Co	D	Co	1–50	Viv	2–6
Himantura fai (Jordan & Seale 1906)	pink whipray	D, Sh	D	Sh	?	Viv	2–6
Himantura granulata (Macleay 1883)	mangrove whipray	D, Co, Sh	D	Co, Sh	2–140	Viv	2–6
Himantura jenkinsii (Annandale 1909)	Jenkins' whipray	D, Co	D	Co	50–150	Viv	2–6
Himantura sp. A	brown whipray	D, Co	D	Co	?	Viv	2–6

7. Sharks and Rays



Species	Common name	Habitat	Habitat	Area	Depth (m)	Reproductive mode	Litter size
Himantura toshi (Whitley 1939)	black-spotted whipray	D, Sh	D	Sh	10–140	Viv	2–6
Himantura uarnak (Forsskal 1775)	reticulate whipray	D, Co, Sh	D	Co, Sh	1–80	Viv	2–6
Himantura undulata (Bleeker 1852)	leopard whipray	D, Co	D	Co	1–100	Viv	2–6
Irolita sp. A	western round skate	D, Sh	D	Sh	150-–200	Ovi	-
Manta birostris (Donndorff 1798)	manta ray	P, Co, Sh	P	Co, Sh	2–200	Ovo	1
Mobula eregoodootenkee (Bleeker 1859)	pygmy devilray	P, Co, Sh	P	Co, Sh	20–200	Ovo	1
Myliobatis hamlyni (Ogilby 1911)	purple eagle ray	P, Co, Sh	P	Co, Sh	3–200	Ovo	-
Narcine lasti (Carvalho & Séret 2002)	western numbfish	D, Sh	D	Sh	105-–350	Ovo	-
Narcine westraliensis (McKay 1966)	banded numbfish	D, Sh	D	Sh	10–88	Ovo	-
Narcine sp. A	ornate numbfish	D, Sh	D	Sh	50–60	Ovo	-
Pastinachus sephen (Forsskal 1775)	cow-tail stingray	D, Co	D	Co	12–60	Viv	2–6
Dipturus sp. D	false Argus skate	D, Sh	D	Sh	60–255	Ovi	-
Rhina ancylostoma (Bloch & Schneider 1801)	shark ray	D, Co, Sh	D	Co, Sh	2–200	Ovo	-
Rhinobatos typus (Bennett 1830)	giant shovel-nose ray	D, Co, Sh	D	Co, Sh	2–159	Ovo	-
Rhinoptera javanica (Muller & Henle 1841)	Javanese cownose ray	P, Co, Sh	P	Co, Sh	2–50	Ovo	-
Rhynchobatus australiae (Whitley 1939)	white-spotted shovel-nose ray	D, Co, Sh	D	Co, Sh	2–200	Ovo	-
Taeniura lymma (Forsskal 1775)	blue-spotted fantail ray	D, Co	D	Co	5–20	Viv	2–6
Taeniura meyeni (Muller & Henle 1841)	blotched fantail ray	D, Co, Sh	D	Co, Sh	5–439	Viv	2–6
Urogymnus asperrimus (Bloch & Schneider 1801)	porcupine ray	D, Co	D	Co	?	Viv	2–6



8. Sawfish

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8. Sawfish

Tag and release of a green sawfish (5.4m total length) caught in commercial net off Cairns, 2003 ***Source:*** *S Peverell*

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Species group name and description

Sawfish belong to the super order Rajomorphii within the subgroup Elasmobranchii (Hamlett 1999). They belong to the family Pristidae and are unique creatures with body form and features more like those of a shark than those of a ray. Members of the family reach extraordinary lengths, exceeding 7 m. The similarities to sharks include pectoral fins distinctly separate from the head, two enlarged dorsal fins and a prominent caudal fin (Last & Stevens 1994). The most distinctive feature characterising a sawfish as a ray or batoid is the positioning of the gill slits. In sawfish the gill slits are situated ventrally on the head rather than laterally as in sharks. Pristids also possess an extended rostrum with lateral teeth (Bigelow & Schroeder 1953). The Pristidae comprise the two genera, *Pristis* and *Anoxypristis*, and currently between four and seven species are known from Australia (Last & Stevens 1994).

Sawfish have a global distribution, favouring shallow coastal waters and river systems in tropical and subtropical latitudes. Pristids are one of four cartilaginous families that occur in fresh water (Compagno & Cook 1995a). However they are not classified as obligate (not known from any other environment) freshwater animals. Australian sawfish species *Anoxypristis cuspidata*, *Pristis microdon*, and *P. zijsron* are classified as being euryhaline (inhabiting marine inshore waters, estuaries, lagoons and freshwater) based on museum records, and P. clavata as being brackish marginal (inhabiting brackish to fresh water). Compagno and Cook (1995a) report that P. microdon has been known to breed in fresh water.

Elements of pristid life history resemble those of marine mammals more closely than that of teleost fishes (Table 8.1). All chondrichthyans reproduce via internal fertilisation, with 60% of shark species being viviparous (producing live young from within the body of the parent female) (Compagno 2003). The physical constraints of internal fertilisation and embryonic development limit an individual animal's fecundity. From what little published information is available on pristid biology and life history it is evident that they share the same characteristics of many other large cartilaginous fishes, including long gestation periods, giving birth to live and often large offspring, late sexual maturation, long life and intermittent breeding. This life history places sawfish at high risk and vulnerable to overfishing (Stobutzki et al. 2002).

Table 8.1: *Broad habitat preference and life history data for sawfish within the NPA*

D = demersal, BP = Bentho-pelagic, Co = coastal, inshore, Sh = offshore, shelf; Ovo = ovoviviparous, Ovi = oviparous, Viv = viviparous.

Species	Common Name	Habitat	Area	Depth	Reproductive mode	Litter size
Pristis microdon (Latham 1794)	Freshwater sawfish	D	Co, Sh	25	Ovo	1–11
Pristis clavata (Garmon 1906)	Dwarf sawfish	D	Co	4	Ovo	???
Pristis zijsron (Bleeker 1851)	Green Sawfish	D	Co, Sh	25	Ovo	???
Pristis pectinata (Latham 1794)	Smalltooth sawfish	D	Co	???	Ovo	15–20
Anoxypristis cuspidata (Latham 1794)	Narrow sawfish	BP	Co, Sh	30	Ovo	6–23

This life history has led to a high proportion of the subgroup Elasmobranchii, consisting of large apex predators (including sawfish), exhibiting low abundances even in undisturbed habitats. The Pristidae are therefore of particular interest because they are highly vulnerable to direct and indirect exploitation (Anon 2000).

Status

The scientific community has recognised a decline in sawfish populations across their entire range (Cavanagh et al. 2003). The true extent of this decline is extremely difficult to quantify due to lack of reliable historical catch and biological data. Historically, fisheries management has focused primarily on high-value finfish species. This trend has since changed with the demand for cartilaginous fish products escalating in recent times (Kroese & Sauer 1998, Rose 1996).

The International Union on the Conservation of Nature (IUCN) shark specialist group (Cavanagh et al. 2003) categorised Australian sawfishes as endangered on the basis of their rapid decline in range. In recognition of global concern about the status of sawfish populations (Anon 2000) and other threatened elasmobranchs, a National Plan of Action (NPOA) has been established (Anon 2002). The NPOA was designed to address the lack of information on these threatened species. Currently, *P. microdon* is the only species listed (vulnerable) under the *Environmental Protection and Biodiversity Act 1999* (EPBC Act), whilst *P. clavata*, *P. zijsron* and *Anoxypristis* cuspidata are under close consideration.

The current population status of Australian sawfish is largely unknown. However, Pogonoski et al. (2002) identified northern Australia as possibly one of the few remaining geographical regions where viable populations of pristids remain. Thorburn et al. (2003) identified the current state of knowledge of Australian sawfish populations as fragmentary with species inhabiting fresh to brackish waters exhibiting sparse localised ranges. A baseline study of sawfish abundance and distribution by Peverell (submitted 2003) in the Gulf of Carpentaria (GoC) inshore and offshore set net fisheries is the only current information available for this family in the NPA. *P. microdon*, *P. zijsron*, *P. clavata* and *A. cuspidata* were found to be distributed throughout the northern, southern and western regions of the Queensland portion of the NPA. The relative abundance of Pristidae in this area is low and variable.

Both inshore and the offshore commercial set net fisheries have a closed season set in accordance with the lunar cycle for spawning barramundi (Garrett 1987), a period of approximately four months over summer. The Northern Territory (NT) commercial gill net fishery for barramundi has a similar seasonal net closure. This offers some protection to pristid populations inhabiting the Queensland portion of the NPA.

Distribution and abundance of sawfish populations in the NT area of the NPA is unknown. Current sources of sawfish information or databases applicable to the NPA are held by the contacts listed in Table 8.2. There is no specific legislation protecting pristids in the NT or Queensland, beyond the federal EPBC Act and the general protection afforded to all native species not included under fishing licences and permits.

8. Sawfish

Habitat and distribution

Within the NPA sawfish have been found to occupy a diverse range of habitats, namely marine, hypersaline and freshwater (Last & Stevens 1994, Peverell submitted 2003). A. cuspidata has been identified by Stobutzki et al. (2001) and Peverell (submitted 2003) as being bentho-pelagic (bottom-dwelling travelling the water column) whilst the other pristid species are classified as being demersal. Pristids inhabit hard and soft substrate (ie soft silty mud to coarse sand).

The distribution of sawfish in Australia has been poorly reported other than in the broadscale distribution map provided in Last and Stevens (1994). Within the Queensland (QLD) portion of the NPA there are a number of confirmed pristid records (Figure 8.1). *P. microdon*, *P. clavata*, *P. zijsron* and *A. cuspidata* are known bycatch species in the northern prawn fishery (NPF) (Stobutzki et al. 2002) and set net fisheries (Peverell submitted 2003). In addition, *P. zijsron* and *A. cuspidata* have also been recorded in Arthurs Creek, a coastal estuarine system in the central GoC (QLD Museum records).

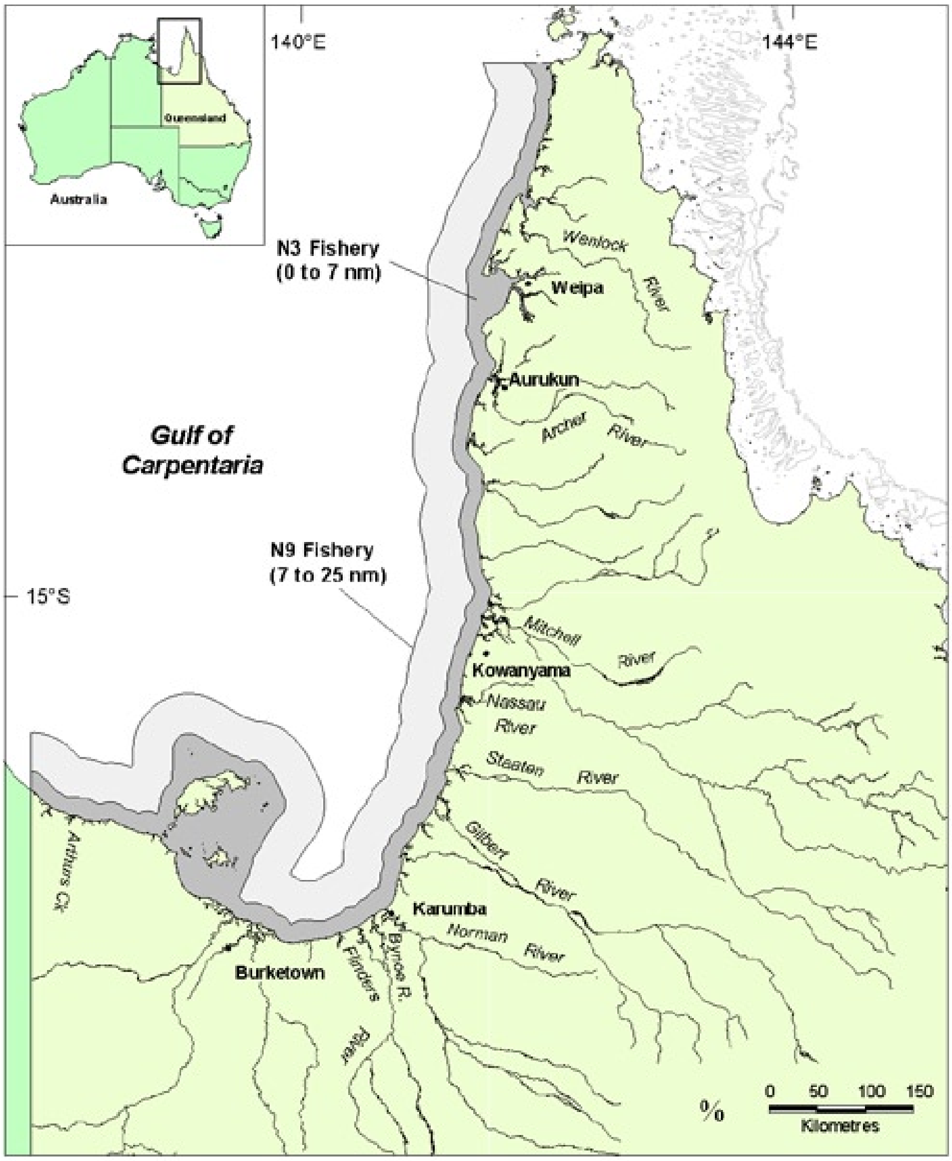
P. microdon has been recorded in the Gilbert River (Tanaka 1991, Thorburn 2003, and L Squires, Cairns Marine, pers. comm. 2003); Wenlock River (L Squires, Cairns Marine, pers. comm. 2003, and Thorburn 2003); Flinders, Bynoe River (L Squires, Cairns Marine, pers. comm. 2003); and Norman River (QLD Museum records, L Squires, Cairns Marine, pers. comm. 2003). *P. clavata* and *P. zijsron* have been recorded in Missionary Bay, Weipa (Thorburn 2003, L Squires, Cairns Marine, pers. comm. 2003 and J Salini, CSIRO Marine Research Cleveland, pers. comm. 2003).

Sawfish records in the NT portion of the NPA are poorly documented. Only one specimen from this part of the NPA, a *P. microdon* from the Goomadeer River, is held at the NT Museum and Art Gallery. Thorburn et al. (2003) reported *A. cuspidata* from the Liverpool and Blythe Rivers and *P. microdon* from the McArthur, Wearyan and Robinson Rivers (specimens not retained).

Additional records are within unpublished technical reports by NT Fisheries. It is reasonable to assume, based on similarities in habitat, that the NT barramundi fishery which operates inshore gillnets out to approximately 3 nautical miles (nm) would interact with pristids. Observer survey reports from the Fisheries Research and Development Corporation (FRDC) funded Sustainability of Northern Australian Sharks and Rays project have documented A. cuspidata interactions within the NT offshore set net shark fishery (Joint Authority – combined Commonwealth/NT managed under NT legislation).

Currently there has been no confirmed record of *P. pectinata*, although this species was described by Last and Stevens (1994) as inhabiting the NPA (John Stevens, CSIRO Principal Scientist, pers. comm. 2001).

Figure 8.1: Locality map indicating rivers of known sawfish records within the QLD portion of the NPA



Significance of the species group in the Northern Planning Area

Australia has a high diversity of elasmobranch fauna of which half are endemic (Last & Stevens 1994). On a global and national scale pristid species have been identified as being under severe threat of extinction. Of extreme concern is the lack of knowledge, namely life history and biological parameters of the Pristidae (Thorson 1982, Tanaka 1991, Compagno & Cook 1995a, Zorzi 1995, Simpfendorfer 2000). This situation applies to the current knowledge in chondrichthyans worldwide (Oliver 1996).

Pogonoski et al. (2002) inferred that the Queensland and NT portions of the NPA could be the last remaining global areas to contain viable sawfish populations. This characterises the NPA as an extremely important region for sustainable sawfish habitat. The NPA's isolation has meant that habitat degradation by anthropogenic influences has remained minimal. Although sawfish fishing mortality in the NPA is unknown, it seems that it is not too late to conserve these animals through better education and awareness programs aimed at industry, and perhaps by more direct means of conservation.

Impacts/threats

The global decline in sawfish populations is a product of the animal's inability to adapt (due to its biology) to changes within its environment. These changes have been brought about largely through anthropogenic influences (threatening processes) over the short term (Compagno & Cook 1995b). In Australia these threatening processes include commercial net fisheries, demersal prawn trawling in the Northern Prawn Fishery (NPF), recreational line/net fisheries, indigenous fisheries, aquarium collectors, trophy hunters, and habitat degradation.

Net fishing has been identified as being responsible for the rapid decline in global sawfish populations (Simpfendorfer 2000, Stobutzki et al. 2002, Kroese 1998) in particular within artisanal fisheries. A combination of the shallow water coastal distribution of pristids and the teethed rostrum of these sawfish makes all size classes vulnerable to capture in gill nets.

Fish and prawn trawling has been identified as a threat to sawfish in the NPF. Despite the introduction of bycatch reduction devices and turtle exclusion devices in the prawn trawl fleet, sawfish continue to be caught by trawlers as these devices have had little impact on the mortality of sawfishes. Some 'observer' records of sawfish catches in pre-season sampling indicate A. cuspidata (94%) is the dominant species caught, followed by *P. zijsron* (4%). A total of 285 sawfish was recorded during these surveys: 152 were positively identified and 30% were released alive (B Hill, CSIRO, pers. comm. 2003). The catch of sawfish in the fish trawl fishery operating in the NPA is currently unknown though there are reports of sawfish interaction.

Artisanal fisheries are generally multi-species fisheries and fishers prefer gill nets and long-lines because of the bycatch of teleosts, turtles, and marine mammals (Kroese 1998). Fishers mainly fish local inshore waters with often-substandard equipment during favourable fishing conditions. Compounding this threat to sawfish populations is the lack of fisheries-based enforcement and sustainable management practices. The selling of shark product is a lucrative and attractive business for poor fishing families (Compagno & Cook 1995b).

Within Queensland the capture of sawfish by commercial net fisheries has been poorly reported (Gribble 1999) and the status of sawfish populations is unknown. Peverell (submitted 2003) reported on the interaction of sawfish within the GoC set net fisheries and has provided a summary of fishery-derived data. The incidental capture of sawfish in the NT gill net fishery is largely unknown. Commercial set net operations take place in tidal waters with strict net closures on all non-tidal waters and specified areas.

Queensland records of sawfish capture by recreational line fishers are also limited. Nelson (1994) referred to sawfish as a target sport fish within GoC rivers, estuaries and landings. Helmke (1999) monitored the catch landed in the Normanton and Burketown recreational fishing competitions and identified sawfish as part of the weigh-in catch. Sawfish are vulnerable to capture by baited line. Like most elasmobranchs, they exhibit both scavenging and predatory feeding behaviour (Last & Stevens 1994). When sawfish are confined to drying waterholes, line fishing becomes a threat and is a serious resource management and educational awareness issue.

Sawfish have significant cultural and spiritual relevance to Indigenous Australians within the GoC (McDavitt 2001), but the level of harvest of sawfish by Indigenous Australians is currently unknown. From anecdotal reports, the Indigenous harvest in some areas of the GoC is significant and could threaten localised sawfish populations (S Peverell pers. comm. 2004). Along the eastern GoC the Indigenous take of sawfish is primarily used for bait or consumed as part of the diet (Kowanyama Indigenous Ranger "Anzac", pers. comm. 2003).

The Australian Bowhunter Association (ABA) recognises pristids as trophy animals under their awards points. Currently, no legislation is in place protecting pristids from this identified threat and the current take is unknown. Recreational fishers are permitted in Queensland and the NT to use 'bow and arrow' as a form of fishing apparatus. The *Queensland Fisheries Act 1994* recognises bow hunting as a form of spear fishing and it is prohibited in all non-tidal waters and some regulated special use zones (Bob Koch, Queensland Boating and Fisheries Patrol, pers. comm. 2003).

Sawfish are known to inhabit non-tidal predominantly freshwater environments, which are considered critical to their range. Unfortunately this makes them vulnerable to habitat loss or degradation (Simpfendorfer 2000, Camhi et al. 1998, Compango & Cook 1995a & 1995b, Zorzi 1995) in a way that does not normally affect marine elasmobranch populations.

Freshwater environments tend to be less stable than marine equivalents. Short-term and long-term fluctuations in temperature, oxygen level, mineral content, turbidity, water flow, rainfall, and major

changes in river and lake beds can readily exceed the tolerances of elasmobranchs (Compangno & Cook 1995b). If anthropogenic influences, such as poor land resource management, water extraction, mining and urbanisation, are added then freshwater/estuarine elasmobranch populations are less likely to survive such pressures.

With increasing anthropogenic pressures on coastal ecosystems in the NPA and their known negative effects on sawfish populations (Compagno & Cook 1995b), an understanding of sawfish distribution, life history, and biology is critical in the development of appropriate strategies to deal with the conservation of these species.

Information gaps

The global decline in sawfish populations is extremely difficult to quantify due to a lack of reliable historical catch and biological data. Sawfish populations in the NPA are no exception, with data gaps existing in species distribution and range, specific habitat requirements, biology and general life history. This is especially the case for the NT coastal area of the NPA. As noted previously, the distribution and abundance of sawfish populations in the NT area of the NPA is relatively unknown compared to the data available from research that has been carried out in Queensland. An obvious immediate need is to extend the joint research/observer surveys of sawfish across the whole of the NPA.

Within the NPA habitat degradation has been kept to a minimum; therefore, commercial, Indigenous and recreational net and line fishing are the key threats affecting sawfish populations. Presently, there is very little monitoring of the incidental catch of sawfish in the above fisheries.

Fishery observer work has been, and still is being, undertaken in the commercial net fisheries of the NPA with varying degrees of coverage and efficiency. The Queensland compulsory observer program in the Gulf offshore set net fishery is the only program dedicated to the monitoring of bycatch species. Information collected to date on sawfish has been extremely useful and highlights the benefits of such a program. In contrast the information supplied through voluntary observer programs has been relatively sparse and fragmentary. This is because the information collected is secondary to the study being undertaken, with work normally focusing on target species such as barramundi. To take advantage and maximise the benefits of other observer programs, sawfish need to be made a priority species. This is often difficult, especially when work is being undertaken on other more economically valued species.

Revamping existing observer programs, making sawfish a priority species and utilising the results from intensive research surveying (like Thorburn et al. 2003) can address the lack of biological and life history information. The methodology developed by Buckworth and Martell (2003), gene tagging, is attractive and might merit further investigation provided specimen mortality is kept to a minimum (since sawfish have a high conservation status). Gene tagging can provide information on populations and their movements.

Tackling the data gaps identified within the recreational and Indigenous line and net fishery will be more difficult to resolve than that for the commercial fishing sector. Intensive surveys working with Indigenous communities looking for sawfish has proven successful and should be further investigated (FRDC Sustainability of Northern Australian Sharks & Rays – phase II). Some of the issues in dealing with Indigenous communities include level of literacy and ability to identify species. These can be overcome through simple picture-based keys and field training.

Posters were used by the Queensland survey team to encourage reporting of sightings of sawfish and other elasmobranch by recreational fishers within freshwater systems (Thorburn et al. 2003). This method had varying degrees of success and since the completion of the project information has still been filtering back through INFO Fish Services, a national recreational tagging database service and the QDPIF call centre.

Other education material should be developed to increase the profile of sawfish in terms of their conservation status. This will aid in maximising the information exchange required for the success of existing and historical tagging programs, by intensive research netting programs, and fisheries observer programs. This might also provide some form of immediate protection for pristids as their conservation plight becomes more public. In addition there is also scope to develop a recreational fishing tag and release program similar to that developed for key recreational species such as barramundi, bream, mangrove jack and grunter.

An opportunity to obtain valuable growth, genetic and dietary information is also possible through the limited take of sawfish by the aquarium trade. Cook et al. (1995) identified aquarium and museum collections as being a potential key threat to the survival of pristids, although if this perceived threat is managed and approached sensibly it could yield some interesting biological information. Casey et al. (1985) used aquarium trials to aid in the interpretation of age rings in the vertebrae of *Carcharhinus plumbeus*.

Key references and current research

Key datasets are held at state museums in the form of specimens and their intrinsic information; this data will become more easily available when OZCAM (Online Zoological Collections of Australian Museums) come online to the public. Apart from museum collections there is an absence of published literature on pristid biology and ecology especially in the Southern Hemisphere.

Presently, the only project investigating pristid biology and life history is the FRDC 2002/064 funded "Sustainability of Northern Australian Sharks and Rays" with CSIRO as the lead agent. This three year funded project began in July 2002 and is a collaborative project involving representatives from WA, NT, Queensland fisheries and CSIRO. Stirling Peverell, QLD AFFS project biologist for the FRDC Northern shark sustainability project is currently undertaking his Master of Science in sawfish distribution and biology for north Queensland through James Cook University, Townsville.

During the final drafting of this report the National Oceans Office has provided funding to the Queensland Department of Primary Industries to conduct a pilot study in early May 2004 to attach acoustic tags and time depth recorders to two sub-adult (2–3m) sawfish (either *P. microdon*, *P. clavata* or *P.zijsron*) and track the animals over a 48 hour period. The data gained from this preliminary study will be used to determine the short-term activity patterns, swimming speed, movement and diurnal activity within shallow coastal marine environments. Time depth recorders will be attached to the animals to record swimming depth and temperature. These data will then be analysed with a track of water depth to determine which area of the water column is utilised by the animals. Data from daily movement patterns (tidal and diurnal patters) will assist in determining the spacing of listening station arrays that will monitor sawfish movement patterns over long periods (months to years) in future research. Data will contribute to the baseline information on sawfish biology and ecology already collected under the FRDC-funded project, Northern Australian sharks and rays: the sustainability of target and bycatch species, phase 2. FRDC 2002/064.

A report will be provided to the National Oceans Office at the completion of the pilot study. The report will present the results of the study and make recommendations for future acoustic monitoring of sawfish movements. Specifically, estimates of daily movement rates, swimming speed, swimming behaviour and diurnal shifts in behaviour will be documented.

Table 8.2: *Contact list of scientist holding sources of sawfish information applicable to the NPA, Australia*

State	Contact	Organisation	Project
QLD	Stirling Peverell Stirling.peverell@dpi.qld.gov.au	QDPI Agency for Food & Fibre Science	MSc Thesis & FRDC 2002/064
QLD/NT	Dr Burke Hill Burke.Hill@csiro.au	CSIRO Marine Cleveland	NPF observer program records
NT	Dr Helen Larson Helen.Larson@nt.gov.au	NT Museum & Art Gallery	NHT – Freshwater sharks & rays Museum collections
NT	Rik Buckworth rik.buckworth@nt.gov.au	NT DPI Fisheries	FRDC 2002/064
WA	Roly McAuley rmcauley@fish.wa.gov.au	WA Fisheries	FRDC 2002/064
WA	Dean Thorburn dean.thorburn@mudoch.edu.au	Murdoch University	NHT – Freshwater sharks & rays
WA/NT/QLD	John Stevens John.D.Stevens@csiro.au	CSIRO Marine Hobart	FRDC 2002/064 & NHT – Freshwater sharks & rays
WA/NT/QLD	John Salini John.Salini@csiro.au	CSIRO Marine Cleveland	FRDC 2002/064

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9. Cetaceans: Whales and Dolphins

This chapter should be cited as:
Hale, P, Brieze, I, Chatto, R & Parra, G (2004). Cetaceans: Whales and Dolphins. In National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia

Indo-Pacific humpbacked dolphin [Sousa chinensis] (left) and inshore bottlenose dolphin [Tursiops aduncus] **Source:** P Hale

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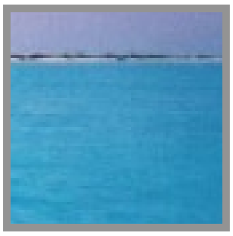
Species group name and description

The order Cetacea includes the baleen whales (Mysticeti) and the toothed whales, dolphins and porpoises (Odotoceti). In Australian waters 43 species of cetacea have been identified (Bannister et al. 1996), of a worldwide total of about 78 species (Jefferson et al. 1994). The number of species recognised in northern Australian waters by Bannister et al. (1996) is fewer than the Australian total as some species have exclusively temperate distributions and do not inhabit lower latitudes. Chatto and Warneke (2000) compiled records of cetacean strandings, and one confirmed sighting of a species that has yet to be recorded as a stranding, in the Northern Territory (NT) over 50 years. Listed in Table 9.1 are the eighteen species identified in the Northern Planning Area (NPA) or predicted to occur there based on known occurrence in the Timor Sea or Arafura Sea to the west of the NPA (Chatto & Warneke 2000, Porter & Chilvers 2003, I Brieze pers. comm., Hale unpublished). A dedicated boat-based survey of small cetaceans in northern and southern parts of the Timor Sea in October 2002 and March 2003 (Porter & Chilvers 2003), sponsored by Environment Australia, identified several species (Table 9.1).



C'wealth status: Refers to the conservation status classification of Bannister et al. (1996) and Commonwealth *Environment Protection & Biodiversity Conservation Act 1999*, and conservation status suggested by Ross (2003) if *T. truncatus* and *T. aduncus* are recognised as separate species. Codes used under C'wealth status: K, insufficiently known; V, vulnerable; E, endangered; NCA-a, no category assigned due to insufficient information; -b, NCA but possibly secure; -c, NCA but probably secure.

Qld status: (Queensland *Nature Conservation Act 1992*). *Codes used: V, vulnerable; R, rare; C, common.*

STS & NTS: *Cetacean species confirmed (X) from Australian (southern) and Indonesian/Timor-Leste (northern) area of the Timor Sea during a boat-based survey in October 2002 and March 2003 (Porter & Chilvers 2003).*

Known (K) / Predicted (P) in NPA: *Species known from the Northern Planning Area or predicted to occur in that area based on presence in the Timor Sea or Arafura Sea to the west of the NPA.*

Table 9.1: *List of cetacean species known or predicted to be present in the Northern Planning Area.*

Common name	Scientific name	C'wealth status	Qld status	STS	NTS	K/P in NPA
Indo-Pacific hump-backed dolphin	*Sousa chinensis*	K	R	X		K
Irrawaddy River dolphin	*Orcaella brevirostris*	K	R	X		K
Offshore bottlenose dolphin	*Tursiops truncatus*	NCA-a	C	X		K
Inshore bottlenose dolphin	*Tursiops aduncus*	NCA-a	C	X	X	K
Common dolphin	*Delphinus delphis*	NCA-b	C			K
Spinner dolphin	*Stenella longirostris*	K	C	X	X	P
Pantropical spotted dolphin	*Stenella attenuata*	NCA-a	C			P
Melon-headed whale	*Peponocephala electra*	NCA-a	C		X	K
False killer whale	*Pseudorca crassidens*	NCA-b	C	X		K
Short-finned pilot whale	*Globicephala macrorhyncus*	NCA-b	C			P
Killer whale	*Orcinus orca*	NCA-c	C			K
(Cuvier's) goose-beaked whale	*Ziphius cavirostris*	NCA-b	C			P
Sperm whale	*Physeter macrocephalus*	K	C			K
Dwarf sperm whale	*Kogia simus*	NCA-a	C		X	P
Rough-toothed dolphin	*Steno bredanensis*	NCA-a	C			P
Fraser's dolphin	*Lagenodelphis hosei*	NCA-a	C	X		P
Blue whale	*Balaenoptera musculus*	E	C			P
Humpback whale	*Megaptera novaeangliae*	V	V			K

Status

Bannister et al (1996), in their assessment of the conservation status of cetacean species in Australian waters, defined categories based on International Union for Conservation of Nature and Natural Resources (IUCN) criteria; eg, 'Extinct', 'Endangered', 'Vulnerable' and 'Insufficiently Known'. As there is insufficient information to enable the conservation status of most Australian cetaceans to be assessed adequately, Bannister et al. (1996) defined three additional categories to accommodate this lack of information; No Category Assigned: (a) because of insufficient information, (b) but possibly secure, (c) but probably secure. Most Australian cetaceans fit into one of these last three categories. The Bannister et al. (1996) classification for those cetaceans identified in or likely to be present in the NPA is included in Table 9.1. Only one of these, the killer whale, is considered to be in category NCA(c); No Category Assigned but probably secure. The sperm whale Physeter macrocephalus is now listed as 'Vulnerable' on the IUCN Red List. Also shown in Table 9.1 are the conservation categories for species under the Queensland Nature Conservation Act 1992.

All cetacean species are protected in Australian waters and most are listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices I or II.

Some species found in the NPA worth considering in some detail, due to the likelihood of impacts from human activities, are the inshore and offshore bottlenose dolphins *Tursiops aduncus* and *T. truncatus*, the Indo-Pacific hump-backed dolphin Sousa chinensis, the Irrawaddy River dolphin *Orcaella brevirostris* and the spinner dolphin *Stenella longirostris*.

Morphological and genetic evidence (Hale & Crawford 1997, Wang et al. 1999, 2000, 2001, Hale et al. 2000) supports the division of Tursiops into at least two species, *Tursiops aduncus*, the inshore bottlenose dolphin, and T. truncatus, the offshore bottlenose dolphin. On the east coast of Australia, the inshore bottlenose dolphin inhabits estuaries and shallow offshore waters (<30m) while the offshore bottlenose dolphin inhabits deeper offshore waters (Hale et al. 1998, Hale et al. 2000). Both species have been identified within

the NPA and adjacent waters (I Brieze pers. comm., Hale unpublished). Discrete populations of bottlenose dolphins occupying an inshore habitat, including the inshore bottlenose dolphin, have been described from behavioural (Shane et al. 1986, Smolker et al. 1992) and genetic data and, as for many mammal species, are known, from genetic data, to exhibit female natal philopatry (female attachment to natal site; Hanson & Defran 1993, Gratten & Hale 1997, Hale et al. 1999, Hale 2002).

Indo-Pacific hump-backed dolphins usually inhabit shallow coastal waters of less than 20 m depth and is often associated with tidal riverine and estuarine systems, enclosed bays and coastal lagoons, mangrove areas and seagrass meadows (Corkeron et al. 1997, Hale et al. 1998, Jefferson 1999, Jefferson & Karczmarski 2001). Analysis of population structure using molecular genetic data indicates that genetically distinct populations occur over discrete geographic ranges (Hale & Pople 2003, Frere & Hale in prep.). Both genetic data (Frere & Hale in prep.) and that obtained from monitoring populations in the field (Taverney & Hale in prep.) indicate that local populations are both small in size and discrete in geographic range. In the Moreton Bay region of Queensland there are about 160 Indo-Pacific hump-backed dolphins (Corkeron 1990, Taverney & Hale in prep.). The population of Indo-Pacific hump-backed dolphins in the Cleveland Bay region of North Queensland is estimated at about 200 (Parra et al. 2002).

The Irrawaddy River dolphin is documented from the NPA and other areas throughout its range as occurring in rivers, estuaries, inshore waters (Marsh et al. 1989, Perrin et al. 1996) and shallow offshore waters (Freeland & Bayliss 1989). Morphological variants of *Orcaella* in different parts of their range have been described (Perrin et al. 1996), with Stacey and Arnold (1999) proposing that Orcaella in Australian waters are at least a subspecies and perhaps a separate species to those in South-east Asia. This evidence for restricted gene flow among localities within the species range suggests the geographic range of distinct populations is small.

Data for these species support a model of discrete local populations with restricted distributions. In the NPA and other parts of the Arafura Sea the geographic range of distinct populations of inshore bottlenose dolphins is likely to be larger because there are extensive areas of offshore shallow water. The range of populations of Indo-Pacific hump-backed dolphins is likely to be restricted, as it is on the east coast of Australia, because their habitat is primarily enclosed rather than open waters, while that of inshore bottlenose dolphins appears to be limited only by depth (Hale et al. 2000).

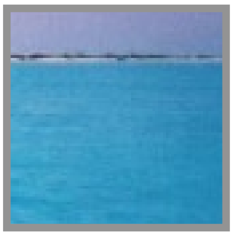
It is reasonable to expect that Irrawaddy River dolphins also comprise small populations with discrete geographic ranges not larger than those of Indo-Pacific hump-backed dolphins.

A driftnet fishery operating from 1981 to 1985 in offshore waters in the Arafura and Timor Seas, mostly in the western part or to the west of the NPA, was estimated to have caught 14 000 dolphins as bycatch, with inshore bottlenose dolphins and spinner dolphins comprising 60% and 35% respectively of the cetacean bycatch in that fishery (Harwood & Hembree 1987).

The small size and restricted range of populations, and female natal philopatry in Indo-Pacific hump-backed dolphins and (likely) Irrawaddy River dolphins suggests that their populations would be more vulnerable to the consequences of incidental mortality through human impacts, especially when females are lost from populations. The geographic range of distinct populations is also likely to be restricted for the other predominantly inshore dwelling cetacean listed in Table 9.1, *T. aduncus*, but not to the extent that it is for Indo-Pacific hump-backed dolphins and Irrawaddy River dolphins.

Habitat and distribution

The distribution of all cetacean species found in or predicted to occur in the NPA extends beyond that area. Irrawaddy River dolphins have a relatively restricted distribution, inhabiting coastal areas and rivers from the Bay of Bengal through the Indo-Malay Archipelago. In Australian waters they inhabit tropical and subtropical coastal waters between Coral Bay in the west and Gladstone in the east (Marsh et al. 1989). Although Irrawaddy dolphins are known to occur in several major river systems of Southeast Asia, in Australia they have been documented almost exclusively in coastal and estuarine waters. The occurrence of Irrawaddy dolphins in the upper tidal reaches of the Brisbane river appear to be extralimital and it is doubtful if they venture very far upstream in river systems throughout their Australian range (Parra et al. 2002).



The humpback dolphin is distributed from the south-east coast of Africa along the continental coastlines of the Indian Ocean, through South-east Asia to the South China Sea. In Australian waters the Indo-Pacific humpback dolphin inhabits coastal areas from the Moreton Bay region on the east coast along the northern coastline to about Shark Bay on the west coast (Ross et al. 1994, Hale et al. 1998, Parra et al. 2004).

Inshore bottlenose dolphins inhabit coastal and shallow offshore areas around the entire Australian coastline, and their range includes South-east Africa and the continental coastlines of the Indian Ocean, South-east Asia to the South China Sea (Hale et al. 2000). Offshore bottlenose dolphins are distributed in offshore tropical and temperate waters throughout the world, as are spinner dolphins. Overall, the NPA constitutes a small part of the range of all species listed in Table 9.1. For example, the humpback whale has a worldwide distribution. In Australian waters its migratory routes from summer feeding grounds in Antarctic waters to breeding and calving grounds are along the east and west coasts, generally south of latitude 17°S. The Arafura and Timor Seas do not appear to be part of the usual migratory pathway of the humpback whale, but they have been sighted in the winter months in the western part of the Arafura Sea.

General information on the distributions and life histories, including prey items, of species in Table 9.1 can be found in Jefferson et al. (1994). Different species may be specialised for prey items. Beaked whales feed almost exclusively on squid (Cephalopoda), a favoured prey item for many cetacean species. Inshore dolphins also feed on crustacea including penaid prawns, crabs and a variety of smaller fish including mullet (*Mugil* spp.) and tailor (*Pomatomus saltatrix*); bottlenose dolphins prefer small fish associated with reefs and sandy bottoms while hump-backed dolphins prefer fish associated with mangrove communities (Hale et al. 1998). Larger-toothed whales such as killer whales, false killer whales and pilot whales take larger fish species, including tuna (Scombridae) and other species hooked on commercial long-lines.

As mentioned in the previous section, those species with a coastal habitat (the Indo-Pacific hump-backed dolphin, the Irrawaddy River dolphin and to a lesser extent the inshore bottlenose dolphin) are likely to comprise discreet local populations having a restricted geographic range, with limited dispersal of males between adjacent populations, maintaining gene flow. The consequence of female natal philopatry is that females and their female descendents stay at or close to their natal site. Young are reared within the maternal home range and female offspring remain with the group. Thus the matriline is site-attached. The integrity of the group within the home range is most likely maintained by related females. Impacts that remove females from the population may affect population viability because there will be no female immigrants to replace females lost from populations.

Significance of the species group in the Northern Planning Area

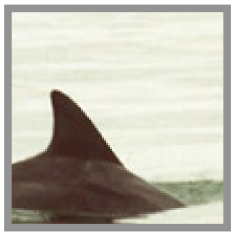
Cetaceans have minimal economic significance within the NPA because they are protected species and at this stage whale and dolphin viewing enterprises do not operate within the NPA. They are of little if any cultural significance to Europeans inhabiting the coastlines of or utilising the NPA. There is evidence that they are, or were, consumed by Aboriginal peoples in the NT, but are unlikely to have constituted an important dietary component (Chatto & Warneke 2000). Cetaceans may have cultural significance as totem animals for Aboriginal peoples within the NPA, as suggested by Chatto & Warneke (2000), as they do for the Quandamooka People in the Moreton Bay region of South-east Queensland.

Impacts/threats

Set mesh nets

The primary threat to cetaceans in the NPA is incidental mortality as a result of fishing activities.

Fisheries using set mesh nets operate in inshore and offshore waters of the NPA (Roelofs 2003). Objective 2 of the management plan for the N3 and N9 Gulf of Carpentaria (GoC) Inshore Finfish Fisheries is that 'the fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species …' (Roelofs 2003). To this end there are procedures in place that may serve to minimise the risk of cetaceans becoming enmeshed in set mesh nets: the requirement for attending nets, restrictions on net length, closed water declarations in areas identified as being important for protected species, and minimum and maximum mesh sizes for nets (Roelofs 2003). The code of conduct for the GoC Inshore Finfish Fishery specifies trialling of acoustic pingers to warn dolphins of net locations (Roelofs 2003, see below).



Seismic testing

Seismic testing, involving the generation of a shockwave from a blast of compressed air from a gun towed behind a vessel, is used to search for resources such as oil under the seabed. Female humpback whales have been shown to avoid seismic air guns while males are attracted to them (McCauley et al. 2000). There is a requirement in Australian waters that areas to be tested are clear of cetaceans before testing commences.

Sonar

Two types of anti-submarine sonar are being assessed for effects on marine mammals: mid-frequency and low frequency sonars. Mid-frequency sonar has been related to mass strandings of cetaceans, particularly beaked whales (Evans & England 2001). The use of low frequency sonar has been restricted by the United States Navy to areas that are not of biological or recreational importance (AWI 2001).

Information gaps

As noted by Bannister et al. 1996, there is insufficient information available about all the species in Table 9.1 to enable an assessment of conservation status to be made with confidence. The species in the table have extensive ranges, but in most cases the extent of population structure within species is not well understood, so that decisions about whether discrete populations may be threatened cannot be made. Gaps in knowledge about life history parameters for some species can be filled in with information from related species where our knowledge is more complete. If information on population sizes, geographic ranges and movements among populations is available (whether real time data or deduced from estimates of gene flow) then the effect of human threats to population viability can be modelled adequately if the extent of any impacts is known.

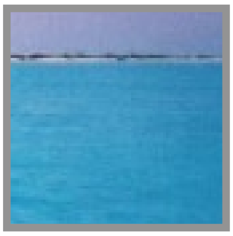
Information about the distribution of cetacean species in the NPA is lacking. The region is remote and comprises relatively undisturbed habitats. An opportunity exists to conduct baseline research and monitoring on cetaceans before human expansion and development affect populations. Dedicated surveys are expensive and very time-consuming, but such work need not necessarily be costly when government agencies conducting routine surveillance in the area for national security could be enlisted to collect data on the distribution and abundance of wildlife. As well, fisheries management observers on vessels could be required to record cetacean sightings when at sea. Cetaceans could be identified with the aid of a species identification manual. Distribution and frequencies of sightings, with corrections for visibility (eg, sea state), would be very helpful in learning about species composition, distribution and (seasonal) abundance in the NPA. Aboriginal communities in remote areas could initially be encouraged to report incidents of cetacean strandings and in the longer term be involved in programs for wildlife monitoring.

Data on fishing effort and incidental mortality should be collected for all fisheries operating in the NPA, not only those fisheries with an observer program or individual vessels with observers on board. Cetacean bycatch is an emotive subject generally. As a reward for honesty in reporting incidental mortality, fishers need assurance from government that public response to information about incidental mortality will not threaten their livelihoods.

Key references and current research

Studies of the habitat requirements, ranges of distinct populations, and population sizes of Indo-Pacific hump-backed dolphin and Irrawaddy River dolphin are underway in parts of the species range, including Australia, outside the NPA. The conservation and management of viable populations of Irrawaddy and Indo-Pacific humpback dolphins, in Australian waters is uncertain. Most of this uncertainty is due to the general lack of species-specific information on their ecology, which consequently has hampered conservation and management efforts (Parra et al. 2002, 2004). These are the two species most likely to be at risk from the main potential threat to population viability, set mesh nets. Research into the effects of dolphin mortality as a result of the Queensland Shark Control Program (Gribble et al. 1998) on the viability of cetacean populations is under way. Life history parameters (fecundity, maturation age, longevity) obtained for bottlenose dolphins (Wells & Scott 1990, Dunn et al. 2001, Hale 2002) are unlikely to differ significantly from those described briefly for Orcaella (Marsh et al. 1989) or Sousa (Ross et al. 1994) and can be used as a basis for establishing population parameters for these species, to be used as a basis for population viability analysis (PVA). Data on bycatch for this work does not derive from the NPA, but the results are directly relevant to an assessment of the viability of populations within that area (Hale & Pople unpublished).

Studies in Australia and overseas on the usefulness of acoustic pingers attached to nets as a deterrent for cetaceans are continuing, as previous studies (Goodson



et al. 1997, Kraus et al. 1997, Stone et al. 1997, Barlow & Cameron 2003, Cox et al. in press), although well designed, have failed to show that the pingers are directly responsible for lowered levels of entanglement of cetaceans in set nets. Nonetheless, the decision to use pingers on mesh nets in the NPA (Roelofs 2003) is a positive step because it is not proven that they are inneffective. Encounter rates with dolphins are low in the N3 and N9 fisheries and dolphin mortality is very low (Roelofs 2003). It would take a long time to achieve sufficient statistical power in these fisheries to decide unequivocally whether or not pingers are effective. Nonetheless, the trialing of these devices demonstrates a commitment by fishers to management of these fisheries for ecological sustainability (Hale et al. 2000).

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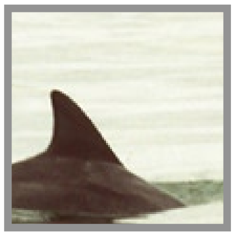

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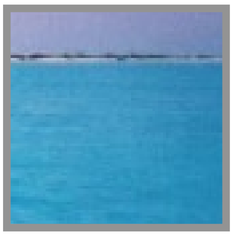

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10. Dugong

Dugong surfacing at Ashmore Reef on the edge of the Australian continental shelf, some 840 km west of Darwin and 610 km north of Broome ***Source:*** *Scott D Whiting*

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Species group name and description

Dugong dugon: Dugong, Sea Cow

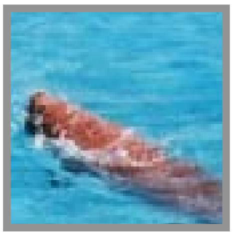
The dugong is a large, herbivorous, exclusively marine mammal and is the only extant (living) member of the family Dugongidae. It is one of only four extant species of the order Sirenia, which are descended from terrestrial mammals that browsed in shallow grassy swamps during the Eocene period. Their closest modern relative is the elephant.

Adult dugongs grow up to about 3 m in length and up to 450 kg (Spain & Heinsohn 1975) and have a rotund body with a horizontal tail and forward pectoral fins. Dugong eyes are set laterally. The auditory (ear) openings are small and set laterally behind the eyes.

Status

International

The dugong is listed as vulnerable to extinction in the International Union for the Conservation of Nature, World Conservation Union's Red Data Book of Threatened Species (IUCN 2000). The dugong is listed on the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) and on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Indigenous dugong fishery in Torres Strait is also listed as an Article 22 fishery in the Torres Strait Treaty between Australia and Papua New Guinea.



Australian Government

The Convention on Biological Diversity, the Convention on the Conservation of Migratory Species, and the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES) all oblige Australia to protect the dugong stocks in northern Australian waters (Stokes and Dobbs 2001). *The Australian Government Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) makes it an offence to take any action that may have a significant impact on a matter of national environmental significance without prior approval from the Minister for the Environment and Heritage. Matters of national significance include listed migratory species.

The dugong is listed both as a migratory species and as a listed marine species under the EPBC Act. Any actions that might significantly impact on a population of the species must be referred to the Minister for the Environment and Heritage for approval. The EPBC Act also makes it an offence to recklessly kill, injure, take, trade, keep or move a member of a listed migratory species in a Commonwealth area, unless the person taking the action holds a permit under the EPBC Act.

However, nothing in the EPBC Act affects the operation of section 211 of the *Native Title Act 1993* which states that Indigenous people with a Native Title right carrying out traditional hunting of dugongs do not need a permit under the EPBC Act authorising them to undertake the activity, nor do they need approval under that Act.

The Commonwealth gives effect to the provisions of the Torres Strait Treaty between Australia and Papua New Guinea through the *Commonwealth Torres Strait Fisheries Act 1984* which recognises the dugong fishery as an Article 22 Fishery.

Queensland

The dugong is protected wildlife in Queensland waters under the *Nature Conservation Act 1992*, under which it is classified as vulnerable. The Act prohibits the taking, interference with, possession, control or movement of protected wildlife, unless authorised to do so under the Act. The Act recognises the rights of Aboriginal and Torres Strait Islander people to take, use or keep protected wildlife under Aboriginal tradition or Island custom subject to any provision of a conservation plan that expressly applies to the taking, using or keeping of protected wildlife under Aboriginal tradition or Island custom. However, this section of the Act has not been proclaimed and so the act is effectively silent on the issue of Indigenous hunting as discussed below. Additionally, the Act does not permit an Aboriginal or Torres Strait Island person to take, use or keep protected wildlife under Aboriginal tradition or Island custom in a protected area unless authorised to do so under the Act.

Queensland gives effect to the provisions of the Torres Strait Treaty between Australia and Papua New Guinea through the *Torres Strait Fisheries Act Qld 1984* which, like the corresponding Commonwealth legislation, recognises the dugong fishery as an Article 22 Fishery.

Northern Territory

In the Northern Territory (NT), dugongs are protected wildlife under the *Territory Parks and Wildlife Conservation Act 2001* (TPWC Act). The Act prohibits the taking, interference with, possession, control or movement of protected wildlife, unless authorised to do so under the Act. The Act recognises the rights of Aboriginal people who have traditionally used an area of land or water to continue to use that area for traditional hunting, food gathering (other than for sale) and for ceremonial or religious purposes. Traditional hunting of dugong by Aboriginal people is covered by section 122 of the Act and Aboriginal people carrying out traditional hunting of dugong do not need a permit under the TPWC Act authorising them to undertake the activity, nor do they need the approval of the Act.

General comment

The different jurisdictions in the Northern Planning Area (NPA) differ in their listing of the dugong for two reasons: (1) it is legitimate to estimate extinction probability differently at different spatial scales and (2) jurisdictions differ in their definitions of the categories of threat. Nonetheless, as outlined above, most Commonwealth, Queensland and NT laws consider dugongs as species to be protected, except from hunting by Indigenous peoples under prescribed circumstances. However, the legislative environment is completely different in the Torres Strait Protected Zone (TSPZ) and adjacent waters, where the dugong is considered as the target species of an Indigenous fishery rather than as a protected species. The concept of 'sustainability' only emerged in Australian law after the 1992 Rio Earth Summit in the National Strategy for Ecologically Sustainable Development (ESD) which became State and Commonwealth policy under the Inter Governmental Agreement on the Environment (IGAE) 1992.

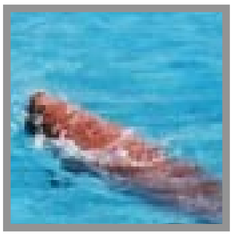
10. Dugong

In 1992, the Australian High Court made the landmark decision to recognise the potential existence of Native Title on land in Australia *(Mabo v The State of Queensland [No 2] (1992) 173 CLR 1)*. This decision provided a new framework for the recognition of Indigenous rights to land, sea and wildlife, and gave Indigenous peoples who are Native Title holders some bargaining power over the management of their traditional lands. The Commonwealth Government's legislative response to this decision was the Commonwealth *Native Title Act 1993*. The Queensland and NT Governments subsequently also passed Native Title legislation. As explained above, Section 211 of the Commonwealth Act negates a Native Titleholder's need to obtain permits for certain activities including hunting, provided hunting is for the purpose of satisfying personal, domestic or non-commercial communal needs and is exercised as part of the hunter's Native Title rights and interests. This right was affirmed in 1999 by the Yanner decision of the High Court of Australia which concluded that Queensland State fauna licensing requirements did not apply to Native Title holders exercising rights for 'personal, domestic or non-commercial needs' by virtue of s211 *Native Title* Act and s109 of the Australian Constitution *(Yanner v Eaton [1999] HCA 53 7 October 1999)*.

The use of s.211 in the sea countries of the Indigenous peoples in the dugong's range in the NPA will ultimately turn on the existence of their Native Title right. Native Title over the customary sea area surrounding Croker Island in the NT was recognised in the Croker Island Native Title judgment *(Mary Yarmirr & Others v The Northern Territory and Others, 1998)* and confirmed by the High Court of Australia in October 2001 *(The Commonwealth of Australia v Yarmirr; Yarmirr v Northern Territory [2001] HCA56 11 October 2001)*. The High Court determined that Native Title over the sea in this case was not exclusive and that interests of importance to Native Title holders specifically include traditional hunting of dugongs. A similar decision was made with respect to the Wellesly Islands in the Gulf of Carpentaria in March 2004. *(The Lardil Peoples v State of Queensland [2004] FCA 298)*.

The rights of Indigenous peoples who are historically associated with the coastal waters in the dugong's range in the NPA are less clear and have changed several times. For example, since the early years of the 20th century, Queensland and NT fauna and/or fisheries legislation generally permitted all Aboriginal peoples to take native marine fauna such as dugongs for subsistence. This is still the case in the NT as well as in Torres Strait. In contrast in other parts of Queensland, the legislation has changed several times. Since 1974 and exemptions for Indigenous peoples have been varied through time. The Queensland *Community Services (Aborigines) Act 1984* exempts members of an Aboriginal community resident on trust areas from fisheries legislation. The legislative regime governing dugong and turtle hunting was eventually changed to the *Queensland Nature Conservation Act 1992*. This legislation allows Indigenous peoples to take, use or keep wildlife taken in accordance with Aboriginal tradition or Islander custom subject to the provisions of a conservation plan, which is required for protected wildlife such as dugongs and turtles. This section of the *Queensland Nature Conservation Act 1992* has never been proclaimed as noted above. Nonetheless, the Queensland *Nature Conservation (Dugong) Conservation Plan 1999* states that the Indigenous hunting of dugongs by Aboriginal people will be managed in a manner consistent with the Commonwealth *Native Title Act 1993*, which confirms the rights of traditional owners but is silent on the rights of traditionally associated peoples.

Since 1999, the EPBC Act regulates activities within Australian jurisdiction likely to have a significant impact on the Commonwealth Marine Area, which is defined in this Act as essentially that area under Commonwealth title and jurisdiction, except for state and NT waters (s23–24a). The EPBC Act explicitly states that it does not affect the operation of s211 of the Commonwealth *Native Title Act 1993*. Nonetheless, where Native Title has survived, it is subject to the important qualification that its exercise has usually to be in accordance with the provisions of other relevant legislation. Presumably this means that any Indigenous person (including traditional owners) practising unsustainable levels of hunting for dugongs in the NPA could be prosecuted under the EPBC Act. It is arguable that these powers could also be applied to other activities in the NPA if they impact on the conservation and management of such species in the Marine Area (Professor Martin Tsamenyi, Centre for Maritime Policy University of Wollongong, pers. comm. 2002). A key management priority then should be to develop and implement a method of ensuring that the Indigenous harvest of dugongs in northern Australia is sustainable. As a key object of the EPBC Act is the need to promote a cooperative approach to the conservation and ecologically sustainable use of Australia's biodiversity, it would be consistent with that Act for this method to be determined cooperatively by Indigenous communities and the relevant managing agencies. Given that dugongs move large distances and that there are no clearly defined stock boundaries, sustainable harvest levels need to be calculated at appropriate spatial scales. This is a considerable challenge given the differences in the laws relevant to species conservation and the hunting rights of Indigenous peoples outlined above.



Habitat and Distribution

Life history and reproductive ecology

Life history models for the dugong (Marsh et al. 1984, Boyd et al. 1999) indicate that they are long-lived animals with a low reproductive rate, long gestation period and high investment in each offspring.

Marsh (1980) estimated the age of dugongs by counting seasonally deposited growth layer groups in the tusks. Their maximum life span is approximately seventy years. Dugongs over 2.5 m are generally mature, while male and female dugongs less than 2.2 m are probably immature (Marsh et al. 1984). The pre-reproductive interval ranges between 6 and 15 years (Marsh et al. 2003 & in press).

Female dugongs usually bear a single calf every 2.5 to 7 years. The gestation period is about 13 months and the calf suckles for about 18 months. At least some calving occurs in the shallow waters of tidal sandbanks (Marsh et al. 1984) and estuaries (Hughes & Oxley-Oxford 1971); possibly a strategy to avoid shark attacks (Anderson 1981). Breeding is diffusely seasonal, with breeding activity more likely to occur in the second half of the year than in the first (Boyd et al. 1999).

Population simulations indicate that even with the most optimistic combinations of life history parameters (eg low natural mortality and no human-induced mortality) a dugong population is unlikely to increase at more than 5% per year (Marsh 1995b, Boyd et al. 1999) with more realistic predictions of increase ranging from 1 to 3% per year (Marsh et al. 2003 & in press).

Diet and habitat

Dugongs feed on seagrasses found in the shallow tidal and subidal coastal marine environment. They were originally believed to feed opportunistically on available seagrasses (Marsh et al. 1982, Lanyon et al. 1989), but Preen (1992) indicates that preferential grazing occurs in at least some areas, apparently based on the nutritional quality of the seagrass. Lanyon (1991) and Aragones (1996) found that the most frequently selected seagrass species are lowest in fibre and highest in available nitrogen and presumed digestibility. In many areas, seagrass species of the genera *Halophila* and *Halodule* are favoured.

Marine algae are also eaten (Spain & Heinsohn 1973, Marsh et al. 1982). Macroinvertebrates are also consumed particularly at the higher latitude limits of the range (Heinsohn & Spain 1974, Anderson 1989 and Preen 1995a). Algal feeding is believed to occur only when seagrass is scarce (Spain & Heinsohn 1973).

When feeding on the preferred seagrasses, dugongs dig up the whole plant including the nutrient-rich rhizomes (Heinsohn & Marsh 1978, Marsh et al. 1982). This produces the distinctive feeding trails that are seen particularly in low biomass seagrass beds. Dugongs consume between 28 and 40 kg of seagrass each day.

Dugongs have also been reported in deeper water further offshore. Large numbers have been sighted in waters more than 10 m deep (Marsh & Saalfeld 1989, 1991) and Marsh and Saalfeld (1989) sighted dugongs up to 58 km from the north Queensland coast in water up to 37 m deep. This distribution reflects that of deeper seagrasses such as *Halophila spinulosa* (Lee Long et al. 1993). Whiting (1999) reported dugongs, including calves, at Ashmore Reef on the edge of the Australian continental shelf, some 840 km west of Darwin and 610 km north of Broome.

Movements

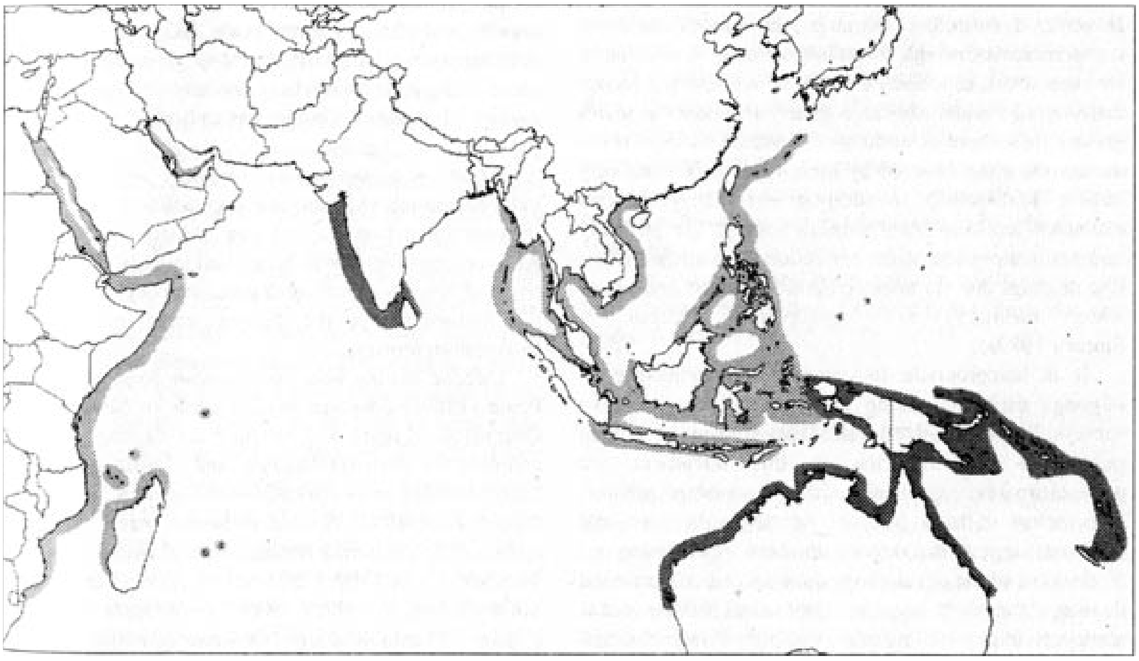
Dugong movements have been tracked in several studies using VHF and satellite transmitters. Movements appear to be individualistic. Most animals restrict their movements to tens of kilometres within the vicinity of seagrass beds (Marsh & Rathbun 1990, Preen 1993, 1995b, 1999 & 2001, de Longh et al. 1998). A number of animals have been observed to travel large distances – up to 600 km in a few days (Marsh & Rathbun 1990, Preen 1995b, 1999 & 2001). These observations indicate that dugongs have the capacity to undertake long-distance movements, a factor which must be taken into account in their management and significantly affecting habitat management. The results of repeated surveys of the same regions provide strong evidence for large-scale movements of dugongs in response to seagrass dieback as outlined below.

Distribution and abundance

The range of the dugong (Figure 10.1) spans 37 countries throughout the tropical and subtropical coastal and island waters of the Indo-West Pacific from east Africa to the Solomon Islands and between about 26° and 27° north and south of the equator (Marsh et al. 2002). Over much of this range the dugong is believed to be represented by relict populations separated by large areas where they are close to extinction or extinct.

10. Dugong

Figure 10.1: *The known range of the dugong*



The different shadings illustrate different dugong populations, although a genetic basis for these populations has generally not yet been confirmed. Australian dugongs are genetically distinct from those in South-east Asia (from Marsh et al. 2002).

Marsh et al. (2002) reports that, while dugong numbers have declined over much of their range, they are higher than previously supposed in many areas. However, most of the knowledge of dugong distribution and abundance over much of their range is derived from incidental sightings, accidental drownings, and the anecdotal reports of fishers (Marsh et al. 2002). More detailed information is available for several countries based on spatially and temporally limited surveys generally conducted parallel to the shoreline and providing minimum counts only (Marsh et al. 2002). Only in northern Australia, the Arabian Gulf region and New Caledonia have extensive quantitative aerial surveys incorporating corrections for visibility biases been conducted, providing comprehensive knowledge of dugong distribution and abundance in the coastal waters of most of the dugong's range in these areas (Marsh et al. 2002 and Garrigue pers. comm.).

A significant proportion of the world's dugong stocks is found in northern Australian waters between Shark Bay in Western Australia and Moreton Bay in Queensland (Marsh & Lefebvre 1994). It is generally accepted that Australia is the stronghold for the species, with the dugong being the most abundant marine mammal in inshore waters (Marsh unpublished data). Most recent estimates put the Australian population at more than 80 000 dugongs (Marsh et al. 2002). This is likely to be an underestimate as some areas of suitable habitat have not been surveyed.

Table 10.1 summarises available knowledge of dugong numbers in the NPA derived from aerial surveys. Figures 10.2, 10.3, 10.4 and 10.5 show the distribution of dugong in the coastal waters of the NPA based on the most recent aerial surveys.

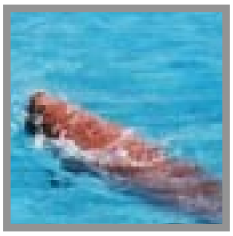


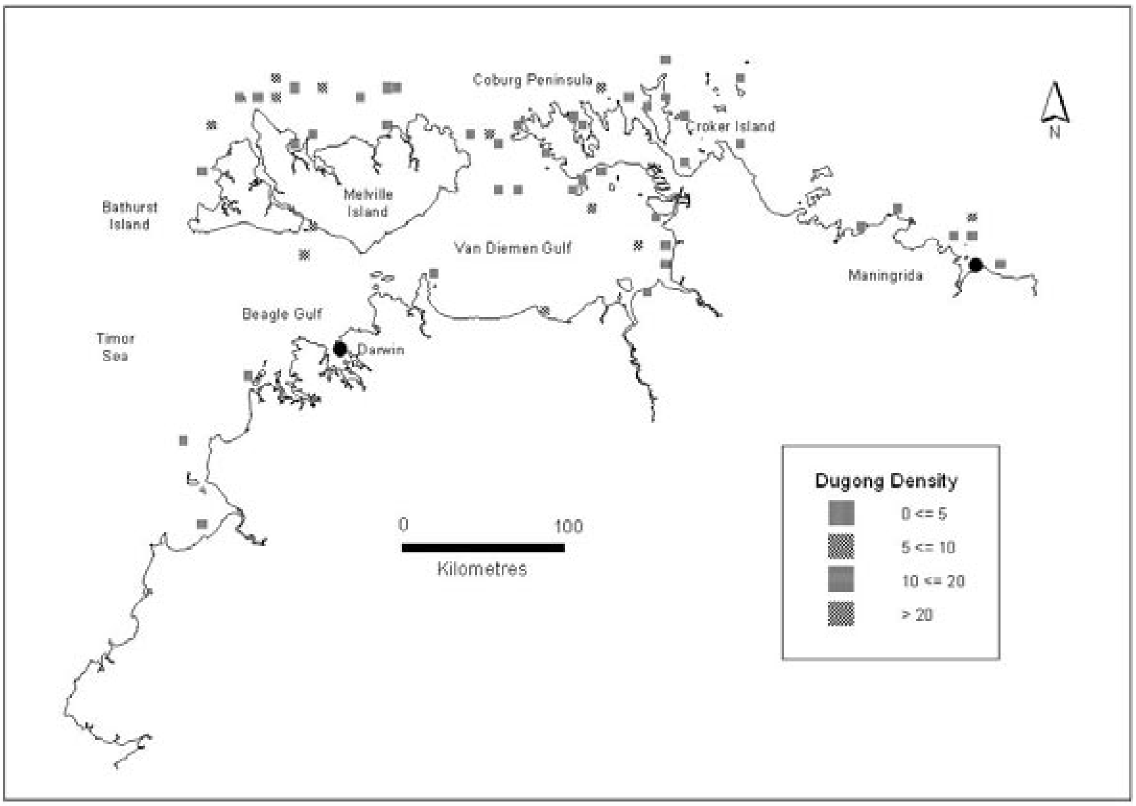
Table 10.1: *Numbers and density (± standard errors) of dugong in the Northern Planning Area The variation in the population estimate for Torres Strait results from dugongs moving in and out of the survey area as explained below.*

Location	Date	Area (km^2)	Number $\pm$ S.E.
Northern Arnhem Land (Goulburn Islands to Milingimbi)	December 1995[1]	9096	1763 ± 956
Gulf of Carpentaria coast of the Northern Territory	February 1985[2] November 1994[1]	27 216 24 770	16 846 ± 3259 23 336 ± 3040
Gulf of Carpentaria Coast of Queensland	December 1997[3]	33 026	4,266 ± 657
Torres Strait[4]	November 1987 November, December 1991 November 1996 November 2001 November 2001	30 560	13 319 ± 2136[5] 24 225 ± 3276[5] 27 881 ± 4720[5] 14,106 ± 2314[5] 14 029 ± 2342[6]
Total[7]		97 452	36 981 ± 4162

[1] Saalfeld (2000).
[2] Bayliss & Freeland (1989).
[3] Marsh et al. (1998).
[4] Marsh et al. (2003 & in press).
[5] estimated using methodology of Marsh and Sinclair (1989a).
[6] estimated using methodology of Pollock et al. (2003 & in review).
[7] sum of population estimates of most recent surveys and for area of surveys only (Saalfeld 2000 data not used as unreviewed, see Preen 1995b).

The survey data suggest that distribution of dugong along the Arnhem Land coast of the NPA is patchy, with a single aggregation offshore from Maningrida being the largest detected (Figure 10.2).

Figure 10.2: *Distribution of dugong density (dugong/km²) along the northern coast of the Northern Territory from the December 1995 survey Sightings near Maningrida are within the NPA.*



10. Dugong

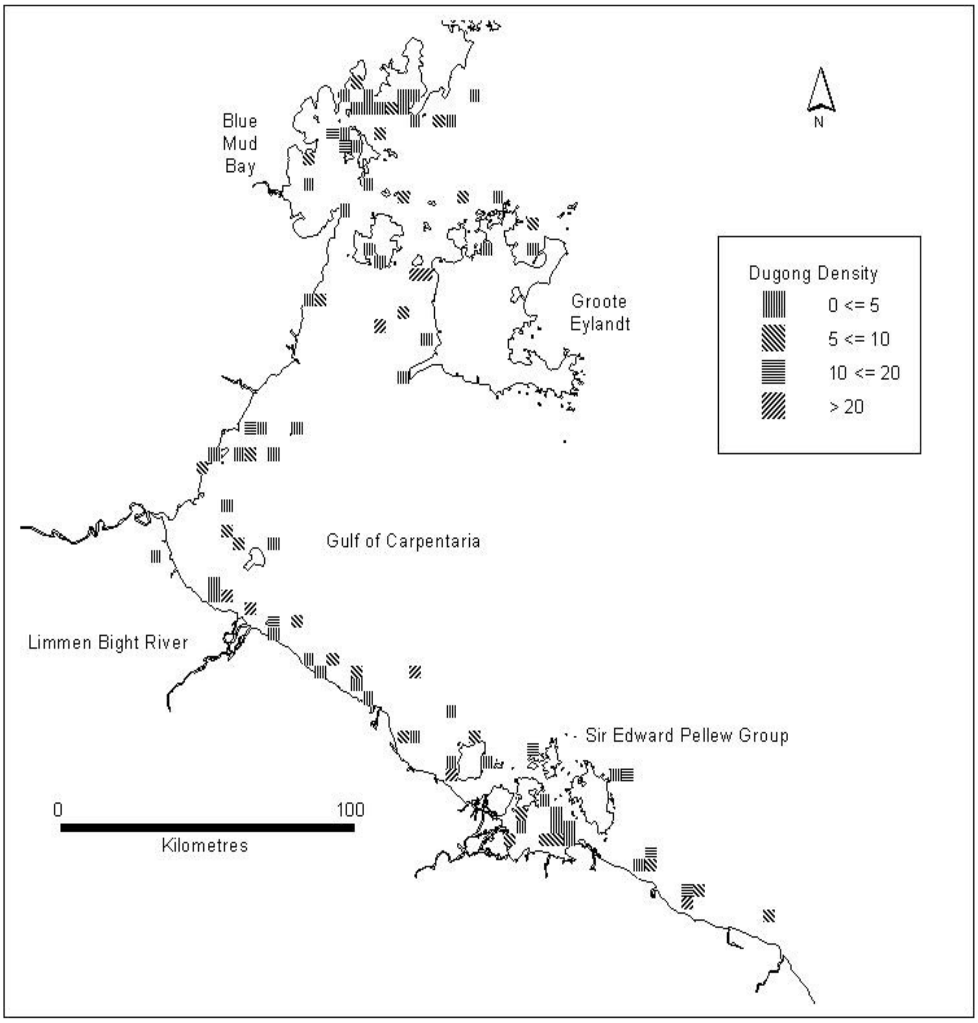
The surveys suggest that the distribution of dugongs along the western Gulf of Carpentaria (GoC) coastline is much more uniform (Figure 10.3), with dugongs occurring along almost the entire length of coastline at medium to high densities. Within this relatively uniform distribution three areas are significant: the top half of Blue Mud Bay, the mouth of the Limmen Bight River and the Sir Edward Pellew Group of islands. The coastal strip from the mouth of the Limmen Bight River to east of the Sir Edward Pellew Group has the largest population of dugongs in the NT and ranks in the top four dugong areas in Australia. Saalfeld (2000) estimates that some 8000 dugongs occur along this strip of coast and within the island group. Blue Mud Bay was estimated to have some 4200 dugongs, giving it the fourth largest population of dugongs in the NT (Saalfeld 2000) and also ranking in the top eight dugong areas in Australia.

Preen (1995b) surveyed the Sir Edward Pellew Group to mouth of the Limmen Bight in the dry season of 1994 and wet season of 1995. Initial analysis indicates a marked difference to the results of the November 1994 survey of Saalfeld (2000). Both of Preen's estimates are 60% lower than that of Saalfeld. This difference is difficult to reconcile given that Preen's surveys were conducted both before and after those of Saalfeld. The area needs to be resurveyed as part of a comprehensive survey of the GoC to derive current baseline abundance estimates.

Almost all sightings of dugongs in the western GoC occurred within the shallow coastal territorial waters of the NT. Few sightings occurred within Commonwealth waters.

Marsh et al. (1998) surveyed the Queensland coast of the GoC, including the Wellesley Islands in December 1997. Of the estimated 4000+ dugong along this coastline more than 60% occurred in the Wellesley Islands area. Most of the remainder was sighted on the northern half of Cape York Peninsula (Figure 10.4).

Figure 3: *Distribution of dugong density (dugong/km^2) along the Gulf of Carpentaria coast of the Northern Territory from the November 1994 survey*



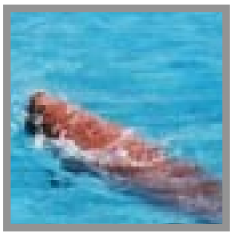
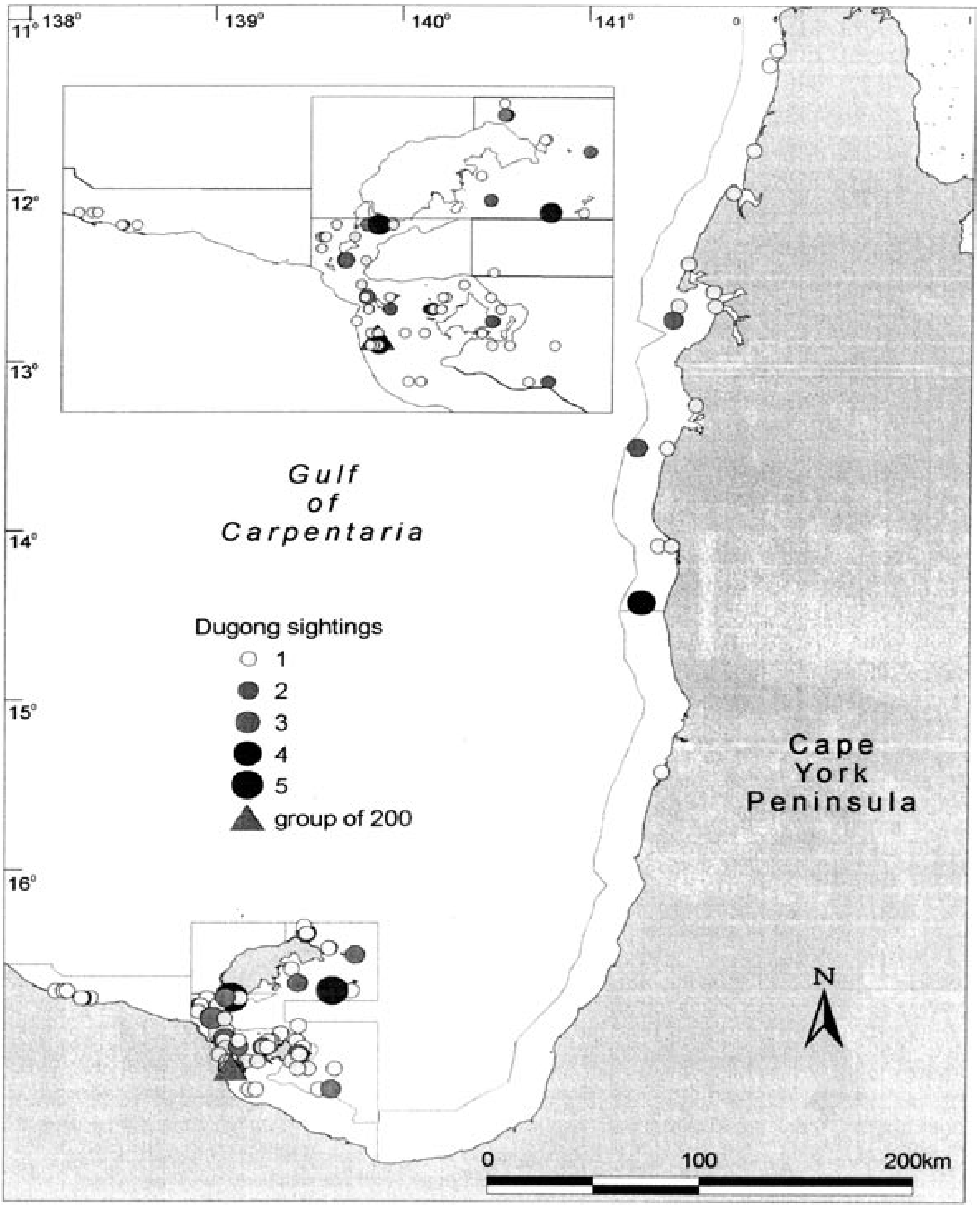


Figure 10.4: Distribution of dugong sightings along the Gulf of Carpentaria coast of Queensland from the November 1997 survey (from Marsh et al. 1998)

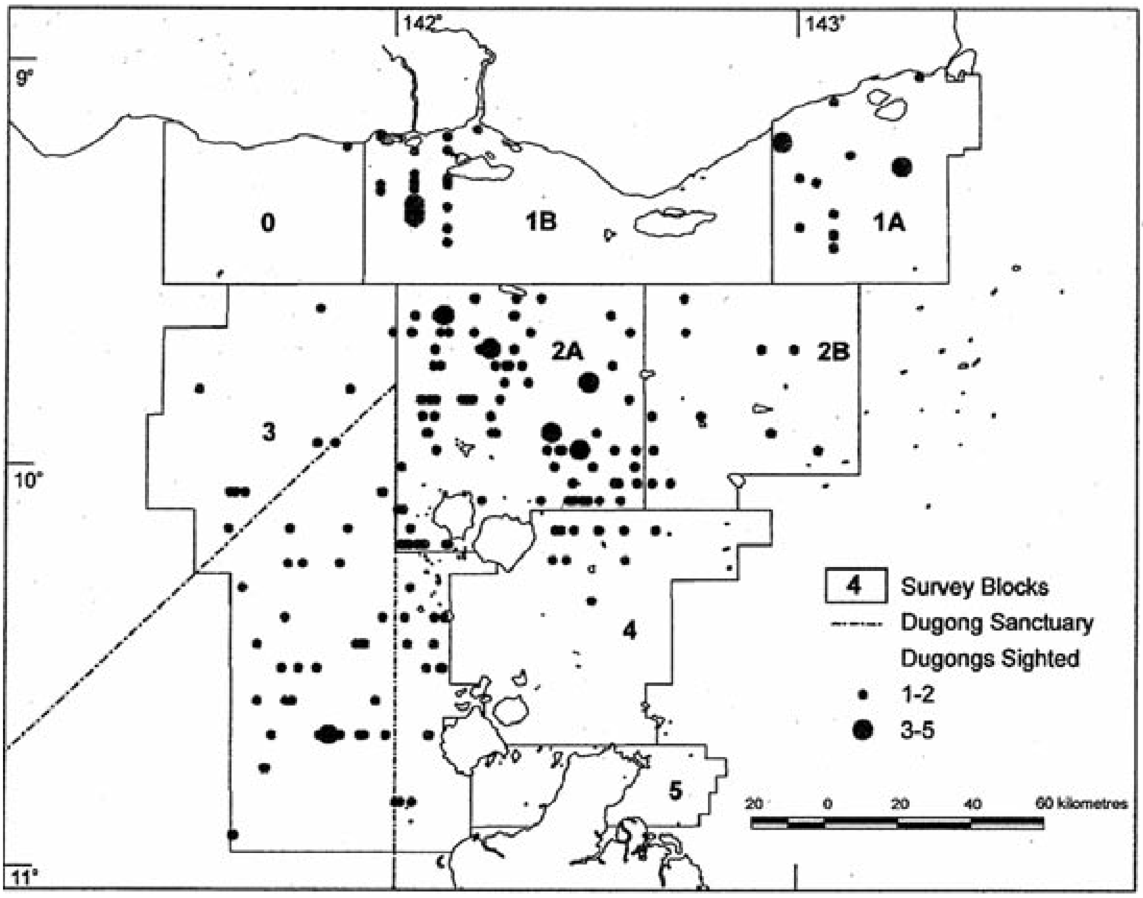


Of the estimated 27 602 (± 3110) dugongs in the GoC, only 15% occurred in the waters of the Queensland coast, reflecting the much greater area of seagrass along the NT coast. Poiner et al. (1987) estimate the area of seagrass along the NT coast of the GoC at 751 km^2 compared with just 155 km^2 (17%) for the Queensland coast1.

Torres Strait has been identified as probably the most important dugong habitat in the world (Marsh et al. 2003) and the Torres Strait dugong population is globally significant. Torres Strait is the most intensively surveyed dugong habitat within the NPA, with four broad-scale surveys of the area between 1987 and 2001. Table 10.1 gives population estimates for the Torres Strait based on these surveys, with population estimates ranging between 13 000 and 27 000 during the 14-year period. Figure 10.5 shows the distribution of dugong sightings from the November 2001 survey of Torres Strait.

[1]For further information on seagrasses in the Northern Planning Area see chapter 2 (Seagrasses).

Figure 10.5: *Distribution of dugong sightings in the Torres Strait from the November 2001 survey (from Marsh et al. 2003).*



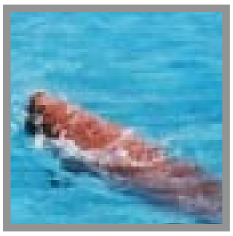
There were significant differences in the four population estimates obtained for the Torres Strait over the past 14 years (Marsh et al. 2003 & in press). Marsh and her group propose that these differences are due to large-scale movements of dugong in and out of the Torres Strait area. Anecdotal evidence supporting large-scale movements is available (Marsh et al. 2003 & in press) and supports the hypothesis that variation in population estimates is due to large-scale movements associated with seagrass dieback in the Torres Strait region.

Within Torres Strait, Block 2A (Figure 10.5) (Orman Reefs region) had the highest dugong population in the 1987, 1991 and 1996 surveys of the Torres Strait (between 36 and 48% of total population) and second highest estimate in 2001 (25%). The second ranked area in Torres Strait is the western region (Block 3, Marsh et al. 2003) with between 21 and 39% of the total population across the four surveys. In 2001, when the Orman Reef area ranked second in population estimate the western region ranked highest and in the years when Orman Reef area ranked highest the western area ranked second.

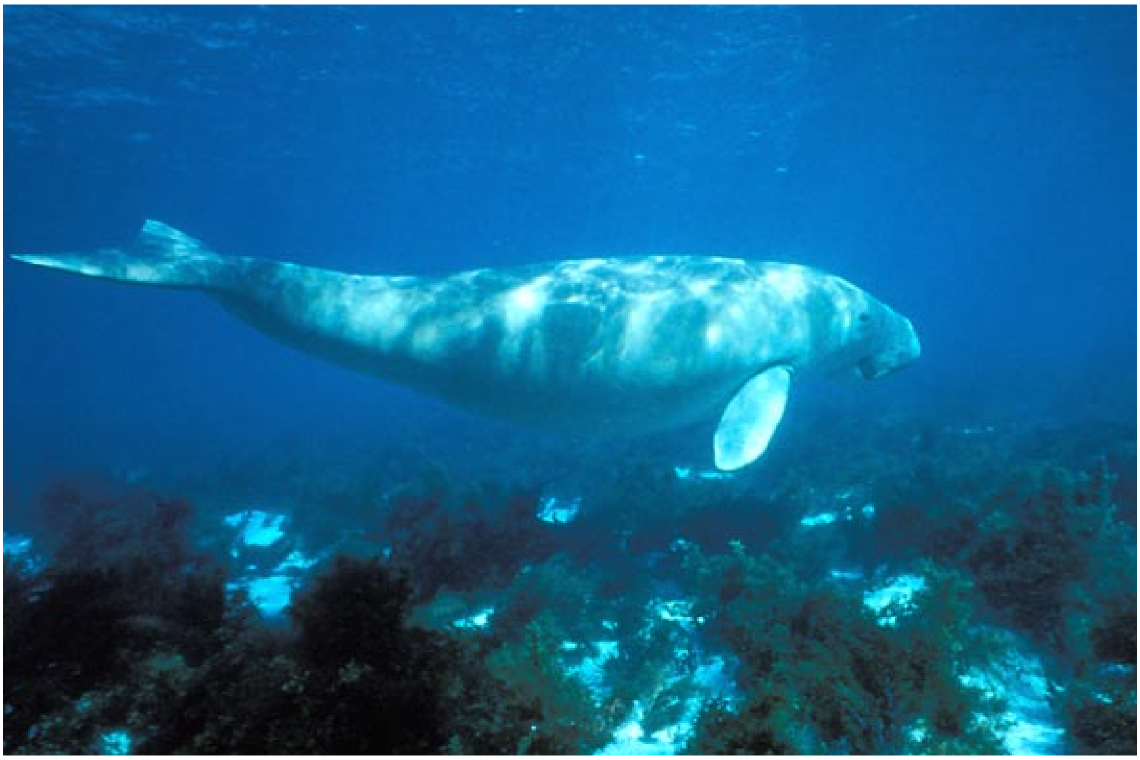
Significance of the species group in the Northern Planning Area

The dugong has significant cultural and dietary value for many Indigenous peoples in the NPA and for many coastal peoples is the most highly valued food. This significance stems from the high status of dugong hunting and hunters in their communities, the essential role of dugong in Aboriginal traditional culture and religion, the quality of dugong meat and the medicinal value of dugong oil.

Dugongs occur all along the NT coast of the NPA in reasonable numbers and are hunted by almost all coastal Aboriginal communities along this coastline. Along the Queensland coast of the NPA, Aboriginal hunting is of greatest significance in the Wellesley Islands area and the Torres Strait region, which includes the Papua New Guinea and Northern Peninsula area. Hunting is less important along the western coast of Cape York Peninsula although dugongs will be hunted when available (see below).



Dugong off the east coast of Australia ***Source:*** *Great Barrier Reef Marine Park Authority*



Seagrass beds have been mapped in Torres Strait and the Queensland coast of the GoC including the Wellesley Island Group, the mouth of the Limmen Bight River to and including the Sir Edward Pellew Group of islands and Blue Mud Bay. However, many of these maps are dated and as seagrass communities tend to be dynamic, may be of limited value for marine planning.

Impacts/threats

Habitat loss and degradation

Habitat loss has been identified as a potential source of localised declines in dugong populations (Thorogood et al. 1990, Johannes & MacFarlane 1991, Preen et al. 1993, Preen & Marsh 1995). Natural events such as cyclones and floods can cause extensive damage to seagrass communities through severe wave action, shifting sand, adverse salinity changes and light reduction (Heinsohn & Spain 1974, Kenyon & Poiner 1987, Thorogood et al. 1990, Preen et al. 1993).

The only confirmed record of habitat loss or degradation along the NT coast of the NPA is in the area of the mouth of the Limmen Bight River to and including the Sir Edward Pellew Group of islands. The seagrass beds of this area were severely damaged by Cyclone Sandy in 1985 (Thorogood et al. 1990). Anecdotal reports (Felicity Chapman pers. comm., Steve Johnson pers. comm.) suggest that extensive damage to seagrass beds in the Sir Edward Pellew area also occurred in 1996 associated with Tropical Cyclones Jacob and Ethel. Dugong hunters from the area have reported that dugong numbers in the area declined following these cyclones.

Given the lack of coastal development along the NT coast of the NPA it is unlikely that anthropogenic inputs into the area will occur or have any impact on important dugong habitat, except around ports. For example, an ore spillage at the McArthur River Mine harbour facility could result in heavy metal pollution of dugong habitat in the Limmen Bight/Sir Edward Pellew Group region. This possibility is of great concern to local Aboriginal people.

Limited coastal development along the Queensland coast of the NPA is also expected to result in little or no anthropogenic impact on dugong habitat, except in the immediate region of ports such as Karumba and Weipa. Loss of seagrass in the Karumba area (Marsh et al. 2002) could affect the ability of dugongs to move between feeding grounds in the south-east GoC.

Anthropogenic impacts on dugong habitat in the Torres Strait area are also expected to be slight (Marsh et al. 2002) unless changes in landuse, such as forestry and mining along the southern Papua coast, affect seagrass

beds through terrestrial runoff (Marsh et al. 2002). Marsh et al. (2002) identified possible outcomes from a re-evaluation of the Mining Moratorium for Torres Strait as a potential threat to both dugong habitat and populations. If the moratorium is not renewed and mining and hydrocarbon exploration and production are allowed, the management of any exploration and production activities must take into account possible direct and indirect impacts on dugongs and their habitats. Marsh et al. (2002) notes that there has been little relevant research on the acoustic impacts of mining exploration on dugongs in shallow tropical waters. The likely extent of such impacts is unknown but they are of great concern to Islanders. These activities can also occur in other waters of the NPA where dugongs are found, though there has been little activity to date.

Habitat loss or degradation associated with catastrophic events such as cyclones or 'big' wet seasons, resulting in the loss of seagrass beds through increased siltation, mechanical damage and freshwater influx, is likely to be a greater threat, and is not amenable to management intervention. Such losses have been implicated in the large-scale movement of dugong populations (Preen et al. 1993 & 1995, Preen & Marsh 1995, Marsh et al. 2003 & in press). Seagrass dieback in the Torres Strait region is considered to be the major contributor to variation in estimates of dugong abundance in the region over the period 1987 to 2001 (and earlier) due to emigration and immigration associated with seagrass dieback and recovery. Differentiation of these movement effects on population abundance from changes in population size *per se* and other anthropogenic effects is difficult at best and, without detailed information on the other sources of anthropogenic impact (see below), probably impossible. The Population Viability Analysis of Heinsohn et al. (in press) demonstrates that, when harvesting is high in some areas, mobility of dugongs between populations increases the probability of quasi-extinction for the meta-population.

Trawling on seagrass beds has proven to be damaging and as a consequence the Northern Prawn Fishery has closed specific areas to trawling, to protect seagrass beds because of their importance as prawn nursery areas (Marsh et al. 2002).

Incidental Catch

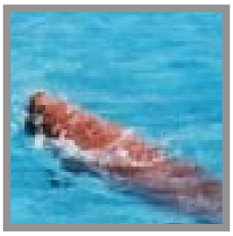
Entanglement in large mesh (150 mm and greater) fishing nets is a documented source of dugong mortality. However, the data necessary to determine the magnitude of the impact of incidental catch on dugong populations in NT and Queensland waters of the GoC and the Torres Strait are not available and are likely to be very difficult (or impossible) to collect as the catch rates are likely to be sporadic, and making observers compulsory is a logistical and financial challenge in remote areas in this fishery.

Fishing activities which could potentially affect dugong populations are commercial barramundi fishing using set nets, inshore shark fishing using pelagic nets, bait fishing using nets to catch bait for mud-crabbing and staked coastal nets used by coastal net fishery.

No data exist concerning the impact of commercial net fisheries along the north Arnhem Land coast of the NPA. Very limited data on the impact of commercial net fisheries along the NT GoC coast of the NPA is available. Coates (2002) reported for the Borroloola region that, during the course of a 15-month study, a minimum of 40 dugongs died as a result of non-Indigenous mortality. This represented some 42% of the total mortality reported for the region (Coates 2002). Of this minimum, some 15% (six animals) could be directly attributable to commercial barramundi fishing; this proportion is likely to be underestimated (Coates 2002).

An inshore commercial finfish fishery occurs along all tidal waters in the GoC and adjoining waterways between the 25 nautical mile line and the shore (Marsh et al. 2002). Marsh et al. (2002) reports: 'anecdotal evidence suggests that incidental captures were not uncommon in the late 1970s and early 1980s when the number of meshnetters operating along the Queensland coast of the GoC (R Garrett pers. comm. 1998), and the fishing effort (Magro et al. 1996) were much higher than today'. Several initiatives have been introduced which have the potential to reduce the bycatch of dugongs in this fishery *(Fisheries (Gulf of Carpentaria Inshore Finfish) Management Plan 1999):*

- the barramundi mesh net fishery is closed between early October and the end of January
- several spatial closures to netting have been introduced
- changes to net fishing regulations in the Wellesley Island Protected Wildlife Area, the most important dugong area along the Queensland Gulf Coast
- the ban on setting nets across waterways or channels within 100 m of another net
- the encouragement of commercial fishers to undergo an Endangered Species Awareness Course as part of their code of conduct



Pingers/acoustic alarms are being trialled as deterrents to marine mammals in the gill net fishery. However, this initiative is unlikely to have a significant effect on dugong mortality. The behaviour of wild dugongs was not altered by similar alarms in experimental trials (Amanda Hodgson pers. comm. 2003).

In 2002, there were reports of dugongs being caught in the GoC in gill nets in areas where they have not been seen for many years (B Kehoe pers. comm. 2002). It is likely that dugongs had moved into these areas as a result of seagrass dieback in Torres Strait. The movement of dugongs to new areas as a result of dieback events means that dugong management must have the flexibility and coordination to respond in a timely manner. This is very difficult in remote areas.

The impacts of commercial net fisheries on dugong populations in the Torres Strait are considered to be low except along the Papua New Guinea coast. However, there is anecdotal evidence of dugong mortality due to Indonesian and Taiwanese vessels operating illegally in the region (Marsh et al. 2002) and reports of incidental or deliberate catches of dugongs in nets in waters in the Papua New Guinea sector of the Protected Zone and Boigu and Saibai Islands (Marsh et al. 2002).

Although the extent of the threat posed by commercial net fisheries to dugong populations along the coast of the NPA is unquantified, sufficient information is available to identify it as a threat that needs to be addressed in a coordinated manner by management across the region. It is a very important issue for traditional owners in the region and should be formally addressed in traditional use marine resource agreements.

Indigenous use and hunting

Few data exist on the extent of traditional hunting in the NPA outside Torres Strait. Bertram and Bertram (1973) reported that an average of 62 dugongs were harvested per year at Numbulwar during the 1960s. Bayliss and Freeland (1989) reported that this had reduced to approximately 10 per year in the 1980s. Local hunters attributed the decrease to a decline in dugong abundance. However, no data were available to determine whether this perceived decline was due to an actual decline, change in dugong behaviour, change in hunting effort, or a combination of all of these. Catches of between eight and 16 dugongs per year between 1980 and 1993 have been reported for Borroloola (Marsh et al. 1994). Coates (2002) has reported an annual harvest of 45 dugongs per year for the Borroloola region (the Limmen River to Weayran River including the Sir Edward Pellew Islands group), representing in excess of 50% of the reported mortality for the region Coates (2002). Bradley (1997) has reported a gradual decline in dugong hunting in the region, particularly from pre-1960 (Coates 2002).

Extrapolation of available information results in an estimate of an Indigenous harvest of 190 dugongs per year for the NT coast of the NPA (derived Henry & Lyle 2003). However, there is no measure of uncertainty associated with this estimate. As it is based on a low sampling effort in a survey that was not designed to estimate the extent of the dugong harvest, its reliability is uncertain. Nonetheless, the entire NT coast of the NPA appears to be significant in relation to Indigenous hunting.

Marsh et al. (2002) provides Indigenous harvest levels of dugongs in the Wellesley Islands area (21–50 and 51–100 dugong per annum) and at Mornington Island (40 dugong per annum) for the mid to late 1970s. No data on current Indigenous harvest levels for this area are available (Marsh et al. 2002) as the data in Henry and Lyle (2003) are aggregated at a state level. However, within the Queensland coast area of the NPA, the Wellesley Islands region appears to be particularly significant in relation to Indigenous hunting.

The Indigenous harvest of dugongs along the western coast of Cape York Peninsula is generally lower than in the remainder of the NPA, presumably reflecting the relatively low dugong abundance (Marsh et al. 2002; Figure 10.4). However, opportunistic hunting occurs when dugongs are sighted. For example, in early 2002 there were numerous reports of herds of dugongs in unusual locations including off Weipa in the GoC (Michael Rasheed, QDPI, pers. comm. 2002), and reports of 30–60 dugongs killed off Weipa, particularly by residents of the Naparum community (David Donald & Ian Little pers. comm. 2002).

Within the Torres Strait region the Indigenous dugong harvest is a legal fishery as explained above. The sustainability of this fishery has been of concern since the early 1980s (Marsh et al. 1997, 2002, Marsh et al. 2003 & in press, Heinsohn et al. in press). Marsh et al. (2003) compiled Indigenous harvest data for Torres Strait covering the period 1973 to 2001, with coverage ranging from individual islands to most of the Torres Strait (see Marsh et al. 2003 for sources). These data indicate an Indigenous harvest over the entire Torres Strait approaching or exceeding 1000 animals per annum. This estimate does not include the Northern Peninsula area or the Papua New Guinea coast.

Modelling using both the Potential Biological Removal method (Marsh et al. 2003 & in press) and Population Viability Analysis (Heinsohn et al. in press) suggest that the present harvest is an order of magnitude too high. The region can probably sustain a sustainable harvest of about 100 dugongs per year, a number exceeded by the Mabuiag community alone in 1997 and 1998 (Kwan 2002).

In our opinion, supporting the Indigenous communities of the Torres Strait region to manage their harvest sustainably (including the Northern Peninsula Area and the Papuan coast) is the most urgent management action required for dugongs in the NPA.

Other threats/impacts

Several other threats to dugong populations have been identified (see Marsh et al. 2002 for details). These include mortality associated with boat strikes, illegal harvest and natural causes such as disease, and mortality associated with catastrophic events such as cyclones and 'big' wet seasons.

Coates (2002) reported that traditional owners from the Borroloola region were particularly concerned about the impacts of these 'other threats' on the dugong population and habitat in the region. Of particular concern was the perceived impact of increased boat traffic leading to significant changes in dugong behaviour and distribution, through the fragmentation of herds and restriction of their use of inshore seagrass beds. Increased boat traffic was also associated with direct mortality due to boat strike and damage to seagrass beds (Coates 2002). Experimental work by Amanda Hodgson (pers. comm. 2004) in Moreton Bay near Brisbane indicates that direct mortality from vessel strike is a much greater threat to dugongs than displacement due to vessel activity. However, it is likely that traditional owners will disagree with this assessment.

Stranding events due to tidal surges associated with tropical storms have been reported (Marsh 1989). The extent of mortality associated with these events can be high in a localised area. Marsh (1989) reported the stranding of at least 27 dugongs by a tropical cyclone. Twenty-three animals were returned to the sea in a rescue operation; however, the potential existed for all the animals to have perished due to injuries sustained during the stranding.

All these threats are of great concern to the Indigenous peoples of the area and will need to be addressed as part of an overall dugong management strategy for the region.

Information gaps

There are significant information gaps in the NPA with respect to dugongs and their habitats.

Accurate and up-to-date data on dugong distribution and abundance

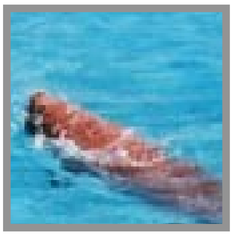
Information on dugong distribution and absolute abundance is required to provide:

- estimates of sustainable levels of anthropogenic mortality from all causes using the Potential Biological Removal Method, which is mandatory to use in similar circumstances in the United States
- a basis of large-scale regional marine planning – the present data are inadequate with respect to: (1) dugong use of potential 'deep-water' seagrass areas of the NT coast; (2) the Limmen Bight/Sir Edward Pellews region where previous surveys have produced anomalous results; (3) a large section of coast between Milingimbi to Blue Mud Bay which has not been surveyed for 19 years
- regional scale trends of dugong abundance over long periods (decades)
- information for Population Viability Analysis of the status of the dugong population in the region – at present, this information is available only for the Torres Strait region (Heinsohn et al. in press).

Aerial surveys are the only means of obtaining this information at the required spatial scales. The capacity of regional scale surveys to provide the information will be greatly enhanced if the surveys are coordinated across the NPA because of the propensity of dugongs to undertake large-scale movements in response to habitat loss associated with extreme weather events.

Recommendation 1:

That the National Oceans Office undertake a coordination role to ensure that broad-scale aerial surveys for dugongs in the coastal waters of the entire NPA are conducted in a regular and coordinated fashion. The program must include training for Indigenous observers to enable them to participate effectively in survey teams.



Accurate data on anthropogenic mortality from all causes

Such data are required to compare with estimates of sustainable levels of anthropogenic mortality from all causes obtained from the aerial survey data and Potential Biological Removal Modelling to determine if the present levels of anthropogenic mortality are sustainable. Given the sporadic incidence of dugong catches in most communities, continuous community-based monitoring is likely to be more effective than a sampling program although some scientific validation of monitoring will be important.

Recommendation 2:

That a community-based traditional harvest monitoring program with appropriate scientific validation be developed and implemented for the NPA with high priority. Minimum data to be collected within constraints imposed by Indigenous traditional culture and law: a) number of animals caught; b) date of catch; c) sex of catch; d) details of hunting method, hunting party, hunting location and hunting effort. The area of highest priority is the Torres Strait region including the Northern Peninsula Area and the Papuan coast.

Recommendation 3:

That the National Oceans Office work with the Queensland and NT governments to develop a coordinated incidental protected species catch monitoring program for fisheries in the region. Minimum data to be collected include: a) number, species identification and fate of animals caught; b) date and circumstance of catch. As these data will be very difficult to collect in such a remote area, the program should concentrate on areas of highest risk - localities which: (1) support significant numbers of dugongs and a high mesh-netting effort, (2) where incidental catch is of particular concern to traditional owners, and (3) where anecdotal reports indicate that the probability of incidental capture is high (eg Borroloola region).

Information about the customary laws limiting dugong harvest

Customary Indigenous laws impose restrictions on traditional hunting of dugongs in some regions such as the northern minor bays of Blue Mud Bay during calving (unidentified traditional owners pers. comm.). Such laws have the potential to provide an effective basis for developing contemporary controls of dugong harvest in areas where that harvest is shown to be unsustainable.

Recommendation 4:

That with the cooperation of traditional owners, customary laws regarding dugong harvest be recorded as a basis for the management of dugong harvest in areas where traditional owners and/or the aerial surveys and catch monitoring indicate it is sustainable .

Maps of seagrass, biomass and community structure

Recommendation 5:

That the National Oceans Office coordinate a comprehensive program of seagrass mapping in the NPA with emphasis on: (1) areas which have not previously been mapped; (2) areas identified as critical dugong habitats and which have not been mapped for many years; (3) areas where there is concern about changes in seagrass distribution as a result of extreme weather events or anthropogenic impacts.

The extent and range of dugong movements and habitat use within the NPA

Recommendation 6:

1. Within the constraints of traditional culture and law and if Traditional Owners wish, Indigenous knowledge of dugong habitat use and local movements be recorded and incorporated into planning and management initiatives.
2. A coordinated program of satellite tracking of dugongs be developed with the cooperation of traditional owners.

Key references and current research

Dugong research is being carried out as part of the Co-operative Research Centre (CRC) Torres Strait program. This program commenced in July 2003 and includes the following task relevant to dugong research:

- an information base for a sustainable traditional fishery of green turtles and dugongs in the Northern Peninsula Area and Inner Islands of Torres Strait (Jillian Grayson)

10. Dugong

Data locations

Primary 'scientific' data locations for dugong and their habitats within the NPA:

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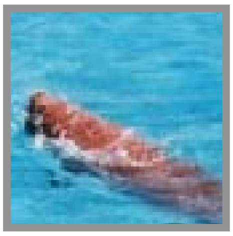

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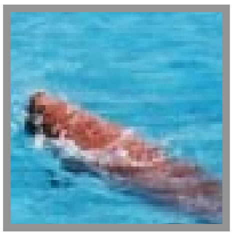

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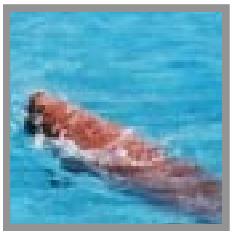

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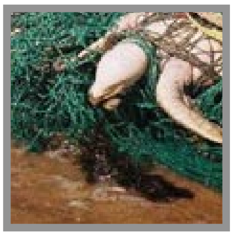
1 For further information on seagrasses in the Northern Planning Area see chapter 2 (Seagrasses).



11. Marine turtles

This chapter should be cited as:
Limpus, C & Chatto, R (2004). Marine Turtles. In National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office. Hobart, Australia.

Nesting green turtle tracks, Bountiful Island **Source:** C Limpus

Nesting flatback turtle, Crab Island **Source:** D Limpus

Indigenous turtle egg harvest, Cape Arnhem **Source:** C Limpus

Fisherman returning with green turtles, Daru **Source:** C Limpus

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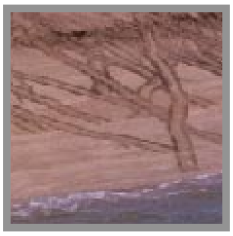
Species group name and description

Marine turtles are reptiles of the order Testudines, sub order Cryptodira. On a global scale, marine turtles have undergone a considerable reduction in their biodiversity since their peak in the Cretaceous period. Of the five marine turtle families of the Cretaceous, only two are represented among the present day turtle fauna (Pritchard & Trebbau 1984). Both these extant families of marine turtles occur in Australia and within the Northern Planning Area (NPA):

Cheloniidae, hard-shelled turtles, with five species from five genera (*Caretta*, *Chelonia*, *Eretmochelys*, *Lepidochelys* and *Natator*), one of which (*Natator*) is endemic to the Australian-New Guinea continental shelf. These species are:

- Loggerhead turtle *(Caretta caretta)*
- Green turtle *(Chelonia mydas)*
- Hawksbill turtle *(Eretmochelys imbricata)*
- Olive ridley turtle *(Lepidochelys olivacea)*
- Flatback turtle *(Natador depressus)*

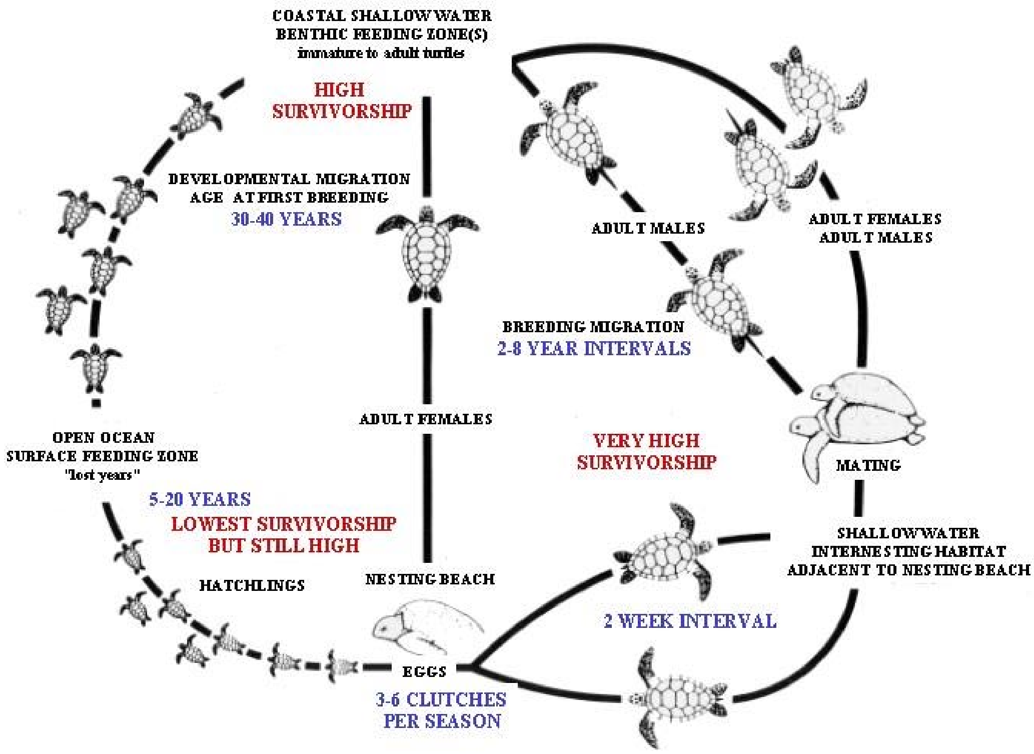


The remainder have a global distribution in tropical and temperate waters ranging from lower estuarine to oceanic pelagic habitats. The family is characterised by non-retractable, large, paddle-like flippers, each with one or two claws and keratinised epidermal scutes (horny, scale like structures) on 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 & Miller 1993).

Dermochelyidae, leatherback turtles, with one genus (*Dermochelys*) and a single species. The family has a global distribution from tropical seas to subarctic and subantarctic waters ranging from oceanic to coastal waters but avoiding reefs. The family 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).

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 substantially reduced level, while offshore from the nesting beach in the internesting habitat where she prepares her eggs for laying (Limpus et al. 2001, Tucker & Read 2001) (Figure 11.1). 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 is a function of nest temperature (Miller 1997, Miller & Limpus 2003, Wibbels 2003). Hatchlings are imprinted to the earth's magnetic field as they leave the nest and they navigate across the beach using light horizons (Lohmann et al. 1997). They disperse rapidly from inshore waters without using the inshore 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.

Figure 11.1: *Life cycle diagram of marine turtles* ***Source*** *C Limpus*



11. Marine turtles

The hard-shelled turtles remain in the ocean pelagic environment for a few years (hawksbill and green turtles) or up to about 20 years (loggerhead turtles) before they return to coastal waters where they change to a benthic feeding life history phase with diet varying with the species (Bjorndal 1997, Conway 1994, Lanyon et al. 1989, Limpus & Limpus 2000, Limpus et al. 2001). Green turtles are primarily herbivorous, foraging on algae, seagrass and mangroves. Hawksbill turtles are omnivorous, feeding on algae, sponges, soft corals and other soft-bodied invertebrates. The remainder are predominantly carnivorous: loggerhead and olive ridley turtles feed mostly on crabs and shellfish and flatback turtles feed on soft-bodied invertebrates such as seapens, soft corals, bêche-de-mer and jellyfish. Leatherback turtles remain planktivorous throughout their life, feeding on jellyfish and large planktonic ascidians (eg sea squirts) in the water column.

All marine turtles are slow-growing with delayed maturity (Chaloupka 1998, Chaloupka & Musick 1997, Chaloupka & Limpus 1997, Limpus & Chaloupka 1997). Green and hawksbill turtles may take about 40 years from hatchling to first breeding. Loggerhead turtles take about 30 years. Leatherback turtles are the fastest growing, reaching maturity at less than 20 years. Population genetics analyses indicate that widely spaced clusters of breeding aggregations are genetically discrete and that the adult returns to breed at the region of its birth (Bowen & 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 characteristic require annual survivorship to be high throughout all their life history phases in order to maintain stable populations (Chaloupka 2002). As a result, marine turtles are highly vulnerable to even small, long-term increases in mortality from human-related sources.

Status

All six marine turtle species in Australia are listed as threatened under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999:

- Endangered: *Caretta caretta, Lepidochelys olivacea*
- Vulnerable: *Chelonia mydas, Dermochelys coriacea, Eretmochelys imbricata, Natator depressus.*

These six species also attract special attention under Australian legislation because they are listed under international treaties to which Australia is a signatory country:

- Convention for International Trade in Endangered Species (CITES): Appendix I species
- Convention for Conservation of Migratory Species of Wild Animals (CMS): Appendix I species.

In Queensland, all six species are scheduled as threatened species under *Nature Conservation Act 1992* Regulations:

- Endangered: *Caretta caretta, Dermochelys coriacea, Lepidochelys olivacea*
- Vulnerable: *Chelonia mydas, Eretmochelys imbricata, Natator depressus.*

In the Northern Territory (NT), only two marine turtle species are listed as threatened under the *Territory Parks and Wildlife Conservation Act 2000:*

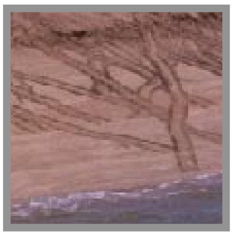
- Endangered: *Caretta caretta*
- Vulnerable: *Dermochelys coriacea*
- Least concern: *Chelonia mydas*
- Data deficient: *Eretmochelys imbricata, Lepidochelys olivacea, Natator depressus*

Loggerhead turtle (*Caretta caretta*)

The global biology of loggerhead turtles has been reviewed by Dodd (1998) and Bolten and Witherington (2003).

There is no breeding by loggerhead turtles in northern Australia or in neighbouring countries to the north. The nearest nesting to the NPA occurs about 2000 km distant in south Queensland and in central Western Australia or further afield in southern Japan (Limpus & Limpus 2003a) (Figure 11.2a). These widely separated clusters of aggregated loggerhead turtles nesting each represent a separate genetic stock (= management unit) (Bowen 2003, Dutton et al. 2002). There are thus two genetic stocks of loggerhead turtle for Australia, each identified by the area in which they aggregate for breeding: East Australian (EA) stock and West Australian (WA) stock.

The EA stock has been extensively surveyed and mark-recapture tagging studies have been undertaken since 1968. The number of adult females breeding annually within the EA stock has declined by approximately 86% from an annual nesting population of about 3500 females in the 1970s to a present level of less than 500 females breeding (Limpus & Limpus 2003a). A decline of this magnitude within less than one generation qualifies this major stock of loggerhead turtles for the South Pacific Ocean for a critically endangered rating (IUCN SSC 1994).



Assessment of the conservation status of the WA stock is hindered by the paucity of critical data. While the WA nesting population is about an order of magnitude greater than the EA population (Baldwin et al. 2003), there are no long-term census data from any index beach within this population, from which population trends can be assessed (Limpus 2002). The EA and WA stocks have been subjected to similar threatening processes of trawl bycatch mortality, fox predation of eggs, vehicular traffic on nesting beaches, coastal development encroaching onto nesting beaches and, although their impacts have not been adequately quantified for the WA stock, Limpus (2003) expressed concern for the stability of the WA stock.

Figure 11.2: *Loggerhead turtles in the Northern Planning Area*
Figure 11.2a: *Loggerhead turtle nesting distribution in Australia*

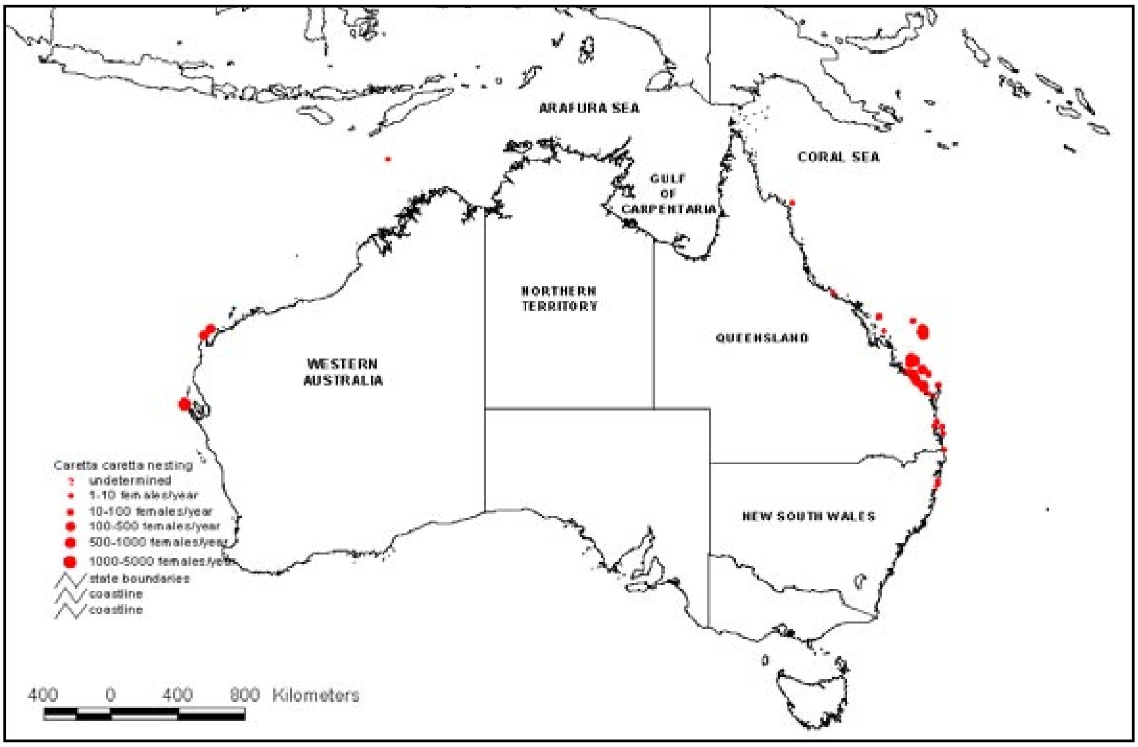
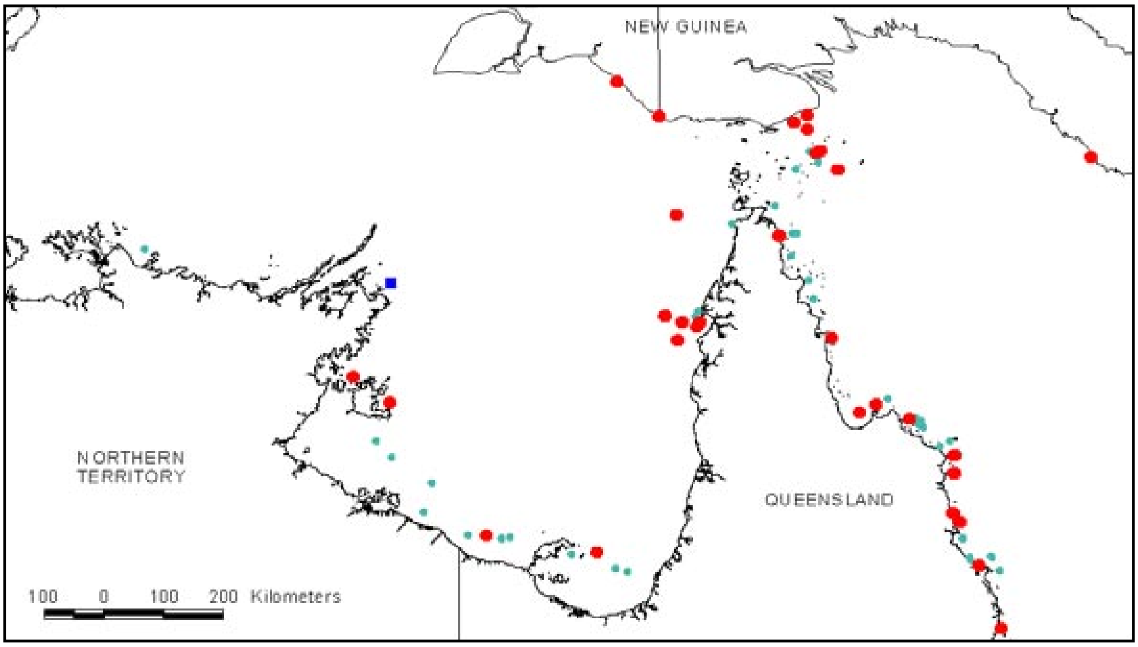
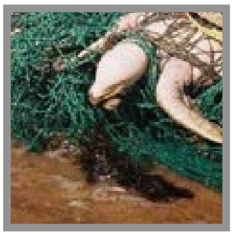


Figure 11.2b: *Post nesting migration recaptures of tagged loggerhead turtles of known breeding (stock) origin. Origin of loggerhead turtles denoted by large circles from the east Australian nesting beaches, squares from the west Australian nesting beaches. These data area also incomplete with respect to the recaptures of tagged loggerhead turtles from the west Australian nesting beaches. Small circles denote other captures of loggerhead turtles in the region. This dataset is incomplete with respect to recorded captures in trawl fisheries.*



11. Marine turtles



Green turtle (*Chelonia mydas*)

The global biology of green turtles has been reviewed by Hirth (1997) and Parsons (1962). Limpus et al. (2001, 2003), Limpus and Chaloupka (1997), and Chaloupka (2002) provide a representative description of the biology of green turtles for northern Australia.

Green turtles are the most numerous turtle in the NPA, both as nesting and foraging turtles[1]. There are seven recognised genetic stocks of green turtle breeding in northern Australia (Moritz et al. 2002), spread from the southern Great Barrier Reef (GBR) in the east to Ningaloo in the west (Figure 11.3a). Two of these stocks (northern GBR and Gulf of Carpentaria (GoC) stocks) breed within the NPA (Figure 11.3a). The genetic status of green turtles breeding in western Arnhem Land has yet to be defined. The breeding males and females display a high level of philopatry (the drive or tendency of an individual to return to, or stay in, its home area, birthplace, or another adopted locality) to their natal areas, irrespective of how far they have to migrate for breeding (FitzSimmons et al. 1997a,b).

The two eastern Australian stocks have been extensively surveyed and mark-recapture studies have been

Figure 11.3: *Green turtles in the Northern Planning Area*
Figure 11.3a: *Green turtle nesting distribution in Australia*

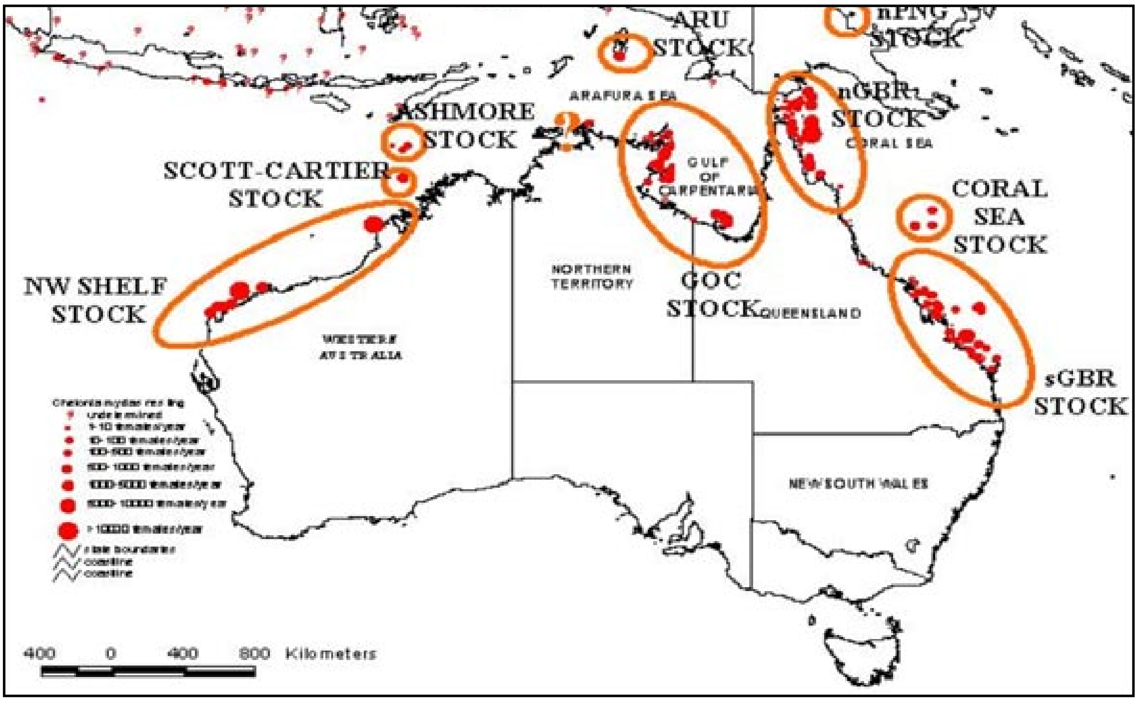


Figure 11.3b: *Foraging area captures of green turtles that migrate to breeding in the northern GBR (cross = nesting beach; circle = foraging sites).*

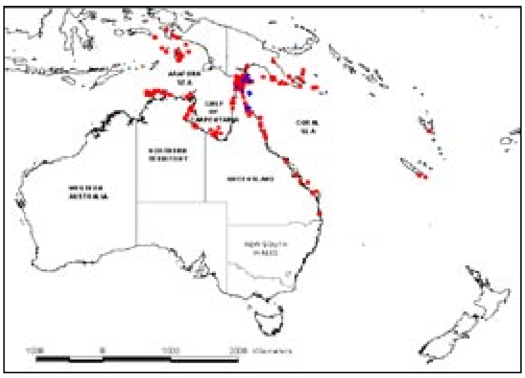
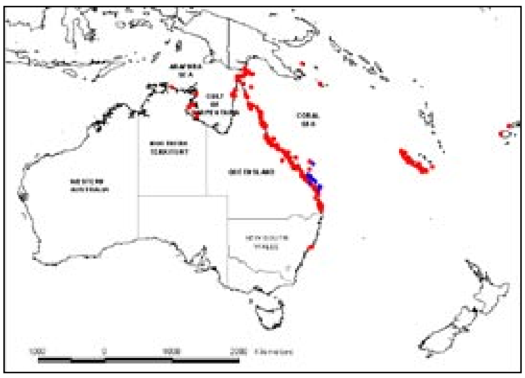


Figure 11.3c: *Foraging area captures of green turtles that migrate to breeding in the southern GBR (cross = nesting beach; circle = foraging sites).*



[1] The extensiveness of Natator depressus nesting around the entire coast of the Northern Territory section of the NPA suggest the total numbers of nests of this species would be close to, if not more than, the number of C. *mydas* nests in this area (Chatto in prep).

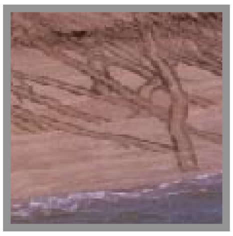


Figure 11.3d: Foraging area captures of green turtles that migrate to breeding in the Gulf of Carpentaria (cross = nesting beach; circle = foraging sites).

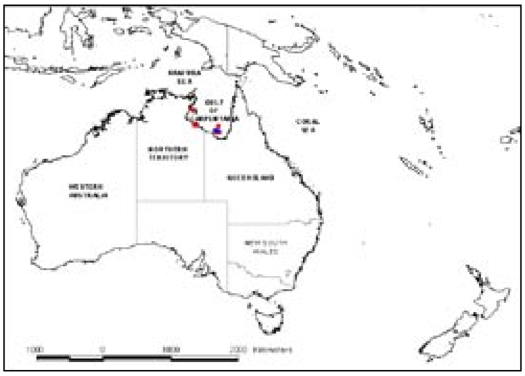
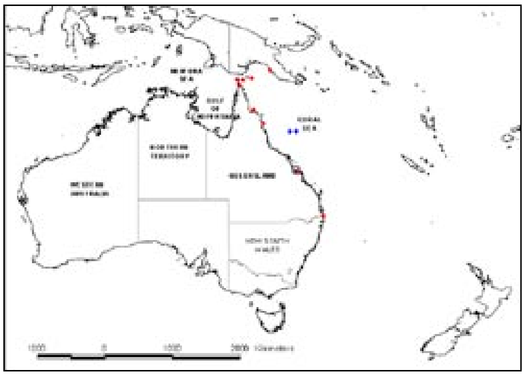


Figure 11.3e: Foraging area captures of green turtles that migrate to breeding in the Coral Sea (cross = nesting beach; circle = foraging sites).



undertaken since 1974. The northern GBR stock, which includes the green turtles breeding in Torres Strait and supports the largest breeding aggregation for the species in the world at Raine Island, appears to be in the early stages of population decline (Limpus et al. 2002, 2003). In addition, the nightly nesting success is now extremely low (less than 10%) at Raine Island and hatchlings production has failed in recent years because of flooding of the nests (Limpus et al. 2003). These changes must have severely depleted recruitment of young green turtles to the dispersed foraging areas supporting this stock within the last decade. There is a reasonable probability that this stock will have a severe reduction in the numbers of near adult and adult turtles within a few decades (one generation). The southern GBR stock is also displaying demographic characteristics consistent with the early stages of a population decline.

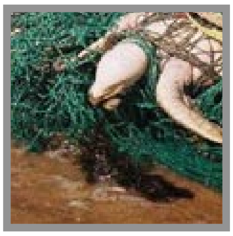
While there have been studies of the green turtle nesting populations associated with the GoC, WA and Ashmore Reef stocks (Prince 1994, Whiting et al. 2000), there are no long term census data from any index beach that are suitable for assessing long term population trends for these stocks (Limpus 2003).

There are increasing numbers of studies of the green turtle foraging populations within the NPA (Parmenter 1980, Kwan 1989, 1991, Johannes & MacFarlane 1991, Bradley 1998, Kennett et al. 1998, Harris et al. 2000). However, there are none from which the stability of populations could be judged. Concern has been expressed by traditional owners in the Gove area regarding turtle numbers (Kennett et al. 1998).

Hawksbill turtle (Eretmochelys imbricata)

The global biology of hawksbill turtles has been reviewed by Witzell (1983) and *Chelonian Conservation and Biology* 3(2). Dobbs et al. (1999), Chaloupka and Limpus (1997), Limpus and Miller (2000) and Miller et al. (1998) provide a representative description of the biology of hawksbill turtles in northern Australia.

There are two recognised genetic stocks of hawksbill turtle breeding in Australia (Figure 11.4a) (Moritz et al. 2002, Dutton et al. 2002). Each of these stocks supports an annual nesting population of several thousand females (Limpus & Miller 2000, Limpus 2003). Thus each of them is about the largest remaining nesting population for the species in the world (Meylan & Donnelly 1999). One of these stocks (north-eastern Australia) breeds mostly within the NPA in central and western Torres Strait (and the adjacent northern GBR) and in eastern Arnhem Land (Broderick et al. 1994). Because of the differences in physiology required to have a summer peak of breeding in the Torres Strait area and a winter-spring peak of nesting in north-eastern Arnhem Land, these two sub populations are unlikely to be interbreeding. It is highly likely that a reanalysis of these populations with more sensitive tests will separate these two nesting aggregations to separate stock status. The Australian stocks of hawksbill turtles are genetically different to the stocks that breed in neighbouring countries such as Solomon Islands and Malaysia (Moritz et al. 2002).



The NE Australian stock has been extensively surveyed and mark-recapture tagging studies have been in place since 1990 (Dobbs et al. 1999, Limpus & Miller 2000). The number of adult females breeding annually at Milman Island, the index beach for this stock, has been declining at 3% per year for a decade (Limpus & Miller 2000). A decline of this magnitude would be sufficient to consider the NE Australian stock of E. imbricata for a critically endangered rating (IUCN SSC 1994).

There is a paucity of data for hawksbill turtles from the NPA outside of Torres Strait.

Figure 11.4: *Hawksbill turtles in the Northern Planning Area*

Figure 11.4a: Hawksbill turtle nesting distribution in Australia.

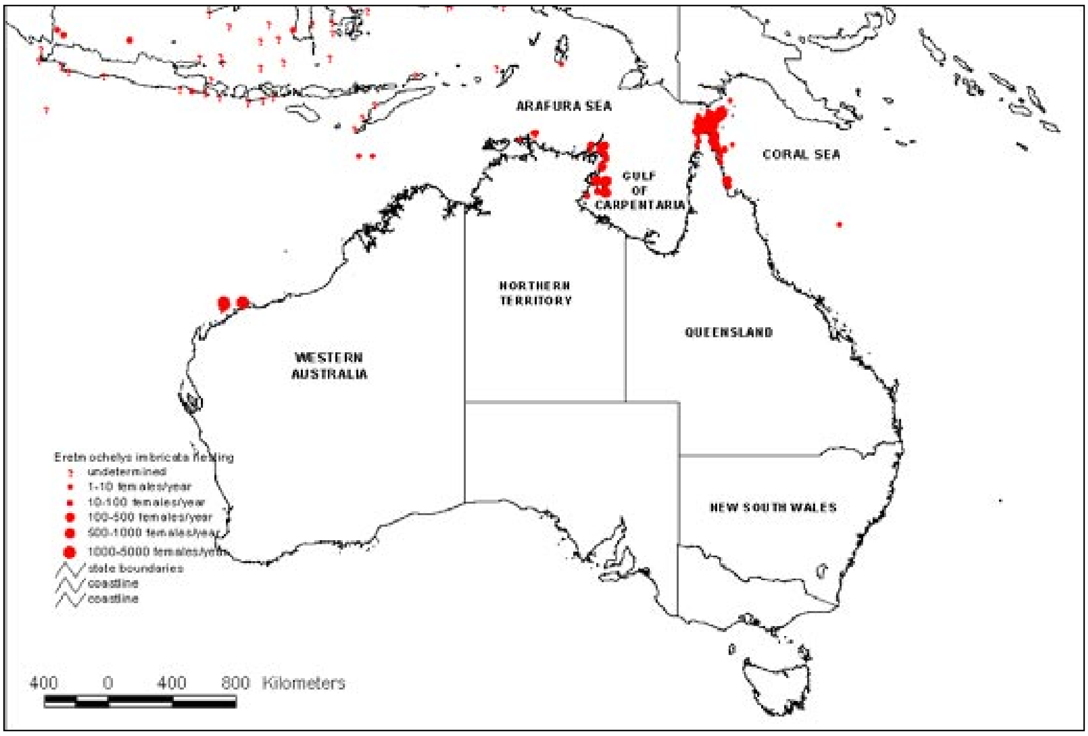
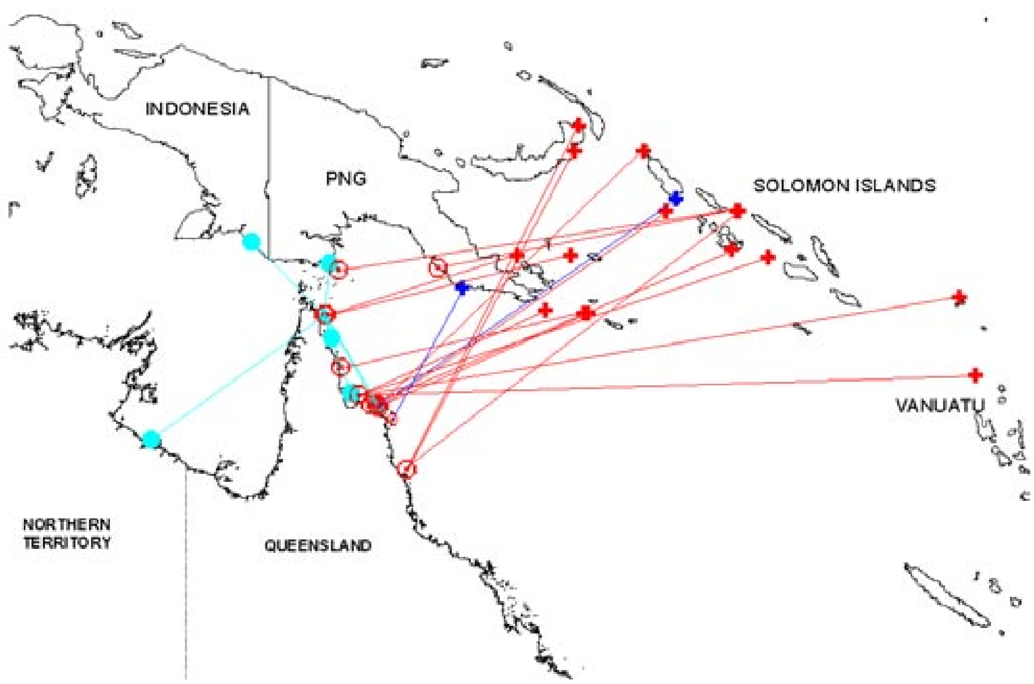
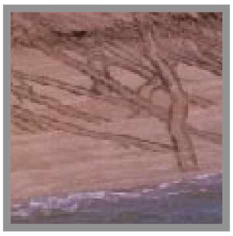


Figure 11.4b: *Breeding migration captures of hawksbill turtles from the Coral Sea region. Cross = breeding site; dot = foraging site for a turtle breeding in Australia; open circle = foraging site for a turtle breeding internationally.*





Olive ridley turtle (Lepidochelys olivacea)

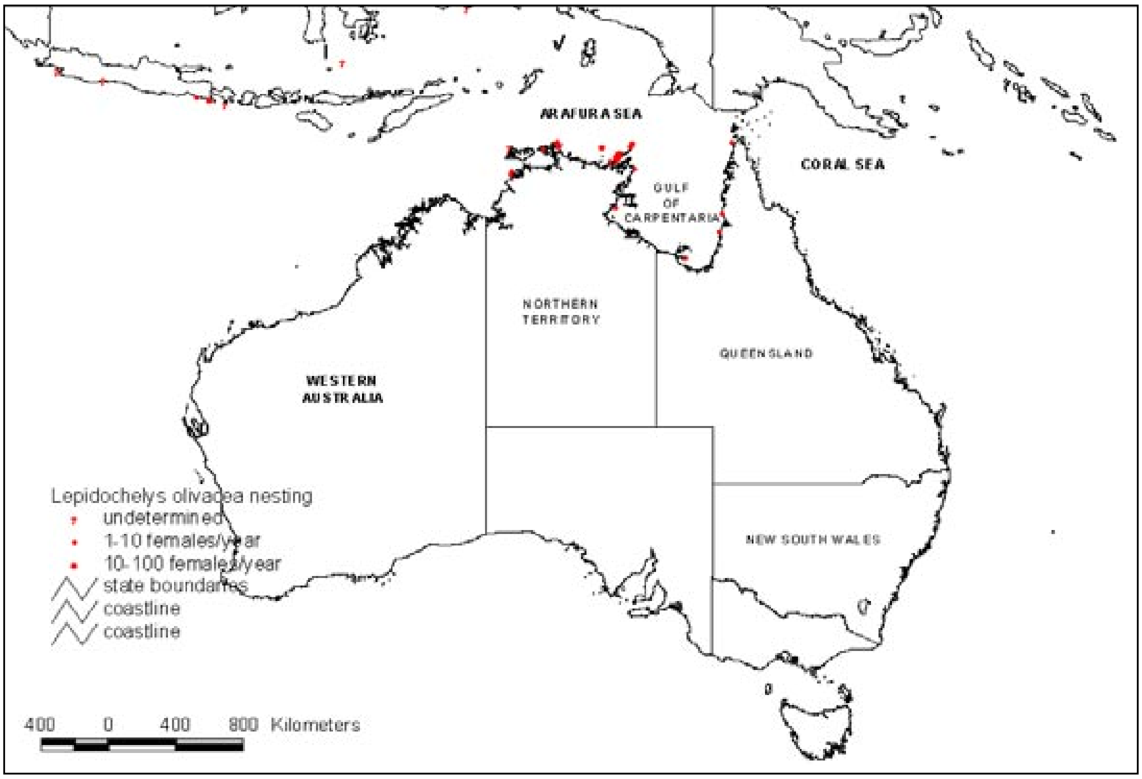
Reviews of the biology of olive ridley turtles include Reichart (1993).

Olive ridley turtles are the most abundant marine turtle species globally but one of the least abundant in Australian waters. The Australian nesting population is significantly different to all international stocks tested (Dutton et al. 2002). Thus we currently recognise one stock of olive ridley turtles for Australia. Future analysis may identify representatives from other stocks.

Olive ridley turtles nest at low density on a great array of beaches in the northern part of the NT (Chatto 1998). Within this distribution there are two main aggregations of rookeries, north-west Arnhem Land, including Melville Island in particular, and north-east Arnhem Land. Only the latter occurs within the NPA (Figure 11.5a. Chatto 1998, Limpus & Miller 2000). The Melville Island nesting is quite dense in certain areas, and although an assessment of numbers is planned for this year, there is clearly quite a number of turtles coming ashore to nest in a short period (Chatto pers. obs.). An additional, possibly small, nesting concentration has recently been identified on the mainland coast of Cape York Peninsula north from Weipa. There have been no detailed studies of this species in Australia. Therefore the size of the annual nesting population is vague although there is currently no indication that Australia has the massed nesting aggregations (arrabadas) that characterise this species in other countries. It is presumed on the basis of the available scant data that the annual nesting population is in the order of low thousands. Similarly there is no quantified indication of the stability or otherwise of the Australian population.

The past extensive mortality of this species in the Northern Trawl Fishery (Poiner & Harris 1996, Guinea et al. 1997) and in gill net fisheries (Guinea and Chatto 1995) and its limited population in Australia were used to argue that this species was probably at high risk in Australia and that it warranted being listed as an endangered species along with olive ridley turtles.

***Figure 11.5** Olive ridley turtles in the Northern Planning Area*
***Figure 11.5a:** Distribution of nesting by olive ridley turtles in Australia*



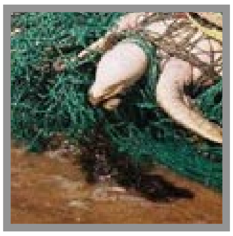
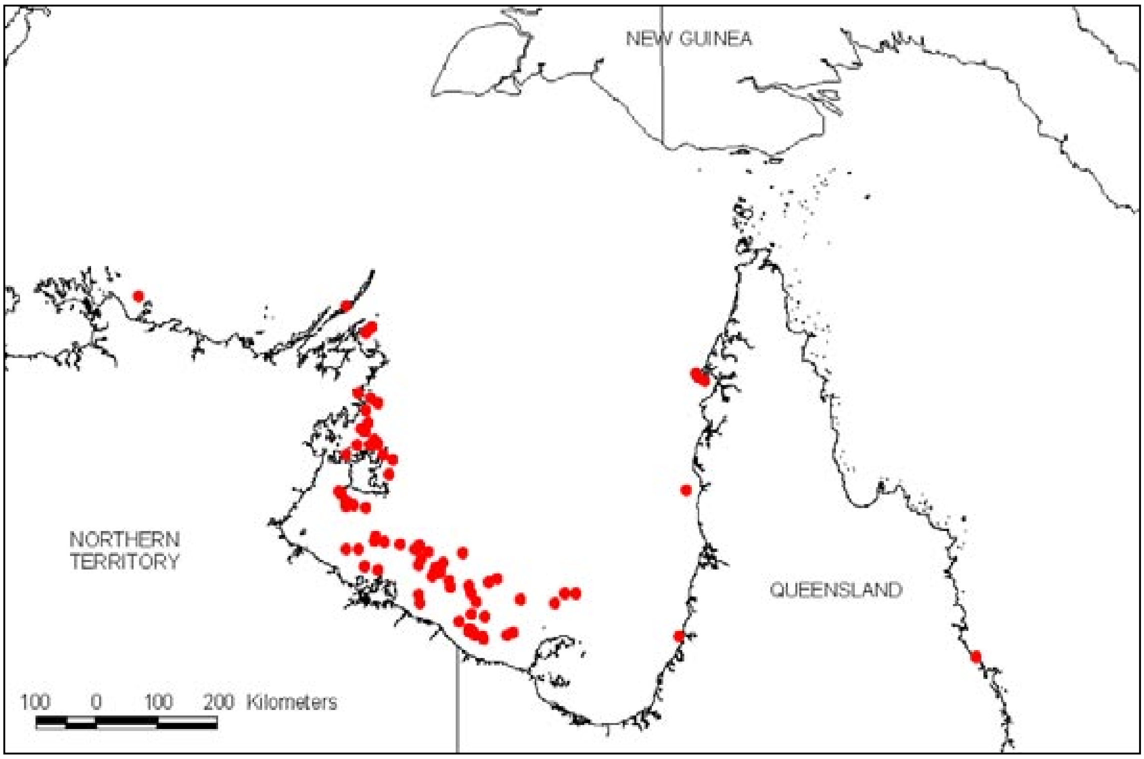


Figure 11.5b: Foraging area captures of olive ridley turtles within the NPA. Most capture data are from Northern Prawn Fishery bycatch data.



Flatback turtle (*Natator depressus*)

Flatback turtles are endemic to the northern Australian-southern New Guinea continental shelf with all breeding restricted to Australian beaches (Limpus et al. 1988). The biology of flatback turtles has been reviewed by Limpus (1995). Limpus (1971), Limpus et al. (1983a, 1984, 1993) and Parmenter and Limpus (1995) provide a representative description of the biology of flatback turtles in northern Australia. Flatback turtles differ from other marine turtles in that they do not have an oceanic dispersal of the pelagic post-hatchling life history phase, rather the post-hatchlings remain within pelagic habitats over the continental shelf (Walker 1994, Limpus et al. 1994).

Approximately two-thirds of the world's population of flatback turtles breed within the NPA (Figure 11.6a. Limpus & Miller 2000, Limpus et al. 1989, 1993) with a major part of them foraging within the area as well. No genetic separation into separate stocks is recognised within the continuum of flatback turtles nesting from Exmouth Gulf in the west through to Torres Strait in the east (Dutton et al. 2002). However, the discrete eastern central Queensland breeding represents a genetically and physiologically discrete stock (Dutton et al. 2002, Limpus et al. 1993). The largest breeding aggregation for the species occurs on Crab Island and adjacent islands of western Torres Strait and western Cape York Peninsula, north from Weipa (Limpus et al. 1993, Sutherland & Southerland 2003). Flatback turtle nesting occurs on virtually all island and mainland beaches where marine turtles nest around the entire NT coast from the Western Australian border to the Queensland border (Chatto 1998).

While the eastern Queensland stock has been stable over the past 30 years (Limpus et al. 2002b), there are no long-term studies within the NPA from which the stability or otherwise of the flatback turtle populations can be assessed. At Crab Island, three census events over 20 years (1978, 1991 and 1997) would suggest that the size of the adult population has maintained some stability over this period (Limpus et al. 1983b, 1993, Sutherland & Sutherland 2003). However, given the high level of pig predation of clutches laid along the mainland beaches of western Cape York Peninsula and other threats to the population in recent decades, it is highly unlikely that this major population can maintain its stability.

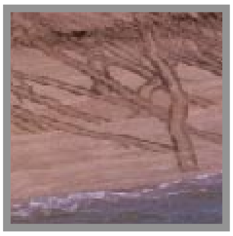


Figure 11.6: *Flatback turtles in the Northern Planning Area*
Figure 11.6a: *Flatback turtle nesting distribution in Australia.*

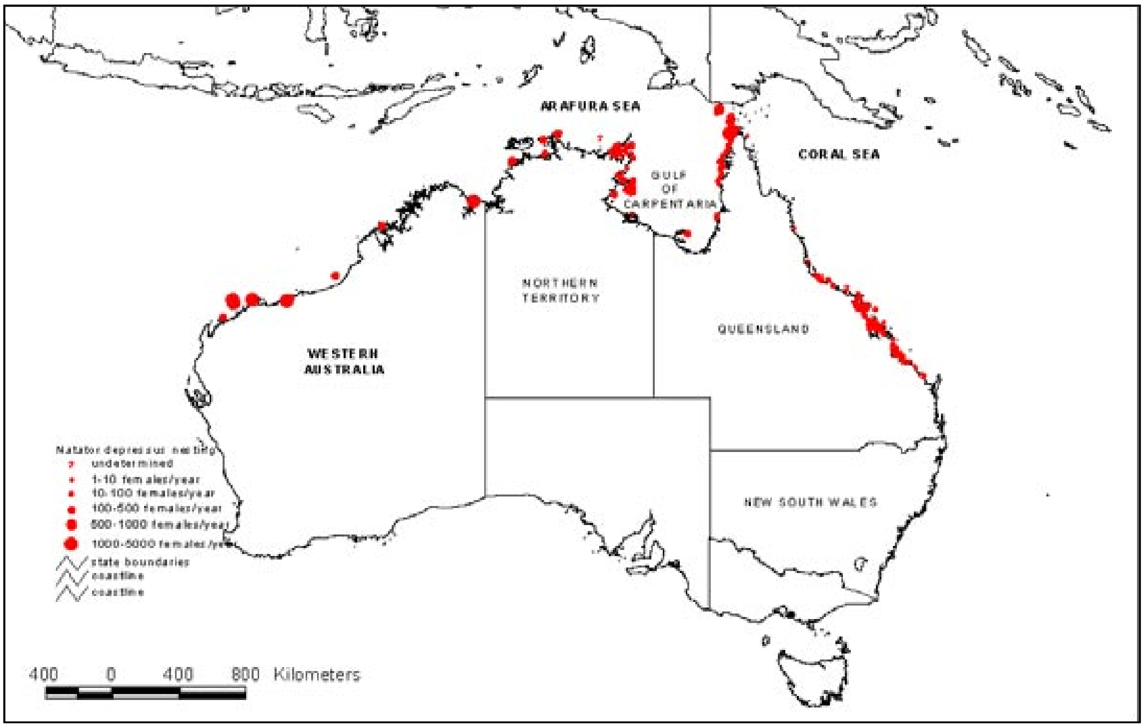
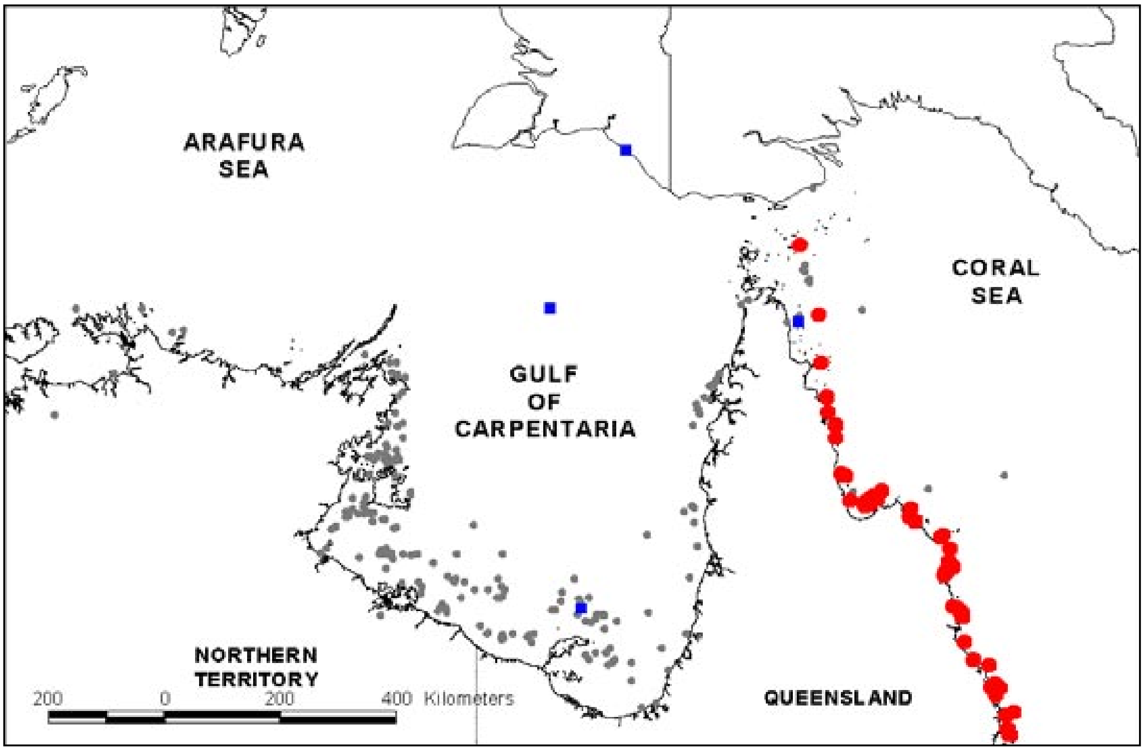
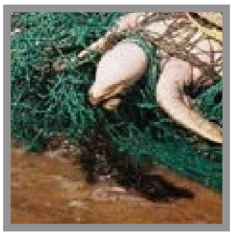


Figure 11.6b: *Distribution of foraging area records of flatback turtle in northern Australia.*
Post nesting migration captures of adult females tagged at nesting beaches: large dots = from mid-eastern Queensland stock; squares = from GOC nesting populations. Small dot = general foraging capture. Most of the later are from trawl and gill net bycatch records.



11. Marine turtles



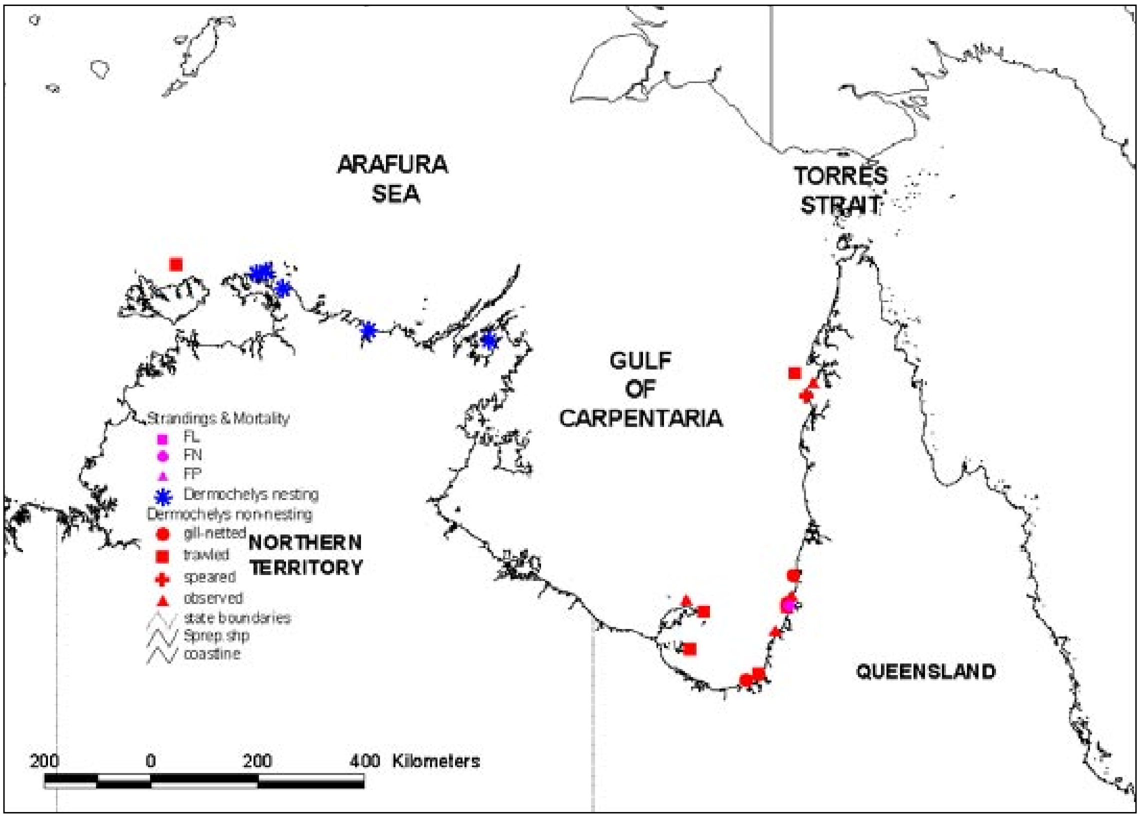
Leatherback turtle (Dermochelys coriacea)

The global biology of leatherback turtles has been partly reviewed in the 1996 issue of *Chelonian Conservation and Biology* 2(2). The biology of the species in Australia has been reviewed by Limpus (1995).

Within the Pacific-Indian Ocean basins, leatherback turtles are facing serious problems with significant major population declines recorded for almost all stocks (Spotila et al. 1996, 2000, Limpus 1997). In Australia, there have been two recognised breeding areas. The east coast nesting population (Limpus & McLachlin 1979, 1994) was not large when it was discovered in the 1970s and now appears to be approaching extinction (Limpus & McLachlin unpub. data). The nesting population of northern Arnhem Land (Figure 11.7, Limpus & McLachlin 1994) remains unquantified.

There has been no genetic stock assessment of leatherback turtles from Australia.

Figure 11.7: *Distribution of nesting and foraging records for leatherback turtles with the NPA*



Habitat and distribution

Loggerhead turtle (*Caretta caretta*)

Within the NPA, loggerhead turtles forage at low density across a wide range of habitats including rocky and coral reefs, seagrass pastures, and estuaries where they forage sympatrically (in the same location) with the other species of Cheloniid turtles. Throughout the areas worked by the Northern Prawn Fishery, loggerhead turtles forage over the extensive soft-bottomed habitats at less than 40 m depth and shares these habitats with olive ridley and flatback turtles (Poiner & Harris 1996, Robins et al. 2002).

Recaptures of turtles originally tagged at nesting beaches (Figure 11.2b) indicate that the loggerhead turtle population within the GoC and Torres Strait is dominated by turtles from the EA stock. In contrast, along the northern Arnhem Land coast, the loggerhead turtle population is dominated by turtles from the WA stock.

Green turtle (*Chelonia mydas*)

Green turtles forage within estuarine, rocky and coral reef and seagrass habitats of coastal waters throughout the NPA. They also occur in the deeper habitats worked by the trawl fisheries, mostly within the GoC (Poiner & Harris 1996, Robins et al. 2002) (Figure 11.8).

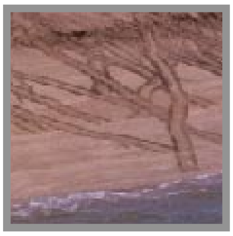
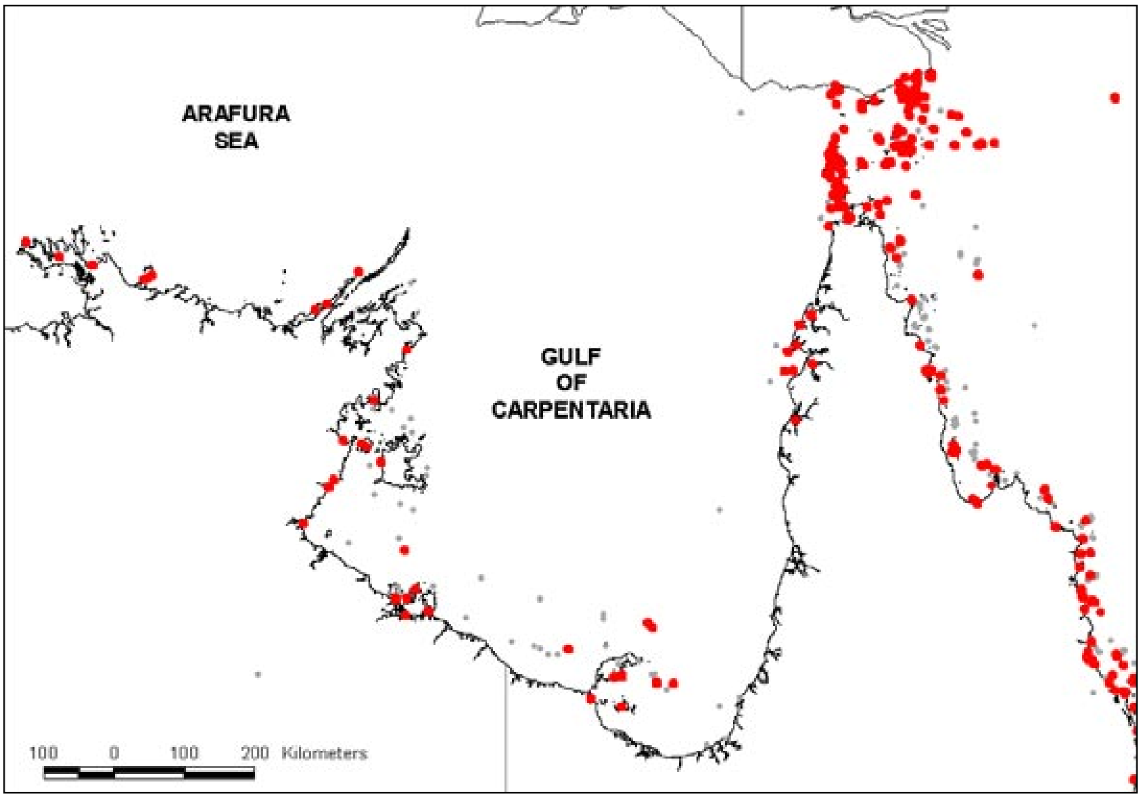


Figure 11.8: *Foraging distribution of green turtles in NPA.*
Large dots = tag recaptures of adult females; small dots = other foraging C. mydas, mostly from prawn trawl captures.



Migration mark-recapture data from adult female green turtles clearly demonstrate that the resident foraging populations of Torres Strait, GoC and northern Arnhem Land are mixed stocks derived from multiple nesting beaches up to 2500 km distant. Five stocks have been identified as contributing significantly to these foraging populations: southern GBR, Coral Sea, northern GBR, GoC (Figure 11.3b–11.3e), and north-west shelf (Prince 1998). The Aru stock of eastern Indonesia also is expected to be represented in these same foraging areas. Post-nesting migration of adult female green turtles tracked from eastern Arnhem Land rookeries with satellite telemetry (R Kennett pers. comm.) and from Wellesley Group flipper tagging studies (Figure 11.3d) indicate that the GoC breeding stock is drawn primarily from the GoC foraging area.

Torres Strait is an extreme example of the complexity of marine turtle population dynamics. The Torres Strait supports a significant foraging population as well as significant nesting populations in eastern Torres Strait for green turtles. It is the principal courtship area for green turtles migrating to the northern GBR rookeries. In addition it is a migratory bottleneck aggregating turtles on breeding migrations between the GBR and Gulf-Arafura Sea habitats. These assemblages of turtles in their different life history phases do not necessarily have the same stock composition.

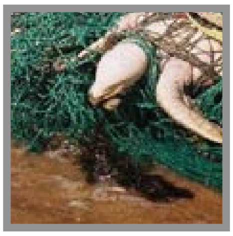
Hawksbill turtle (*Eretmochelys imbricata*)

Hawksbill turtles forage within rocky and coral reef and less frequently within seagrass habitats of coastal waters throughout the NPA. They also occur at low frequency in the deeper habitats worked by the trawl fisheries (Poiner & Harris 1996, Robins et al. 2002).

Migration data (Figure 11.4b) indicates that mixed stocks of hawksbill turtle forage sympatrically. Torres Strait supports a foraging population of turtles from the Solomons and Torres Strait stocks and possibly other stocks. Hawksbill turtles that breed in the Torres Strait-northern GBR include turtles from GoC foraging areas. Given the lack of hawksbill turtle studies from the NPA outside of Torres Strait, no further specific comment can be made regarding the habitat and distribution of the species in the NPA.

Olive ridley turtle (*Lepidochelys olivacea*)

In northern Australia, the olive ridley turtle is rarely seen in inshore shallow waters. It is commonly captured in trawl fisheries out to depths of 60 m (Poiner & Harris 1996, Robins et al. 2002) and gill net fisheries (Guinea & Chatto 1992). The incident in Fog Bay, where olive ridley turtles were meshed in inshore shallow waters suggests that they may come closer inshore on occasion.



This species does not appear to associate with rock or coral reef habitats.

Flatback turtle (*Natator depressus*)

Flatback turtles forage over soft bottom habitats throughout the northern Australian continental shelf, including the broader Sahul Shelf waters of Indonesia. They have been tagged in intertidal habitats in the vicinity of Karumba but are most commonly captured in trawl fisheries out to depths of 60 m (Figure 11.6b. Poiner & Harris 1996, Robins et al. 2002).

The mid-eastern Queensland nesting population extends in to foraging areas as far north as Torres Strait. This distribution overlaps with the foraging range of Crab Island nesting turtles which range into northern GBR waters and coastal waters of Irian Jaya (Figure 11.6b).

Leatherback turtle (*Dermochelys coriacea*)

Leatherback turtles are normally regarded as an oceanic, pelagic, migratory species (Plotkin 2003) that feed primarily on jellyfish and colonial planktonic tunicates (Bjorndal 1997). The concentrations of foraging leatherback turtles in Bass Strait, off south-west Western Australia and south-east Queensland are consistent with this. However within the NPA, leatherback turtles atypically cross wide expanses of shallow continental shelf waters to forage on jellyfish in intertidal waters of the south-east GoC (Figure 11.8). There have been no tag recoveries from the few leatherback turtles tagged and released from inshore gill net fisheries near Karumba.

Significance of the species group in the Northern Planning Area

The NPA supports globally significant breeding populations of green, hawksbill and flatback turtles. All three of these species are exposed to significant threats within the NPA that threaten their survival.

Torres Strait is a significant migratory corridor for marine turtles moving between breeding sites and foraging area within the GBR and GoC–Arnhem Land–Indonesia regions.

Impacts/threats

Loggerhead turtle (*Caretta caretta*)

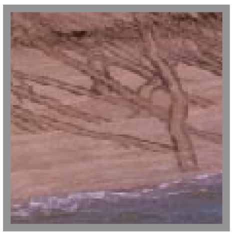
Trawl bycatch mortality has been identified as the primary cause of the recent decline in east Australian loggerhead turtle breeding numbers (Limpus & Limpus 2003). Significant numbers of loggerhead turtles relative to their small declining population were being drowned by the Northern Prawn Fishery prior to 2000 (Poiner & Harris 1996, Robins et al. 2002). With the regulated requirement for turtle exclusion devices (TEDs) to be used in the Northern Prawn Fishery and the East Coast Trawl Fisheries for the last three years, mortality from this source has been reduced to a much lower level (Robins et al. 2002).

Loggerhead turtle in NPF trawl bycatch ***Source:*** *C Robins*

Apart from the trawling bycatch data, there are few data available on loggerhead turtle mortality from anthropogenic sources within the region. Within Torres Strait an undefined but probably small number of large loggerhead turtle are harvested annually by coastal communities, mostly along the New Guinea coast. Within increasing coastal development throughout the NPA, the current low level of kill of loggerhead turtles from boat strike (Haines & Limpus 2001) and port dredging activities (Greenland et al. 2004) can be expected to increase.

Green turtle (*Chelonia mydas*)

The area encompassing northern Australia, Papua New Guinea and eastern Indonesia has supported the largest remaining direct harvest of green turtles in the world in recent decades (Limpus 1997). Since the 1980s this harvest has accounted for many tens of thousands, possibly of the order of 100 000 turtles, annually (Adnyana 1995, Limpus 1997, Dethmers 2000, Saurez 2000). This regional harvest, not just the harvest within the NPA, must be considered when assessing the sustainability of the harvest for a particular stock. Within the NPA the annual harvest of green turtles is large although not precisely quantified. The annual harvest in Torres Strait from Papua New Guinea villages amounts to thousands of turtles, mostly adult and near-adult turtles (Kwan 1989, 1991). Within the Torres Strait Protected Zone, the harvest by Queensland hunters is similarly large with thousands of green turtles taken annually and again these are mostly adult and large immature turtles (Limpus & Parmenter 1986,



Johannes & MacFarlane 1991, Harris et al. 2000). The green turtle harvest in southern Torres Strait through the GoC and across northern Arnhem Land also accounts for thousands of large immature and adult turtles annually (Kennett et al. 1998, Henry & Lyle 2003). Because Torres Strait is a migratory bottleneck for breeding turtles as well as a significant courtship and nesting area, a large proportion of turtles harvested will be breeding adults (Kwan 1989).

The mortality of green turtles within prawn trawl bycatch of the Northern Prawn Fishery and Torres Strait Trawl Fishery has in recent decades caused the death of possibly tens of green turtles annually (Poiner & Harris, 1996). With the regulated use of TEDs now required in these fisheries, this mortality is expected to be much lower (Robins et al. 2002) and trivial.

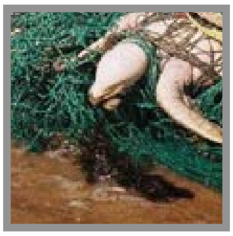
Gill net fisheries within the NPA kill an unquantified but possibly low number of green turtles annually. There is a much larger kill of green turtles annually throughout the GoC from entanglement in lost or discarded net (ghost nets) (Leitch 2001, Haines & Limpus 2001, Greenland et al. 2004). This mortality is mostly of small immature green turtles, including young turtles that may still be within their pelagic life history phase. In western Cape York Peninsula, the majority of the mortality is the result of previously beach-washed nets being put back to sea by cyclonic erosion of the beaches and turtles entangling in these nets in the weeks that follow as the nets are washed back ashore. It is estimated that, in order of magnitude, about 400 turtles die from this source annually along western Cape York Peninsula with a large proportion of them being green turtles (Limpus & Miller 2002).

Green turtle in ghost net, Weipa ***Source:*** *C Jenkins*

Within increasing coastal development throughout the NPA, the current low level of kill of green turtles from boat strike and port dredging activities (Greenland et al. 2004) can be expected to increase. Similarly, with coastal development including ports and mining industry infrastructure, damming of streams for irrigation, developing tourist industry accommodation and generally expanding human residence along the coast, there will be an increased risk to the integrity of inshore seagrass pastures and coral reefs resulting from increased turbidity and agricultural and industrial pollution outflow. These changes would have the potential to increase the incidence of green turtle fibropapilloma disease (GTFD) and possibly other diseases in the turtle herds. GTFD has recently been reported by traditional owners in the Wellesley Group. Negative impacts on the available forage can be expected to increase turtle mortality and reduce carrying capacity, growth rates and rates of annually preparation for breeding. Vehicle traffic on beaches is now commonplace on the nesting habitat of beaches bordering the NPA and there can be an expected increased mortality of turtle eggs. This is totally unquantified at present.

Based on demographic modelling of the southern GBR stock, Chaloupka (2002) has demonstrated that only a small harvest of a few hundred adult females is sustainable in the long term from a stock with an annual nesting population of a few thousand. Assuming that the demography of the other northern Australian green turtle stocks are similar to that of the southern GBR, it is highly unlikely that the current combined green turtle harvest for the NPA is sustainable, even with the large number of green turtles that breed within the area. The total harvest within northern Australia and neighbouring countries definitely is not sustainable. The harvest of green turtles in coastal communities of northern Australia, Papua New Guinea and Indonesia represents the greatest threat to the conservation of Australian green turtle stocks and the maintenance of the associated cultural activities.

11. Marine turtles



The structure of the coastline in the vicinity of the Sir Edward Pellew Islands and the Wellesley Group is such that those rare natural disasters of mass stranding of green turtles with cyclonic storm surge are more likely to occur at these locations. When they occur, mass strandings like the one during Cyclone Kathy at Borroloola in 1984 (Limpus & Read 1985) have the potential to cause significant reductions in the local availability of green turtles.

Hawksbill turtle (*Eretmochelys imbricata*)

The north-east Australian hawksbill turtle stock is declining at an unacceptable rate and there are at least two significant impacts on the stock.

Until 1991, when Japan removed its reservation on international trade in hawksbill turtle products, there was a large harvest of the species from Solomon Islands and other countries to supply tortoiseshell to the Japan Bekko industry (Limpus 1997). Although the international trade has ceased, the intense harvest of hawksbill turtles continues in Solomon Islands and Papua New Guinea and possibly other countries. In addition, there is an unquantified but possibly low level of harvest of hawksbill turtles within the NPA. Collectively this harvest, but particularly the international component, has the capacity to threaten the survival of hawksbill turtles within the NPA.

Also of significance is the harvest of hawksbill turtle eggs within the NPA. Chaloupka (1998), using a model for southern GBR hawksbill turtles, has demonstrated that egg harvest is only sustainable at low levels. Limpus (1993b) has advocated that, within the context of egg harvest, at least 70% of clutches laid should be managed to produce hatchlings. Unfortunately, the rates of egg harvest are not recorded for hawksbill turtle in the Torres Strait and eastern Arnhem Land areas, though as most hawksbills nest on islands the harvesting of eggs in north-eastern Arnhem Land is less significant for hawksbill turtles than for green turtles, which nest along the more easily accessible, outstation-populated mainland beaches south of Gove. However, in Torres Strait it would only require an annual harvest of less than 600 clutches to prevent the recommended goal of 70% of clutches being managed for incubation. On most inhabited Torres Strait islands and immediately adjacent hawksbill turtle rookeries, almost 100% of the clutches are harvested. Similarly in north-east Arnhem Land, there is a loss of clutches at a number of coastal rookeries south of Gove primarily due to harvest. The major offshore rookeries are less harvested in the north-east Arnhem Land region.

There is a high probability that the egg harvest alone could be sufficient to threaten the sustainability of this globally significant hawksbill turtle stock breeding within the NPA. In western Cape York Peninsula, pigs are destroying a high proportion of the limited number of hawksbill turtle clutches laid on these mainland rookeries. Excessive predation by native wildlife including varanids (goannas) as well as pigs and dogs may need to be managed to ensure an availability of eggs for human consumption.

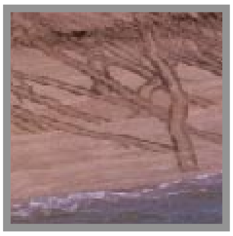
The mortality of hawksbill turtles within bycatch of the Northern Prawn Fishery and Torres Strait Trawl Fishery has in recent decades caused the death of possibly tens of hawksbill turtles annually (Poiner & Harris 1996). With the regulated use of TEDs now required in these fisheries, this mortality is expected to be much lower (Robins et al. 2002) and trivial.

Gill net fisheries within the NPA kill an unquantified but possibly low number of hawksbill turtles annually. There is a much larger kill of hawksbill turtles annually throughout the GoC from entanglement in lost or discarded net (ghost nets) (Leitch 2001, Haines & Limpus 2001, Greenland et al. 2004). This mortality is mostly of small immature hawksbill turtles, including young turtles that may still be within their pelagic life history phase. In western Cape York Peninsula, the majority of the mortality is the result of previously beach-washed nets being put back to sea by cyclonic erosion of the beaches and turtles entangling in these nets in the weeks that follow as the nets are washed back ashore. It is estimated that, in order of magnitude, about 400 turtles die from this source annually along western Cape York Peninsula with a large proportion of them being hawksbill turtles (Limpus & Miller 2002).

The ready availability of 4x4 vehicles has resulted in the nesting habitat of accessible beaches being regularly driven on by vehicles, especially in north-eastern Arnhem Land and Western Cape York Peninsula. This must result in reduced hatchling production, although it remains unquantified, but is likely to be less significant than for green and flatback turtles.

Olive ridley turtle (*Lepidochelys olivacea*)

Trawl fisheries have caused the largest identified mortality of olive ridley turtles in the NPA for many years, with many hundreds dying annually across a wide range of size classes from small immature to adult (Pointer et al. 1990, Poiner & Harris 1996, Guinea et al. 1997, Robins et al. 2002). Although the introduction of regulated use of TEDs in the Northern Prawn Fishery and Torres Strait Trawl Fishery should reduce this source of mortality to a minor level, the



impact of past decades of mortality will have a long impact on population dynamics for the species in Australia. The impact of gill net fisheries has not been quantified but the mortality associated with bottom-set shark fisheries in Fog Bay in November 1990 (over 200 olive ridley turtles killed in two weeks of fishing, Guinea & Chatto 1992) indicate that gill net fisheries bycatch needs a careful and rigorous assessment. Although severe, this was an isolated incident in terms of such a major kill.

Another large source of olive ridley turtle mortality that occurs annually throughout the GoC is from entanglement in lost or discarded net (ghost nets) (Leitch 2001, Haines & Limpus 2001, Greenland et al. 2004). This mortality is mostly of medium-sized immature or larger olive ridley turtles. This type of mortality from ghost nets and ingestion of discarded synthetic debris is widespread in northern Australia and has been affecting olive ridley turtles for some years (Chatto 1994, Chatto et al. 1995). In western Cape York Peninsula, the majority of the mortality is the result of previously beach-washed nets being put back to sea by cyclonic erosion of the beaches and turtles entangling in these nets in the weeks that follow as the nets are washed back ashore. It is estimated that, in order of magnitude, about 400 turtles die from this source annually along western Cape York Peninsula (Limpus & Miller 2002) with a large proportion of them being olive ridley turtles.

Another unquantified source of mortality for olive ridley turtles in the NPA that has the potential for not being sustainable is traditional harvest and poaching. An undetermined number of turtles and clutches of eggs are harvested annually within the NPA and adjacent areas of NW Arnhem Land. In association with this egg harvest consideration needs to be given to the level of egg loss through predation by pigs (western Cape York Peninsula), dogs and varanids in Arnhem Land and vehicle traffic over nests. Control of predation by feral predators, excessive predation by native predators and vehicle traffic on nesting habitat may need to be considered if sustainable harvest for human consumption is required. This is currently occurring on selected beaches on Melville Island (just to the west of the NPA) which may have the densest olive ridley turtle nesting in Australia and are being decimated by dogs.

Flatback turtle (*Natator depressus*)

The greatest threat to flatback turtle populations within the NPA must be the combined loss of eggs from predation by pigs in western Cape York Peninsula, dogs and goannas in Arnhem Land, vehicle damage to nests and the harvest of flatback turtle eggs and turtles throughout the area. Within the NT section of the NPA there is little animal predation on most of the islands; however, there is considerable goanna and/or dog predation on most mainland sites and some of the larger islands. There is very little pig predation on NT beaches within the NPA as yet, despite high pig numbers in places (Chatto in prep).

Although this egg loss is largely unquantified, it needs to be taken seriously because the problems are widespread (Limpus et al. 1989, 1993, Kennett et al. 1998, Blamires & Guinea 2003, Henry & Lyle 2003) and modelling of egg loss with green turtles indicates that even moderate losses will not be sustainable (Chaloupka 1998). The discussion in relation to sustainable hawksbill turtle egg loss (see above) is equally applicable for flatback turtles.

In addition, trawl fisheries have caused a high mortality of flatback turtles in the NPA for many years with hundreds dying annually across a wide range of size classes from small immature to adult (Pointer et al. 1990, Poiner & Harris 1996, Guinea et al. 1997, Robins et al. 2002). Although the introduction of regulated use of TEDs in the Northern Prawn Fishery and Torres Strait Trawl Fishery should reduce this source of mortality to a minor level, the impact of past decades of mortality will have a long impact on population dynamics for the species in northern Australia. Flatback turtles from the NPA are caught and killed in trawl fisheries and gill net fisheries in adjacent Indonesian and Papua New Guinean waters (Limpus 1997). The impact of gill net fisheries within the NPA has not been quantified but the mortality associated with bottom-set shark fisheries in Fog Bay in November 1990 (Guinea & Chatto 1995) indicates that inshore gill net fisheries bycatch needs careful assessment.

Flatback turtle mortality occurs annually throughout the GoC from entanglement in lost or discarded net (ghost nets) (Leitch 2001, Haines & Limpus 2001, Greenland et al. 2004). This mortality is mostly of medium-sized immature or larger flatback turtles but occurs at a lower level than for green, hawksbill and olive ridley turtles. This type of mortality from ghost nets and ingestion of discarded synthetic debris is widespread in northern Australia and has been affecting flatback turtles for some years (Chatto 1994, Chatto et al. 1995). In addition, nesting female flatback turtles can

be trapped in the beach-washed nets on the beach (D Limpus, pers. comm.).

With increasing coastal development throughout the NPA, the current low level of kill of flatback turtles from boat strike and port dredging activities (Greenland et al. 2004) can be expected to increase.

Given the wide range of significant and long-term negative impacts on the flatback turtle populations of the NPA, grave concern must be help for the conservation of these populations.

Leatherback turtle (*Dermochelys coriacea*)

Leatherback turtles are rarely encountered in the NPA. However, there have been infrequent captures and mortality of leatherback turtles within the Northern Prawn Fishery. Leatherbacks have been more frequently captured in inshore gill nets but are only rarely taking during Indigenous hunting (Limpus & McLachlin 1979, Limpus unpubl. data).

Information gaps

The most significant knowledge gaps with in the NPA include:

Population threats

There is a dearth of data on distribution, size and demographic characteristics (species, sex, maturity, genetic stock composition) of turtle harvest within the NPA. The paucity of these data is seriously hindering the capacity to model for management options to maintain sustainable populations in the face of ongoing harvesting.

Other information gaps relating to population threats include:

- spatially quantified egg loss for each turtle species and stock from egg harvest, feral predation and excessive native animal predation
- egg mortality from vehicles driving on nesting beaches
- collective impact of inshore gill net fisheries on marine turtle populations.

Marine turtle biology and demography:

There is an incomplete knowledge of the distribution and size of turtle rookeries across northern Arnhem Land. A quantified survey of nesting distribution by species is warranted. In the NT total nesting distribution has been fairly well covered by Ray Chatto, and a rough categorising made of heavy, medium and low density nesting (Chatto in prep.). However, more needs to be done on more accurate seasonal numbers.

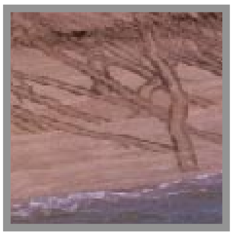
There are no long-term census studies for any marine turtle population in the NPA. A representative index beach should be selected for each stock within each species for monitoring of population trends in responses to management actions. Ideally, there should be in-parallel monitoring of foraging populations but these are more expensive and demanding.

There are no studies to quantify critical demographic parameters for any marine turtle species/stock in NPA – including parameters such as: population size at a key life history stage (such as nesting females), age structure/growth rate modelling across all age classes, recruitment and survivorship within the various life history phases; years between breeding seasons, clutches per breeding season, pivotal temperature, and hatchling production. (Many of the other demographic parameters can be adequately extrapolated from other stocks in Australia for the purposes of population modelling.)

There are no significant data on the biology and population dynamics of olive ridley turtles in Australia. Priority should be given to scientific studies on this species: supporting in-depth studies to describe the distribution and abundance of nesting for the species, to determine the demographic parameters of nesting and foraging populations using a combination of tagging, gonad assessment, hatchling production studies (including egg harvest and predation studies), temperature-dependent sex determination and sex ratio studies, migration studies with satellite telemetry and flipper tags, turtle harvest and mortality in fisheries and ghost nets.

Stock management

The management of no one stock of marine turtle in Australia lies within the jurisdiction of any one management agency or indeed within the bounds of a single region such as the NPA. There is a need to form an interagency (local, state and federal government agencies, Iindigenous stakeholders, scientific community, fisheries agencies and NGOs) to develop a strategy to break the current barriers to effective collaboration in conservation management of stocks of marine turtles across their range. With respect to the NPA, priority should to be directed to green turtles, olive ridley turtles, hawksbill turtles and flatback turtles.



Key references and current research

Other references of significance to the families include;

- Eckert et al. (1999).
- Wyneken (2001).

Marine turtle data:

Major data sets on distribution of marine turtle nesting are managed by:

Qld EPA, Dr Col Limpus
NT Territory Parks and Wildlife, Ray Chatto
WA DCALM, Keith Morris

Major data sets for tagging and mark-recapture studies, including migration data, are managed by:

Qld EPA, Dr Col Limpus
NT Territory Parks and Wildlife Service, Ray Chatto
Charles Darwin University, Dr Mick Guinea
WA DCALM, Keith Morris
Department of Environment and Heritage (DEH), Kakadu NP, Dr Rod Kennett
DEH, Canberra, for Coral Sea Nature Reserve and Ashmore Reefs Nature Reserve (Copies of a large portion of these data are duplicated in the EPA database)

Major data sets on turtle mortality and injury (strandings) are managed by:

Qld EPA, Dr Col Limpus
NT Territory Parks and Wildlife, Ray Chatto
WWF Darwin (ghost net captures)
Major data sets for turtles within fisheries bycatch data are managed by:CSIRO, NPF
AFMA, Torres Strait

Major data sets for turtles within Indigenous hunting records are managed by:

AFMA, Torres Strait
Indigenous communities at Dhimurru, Groote Eylandt, Borroloola
NT, Territory Parks and Wildlife–Gurig National Park

The following groups/agencies are engaged in marine turtle projects:

NT Territory Parks and Wildlife

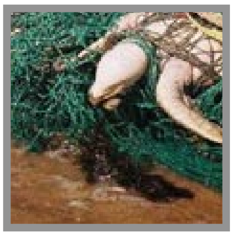
- dog control on Melville Island to reduce olive ridley turtle egg loss
- documenting distribution and status of turtle nesting around the NT
- it is planned to establish monitoring programs at a selected number of sites to assess long-term population status
- monitoring flatback turtle nests on Darwin beaches to ensure the success nest and hatchlings reaching the water
- conducting public education talks on marine turtles, in conjunction with a viewing program to observe hatchlings crossing the beach into the ocean on Darwin beaches

Queensland EPA Turtle Conservation Projects

- monitoring and research of turtle populations in Torres Strait and Gulf of Carpentaria: mapping distribution, tagging, census, migration, hatchling productivity, predation studies, temperature dependent sex determination, population genetics (principal study sites: Crab Island, Weipa to Bamaga Coast, Bountiful Island)
- monitoring and tagging turtles captured as fisheries bycatch in trawl and gill net fisheries
- STRANDNET: monitoring of strandings, death and injury for marine wildlife including turtle, dugong, cetacean throughout Queensland (includes strandings in ghost nets)
- collaboration with indigenous communities to develop community management plans for sustainable hunting: Napranum
- monitoring and reduction of pig predation of turtle eggs on western Cape York Peninsula

NT Darwin University:

- turtle population modelling
- satellite telemetry of green turtles from eastern Arnhem Land rookeries
- monitoring, tagging and population genetics of marine turtle populations in Sir Edward Pellew Islands
- Dr M. Guinea's team: monitoring of turtle nesting and foraging populations, mark recapture studies to measure demographic parameters of growth, recruitment, survivorship, predation studies, hatchling productivity, satellite telemetry (Principal study sites: Fog Bay, Bare Sand Island)



WWF Australia - Arafura Ecoregion Program Marine Turtle Projects 2004:

- Marine Debris in Northern Australia
- The Net Kit: A Fishing Net Identification Kit for Northern Australia
- Marine Debris Database
- Indigenous Sea Rangers
- turtle monitoring in Indigenous communities

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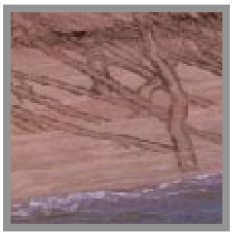

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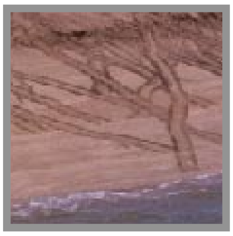

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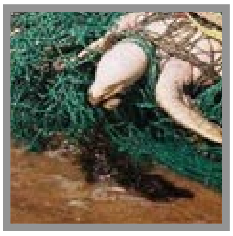

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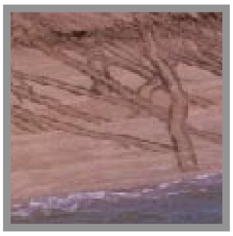

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12. Marine snakes

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Slender-necked sea snake (Hydrophis coggeri) **Source:** *M Guinea*

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Species group name and description

Sea snakes: family Acrochordidae; family Colubridae, subfamily Homalopsinae and subfamily Natricinae; family Laticaudidae, family Hydrophiidae.

Snakes of at least five distinct lineages inhabit the marine environment. These comprise the file snakes (family Acrochordidae), the mud snakes (Family Colubridae: Homalopsinae), the water snakes (family Colubridae: Natricinae), the sea kraits (family Laticaudidae), and the true sea snakes (family Hydrophiidae) (Heatwole 1999). Although the term 'sea snake' mainly refers to the sea kraits and the true sea snakes, representatives of four of the five lineages inhabit the Northern Planning Area (NPA) and share habitats and therefore have common threats.

Two species of file snake inhabit northern Australia and of these only the little file snake, *Acrochordus granulatus*, lives in the marine environment. This non-venomous species is found in coastal rivers, estuaries, mangrove watercourses and the open sea. It feeds on fish and seldom leaves the water.

Mud snakes live in muddy habitats across the northern Australian coastline but are found no further east than Cape York (Cogger 2000, Wilson & Swan 2003). As their closest relatives are in South-east Asia and Papua New Guinea, they are thought to have arrived along the northern shore line during the recent geological past when sea levels were lower (Cogger & Heatwole 1981, Shine 1991). Three species occur in the NPA with *Myron richardsonii* being endemic to Australia. *Cerberus australis* and *M. richardsonii* feed on fish, but *Fordonia leucobalia* feeds only on crabs and mud lobsters. Not surprisingly the homalopsine mud snakes have dorsally positioned valvular nostrils to exclude sea water (Wilson & Swan 2003) and salt glands to remove excess salt from their bodies (Dunson & Dunson 1979). Although water snakes inhabit the marine environment in north and central America (Heatwole 1999), the only member of this subfamily in Australia is the Keelback, *Tropidonophis mairii*, which is restricted to fresh water habitats (Wilson & Swan 2003).

The sea kraits (family Laticaudidae) inhabit the tropical waters of the western Pacific and northern Indian Oceans (Cogger 2000). Currently there are six recognised species of *Laticauda* (Cogger et al. 1987). Two species, *L. colubrina* and *L. laticaudata* occur to the north and east of the NPA (Wilson & Swan 2003) but have not been recorded from within its boundaries.

Presently 58 species of true sea snakes (family Hydrophiidae) are recognised, although researchers have not reached consensus on the integrity of some taxa (Guinea 2003). They inhabit the tropical waters of the Indian and Pacific Oceans. Thirty-one species of true sea snakes have been reported from Australian waters (Wilson & Swan 2003) and of these 21 species are reported from the NPA. Each species exhibits specialisations for its aquatic habits: a paddle-like tail, dorsally positioned nostrils each with a valve, fangs at the front of the mouth, a hinged opening at the front of the mouth through which the tongue is protruded, salt regulating glands, and a single lung that extends nearly the full length of the body (Dunson 1975). All of these adaptations enable sea snakes to dive for long periods and to hunt underwater. These external features readily place a species within the family of true sea snakes. Their body form, colouration and numbers of body scales are used to aid identification to species level (Cogger 2000).

Sea snakes range in size from the pencil-thin and 30 cm long *Myron richardsonii* to the bulky Astrotia stokesii with a mass of up to 5 kg and as much as 2 metres in total length, to the slender and 2 metre long *Hydrophis elegans* (Heatwole 1999). All are air breathers and have to surface to breathe. A single breath may last up to two hours in the case of Pelamis platurus but usually lasts as little as 30 minutes when the snakes are actively foraging (Heatwole 1999). Most sea snakes feed on fish, including eels, or their eggs. However, Fordonia leucobalia preys on crustaceans in mangroves. Only the yellow-bellied seasnake, *Pelamis platurus*, and the bockadam, Cerberus australis, have the ability to capture fish in open water (Kropach 1975, Jayne et al. 1988). All of the other species corner their prey in crevices or burrows. Some such as *Aipysurus laevis* will eat dead fish (Heatwole et al. 1978) but are unlikely to be attracted to discarded trawl bycatch (Fry et al. 2001).

All of the sea snakes in the NPA give birth to living young. Their brood sizes are typically small with about 50% of species having a brood size of less than five young and almost 90% of the species examined had a brood size of less than ten (Heatwole 1997). Species with relatively large brood sizes include *Astrotia stokesii*, *Hydrophis elegans* and possibly *Enhydrina schistosa* (Heatwole 1997, Fry et al. 2001). Reproductive seasonality varies amongst the sea snakes with some species giving birth between March and June. These include *Acalyptophis peronii*, *Disteira kingii*, *D. major*, *Hydrophis elegans*, *H. ornatus* and *Lapemis curtus* (Fry et al. 2001). Female *Aipysurus eydouxii* are likely to give birth in September (Fry et al. 2001). The lengthy gestation periods of between six and seven months that are common for sea snakes (Heatwole 1997) may prevent females from breeding every year in more temperate climates. However, females of most species surveyed by Fry et al. (2001) appear to breed annually as almost all specimens collected between January and March carried full–term embryos.

Little is known of the age at which sea snakes reach sexual maturity. Female *Aipysurus laevis* are thought to reach sexual maturity in their fourth or fifth year (Heatwole 1997) and may live to an estimated age of 15 years (Burns 1984). Larger older female sea snakes produce larger broods (Fry et al. 2001). Natural mortality amongst the young is high with an estimated 10 to 20% of young *Enhydrina schistosa* surviving the first year and only 6% of females of this species surviving to reproduce (Voris & Jayne 1979). Sea snake life histories are characterised by relatively long-lived individuals, growing slowly after birth and taking at least several years to reach sexual maturity. Females produce smaller broods in their early breeding years and have long gestation periods with only one brood per year or every second year as resources allow.

12. Marine snakes

Status

Twenty-five species of sea snakes have been reported from within the NPA. None of these are considered Critically Endangered, Endangered, Vulnerable or Near Threatened under the IUCN Red List Categories (IUCN 2001). Of the sea snake species recorded from the NPA, only the bockadam, *Cerberus*, is listed in Appendix I of CITES. All species of true sea snakes in Australian waters are listed marine species under the Commonwealth Government's *Environmental Protection and Biodiversity Conservation Act 1999*. In the Northern Territory some species of sea snake such as *Aipysurus laevis* and *Hydrophis elegans* are listed as threatened but of least concern because they are believed to be wide spread and abundant taxa. Others such as *Enhydrina schistosa* and *Hydrophis czeblukovi*, are considered data deficient which is not a category of threat. Others including *Acrochordus granulatus* and *Fordonia leucobalia* were not evaluated against the IUCN Red List Criteria. Queensland has listed all species of the family Hydrophiidae as a restricted but common species. A summary to the conservation status of the species recorded from the NPA is provided in Table 12.1.

Table 12.1: *List of sea snakes recorded from the NPA with their common names, Australian Biological Resource Study (ABRS) biocode and their conservation status according to IUCN, EPBC Act 1999 and the legislations of the Northern Territory (NT) and Queensland (QLD) Governments*

IUCN (NL = Not listed)
EPBC Act 1999 (Ma = Listed marine species)
Northern Territory (LC = threatened with least concern; DD = data deficient; NE = not evaluated)
Queensland (R = restricted; C = common)

Common name	Species name	ABRS	IUCN	EPBC Act 1999	NT	QLD
Family Acrochordidae						
Little file snake	*Acrochordus granulatus*	2628	NL	-	NE	C
Family Colubridae, Subfamily Homalopsinae						
Australian bockadam	*Cerberus australis*	-	NL	-	LC	C
White-bellied mangrove snake	*Fordonia leucobalia*	2636	NL	-	NE	C
Richardson's Mangrove Snake	*Myron richardsonii*	2637	NL	-	LC	C
Family Hydrophiidae						
Horned seasnake	*Acalyptophis peronii*	2736	NL	Ma	LC	RC
Dubois's seasnake	*Aipysurus duboisii*	2738	NL	Ma	LC	RC
Spine-tailed seasnake	*Aipysurus eydouxii*	2739	NL	Ma	LC	RC
Olive seasnake	*Aipysurus laevis*	2742	NL	Ma	LC	RC
Stokes' seasnake	*Astrotia stokesii*	2744	NL	Ma	LC	RC
Spectacled Seasnake	*Disteira kingii*	2745	NL	Ma	LC	RC
Olive-headed seasnake	*Disteira major*	2746	NL	Ma	LC	RC
Beaked seasnake	*Enhydrina schistosa*	2748	NL	Ma	DD	RC
Black-ringed seasnake	*Hydrelaps darwiniensis*	2751	NL	Ma	LC	RC
Dwarf seasnake	*Hydrophis caerulescens*	2753	NL	Ma	NE	RC
Slender-necked seasnake	*Hydrophis coggeri*	2024	NL	Ma	NE	RC
Fine-spined seasnake	*Hydrophis czeblukovi*	2025	NL	Ma	DD	RC
Elegant seasnake	*Hydrophis elegans*	2754	NL	Ma	LC	RC
Plain seasnake	*Hydrophis inornatus*	2757	NL	Ma	DD	RC
Small-headed seasnake	*Hydrophis macdowelli*	2026	NL	Ma	LC	RC
No common name	*Hydrophis ornatus*	2761	NL	Ma	LC	RC
Large-headed seasnake	*Hydrophis pacificus*	2762	NL	Ma	LC	RC
No common name	*Hydrophis vorisi*	2027	NL	Ma	NE	RC
Spine-bellied seasnake	*Lapemis curtus*	2767	NL	Ma	LC	RC
Northern mangrove seasnake	*Parahydrophis mertoni*	2750	NL	Ma	LC	RC
Yellow-bellied seasnake	*Pelamis platurus*	2770	NL	Ma	LC	RC

Habitat and distribution

The region of the NPA has been inadequately surveyed for sea snakes. The number of surveys using both commercial and research trawl vessels has biased the existing records to waters mainly 10 to 40 metres in depth. Only two non-trawl surveys have been conducted in the area. Counts of sea snakes on the surface have provided valuable information of the abundance and breeding habits of the pelagic yellow-bellied seasnake, *Pelamis platurus*, (Limpus 2001). Nocturnal surveys using small boats produced a collection of 15 species of sea snakes from the Hey-Embley and Mission Rivers near Weipa (Porter et al. 1997). This survey provided valuable locality records for *Hydrophis pacificus*, observations on the distribution and behaviour of the little-known *Acrochordus granulatus* and highlighted the importance of the estuarine environments to juvenile and subadult sea snakes.

The distribution of sea snakes is influenced by a number of identifiable factors including seasonal factors associated with either mating or breeding aggregations of gravid females. Such aggregations of gravid females have been recorded outside the NPA for *Aipysurus eydouxii* (Limpus 1975) and presumably occur in estuaries within the NPA. The time of day appears to be important, as many sea snakes of various species have been seen resting on the sea surface in late afternoons and early evenings in the Beagle Gulf (Guinea pers. obs.). Sightings of large aggregations of sea snakes were recorded around and to the south of the Wellesley Islands, to the north and west of Groote Eylandt and in Albatross Bay near Weipa (COMALCO 1993). Other anecdotal reports and museum collections of sea snakes have come from Peter John River in Arnhem Bay. In general within the NPA, sea snakes have a patchy distribution. Even their presence in bycatch varies with locality, depth, season and previous trawl history of the area (Ward 2000).

Sea snakes occupy diverse habitats (Table 12.2). Species such as *Aipysurus laevis* are associated with coral reefs yet Aipysurus eydouxii is more commonly found in turbid water habitats. Water depth is an important factor as there is a negative correlation between depth and species diversity. This could be a consequence of all species, with the exception of *Pelamis*, being benthic feeders with decreasing foraging time with increasing depth (Heatwole 1999). The nature of the bottom is important especially with many of the sea snakes being specialists feeders of prey that are restricted to particular habitats. For example, *Hydrelaps darwiniensis* and *Parahydrophis mertoni* are found in coastal and estuarine mud flats and mangrove channels that they share with *Cerberus australis*, *Fordonia leucobalia* and *Acrochordus granulatus*. In the western region of the NPA, Myron richardsonii would be present also in this species assemblage. Some species such as *Aipysurus laevis* and *Aipysurus duboisii* prefer coral reef habitats. Several species such as *Hydrophis ornatus* and *Lapemis curtus* are eurytopic being found in a variety of habitats from coral reefs to turbid estuaries. In addition, *Hydrophis ornatus* and *Disteira kingii* were relatively more abundant in trawls from deeper waters (Ward 2000).

Yellow-bellied seasnake (Pelamis platurus) ***Source*** *M Guinea*

Table 12.2: *Habitat use and diet of sea snakes from the NPA Based on various authors (McCosker 1975, Glodek & Voris 1982, Heatwole 1999, Cogger 2000, Fry et al. 2001, Wilson & Swan 2003).*

Species name	Habitat	Depth	Food
Family Acrochordidae			
Acrochordus granulatus	Intertidal mud flats and mangroves	< 20 m	Small fish and crabs
Family Colubridae			
Cerberus australis	Estuaries and mangroves	< 10 m	Small fish
Fordonia leucobalia	Mudflats and mangroves	<10 m	Crabs
Myron richardsonii	Estuaries and mangroves	< 10 m	Small fish
Family Hydrophiidae			
Acalyptophis peronii	Sandy substrates	<20 m	Gobies
Aipysurus duboisii	Coral reefs	<50 m	Fish in general
Aipysurus eydouxii	Turbid waters	<50 m	Fish eggs
Aipysurus laevis	Coral reefs	<30 m	Fish in general
Astrotia stokesii	Turbid and clear waters	<30 m	Scorpion fish
Disteira kingii	Various habitats	<100 m	Fish
Disteira major	Turbid waters	<100 m	Fish
Enhydrina schistosa	Bays and estuaries	<10 m	Catfish
Hydrelaps darwiniensis	Mangroves and mudflats	<10 m	Gobies
Hydrophis caerulescens	Mud substrates	<20 m	Eels and gobies
Hydrophis coggeri	Sand around coral reefs	<50 m	Eels
Hydrophis czeblukovi	Deep water	<50 m	Eels
Hydrophis elegans	Turbid / reefal waters	<50 m	Eels
Hydrophis inornatus	-		
Hydrophis macdowelli	Turbid estuaries	<30 m	-
Hydrophis ornatus	Eurytopic	< 50 m	Fish
Hydrophis pacificus	-	<50 m	-
Hydrophis vorisi	-	<50 m	-
Lapemis curtus	Eurytopic	< 50 m	Fish in general
Parahydrophis mertoni	Mudflats and mangrove channels	< 10 m	-
Pelamis platurus	Open water	Any depth	Pelagic fish

Significance of the species group in the Northern Planning Area

The NPA contains some of the most common species, such as *Hydrophis elegans* and *H. ornatus*, and some of the rare sea snakes such as Parahydrophis mertoni and Hydrophis czeblukovi. The Gulf of Carpentaria (GoC) is famous for the numbers of sea snakes caught in trawls. Yet the diversity of sea snake species is often overlooked because trawlers operate in a limited range of habitats. It is important to consider also those species that are absent from the NPA. Of the ten true sea snake species found elsewhere in Australia but not recorded from the NPA, two are regional endemics from the Coral Sea, three are regional endemics from the Western Australian coast, three are regional endemics from the Sahul Bank and the remaining two appear in samples from the Northern Prawn Fishery (NPF) but are not recorded as yet from the NPA (Wilson & Swan 2003). Species such as *Hydrophis vorisi* and *H. macdowelli* should be considered as regional endemics of the NPA with the known distributions restricted to regions of the GoC. The NPA contains all of the widely distributed Australian species of true sea snakes plus two regional endemics, all of the Homalopsine mud snake species and the marine file snake species. This makes the NPA one of the richest areas for sea snake species along the Australian coastline.

Such large numbers of sea snakes and the diversity of species would logically perform an important role in the ecology of the NPA as has been demonstrated in Asia (Voris 1972) and in other marine regions of the Australian coastline (Heatwole 1975a, b, Limpus 1975, McCosker 1975, Minton & Heatwole 1975). However such ecological studies have been confined largely to

the GoC and to species obtained as trawl bycatch. Estuarine studies of sea snakes have concentrated on only a single locality in the vicinity of Weipa. Yet it has revealed similar numbers of species as trawl surveys but with a bias towards inshore species and immature individuals (Porter et al. 1997). The NPA is a significant region for sea snakes and as such is rated highly for its biodiversity values. Sea snakes have little economical significance as the proposed leather industry based on the bycatch proved unsustainable (Heatwole 1997). Income from the sale of venom from *Enhydrina schistosa* provided the financial incentive to conduct surveys and funded collecting trips to the Weipa region (Porter et al. 1997) although the sustainability of such activity remains uncertain.

Impacts/threats

The NPA occupies part of the NPF that extends from Cape Londonderry in the west and abutting Torres Strait in the east (AFMA 1998, Ward 2000). Sea snakes have been an obvious component of the bycatch of the NPF and other trawl fisheries in the area (Heatwole 1975b, Redfield et al. 1978, Ward 1993, Wassenberg et al. 1994, Ward 1996a, b, Fry et al. 2001). The annual trawler bycatch of sea snakes during 1984 to 1986 in the GoC was estimated at almost 120 000 sea snakes of which almost half of the individuals died (Wassenberg et al. 1994). Similar catch rates were recorded in the GoC in 1989 and 1990 (Ward 2000).

Table 12.3: *Relative abundance of sea snakes recorded in trawling activities in Northern Australia including the NPA The locality of the trawls, the authority and the number of sea snakes captured in each study and the percentage abundance for each species in each study are provided. Species that comprise a major percentage of the trawl bycatch are highlight in bold type.*

Species name	Arafura Sea (Shuntov 1972)	GoC (Heatwole 1975b)	Eastern GoC (Redfield et al. 1978)	GoC Research Trawls (Wassenberg et al. 1994)	Northern Australia Fish Trawls (Ward 1996a)	Northern Australia Pawn Trawls (Ward 1996b)	Northern Australia Tiger & Endeavour Prawns (Ward 2000)	Northern Australia NPF Research 1976–79 (Fry et al. 2001)	Northern Australia NPF Commercial 1986 (Fry et al. 2001)	Northern Australia NPF scientific Observer 1996–98 (Fry et al. 2001)
Sample size			341	1276	206	5203	4546	1266	163	133
Acalyptophis peronii	8.0		3.2	1.7	9.2	0.7	0.7	1.7	3.1	
Aipysurus apraefrontalis[1]	0.5				0.5					
Aipysurus duboisii	-		1.8	0.5	3.9	0.8	0.9	0.4	1.2	1.5
Aipysurus eydouxii	2.0		2.3	6.0	4.9	9.2	10.4	6.0	6.8	2.3
Aipysurus foliosquama[1]	2.0				2.9					
Aipysurus laevis	3.0		1.8	1.6	18.4	3.2	3.6	1.6		3.8
Aipysurus tenuis[1]	1.0									
Astrotia stokesii	2.0	5.0	4.1	4.7	2.9	2.7	2.6	4.6	3.7	5.3
Disteira kingii	2.0		2.1	2.7	1.0	6.4	6.8	2.6	4.3	3.8
Disteira major	**6.0**	**25.0**	**3.5**	**2.7**	**2.4**	**17.6**	**16.1**	**2.8**	**29.5**	**27.8**
Emydocephalus annulatus[2]					1.0			0	0.6	
Enhydrina schistosa			6.2	8.2	0.5	0.2	0.1	8.1	0.6	
Hydrelaps darwiniensis										
Hydrophis atriceps						0.1	0.1			
Hydrophis caerulescens			0.3	0.6				0.6		
Hydrophis coggeri										
Hydrophis czeblukovi					0.5					
Hydrophis elegans	**7.0**	**54.0**	**9.7**	**16.2**	**15.0**	**33.1**	**32.0**	**16.3**	**2.5**	**30.7**
Hydrophis fasciatus	1.0									
Hydrophis inornatus	6.0	2.0							0.6	
Hydrophis macdowelli			2.6[3]	0.7	3.9	1.4	1.5	0.7	3.1	
Hydrophis ornatus	**36.0**	**2**	**1.2**	**0.9**	**30.6**	**15.3**	**17.1**	**0.9**	**43.4**	**6.0**
Hydrophis pacificus						0.4	0.4			3.0
Hydrophis vorisi					0.5	0.1	0.1			
Lapemis curtus	**19.0**	**12.0**	**61.2**	**53.4**	**1.9**	**8.9**	**7.4**	**53.5**	**0.6**	
Parahydrophis mertoni										
Pelamis platurus	1.0			0.2				0.2		
Unidentified sea snakes	0.5									15.8

[1] *Possibly collected outside the NPA*
[2] *Not recorded from within the Gulf of Carpentaria*
[3] *As Hydrophis sp Cogger 1975*

[1] The venom is five times more toxic than that of the cobra. It is used to make antivenom.

12. Marine snakes

Trawling appears to be the largest and most obvious threat to sea snakes in the NPA. Coupled with a high catch rate is the high mortality rate of snakes caught in trawl nets (Wassenberg et al. 1994). Even when retained aboard to recuperate, captured sea snakes seldom survive (Heatwole 1997). The species with a high presence in the trawls are: *Hydrophis elegans*, *Hydrophis ornatus*, *Lapemis curtus* and *Disteira major* (Table 12.3). As a consequence of this high mortality the Queensland Government issued licences for the retrieval of sea snake bycatch and processing of their skins for the leather industry. The NT Government also issued a scientific developmental licence. The sea snake leather industry proved unviable and ceased. Sea snakes are typified by being slow-growing, late-maturing individuals that reproduce by live birth either infrequently or only once a year over a lifetime that may span more than a decade. A number of species are specialist feeders and have a preference for fish species and habitats associated with the trawl grounds. Such life history characteristics and habits make the species vulnerable to over exploitation by harvesting (Heatwole 1997). Despite such claims, catch rates remain relatively constant and there is no detectable decrease in adult size in the bycatch (Fry et al. 2001). Additionally, Fry et al. (2001) detected a bias towards both non-gravid and gravid females in the catch. As trawling occurs in only 20% of the GoC, recruitment onto the trawl grounds is assumed to come from neighbouring areas (Fry et al. 2001). Should this be the case then there is a very strong argument for not expanding trawl grounds and for developing bycatch reduction devices that further reduce the negative impact of trawling on sea snakes (Ward 2000). Significant reductions in the sea snake bycatch have been demonstrated by the recent implementation of bycatch reduction devices in the NPF (Brewer et al. 1998).

In addition to developing bycatch reduction devices the NPF has established a number of permanent and seasonally closed areas. The permanent closure areas include: Caledon Bay, Blue Mud Bay and Bickerton Island to the West of Groote Eylandt, five bays on Groote Eylandt, regions south of Vanderlin Island, areas south of the Wellesley Islands and Arnhem Bay (AFMA 1998). The establishment of the Vessel Monitoring System (VMS) that deploys transceivers aboard NPF vessels has strengthened the surveillance and monitoring of such permanent and seasonal closure areas. The Australian Fisheries Management Authority (AFMA) is alerted by the transceiver when a vessel has entered a permanent or seasonal closure area (AFMA 1998). Such closure areas are declared 'no-go' areas by AFMA.

Major coastal developments in the GoC are associated with mining and the movement of ore to ships. Increased shipping traffic brings with it an increased risk of oil spills and other environmental disturbances. The impact of these coastal mining developments on sea snakes by loss of habitat has not been assessed. Being air-breathers, sea snakes are particularly susceptible to the negative impacts of oil spills. Many species of sea snake have a restricted diet and feed on only a few species of fish. As specialist feeders, any increase in turbidity that impacts on either their prey or their ability to detect their prey would impact negatively on sea snake populations. Dredging or increased boat traffic has the potential to disrupt normal feeding activities. In addition the noise generated by increased boat traffic and associated machinery is a source of potential disruptive noise pollution capable of forcing sea snakes out of an area. Boat strikes are a common cause of sea snake mortality in areas where sea snakes and small boats share the same waterways. These activities either singularly or in combination with each other have the potential to alter the habitats so critical to sea snakes and about which we know so little. The habitat needs of sea snakes clearly warrant further study.

The uninhabited shoreline of the NPA and the equable climate provides an ideal location for aquaculture ventures. Through habitat removal and nutrient influx these ventures have the potential to negatively impact on coastal and offshore species of sea snakes. Such aquaculture ventures should be scrutinised for their possible environmental impact on habitats and species of sea snake.

Information gaps

Our knowledge of the biology of sea snakes is scant. Little is known of their ecology and life history and in-water studies have generally been restricted to areas of clear water close to population centres on the eastern coastline of Australia. Most samples of marine snakes in the NPA relate to NPF bycatch and thus are within the trawled areas of the fishery. Areas outside the trawled areas, apart from a couple of local studies (eg Weipa), have not been surveyed at all. In addition, as many species appear habitat-specific our basic lack of information on habitats in the NPA is an issue that requires immediate attention.

Within the NPA there needs to be a regionally specific management plan for the sea snakes. The management plan should take into account the diversity of species and habitats occupied by the sea snakes. Additionally the high mortality rates experienced by some species in the past could require threat abatement measures to be introduced. There needs to be a validation of species and population status independent of trawling techniques. This is important to gauge the success of bycatch reduction devices and changes in trawling gear and mode of operation. It is unfortunate that, in the preparation of this review, examples from overseas sea snake studies have to be incorporated because of the absence of suitable Australian studies. It is hoped that the National Oceans Office and *Environmental Protection and Biodiversity Conservation Act 1999* will address this lack of basic knowledge about Australian sea snake species.

Key references and current research

There is currently no sea snake research being conducted in the NPA. Neither Queensland nor the NT Governments have sea snake research and monitoring programs in the NPA. Commonwealth Government offices such as CSIRO will continue monitoring of the bycatch in trawl fisheries and bycatch reduction devices.

An appreciation of the complexity of sea snake life histories and information gaps can be gained from Hal Heatwole's (1999) Sea Snakes and William Dunson's (1972) The Biology of Sea Snakes. Both books provide an excellent introduction into sea snake biology. Sea snake identification is covered expertly by Hal Cogger's (2000) *Reptiles and Amphibians of Australia* with Steve Wilson and Gerry Swan's (2003) *A Complete Guide to Reptiles of Australia* updating recent name changes. The results of several years of bycatch data from regions in the NPA are documented by Fry, Milton and Wassenberg's (2001) review as are the publications of Tim Ward that are listed in the references.

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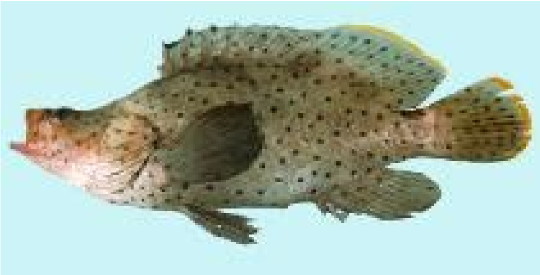
13. Groupers

Barramundi cod (*Cromileptes altivelis*) **Source:** CSIRO



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Williams, A, Begg, G, Pears, R, Garrett, R, Larson, H, Griffiths, S & Lloyd, J (2004) Groupers. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.*

Species group name and description

Groupers: Family Serranidae, subfamily Epinephelinae Groupers are also known as cods, rockcods, gropers, coral cods, coral trouts, hinds, and sea basses.

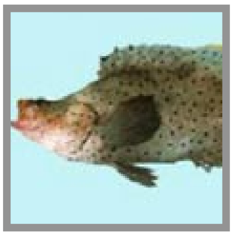
Groupers are a very diverse group comprising over 150 species, although the number of described species is still under revision. Heemstra and Randall (1993) described 159 species of grouper worldwide within 15 genera. More recently, these authors have revised the classification of groupers, particularly in relation to the number of genera within the Epinephelinae subfamily, and subsequently they described 115 species of grouper within 22 genera in the Western Central Pacific region, in which the Northern Planning Area (NPA) is located (Heemstra & Randall 1999).

Groupers range in size from around 20 cm (eg *Cephalopholis leopardus*) to more than 250 cm (eg *Epinephelus lanceolatus*). Most species of grouper appear to be protogynous (change sex from female to male) and are generally considered to be long-lived, slow-growing and late-maturing (Huntsman et al. 1999). These life history traits are characteristic of species with a low capacity to recover from over-exploitation. Despite their potential vulnerability to over-fishing, groupers are among the most important and highly valued demersal species throughout the tropical and subtropical regions of the world. They contribute significantly to the catch from commercial, recreational and subsistence fisheries in these regions.

Historically, there have been taxonomic difficulties in differentiating between many grouper species due to the diversity of species and varied colour patterns of individual species. Consequently, catch information for groupers is commonly undifferentiated and thus catch information for individual species is not usually available.

Status

Groupers are regarded by the World Conservation Union (IUCN) as a group of special conservation significance. Worldwide, there are several grouper species (*Epinephelus drummondhayi*, *E. itajara* and *E. nigritus*) that are considered to be critically endangered and at high risk of extinction (IUCN 2003). However, these species are not known to occur within the NPA.



Ten of the grouper species known to occur within the NPA (see section on Information gaps for preliminary list of grouper species in NPA) are listed on international or Commonwealth threatened species lists, or both (Table 13.1). However, no groupers are currently listed on either Queensland or Northern Territory (NT) threatened species lists. The giant grouper (*Epinephelus lanceolatus*) is the only species occurring in the NPA that is considered to be vulnerable by any organisation, but only at the international level. This status was given to the giant grouper by the IUCN in 1996 due to an expected reduction in their population worldwide of at least 20% as a result of potentially high levels of exploitation (IUCN 2003). The chocolate cod (*Cephalopholis boenak*) and barramundi cod (*Cromileptes altivelis*) are considered by the IUCN to be 'data deficient' mainly due to the limited catch data available and the increasing fishing pressure on these species in South-east Asia (IUCN 2003).

At the Commonwealth level the giant grouper, barramundi cod and potato cod (*Epinephelus tukula*) are listed by the Australian Society for Fish Biology (ASFB) and in a report by Pogonoski et al. (2002) to Environment Australia (currently the Department of Environment and Heritage) as lower risk. However, this status is considered to be dependent on continued implementation of conservation measures for these species, including minimum and maximum size limits and in-possession limits. Another six species of grouper are also listed as lower risk by the ASFB and Pogonoski et al. (2002), but were considered to be species of least concern. The report by Pogonoski et al. (2002) is the only known conservation overview of groupers in Australian waters. However, their review was limited to only nine of the grouper species known to occur in the NPA.

Table 13.1: *Species of grouper known to occur in the NPA that are listed on international (IUCN – The World Conservation Union), Commonwealth (EA – Environment Australia, ASFB – Australian Society for Fish Biology) or State (QLD – Queensland, NT – Northern Territory) threatened species lists.*

The status of each species was classified by all organisations using the IUCN criteria version 3.1: IUCN (2001) where VU = Vulnerable, DD = Data Deficient, LR (cd) = Lower Risk (conservation dependent), LR (lc) = Lower Risk (least concern).

Common name	Species name	IUCN	EA* and ASFB	NT	QLD
Chocolate cod	*Cephalopholis boenak*	DD	-	-	-
Barramundi cod	*Cromileptes altivelis*	DD	LR (cd)	-	-
Estuary cod	*Epinephelus coioides*	-	LR (lc)	-	-
Purple cod	*Epinephelus cyanopodus*	-	LR (lc)	-	-
Flowery cod	*Epinephelus fuscoguttatus*	-	LR (lc)	-	-
Giant grouper	*Epinephelus lanceolatus*	VU	LR (cd)	-	-
Malabar grouper	*Epinephelus malabaricus*	-	LR (lc)	-	-
Camouflage cod	*Epinephelus polyphekadion*	-	LR (lc)	-	-
Greasy cod	*Epinephelus tauvina*	-	LR (lc)	-	-
Potato cod	*Epinephelus tukula*	-	LR (cd)	-	-

* *Conservation Overview and Action Plan prepared for the Natural Heritage Division of Environment Australia (Pogonoski et al. 2002)*

A new fisheries management plan for Queensland's coral reef fin fish was released in September 2003 (QFS 2003). Under this new management plan the taking of giant grouper, barramundi cod and potato cod from Queensland waters (excluding Torres Strait) is prohibited. The management plan also introduced new minimum and maximum size restrictions and recreational in-possession limits for all other grouper species taken in Queensland waters (Table 13.2). In addition, seasonal closures to reef line fishing have been implemented in Queensland principally to protect spawning aggregations of coral trout species (*Plectropomus spp.*). For the commercial fishers catch quotas were introduced for i) all coral trout species combined, ii) red throat emperor (*Lethrinus miniatus*), and iii) all other species.

Currently, groupers do not receive the same protection in the NT as they do in Queensland. In the NT it is illegal to take any grouper of the *Epinephelus* genus over 120 cm in length and there is an overall recreational possession limit of 30 fish of any species, including groupers (DBIRD 2003c). Apart from these restrictions there are no other regulations for the taking of groupers in the NT.

13. Groupers

Table 13.2: *Summary of size limits (total length) and recreational possession limits for the capture of groupers in Queensland waters*
NA = Not applicable

Common name	Species name	Minimum size (cm)	Maximum size (cm)	Recreational Possession limit*
Coral trout	*Plectropomus leopardus*	38	NA	7 in total of all trout species
Bar cheek trout	*P. maculatus*	38	NA	
Passionfruit trout	*P. areolatus*	38	NA	
High fin trout	*P. oligacanthus*	38	NA	
Coronation trout	*Variola louti*	38	NA	
Lyretail trout	*V. albimarginata*	38	NA	
Blue spot trout	*P. laevis*	50	80	
Greasy cod	*Epinephelus tauvina*	38	100	5 in total of all cod species
Flowery cod	*E. fuscoguttatus*	50	100	
Camouflage cod	*E. polyphekadion*	50	100	
Maori cod	*E. undulatostriatus*	45	NA	
All other cods	*Subfamily Epinephelinae*	38	NA	

**A total recreational possession limit of 20 coral reef fish (all species combined) applies in Queensland waters.*

Assessments of the ecological sustainability of the NT demersal fishery and finfish trawl fishery are currently under review by the Commonwealth Department of Environment and Heritage (DEH) (DBIRD 2003a, b). Groupers are only a relatively minor component of the catch from these fisheries (demersal less than 4%, trawl less than 0.3%) and no assessment of any species of grouper was made in either report.

Assessments of the ecological sustainability of the Queensland Gulf of Carpentaria (GoC) line fishery and the Queensland GoC developmental finfish trawl fishery have been drafted by the Queensland Department of Primary Industries and Fisheries Northern Fisheries Centre. The contribution of groupers to these fisheries is currently unknown.

There are no other known comprehensive ecological assessments for any grouper species known to occur in the NPA and the current status of any species of grouper within the NPA is unknown.

Habitat and distribution

Groupers are found throughout all tropical and subtropical oceans of the world. Although many species of grouper have been reported to occur within the NPA the distribution of individual species remains unknown. The number of grouper species that occur in the NPA is also unclear. Therefore, this section describes the life history of grouper species in general and is not specific to the NPA.

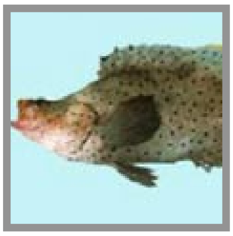
There is little information on habitat associations of grouper at different life stages, particularly for larvae and juveniles. As adults, groupers are demersal fishes and are generally associated with hard substrata such as coral or rocky reefs, although a few species can also be found on sandy or silty areas, seagrass beds or estuaries (Heemstra & Randall 1993). Some species occur at depths of up to 500 m although the majority inhabit depths of less than 100 m (Heemstra & Randall 1993). For the few species where information exists, juvenile groupers are often found in shallower water than adults such as tide-pools on coral or rocky reefs (Griffiths 2003a, b) or in estuaries (Sheaves 1992).

The full extent of suitable habitat for groupers within the NPA is still unclear. Only in May 2003 were large reefs up to 100 km^2 in area mapped in the GoC by Geoscience Australia (2003)[1], which suggests that the amount of suitable habitat for groupers in the NPA may be greater than previously thought.

Groupers are the dominant predatory fishes in coral reef habitats feeding mainly on fish, crustaceans and cephalopods (Heemstra & Randall 1999). The majority of groupers are ambush predators and hide among the coral and rocks in wait for prey. A few species have specialised gill rakers and are adapted for feeding on plankton.

Based on the few grouper species for which the reproductive biology has been studied, the dominant sexual strategy of groupers appears to be protogyny, whereby individuals mature first as females then change sex to male at some stage during their life (Shapiro 1987, Sadovy 1996). Although the mechanism that triggers sex change in groupers is not clear, the size

[1] *See Chapter 4: Corals for more information.*



at sex change appears to be quite variable within species. This suggests that sex change is most likely socially controlled rather than genetically predetermined (Vincent & Sadovy 1998). A consequence of protogyny is that most of the larger and presumably older fish in the population are male, which complicates management of groupers as many fishing techniques, including line fishing, selectively remove the larger fish. Therefore, fishing potentially could reduce the proportion of males in the population, resulting in sperm limitation (uncompensated response: Coleman et al. 1996, Vincent & Sadovy 1998) or reduce the size at which sex change occurs, decreasing the reproductive output (compensated response: Vincent & Sadovy 1998).

The spawning season of groupers varies widely among species and locations (Sadovy 1996). In tropical Australian waters, most grouper species appear to spawn during the spring or summer months. Individuals may spawn more than once during the spawning season and for some species spawning appears to be strongly correlated with the moon phase and stage of the tide (Sadovy 1996). A number of grouper species are also known to form aggregations during the spawning season (Sadovy 1996). The size of these aggregations can vary widely among species, from groups of less than 10 individuals to aggregations of tens of thousands of individuals. Typically, it is the larger-growing grouper species that tend to form the larger spawning aggregations (Sadovy 1996). Around the world some aggregation sites for a number of species have been located by fishers and have been the target of intense fishing pressure during the spawning seasons. Such targeted fishing has resulted in significant declines in populations of some grouper species. For example, intense fishing of Nassau grouper (*Epinephelus striatus*) spawning aggregations in parts of the western North Atlantic resulted in such large population declines that the species is now listed as endangered (Sala et al. 2001, IUCN 2003). Closer to the NPA, in the Indo-Pacific region, targeted fishing of grouper spawning aggregations has been implicated in the decline or disappearance of 'known' spawning aggregations of *Plectropomus areolatus*, *Epinephelus fuscoguttatus* and *E. polyphekadion* in Palau (Johannes et al. 1999).

Groupers are among the most fecund groups of reef fish. Selvaraj and Rajagopala (1973) reported the production of up to 260 million eggs by a single female greasy cod, *Epinephelus tauvina*, but this was most likely a misidentification of the estuary cod, *Epinephelus coioides* (Sadovy 1996). All grouper species produce pelagic eggs and have a relatively long pelagic larval stage which remains in the plankton for up to 60 days (average of about 28 days) (Heemstra & Randall 1993). Potentially, this allows larvae to disperse relatively large distances to other reefs or habitats. As adults, groupers are considered to be relatively sedentary and remain on an individual reef for most of their lives (Heemstra & Randall 1999). However, some species make occasional large migrations to reach annual spawning sites. For these species, this migration may involve movement to a spawning site on the resident or nearby reef that may be less than 1–10 km away. However, the Nassau grouper (*Epinephelus striatus*) in the Caribbean may travel more than 200 km to reach a spawning aggregation (Bolden 2000).

Recent research indicates that groupers are relatively long-lived (up to 50 years), slow growing and late maturing (Huntsman et al. 1999). These life history characteristics coupled with their protogynous sexual strategy, aggregating behaviour and ease of capture render the group vulnerable to over-exploitation.

In general, the stock structure of groupers has received very little attention, and nothing is currently known about the stock structure of any grouper species within the NPA. Furthermore, there have been no formal stock assessments for any species of grouper within the NPA.

Significance of the species group in the Northern Planning Area

Groupers have an important ecological role within the NPA as they are one of the dominant predatory species groups on coral reefs and other areas they inhabit. Groupers predominantly consume other fish, crustaceans and cephalopods and thus represent an important link in the food chain.

Groupers are an important component of the catch from various fisheries that operate partially or wholly within the NPA. In the Torres Strait region, coral trout (*Plectropomus leopardus*, *P. maculatus*, *P. areolatus*, and *P. laevis*) are the dominant species in the catch from non-Islander commercial, Islander commercial, Islander subsistence and recreational line fisheries. Although catch has varied annually in the Torres Strait, catches of coral trout from the non-Islander commercial fishery have exceeded 100 t in some years (Mapstone et al. 2003, PZJA 2003). Catches from the other fisheries in Torres Strait have not yet been quantified, but current research by the CRC Reef Research Centre

indicates that the coral trout catch from the Islander commercial fishery is significantly less than the non-Islander commercial fishery. Barramundi cod (*Cromileptes altivelis*) and a number of other grouper species (species not identified in logbooks) are also captured in these fisheries, but appear to contribute much less to the catch than coral trout (PZJA 2003).

The commercial fisheries in the NT that operate partially within the NPA and report catches of grouper include the demersal, finfish trawl, and coastal line fisheries. The contribution of particular species of grouper to these fisheries is unclear, as individual species are not identified in the catch from any of these fisheries, and are usually reported as cod (*Epinephelus spp.*), coral trout (*Plectropomus spp.*) or placed in a mixed fish category. Cod contribute approximately 4% to the annual catch from the commercial demersal fishery (Coleman 2003, DBIRD 2003a). Coral trout are considered to be byproduct in this fishery with only one species taken (bar cheek coral trout, *Plectropomus maculatus*) and contributing less than 0.1% to the annual catch (DBIRD 2003a). Cods are considered as byproduct in the NT finfish trawl fishery, contributing less than 0.3% to the overall annual catch (DBIRD 2003b). The contribution of groupers to the NT coastal line fishery is unknown (as groupers are placed in a mixed fish category), but is likely to be relatively small as black jewfish (*Protonibea diacanthus*) and golden snapper (*Lutjanus johnii*) are the main target species, contributing approximately 80% to the annual catch from the fishery (Coleman 2003).

In Queensland, the largest catches of coral trout and other groupers are from the coral reef finfish fishery that operates predominantly on the east coast and in Torres Strait. Only incidental catches of groupers have been reported by commercial line fisheries operating in Queensland waters west of the Torres Strait region and in the GoC (Mapstone et al. 1996, Williams 2002).

Coral trout and other groupers are also important target species for recreational, charter and Indigenous fishers in Queensland and the NT (Higgs 2001, Coleman 2003, Henry & Lyle 2003), but estimates of the catch of groupers from these groups are not available for any region within the NPA. On a state-wide level, groupers have been estimated to contribute approximately 5% and 3% to the total recreational finfish catch in the NT (Henry and Lyle 2003) and Queensland (Higgs 2001, Henry and Lyle 2003) respectively. The estimated catch of groupers from the NT commercial charter operators has increased during the past seven years and was 7% of the total finfish catch in 2002 (Coleman 2003). There are no estimates available for the catch of groupers from the Queensland commercial charter operators. Groupers were estimated to contribute approximately 1% and 5% to the indigenous finfish catch in the NT and Queensland respectively (Henry & Lyle 2003).

Impacts/threats

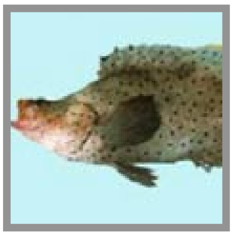
The main potential impacts or threats to groupers within the NPA relate to habitat degradation and overfishing.

Groupers are generally more abundant on coral reefs than in any other habitat type. Consequently, maintenance of coral reef habitats within the NPA is important for the sustainability of grouper populations in this area. Threats to coral reefs in the NPA include coral bleaching, nutrification, sedimentation, cyclones, maritime accidents, pollution incidents, disease and crown-of-thorns starfish outbreaks.

Groupers are particularly vulnerable to over-fishing due to their life history characteristics and behaviour. Currently, the fishing effort for groupers in the NPA may not be high, except perhaps in parts of Torres Strait where coral trout are harvested in relatively high numbers (Mapstone et al. 2003). However, information on fishing effort and catch throughout the NPA is limited at best, and virtually nothing is known about populations of grouper in the NPA. Therefore, it is not possible to estimate sustainable levels of exploitation for groupers in the NPA, and consequently at present we are unable to assess the current status of any species of grouper within the NPA.

The targeting of grouper spawning aggregations by fishers has been reported to lead to significant reductions in population size for a few species of grouper in other parts of the world (eg Sala et al. 2001). The degree to which spawning aggregations of grouper are targeted by fishers within the NPA is unclear, but such targeted fishing may be a potential threat to some grouper populations.

Although a moratorium on the sale of live fish is current in the Torres Strait region, increased fishing pressure through the extension of the live fish trade into other parts of the NPA may be another potential threat to populations of grouper. Currently, it appears that no reef fish are exported live from within the NPA. However, groupers are the preferred species in the live reef fish trade in South-east Asia and demand the highest price of all species. Consequently, there is a high demand for groupers worldwide, and a potential for fishing for live reef fish to commence in the NPA



through the displacement of effort from the Queensland east coast reef line fishery into parts of the NPA.

The location of the NPA in relation to large Australian capital cities makes surveillance of fishing activities and enforcement of fishing regulations in the NPA very difficult. The remoteness of the NPA coupled with the high value of groupers may encourage illegal fishing activities in the NPA by Australian or, given the close proximity of the NPA to other countries, international fishing operations.

The Northern Prawn Fishery (NPF) that operates in the NPA captures a wide diversity of bycatch species. Stobutzki et al. (2001) reported nine species of grouper as bycatch from this fishery; *Cephalopholis boenack*, *Epinephelus heniochus*, *E. malabaricus*, *E. sexfasciatus*, *E. coioides*, *E. quoyanus*, *E. areolatus*, *Plectropomus leopardus* and *P. maculatus*. A large proportion of the groupers captured by prawn trawling are likely to be immature as trawling often occurs in areas where juvenile fish are abundant, and trawl nets retain large quantities of smaller fish. Wassenberg and Hill (1989) and Hill and Wassenberg (1990) found that the majority of finfish bycatch from prawn trawling do not survive. Furthermore, Stobutzki et al. (2001) suggested that groupers were among the groups less likely to be sustainable under current levels of trawl fishing. Therefore, trawling may be a potential threat to the sustainability of groupers in the NPA. However, the amount of finfish bycatch in the NPF is likely to be lessened by the recent introduction of bycatch reduction devices that reduce the initial take of fish species, and hoppers that assist in the separation of prawns from bycatch and return the unwanted species to the sea alive. Other bycatch species captured in the NPF may be important food resources for grouper and thus there is also the potential for trawling in the NPA to reduce available food resources for grouper.

Currently, there are no minimum size limits for the possession of any species of grouper in the NT. Given that many species of grouper mature at a relatively large size, there is the potential for fishing to remove a significant proportion of immature fish from grouper populations in the NT.

Information gaps

Very little is known about populations of grouper within the NPA. As such, there are large information gaps that need to be addressed for grouper species in the NPA, including:

- number and diversity
- distribution
- basic biology and ecology
- environmental and habitat associations
- recruitment patterns
- early life history
- productivity of populations
- status of any population
- stock structure
- catch levels by species and by fishing sector
- sustainability of harvest by fisheries

A preliminary list of grouper species that occur in the NPA was recently compiled by Dr Helen Larson of the Museum and Art Gallery of the NT (Table 13.3). This list was based on Australian Museum collections and draft manuscripts from the Australian Biological Resources Study at the DEH. It is likely that other grouper species not included on this list also occur within the NPA. For example, a number of fisheries that report catches of grouper species operate only partially within the NPA and do not report spatially referenced catch data. (Exceptions are the commercial fisheries in the NT which are required to report exact fishing locations). Therefore, it is not possible to determine conclusively whether these species were caught in the NPA or in adjacent areas. Such species were not included in the preliminary list of grouper species in the NPA. It is recommended that this list be used as a starting point to which additions can be made as further information becomes available. Fisheries-dependent or independent surveys may be needed to provide a more complete catalogue of grouper species that occur in the NPA.

Table 13.3: *A preliminary list of grouper species (Subfamily Epinephelinae) reported to occur within the Northern Planning Area Based on collections from the Australian Museum*

Common name	Species name
Peacock cod	Cephalopholis argus
Chocolate cod	Cephalopholis boenak
Blue-spotted cod	Cephalopholis cyanostigma
Coral cod	Cephalopholis miniata
Barramundi cod	Cromileptes altivelis
Two-banded soapfish	Diploprion bifasciatum
Banded grouper	Epinephelus amblycephalus
Areolate cod	Epinephelus areolatus
Twinspot grouper	Epinephelus bilobatus
Estuary cod	Epinephelus coioides
Coral grouper	Epinephelus corallicola
Black-tipped cod	Epinephelus fasciatus
Flowery cod	Epinephelus fuscoguttatus
Bridled grouper	Epinephelus heniochus
Giant grouper	Epinephelus lanceolatus
Striped grouper	Epinephelus latifasciatus
Malabar grouper	Epinephelus malabaricus
Speckled-fin cod	Epinephelus ongus
Long-fin cod	Epinephelus quoyanus
Six-bar cod	Epinephelus sexfasciatus
Black-dotted grouper	Epinephelus stictus
Bar cheek coral trout	Plectropomus maculatus

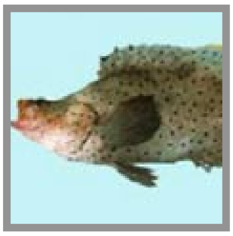
Currently, NT and Queensland fisheries legislation does not require commercial fishers to distinguish between grouper species when reporting their catch in compulsory logbooks. Observer surveys on commercial fishing vessels may be an efficient way to gain essential information on the species diversity of groupers in the NPA, collect catch and effort data for the various grouper species, and obtain important biological information for those species such as size, age, growth, reproduction and genetic information. A CRC Reef Research Centre (CRC Reef) project recently funded by the CRC Torres Strait Program (see current research projects below) will utilise such an observer program to evaluate the non-Islander commercial reef line fishery in the eastern Torres Strait. This project will provide valuable information on the catch and species composition of the fishery, and on the biology of several grouper species in the eastern Torres Strait. Catch and effort data from the Torres Strait Islander commercial and Islander subsistence fisheries will be collected during two current CRC Reef projects (see current research projects below). The NT Fisheries Group coordinates an observer program for the NT finfish trawl fishery. Additional surveys for the collection of biological and ecological information for groupers in the NPA are recommended.

Surveys of recreational and Indigenous fishers may provide a general estimate of the importance of groupers to these sectors, but information on specific species of grouper may be difficult to obtain due to difficulties in distinguishing among species. The Queensland Fisheries Service conducts biannual surveys of recreational fishers in Queensland (Higgs 2001), while the Department of Primary Industries and Fisheries (currently the DBIRD) conducted a single recreational survey in 1995 in the NT (Coleman 1998). A national survey of recreational and indigenous fishers, excluding the Torres Strait region, was also completed in 2001 (Henry & Lyle 2003). However, none of these surveys provide sufficiently detailed information on the catch of particular grouper species in the NPA.

Key references and current research

The current research projects that are relevant to groupers in the NPA are:

- Collation and review of Islander commercial catch history in the eastern Torres Strait reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville. Australian Fisheries Management Authority Project No. R02/1183.
- Evaluation of the eastern Torres Strait reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville.
- Modelling the impact of multiple harvest strategies in the Eastern Torres Strait (ETS) reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville.
- National strategy for increasing the survival of released line-caught fish: Investigating survival of fish released in Australia's tropical and subtropical line fisheries. Joint project between Queensland DPI and CRC Reef, funded by FRDC.



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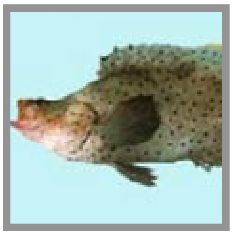

14. Snappers and Emperors

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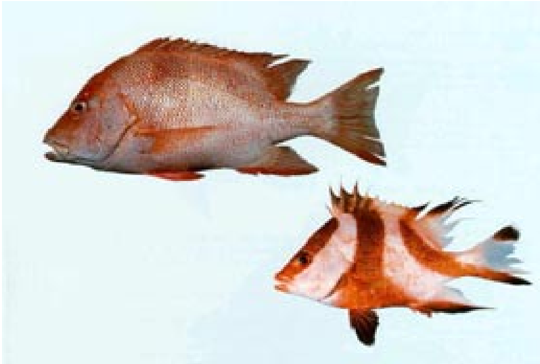
Spangled emperor (Lethrinus nebulosus) (left) and red emperor (Lutjanus sebae) (right) ***Source:*** CSIRO



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Species group name and description

Snappers: Family Lutjanidae

Snappers are also known as tropical snappers, seaperches, seabasses, hussars and jobfishes.

Emperors: Family Lethrinidae

Emperors are also known as sweetlips, tricky snappers, large-eye breams, pig-face breams and scavengers.

Snappers are a very diverse group comprising over 100 species worldwide within 17 genera (Allen 1985). Snappers are found in all tropical and subtropical seas and are an important component of many commercial, recreational and subsistence fisheries throughout the world. Approximately 65 species are currently known to occur in the Western Central Pacific region (Anderson & Allen 2001), but the exact number that occur in the Northern Panning Area (NPA) is unknown.

Snappers range in size from approximately 20 cm to over 150 cm (Anderson & Allen 2001). Most species of snapper are considered to be long-lived (up to at least 50 years of age for some species), slow-growing, and have relatively low rates of natural mortality (Anderson & Allen 2001). These life history traits are characteristic of species with a low capacity to recover from over-fishing. Although snappers are regarded as high quality food fishes and provide good sport on hook-and-line, some species are known to cause ciguatera poisoning in certain areas.

Emperors are not as speciose (rich in number of species) as snappers. There are approximately 39 species of emperor worldwide within 5 genera (Carpenter & Allen 1989, Carpenter 2001). Except for a single species found off West Africa, emperors are restricted to

the tropical and subtropical waters of the Indo-Pacific, where they are an important component of commercial, recreational and subsistence fisheries.

The maximum size of emperors ranges from about 20 cm up to 100 cm. Emperors are considered to be relatively long-lived (up to at least 30 years) and most species appear to be protogynous (ie change sex from female to male) (Carpenter & Allen 1989). It is often difficult to identify species of emperor due to similarities among species and varied colour patterns of individual species. Such difficulties have led taxonomists to consider emperors as one of the most problematic families of tropical marine fish to classify.

Status

Two species of snapper (*Lutjanus analis* and *L. cyanopterus*) are listed as vulnerable on the IUCN Red List of Threatened Species (IUCN 2003). Neither of these species occurs in the NPA. No other species of snapper or any of the emperors are listed on the IUCN Red List. There are also no snappers or emperors listed on any Commonwealth or state level threatened species lists.

Fishing regulations apply to snappers and emperors in both Queensland and Northern Territory (NT) waters. In Queensland, a new fisheries management plan for coral reef finfish was released in September 2003 (QFS 2003). Under this new management plan the taking of red bass (*Lutjanus bohar*), chinamanfish (*Symphorus nematophorus*) and paddletail (*Lutjanus gibbus*) is prohibited in Queensland waters (except Torres Strait). These prohibitions are primarily in response to concerns about ciguatera poisoning arising from consumption of these species. Size limits and recreational possession limits apply to other snappers and emperors in Queensland (Table 14.1). Presently, there is no indication that the new Queensland fisheries regulations will be followed in the Torres Strait. A recreational possession limit of 30 fish in total, including a maximum of five golden snapper (*Lutjanus johnii*), applies in the NT (DBIRD 2003c).

Table 14.1: *Summary of size limits (total length) and recreational possession limits for the capture of snappers and emperors in Queensland waters (currently excluding Torres Strait waters)*

Common name	Species name	Min. size (cm)	Recreational Possession limit*
Snappers:			
Crimson jobfish	*Pristipomoides filamentosus*	38	8
Lavender jobfish	*Pristipomoides sieboldii*	38	8
All other jobfish	*Aphareus furca, Aprion virescens, Etelis carbunculus, E. coruscans, Pristipomoides multidens, P. typus*	38	5
Nannygai	*Lutjanus erythropterus, L. malabaricus*	40	9 in total of both nannygai species
Red emperor	*Lutjanus sebae*	55	5
Hussar	*Lutjanus adetii*	25	10
All other snappers	*Lutjanus spp.*	25	5
Emperors:			
Red throat emperor	*Lethrinus miniatus*	38	8
Spangled emperor	*Lethrinus nebulosus*	45	5
Long-nose emperor	*Lethrinus olivaceus*	38	5
All other emperors	*Lethrinus spp.*	25	5

**A total recreational possession limit of 20 coral reef fish (all species combined) applies in Queensland waters.*

14. Snappers and Emperors

Assessments of the ecological sustainability of the NT demersal fishery and finfish trawl fishery are currently under review by the Commonwealth Department of Environment and Heritage (DEH) (DBIRD 2003a, b). Although the catch from these fisheries is very diverse, snappers are the major target and comprise the majority of the catch. Several species of snappers and emperors are also caught as by-product (non-target species that are retained and sold). Part of the area fished by these fisheries is located within the NPA although, historically, relatively little fishing effort from the demersal fishery has occurred in the NPA, and there is only a single licence currently operating in the NT finfish trawl fishery (DBIRD 2003a, b). The NT Department of Business Industry and Resource Development (DBIRD) considered both of these fisheries to be ecologically sustainable due to the current low levels of effort, passive methods of fishing (demersal fishery) or low-impact fishing gear (semi-pelagic demersal trawl fishery), large area fished, yields below predicted sustainable yields and minimal bycatch (DBIRD 2003a, b).

Habitat and distribution

Although there are some similarities in the habitat and distribution of snappers and emperors, this section discusses the two groups separately in an attempt to highlight important differences between them, particularly with respect to known life history.

Snappers

Snappers are widely distributed throughout the tropical and subtropical regions of the Atlantic, Indian and Pacific Oceans. Many snapper species have been reported from the NPA (see Table 14.4), but the distribution of individual species within the NPA is unknown. Therefore, the following is a description of the life history of snappers in general and is not specific to the NPA.

The majority of snapper species are marine-based, although a few Indo-Pacific species inhabit freshwater (Anderson & Allen 2001). Most snapper species are demersal and are often associated with bottom formations or structures such as coral or rocky reefs, rocky outcrops, shipwrecks or shoals. Deep-water snappers (eg Etelinae and some Apsilinae species) are usually found between 100 and 500 m, but most species inhabit coastal and continental shelf waters less than 100 m deep (Allen 1985, Anderson & Allen 2001). Although often highly valued as food fish, some snapper species, such as red bass, chinamanfish and paddletail, in certain locations are known to cause ciguatera poisoning.

The juveniles of some snapper species are found in inshore coastal habitats, estuaries and even the lower reaches of freshwater systems (Anderson & Allen 2001). As developing adults, these species often migrate further offshore, onto island fringing reefs, shoals and coral reefs where they mature and spawn. Pelagic larvae are then transported by currents back to the juvenile nursery areas where they settle. Species of snapper known to occur in the NPA that undergo this type of ontogenetic migration include the red snappers (*Lutjanus malabaricus*, *L. erythropterus*, *L. sebae*), golden snapper (*L. johnii*), mangrove jack (*L. argentimaculatus*) and Moses snapper (*L. russelli*) (Blaber et al. 1989, Sheaves 1995, Anderson & Allen 2001, Russell et al. 2003). Most of these species also form a significant part of the catch from various fisheries in the NT and Queensland.

Most snapper species are active nocturnal predators of fishes, crustaceans (especially crabs, shrimps, stomatopods and lobsters) and molluscs (gastropods and cephalopods) (Anderson & Allen 2001). A number of species in the *Pristopomoides*, *Paracaesio*, *Ocyurus*, *Pinjalo* and *Rhomboplites* genera are planktivores and have specialised gill rakers that allow them to feed on plankton, particularly pelagic urochordates such as salps (Allen 1985).

Snappers are gonochoristic, having separate sexes throughout life (Anderson & Allen 2001). There is little or no sexual dimorphism in the structure and colour pattern of snappers (Allen 1985). However, a distinct colour or pattern change is evident between juveniles and adults of some snapper species. Snappers usually reach maturity at approximately 40–50% of their maximum length (Sadovy 1996, Anderson & Allen 2001). For some snapper species males have been found to mature at slightly smaller sizes than females (Grimes 1987). However this is not a consistent trend across all species in the snapper family.

Although the spawning season for snappers varies among species, two general types of seasonal reproductive activity have been observed (Grimes 1987, Sadovy 1996, Anderson & Allen 2001). Populations of snapper inhabiting continental waters commonly have a protracted spawning season throughout the summer months. More insular populations (ie those that inhabit island waters) often spawn continuously throughout the year with peaks in reproductive activity in spring and autumn. Histological examination of ovaries indicate that snappers are batch spawners (individual females spawn multiple batches of eggs during the reproductive

season) with spawning activity often following a lunar or semilunar cycle, and peaking during the full or new moon, or both (Grimes 1987). Snappers are also highly fecund, with females of some species capable of producing over 9 million eggs in a season (Grimes 1987).

Although the timing of peak spawning activity has been determined through histology, there have been relatively few direct observations of snapper spawning activity (Allen 1985, Sadovy 1996). Available information suggests that snappers are pelagic spawners and may form aggregations of fewer than 10 to more than 1000 individuals during spawning (Domeier & Colin 1997). While some spawning aggregations may occur locally, some larger snappers are thought to travel large distances to reach aggregation sites (Sadovy 1996).

The larval stage of snappers is pelagic and larval duration varies widely between 25 and 47 days (Allen 1985). Potentially, this allows larvae to disperse relatively large distances to other habitats, including inshore areas that are used as nurseries by some species. Recent ageing work indicates that snappers are generally long-lived and slow-growing with low rates of natural mortality (Anderson & Allen 2001). For example, a number of snapper species reported to occur in the NPA have been estimated to reach in excess of 30 years of age in other Australian tropical locations, including *Lutjanus malabaricus* (Newman 2002), *L. erythropterus* (Newman et al. 2000a), *L. sebae* (Newman and Dunk 2002), *L. quinquelineatus* (Newman et al. 1996), *L. argentimaculatus* (Russell et al. 2003), and *Pristipomoides multidens* (Newman & Dunk 2003). Snappers are likely to be vulnerable to over-exploitation due to these life history characteristics (Musick 1999), their ease of capture and their potential aggregating behaviour.

There is only limited information available on the stock structure of snappers in the NPA. The stock structure of goldband snapper (*Pristipomoides multidens*), scarlet snapper (*Lutjanus erythropterus*) and saddletail snapper (*Lutjanus malabaricus*) in Australian and Indonesian waters of the Arafura Sea has been the focus of recent research. Results from mitochondrial DNA (Ovenden et al. 2002) and otolith microchemistry (Newman et al. 2000b, c) research indicate that goldband snapper in Australian waters are a separate stock from those in Indonesian waters. Results from mitochondrial DNA work suggest a single mixed stock of scarlet snapper in Australian and Indonesian waters (DBIRD 2003a, b). Data for saddletail snapper are inconclusive, as some stock identification methods indicate a single stock while others suggest the possibility of separate stocks between Australia and Indonesia (DBIRD 2003a, b).

Emperors

Emperors are restricted to waters of the Indo-Pacific except for one species, *Lethrinus atlanticus*, which only occurs in the Atlantic, off West Africa. Only a few emperor species have been reported from the NPA (see Table 14.5), and the distribution of these species and occurrence of others within the NPA are unknown. Therefore, the following is a description of the life history of emperors in general and is not specific to the NPA.

All emperor species are marine and are predominantly found associated with coral or rocky reefs or on nearby sand, rubble or seagrass habitats to depths of at least 100 m (Carpenter 2001). Juveniles of many emperor species commonly use shallow water seagrass beds, and occasionally estuaries, as nursery areas (Wilson 1998).

Emperors are demersal carnivorous feeders and their diet, which varies among species, can largely be determined by dentition and head morphology. In general, emperors consume a wide range of prey including polychaetes, molluscs (gastropods, bivalves, squid, octopus), echinoderms (sea urchins, sand dollars, starfish, brittlestars), crustaceans (crabs, shrimps) and fish (Carpenter & Allen 1989). Emperors predominantly feed at night, and diurnal feeding migrations have been reported for some species. In general, however, the movement patterns of emperors are not well known.

From available evidence the dominant sexual strategy for emperors appears to be protogyny (Young & Martin 1982, Carpenter & Allen 1989) whereby individuals mature first as females before changing sex later in life. One exception to this pattern is the spangled emperor, *Lethrinus nebulosus*, which was reported to exhibit juvenile hermaphroditism, whereby sex change occurred prior to reaching sexual maturity (Ebisawa 1990). For most emperor species, the size and age at which females mature is unknown, but information available for some species (*Lethrinus atkinsoni*, *L. miniatus*, *L. nebulosus* and *L. rubrioperculatus*) from areas outside the NPA indicates that female maturation occurs at approximately 50% of the maximum size (Loubens 1980, Ebisawa 1990, 1997, 1999, Williams 2003). Although the mechanism that triggers sex change in emperors is not known, the size at sex change often varies widely within species (Carpenter & Allen 1989). This suggests that sex change is most likely socially controlled rather than genetically predetermined (Vincent & Sadovy 1998). A consequence of protogyny is that most of the larger and presumably older fish in the population are male, which complicates management of emperors as many

fishing techniques, including line fishing, selectively remove the larger fish. Therefore, fishing potentially could reduce the proportion of males in the population, resulting in sperm limitation (uncompensated response: Coleman et al. 1996, Vincent & Sadovy 1998) or reduce the size at which sex change occurs, decreasing the reproductive output (compensated response: Vincent & Sadovy 1998).

The spawning behaviour of emperors is not well known, and available information is mostly derived from fishers' observations. Emperors are presumed to spawn at dusk or after dark, most commonly during the new moon period (Carpenter & Allen 1989). Large catches of emperor during these times has led to the belief that emperors form large aggregations during spawning. Although the seasonality of spawning appears to vary widely among emperor species and among locations for individual species, peak spawning activity usually occurs over a two-to-six-month period between late winter and early summer (Loubens 1980, Carpenter & Allen 1989, Sadovy 1996). All emperors are assumed to be pelagic spawners that produce pelagic eggs (Carpenter & Allen 1989).

Virtually nothing is known about the larval stage of emperors. A single larval spangled emperor, *Lethrinus nebulosus*, was estimated to be 37 days old and 19.1 mm in length at settlement (Brothers et al. 1983). No other estimates of larval duration or larval growth for emperors are available for any location.

Emperors are relatively long-lived and slow-growing fishes. Individuals from a number of species known to occur in the NPA have been estimated to be more than 20 years old, including *Lethrinus atkinsoni* (Loubens 1980, CRC Reef Research Centre unpublished data) and *L. nebulosus* (Loubens 1980). Estimates of natural mortality range between 0.3 and 1.9 (Carpenter & Allen 1989, Williams and Russ 1994), which equates to 74% and 15% survival per year respectively. Some emperor species are likely to be vulnerable to over-exploitation due to their life history characteristics, potential aggregating behaviour and protogynous sexual pattern.

There is no information available on the stock structure of emperors in the NPA.

Significance of the species group in the Northern Planning Area

The ecological roles for snappers and emperors in the NPA are not well understood. However, snappers and emperors are likely to be ecologically important to the NPA as they are two of the most abundant predatory species groups in the habitats they occupy. Snappers and emperors consume a wide diversity of crustaceans, molluscs, echinoderms and other fish and thus are likely to represent important links in the food web.

Snappers and emperors are an important component of the catch from various fisheries that operate partially or wholly within the NPA. Various snapper and emperor species form a minor part of the mixed reef fish catch in the Torres Strait non-Islander commercial, Islander commercial, Islander subsistence and recreational line fisheries in the Torres Strait region (Harris et al. 1995, Mapstone et al. 2003, PZJA 2003). The catch composition of snappers and emperors from these fisheries is generally not well known. Spanish flag (*Lutjanus carponotatus*) and grass emperor (*Lethrinus laticaudis*) were the only snapper and emperor species reported from the Islander subsistence fishery in the early 1990s (Harris et al. 1995), contributing 2.0% and 5.8% to the total finfish catch respectively. Recent research from the CRC Reef Research Centre suggests that snappers and emperors form a relatively minor component of the Torres Strait Islander commercial catch (CRC Reef Research Centre unpublished data). Snappers (mainly *Lutjanus sebae*) and emperors comprised 4.4% and less than 0.1% of the total finfish catch (51 t) from the non-Islander commercial fishery in 2001-02 (PZJA 2003). Forthcoming research by the CRC Reef Research Centre will elucidate further the catch composition of the Islander and non-Islander commercial fishery in the Torres Strait region.

Commercial fisheries in the NT that operate partially within the NPA and report catches of snappers and emperors include the demersal, finfish trawl, and coastal line fisheries. The proportion of the catch from these fisheries that is harvested from within the NPA is unknown, but is likely to be relatively low, particularly for the demersal fishery which at present mainly operates close to the boundary of the Timor Reef fishery (Coleman 2003). In 2002, there were 60 commercial licences for the demersal fishery (only 10 active), one active licence in the finfish trawl fishery, and 58 licences (only 25 active) in the coastal line fishery (Coleman 2003). Catches from the demersal

and finfish trawl fisheries have increased substantially over the past six or seven years. The increased catch in the demersal fishery was attributed to a change in fishing gear from droplines to traps which were more efficient in catching fish that are more dispersed (Coleman 2003). The increased catch in the finfish trawl fishery was mostly due to an increase in effort from the single fishing operation (Coleman 2003). The total catch in 2002 was 120 t in the demersal fishery and 850 t in the finfish trawl fishery (Coleman 2003, DBIRDa, b), and snappers and emperors together contributed over 93% to the total catch from these fisheries (Tables 14.2 & 14.3). Snappers are the major target and contribute over 88% to the total catch. Although the target species vary between fisheries, goldband snapper and red snappers are generally the most abundant in catches. Several other species of snapper are also captured in these fisheries but are usually considered as byproduct. Emperors generally contribute less than 6% to the annual catch from these fisheries and are also usually considered as byproduct (Tables 14.2 & 14.3).

Table 14.2: *Composition of snappers and emperors in the catch from the Northern Territory demersal fishery in 2002 (adapted from DBIRD 2003a)*

Common name	Species name	Importance	% of total catch
Snappers:			
Goldband snapper	*Pristipomoides multidens & P. typus*	target	62.3
Saddletail snapper	*Lutjanus malabaricus*	target	18.5
Red emperor	*Lutjanus sebae*	target	7.1
Golden snapper	*Lutjanus johnii*	byproduct	0.1
Scarlet snapper	*Lutjanus erythropterus*	byproduct	0.1
Rosy snapper	*Pristipomoides filamentosus*	byproduct	<0.1
Spanish flag	*Lutjanus carponotatus*	byproduct	<0.1
Mangrove jack	*Lutjanus argentimaculatus*	byproduct	<0.1
Sub-total			**88.1**
Emperors:			
Emperor general	*Family Lethrinidae*	byproduct	3.3
Mixed reef fish	*Lethrinus olivaceus, L. miniatus, L. laticaudis, L. nebulosus*	byproduct	2.7
Sub-total			**6**
Total			**94.1**

Table 14.3: *Composition of snappers and emperors in the catch from the Northern Territory finfish trawl fishery in 2002 (adapted from DBIRD 2003b)*

Common name	Species name	Importance	% of total catch
Snappers:			
Saddletail snapper	*Lutjanus malabaricus*	target	65.3
Scarlet snapper	*Lutjanus erythropterus*	target	17.2
Goldband snapper	*Pristipomoides multidens*	byproduct	4.4
Mangrove jack	*Lutjanus argentimaculatus*	byproduct	0.7
Red emperor	*Lutjanus sebae*	byproduct	0.7
Golden snapper	*Lutjanus johnii*	byproduct	0.6
Moses snapper	*Lutjanus russelli*	byproduct	0.6
Maroon snapper	*Lutjanus lemniscatus*	byproduct	<0.1
Sub-total			**89.5**
Emperors:			
Red spot emperor	*Lethrinus lentjan*	byproduct	4.0
Total			**93.5**

14. Snappers and Emperors

Snappers and emperors are an important component of the NT commercial coastal line fishery. The total catch from this fishery has increased significantly over the last five years, reaching a peak of 189 t in 2002 (Coleman 2003). Golden snapper are a main target in this fishery and have historically contributed about 16% to the annual catch, but more recently this has declined to approximately 8% (Coleman 2003). This apparent reduction in catch of golden snapper is mainly due to increases in the catch of other species, particularly the black jewfish, *Protonibea diacanthus*. Other snappers caught in the commercial coastal line fishery are reported as a single group that usually contributes about 3% to the annual catch (Coleman 2003). The grass emperor is the most important emperor in the fishery and usually contributes about 2% to the annual catch (Coleman 2003). Other emperor species are not identified in the catch and form a minor component of the mixed reef fish catch.

In Queensland, relatively large catches of snappers and emperors are reported from the coral reef line fishery that operates predominantly on the east coast (Mapstone et al. 1996, Williams 2002). In the Gulf of Carpentaria (GoC), a developmental finfish trawl fishery, principally targeting red snappers, has been in operation since 1998 and has a total quota of 1500 t (M Doohan pers. comm.). Currently, there are only two active vessels operating in this fishery that have a combined total quota for red snappers of 1000 t, while the other 500 t of quota is currently not being utilised (M Doohan pers. comm.). Catch and effort information for this fishery is reported through compulsory Queensland Fisheries Service (QFS) logbooks; however these data are confidential and not publicly available, as there are less than five active operations in the fishery. The QFS have recently implemented an observer program for the fishery with the aim of collecting verified catch and effort data.

Due to difficulties in species identification, catch composition information for snappers and emperors is usually only available at the family level for recreational and Indigenous fisheries in the NT and Queensland. Furthermore, most quantitative estimates of recreational and Indigenous catch from the two states are only available at the state level and catch estimates for specific areas, such as the NPA, are rare. Nevertheless, results from the National Recreational and Indigenous Fishing Survey (Henry & Lyle 2003) indicated that snappers were the most abundant species group in the Northern Territory recreational catch and were estimated to contribute approximately 19% to the total recreational harvest of all aquatic organisms in the NT. In the NT, golden snapper and Spanish flag accounted for the largest proportion of the estimated recreational catch of snappers (Coleman 2003). In Queensland, snappers are also one of the most abundant species groups in the recreational catch and have been estimated to contribute approximately 4–5% to the total annual catch (Higgs 2001, Henry & Lyle 2003), but species-specific catch information is not available.

Generally, fewer emperors than snappers are caught by recreational fishers in the NT and Queensland. Emperors have been estimated to contribute approximately 2% and 3–4% to the total annual recreational catch from the NT and Queensland respectively (Higgs 2001, Henry & Lyle 2003).

There have been a few small surveys of recreational fishing in specific locations in the GoC in recent years. A small pilot study of recreational fishing in the Karumba area was completed in 2002 (Hart 2002). In this survey no snapper or emperor species were reported in the recreational catch. This is most likely due to the limited time over which the survey was done (two weeks), as anecdotal information from recreational fishers suggests catches of golden snapper are relatively common in the Karumba area at certain times of the year. The Kowanyama Land & Natural Resource Management Office have been surveying recreational and Indigenous fishing in their country for several years, but the data collected have not been analysed and are currently not available. Helmke (1999) surveyed recreational fishing competitions in Normanton and Burketown, but no snapper or emperor species were recorded, most likely because barramundi was the main species targeted.

Snappers and emperors are important components of Indigenous fisheries in the NT and Queensland. Snappers were estimated to contribute approximately 8% and 11% to the NT and Queensland Indigenous finfish catch respectively (Henry & Lyle 2003). Emperors appear to be less important than snappers and were estimated to contribute less than 1% and approximately 3% to the NT and Queensland Indigenous finfish catch respectively (Henry & Lyle 2003).

Commercial charter fishing is popular in the NT and Queensland, but the number of commercial charter vessels operating in the NPA is unknown. Nevertheless, snappers and emperors comprise a significant component in the catch from commercial charter operations in the NT. Golden snapper and grass emperor (*Lethrinus laticaudis*) are the most numerous species in the harvested catch, and catches of these species have

increased significantly over the past eight years (Coleman 2003). Other important snapper species harvested include Spanish flag, saddletail snapper and mangrove jack. The catch of snappers and emperors from Queensland commercial charter operators is unknown, but catch and effort data are collected regularly by the QFS through compulsory logbooks.

Impacts/threats

The main potential impacts or threats to snappers and emperors within the NPA relate to habitat degradation and over-fishing.

The habitat of snappers and emperors varies substantially among and within species and may include freshwater habitats, estuaries, coral or rocky reefs, rocky outcrops, shoals, shipwrecks, sand, mud or rubble areas, and seagrass beds. Although the ecological role and habitat associations of snappers and emperors in the NPA are poorly understood, it is likely that the maintenance of such habitats within the NPA will be important for the sustainability of snapper and emperor populations. Potential threats to these habitats include pollution from fuel and oil spills, nutrification, physical damage from benthic trawling, maritime accidents or cyclones, and damage to coral reefs through coral bleaching, disease, sedimentation, and crown-of-thorns starfish outbreaks.

Snappers and emperors are likely to be vulnerable to over-fishing due to their life history characteristics and behaviour. While current harvest rates of some snappers such as scarlet snapper, saddletail snapper and gold band snapper are considered to be below sustainable levels for the NT demersal and finfish trawl fisheries (Ramm 1997, DBIRD 2003a, b), over-fishing of snappers and emperors remains a potential threat in the NPA.

The risk of over-fishing is greatly increased for snapper and emperor species in the NPA that have a single mixed stock dispersed throughout Australian and Indonesian waters, as stocks of these species will be exposed to fishing pressure from both Australian and Indonesian fisheries. Recent research suggests that the stock structure of some snappers in Australian and Indonesian waters of the Arafura Sea varies significantly among species and, for some species, there is evidence to support the existence of a single stock shared between Australia and Indonesia (eg scarlet snapper and saddletail snapper). Although the stock structure of other snappers and emperors is currently unknown, it is possible that similarly shared stocks exist for other species within Australian and Indonesian waters, as the waters of the Arafura Sea are relatively shallow, the distance between Australia and Indonesia is relatively small, and there are no major physical boundaries to the dispersal of fish, either as adults or as pelagic larval forms, between Australia and eastern parts of Indonesia.

Expansion of existing fisheries in the NT and Queensland is a potential threat to snappers and emperors in the NPA. Currently more than 80% of licences in the NT demersal fishery are inactive (DBIRD 2003a). While a limit has been set on the issue of new licences to the fishery, the current licences are freely transferable (DBIRD 2003a). Furthermore, fishers who hold a licence to fish the Timor Reef fishery in the Timor Sea (currently 12 licences) are also permitted to fish in the demersal fishery in the Arafura Sea and GoC (DBIRD 2003a). An increase in fishing effort in the demersal fishery, either through the mobilisation of latent effort in the demersal fishery, or relocation of effort from the Timor Reef fishery to the demersal fishery, is a potential threat to snappers, and possibly emperors, in the Arafura Sea and GoC regions of the NPA. Similarly, more than 50% of licences in the NT coastal line fishery are inactive and freely transferable (Coleman 2003). Activation of latent licences in this fishery may increase fishing pressure on snappers and emperors in the NPA. An expansion of the Queensland developmental finfish trawl fishery that operates in the GoC would also be a potential threat to snapper and emperor populations in the NPA.

Illegal fishing is also a potential threat to snapper and emperor populations in the NPA. Foreign fishing fleets have historically taken large catches of snappers and emperors from the Arafura Sea and northern GoC waters (Ramm 1994). Although foreign vessels have not been licensed to fish within the Australian Fishing Zone (AFZ) since 1991, a large number of foreign vessels have been reportedly fishing illegally within the AFZ since 1991. Relative to the small Australian fishing fleet operating in the NPA, illegal fishing operations could potentially harvest large numbers of snappers and emperors in the NPA that would not be reported or included in stock assessments.

Snappers and emperors are generally thought to form aggregations during spawning, although spawning activity has rarely been observed for either family (Allen 1985, Domeier & Colin 1997). The targeting of spawning aggregations by fishers could lead to significant reductions in population size. The degree to which spawning aggregations of snappers and emperors are targeted by fishers within the NPA is unclear, but such targeted fishing could be a potential threat to some snapper and emperor populations.

14. Snappers and Emperors

The Northern Prawn Fishery (NPF) that operates in the NPA captures a wide diversity of bycatch species. Stobutzki et al. (2001) reported 10 species of snapper (*Lutjanus argentimaculatus*, *L. carponotatus*, *L. erythropterus*, *L. johnii*, *L. lutjanus*, *L. malabaricus*, *L. quinquelineatus*, *L. russelli*, *L. sebae*, *L. vitta*) and three species of emperor (*Lethrinus genivittatus*, *L. laticaudis* and *L. lentjan*) as bycatch from this fishery. A large proportion of snappers and emperors captured by prawn trawling are likely to be immature as trawling often occurs in areas where juvenile fish are abundant, and trawl nets are capable of retaining large quantities of smaller fish. Wassenberg and Hill (1989) and Hill and Wassenberg (1990) found that the majority of finfish bycatch from prawn trawling do not survive. However, based on biological and ecological information, Stobutzki et al. (2001) suggested that snappers and emperors were among the groups of fishes that were likely to be sustainable under current levels of trawl fishing. In addition, the amount of finfish bycatch in the NPF is likely to be lessened by the recent introduction of bycatch reduction devices that reduce the initial take of fish species, and hoppers that assist in the separation of prawns from bycatch and return the unwanted species to the sea alive. However, trawling may still be a potential threat to snapper and emperor populations, as the catch of juvenile snappers and emperors in trawls represents additional mortality that is not currently accounted for in stock assessments. Furthermore, other bycatch species captured in the NPF may be important food resources for snappers and emperors and thus there is also the potential for trawling in the NPA to reduce available food resources for snappers and emperors.

The current fisheries regulations in the NT may have important implications for snapper and emperor populations in the NPA. Currently, there are no minimum size limits for any snapper or emperor species in the NT. Many species of snapper are considered to mature at a relatively large size, including the most important commercial and recreational species in the NPA (saddletail snapper, scarlet snapper, red emperor, golden snapper and mangrove snapper). Therefore, there is the potential for fishing to remove a significant proportion of immature snappers and emperors in the NT.

Information gaps

Most of the existing information for snappers and emperors in the NPA is from the major fisheries that target species such as goldband snapper, scarlet snapper, saddletail snapper, golden snapper and grass emperor. However, the majority of information for these species is limited to far western parts of the NPA, as most of the data for these species was collected by NT Fisheries. Furthermore, information for populations of other snappers and emperors within the NPA is scarce. As such, there are large information gaps that need to be addressed for snappers and emperors in the NPA, including:

- number and diversity of species
- distribution
- basic biology and ecology
- environmental and habitat associations
- recruitment patterns
- early life history
- productivity
- status
- stock structure of emperors and most snappers
- catch levels of emperors and most snappers by species and by fishing sector
- sustainability of harvest by fisheries

Preliminary lists of snapper and emperor species that occur in the NPA were recently compiled by Dr Helen Larson of the Museum and Art Gallery of the NT (Tables 14.4 & 14.5). These lists were based on Australian Museum collections and draft manuscripts from the Australian Biological Resources Study at the DEH. It is likely that other snapper and emperor species not included on these lists also occur within the NPA. For example, a number of fisheries that report catches of snappers and emperors operate only partially within the NPA and do not report spatially referenced catch data. (Exceptions are the commercial fisheries in the NT which are required to report exact fishing locations). Therefore, it is not possible to determine conclusively whether these species were caught in the NPA or in adjacent areas. Such species were not included in these preliminary lists of snapper and emperor species in the NPA. It is recommended that these lists be used as a starting point to which additions can be made as further information becomes available. Fisheries-dependent or -independent surveys may be needed to provide a more complete catalogue of snapper and emperor species that occur in the NPA.

Table 14.4: A preliminary list of snapper species (Family Lutjanidae) reported to occur within the Northern Planning Area based on collections from the Australian Museum

Common name	Species name
Ruby snapper	*Etelis carbunculus*
Tang's snapper	*Lipocheilus carnolabrum*
Mangrove jack	*Lutjanus argentimaculatus*
Indonesian snapper	*Lutjanus bitaeniatus*
Spanish flag	*Lutjanus carponotatus*
Scarlet snapper	*Lutjanus erythropterus*
Black-spot snapper	*Lutjanus fulviflamma*
Golden snapper	*Lutjanus johnii*
Maroon snapper	*Lutjanus lemniscatus*
Big-eye snapper	*Lutjanus lutjanus*
Saddletail snapper	*Lutjanus malabaricus*
Five-lined snapper	*Lutjanus quinquelineatus*
Maori snapper	*Lutjanus rivulatus*
Moses snapper	*Lutjanus russelli*
Red emperor	*Lutjanus sebae*
Brown-stripe snapper	*Lutjanus vitta*
Goldband snapper	*Pristipomoides multidens*
Chinamanfish	*Symphorus nematophorus*

Table 14.5: A preliminary list of emperor species (Family Lethrinidae) reported to occur within the Northern Planning Area based on collections from the Australian Museum

Common name	Species name
Forktail large-eye bream	*Gymnocranius elongatus*
Robinson's sea bream	*Gymnocranius grandoculis*
Yellowtail emperor	*Lethrinus atkinsoni*
Longspine emperor	*Lethrinus genivittatus*
Grass emperor	*Lethrinus laticaudis*
Red spot emperor	*Lethrinus lentjan*
Spangled emperor	*Lethrinus nebulosus*
Yellow-striped emperor	*Lethrinus ornatus*

In the NT, commercial fishers from all fisheries that operate in the NPA are only required to identify seven species of snapper (*Pristipomoides multidens*, *P. typus*, *P. filamentosus*, *Lutjanus erythropterus*, *L. malabaricus*, *L. sebae* and *L. johnii*) and one species of emperor (*Lethrinus laticaudis*) when reporting their catch in compulsory logbooks. However, observer programs in the NT have recorded at least a further four species of snapper (*Lutjanus carponotatus*, *L. argentimaculatus*, *L. russelli* and *L. lemniscatus*) and four species of emperor (*Lethrinus olivaceus*, *L. miniatus*, *L. nebulosus* and *L. lentjan*) that are captured and retained by commercial fishers (See Tables 14.2 & 14.3). In Queensland, the only snapper and emperor species that fishers are required to identify when reporting their catch from areas within the NPA are red emperor and red throat emperor (*Lethrinus miniatus*), except in the Torres Strait where two additional species of snapper (*Lutjanus erythropterus* and *L. argentimaculatus*) are also reported in logbooks. Observer surveys on commercial fishing vessels may be an efficient way to gain additional information on the species diversity of snappers and emperors in the NPA, collect catch and effort data for the various species, and obtain important biological information for those species such as size, age, growth, reproduction and genetic information.

A CRC Reef Research Centre (CRC Reef) project recently funded by the CRC Torres Strait Program (see current research projects below) will utilise such an observer program to evaluate the non-Islander commercial reef line fishery in the eastern Torres Strait. This project will provide valuable information on the catch and species composition of the fishery, including snapper and emperor species. Catch and effort data from the Torres Strait Islander commercial and Islander subsistence fisheries will be collected during two current CRC Reef projects (see current research projects below). The QFS is implementing an observer program for the Queensland developmental finfish trawl fishery in the GoC with the aim of collecting basic catch composition information. There is also an observer program, coordinated by the NT Fisheries Group, for the NT finfish trawl fishery. Additional surveys for the collection of biological and ecological information for snappers and emperors in the NPA are recommended.

Surveys of recreational and Indigenous fishers have provided a general estimate of the importance of snappers and emperors to these sectors, but information on individual species has proved difficult to obtain due to difficulties in distinguishing among species. The QFS conducts biannual surveys of recreational fishers in Queensland (Higgs 2001), while the NT Department of Primary Industries and Fisheries (currently the DBIRD) conducted a single recreational survey in 1995 in the NT (Coleman 1998). A national survey of recreational and Indigenous fishers, excluding the Torres Strait region, was also completed in 2001 (Henry & Lyle 2003). However, none of these surveys provides sufficiently detailed information on the catch of particular snapper and emperor species in the NPA.

Key references and current research

Although there are no comprehensive references that encompass all snappers and emperors that occur in the NPA, a significant amount of relevant information, particularly for commercially important species, can be found in the following documents: Coleman (2003), DBIRD (2003a, b), Newman et al. (2000b,c), Ovenden et al. (2002) and Ramm (1997).

14. Snappers and Emperors

Current research projects that are relevant to snappers and emperors in the NPA include:

- Biology, fishery assessment and management of shared snapper fisheries in northern Australia and eastern Indonesia. Joint project between the CSIRO, the Central Research Institute for Fisheries Indonesia, and the NT Fisheries Group, funded by ACIAR.
- Collation and review of Islander commercial catch history in the eastern Torres Strait reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville. Australian Fisheries Management Authority Project No. R02/1183.
- Evaluation of the eastern Torres Strait reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville.
- Modelling the impact of multiple harvest strategies in the Eastern Torres Strait (ETS) reef line fishery. Fishing and Fisheries, CRC Reef Research Centre, James Cook University, Townsville.
- National strategy for increasing the survival of released line-caught fish: Investigating survival of fish released in Australia's tropical and subtropical line fisheries. Joint project between Queensland DPI and CRC Reef, funded by FRDC.

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15. Mackerels and Tunas

15. Mackerels and Tunas

Commonly encountered mackerel and tuna species in northern Australian fisheries L to R: Spanish mackerel (Scomberomorus commerson), grey mackerel (Scomberomorus semifasciatus), mackerel tuna (Euthynnus affinis), Australian spotted mackerel (Scomberomorus munroi) and leaping bonito (Cybiosarda elegans). ***Source:*** *J Stapley*

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Species group name and description

Mackerels and tunas (Family Scombridae) support very important commercial and recreational fisheries as well as substantial artisanal fisheries throughout the tropical and temperate waters of the world. As a consequence, there is a wealth of information on the economically important scombrids and sparse information on the remainder. Scombrids comprise 15 genera and 49 species worldwide, of which most are epipelagic (occurring in the ocean between the surface and a depth of approximately 200 meters) marine fishes. This family has been classified into 4 tribes (13 genera and 46 species) and 2 genera groups (3 species) (Collette & Nauen 1983).

Mackerels worldwide consist of: the primitive mackerel tribe (Scombrini, 2 genera and 6 species), the Grammatorcynus genus (2 species) and the Spanish mackerel tribe (Scomberomorini, 2 genera and 19 species (Collette & Nauen 1983). According to published literature at least 15 of these 25 species occur in the Western Central Pacific area (WCPA) and, of these, 12 are potentially found in the Northern Planning Area (NPA) (Table 15.1). In total 7 species have been recorded from OZCAM (Online Zoological Collections of Australian Museums), research projects, and observer surveys.

On the higher end of the scombrid classification hierarchy, the tuna tribe (Thunnini) consists of 4 genera and 13 species and the more primitive bonito tribe (Sardini) consists of 4 genera and 8 species worldwide. Again according to published literature at least 13 of these 21 species occur in the WCPA and, of these, 10 are potentially found to occur in the NPA (Table 15.1). A total of 7 species have been recorded in the NPA from OZCAM, research projects, and observer surveys.

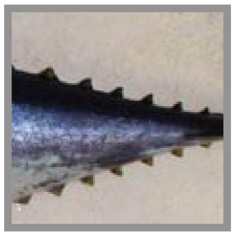
The only reliable indicators of abundance of scombrids in the NPA are from fisheries dependent data, including observer surveys, which are subject to species and size bias due to the selectivity of the fishing apparatus used to target these species (Table 15.1). The most common species reported in the NPA are: narrow-barred Spanish mackerel, *Scomberomorus commerson*, broad-barred mackerel or grey mackerel, *Scomberomorus semifasciatus*, and the longtail tuna, *Thunnus tonggol*.

Mackerels and tunas are known by a range of common and marketing names which vary between regions; the broadly used United nations Food and Agriculture Organisation (FAO) AO scientific and common names have been used in this report.

Status

There are no mackerel or tuna species protected under the Queensland *Nature Conservation Act 1992*, or under the Australian Government *Environmental Protection and Biodiversity Conservation Act 1999*. However, two species of tunas, *Thunnus maccoyii* and *T. obesus*, have previously been listed on the IUCN Red List (version 2.3 1994), but are not known to occur in the NPA. The Red List is highly dynamic with species moving on and off for a variety of reasons and currently no mackerel or tuna are listed.

The IUCN criteria are to '*provide relative assessments of trends in the population status of species across many life forms. However, it is recognized that these criteria do not always lead to equally robust assessments of extinction risk, which depend upon the life history of the species. The quantitative criterion (A1bd) for the threatened categories may not be appropriate for assessing the risk of extinction for some species, particularly those with high reproductive potential, fast growth and broad geographic ranges. Many of these species have high potential for population maintenance under high levels of mortality, and such species might form the basis for fisheries,*' (http://www.iucn.org). This is the case for mackerels and tunas. Taking into account that, in the NPA, scombrid species are predominantly straddling (occur over international boundaries) and highly migratory fish stocks, continual



monitoring and management of these heavily exploited species is required to ensure their conservation status.

On the Queensland coast of the NPA, both inshore and the offshore commercial set net fisheries have a closed season set in accordance with the lunar cycle for spawning barramundi (Garrett 1987), a period of approximately four months over summer. This offers some protection to mackerel and tuna populations inhabiting the Queensland portion of the NPA, as catch-rate patterns in the Gulf of Carpentaria (GoC) and the Torres Strait suggest seasonal movements with fish moving northward in warmer months (Kailola et al. 1993, Roelofs 2003a). That is, migrating stock and migration pathways are partially protected. Additional to commercial fishery operations is fishing tour operators, recreational, and Indigenous sectors accessing this resource in the NPA, all year round.

The commercial harvest of mackerel in the NPA is fairly well documented as this group of species are specifically targeted by gillnet and line fisheries, and rarely captured as bycatch in other fisheries due to their pelagic nature. In contrast, the catch of tunas are underestimated as these species are Australian Government regulated species (regulated as bycatch in Queensland State Fisheries, only 10 fish allowed in possession) and are large contributors to bycatch in the set net fisheries of the NPA (QDPI Fisheries Observer Program, unpublished data). These species rarely survive the trauma of capture in nets.

On the Northern Territory (NT) coast of the NPA, as noted in the recent ecological assessment by the Department of Environment and Heritage on the Spanish mackerel fishery (Anon 2003), fishery-dependant information does not necessarily reflect the status of the stock. That is, fishing showed no detectable impact on the Spanish mackerel stocks; however it was emphasised that this lack of impact may have been due to hyperstability – a phenomenon frequently observed in schooling species where catches and catch rates can remain stable if schools are sequentially targeted, even though the size of the fish stock is diminishing overall.

Habitat and distribution

Scombridae are a diverse pelagic/epipelagic group that range from restricted coastal species that can enter estuaries, to others that carry out wide longshore or oceanic migrations. The life histories of most mackerels and tunas within the NPA are relatively well known globally, but local information is scarce for most of the species of interest.

Generally this group of finfish is confined to marine waters, with the mackerels having fairly restricted coastal ranges. Most tunas are more widespread, preferring an oceanic habitat, and they migrate extensively. Many of these species distributions are associated with preferred water temperature and salinity levels, especially for tunas that regulate their body temperatures (Donguy et al. 1978, Sharp 1978, Sharp & Pirages 1978, Sharp and Vlymen 1978). One tuna commonly encountered in the NPA is the atypical longtail tuna (*T. tonggol*), which is predominantly a neritic (coastal) rather than oceanic species, however it does avoid very turbid and brackish waters (Collette & Nauen 1983).

Mackerels and tunas are dioecious (male and female sexes of a species as separate individuals) and most display little or no sexual dimorphism in morphology (structure) or colour pattern. Females of many species attain larger sizes than males and also grow at a faster rate (Begg 1996, McPherson 1992). Batch spawning of most species takes place in tropical and subtropical waters, frequently inshore and in specific areas (Collette & Nauen 1983, Buckworth & Clarke 2001, McPherson 1981, 1993). The locations of such spawning grounds and frequency of batches is largely unknown in the NPA. The eggs is pelagic and hatch into planktonic larvae.

Scombrid spawning seasons usually depend in large part on temperature regime, thus different geographic locations may have different spawning seasons. Genetic variation, stock structure and fecundity assessments are largely unknown for these species in the NPA, apart from Spanish mackerel. Migratory patterns of the NPA species are also not well known with sparse information available on some species, again mainly for Spanish mackerel and some speculative information on longtail tuna (Kailola et al. 1993, Kishinouye 1923, McPherson 1981, 1988, Moore et al. 2003, Munro 1943, Wilson 1981).

The available information on feeding, habitats, breeding, distribution, schooling behaviour, size, marketed products, temperature and depth ranges, and common presence in the NPA fisheries is broadly summarized in Table 15.2.

Narrow-barred Spanish mackerel

Two genetic stocks of Spanish mackerel are thought to occur in Queensland waters (Ovenden et al. in prep.) of the NPA. Fish in the Torres Strait are thought to comprise a separate genetic stock from the GoC and north-east Australian stocks. In the GoC, the distribution and extent of spawning activity is largely unknown. Mature and spawning fish have been reported September – November in both the north-eastern GoC and Torres Strait. Juvenile Spanish mackerel exhibit very rapid growth in their first year and typically reach about 65 cm fork length (FL: from the tip of the head to the fork in the tail). They recruit to the fishery at the end of their second year of growth, usually reaching about 80 cm FL. Sexual maturity in females usually occurs at about 79 cm FL, slightly larger than the minimum legal size at which they can be harvested. Sexes grow at different rates, with the annual growth rate of females being significantly greater than males after the second year. The two main commercial methods of harvesting Spanish mackerel in the NPA are line and gill net; recreational catch with rod and reel is also significant.

Preliminary research from the FRDC project 'Stock structure of northern and western Australian Spanish mackerel' (98/159), indicates that Spanish mackerel are not as highly migratory as previously thought and that there may be several semi-discrete stocks across the NT coast. However, catch rate patterns in the GoC and the Torres Strait suggest a seasonal movement, with fish moving northward in warmer months (Kailola et al. 1993). Parasite investigation by Lester et al. (2001) provided preliminary evidence of a complex stock structure for Spanish mackerel around Australia. Moore et al. (2003) investigated further and suggested that there are at least six stocks across northern Australia, based on parasite data, with very little movement between stocks. McPherson (1988) also suggested limited movements from anecdotal reports on local stock depletions and incidences of ciguatera poisoning in apparently restricted locations. However genetic studies indicate that a single genetic stock may exist across northern Australia from the Torres Strait to Western Australia (Shaklee et al. 1990, JR Ovenden pers. comm. 2003).

The north-east Australian stock is most likely to spawn mainly in the north-east Torres Strait area. Peak spawning is restricted to high tidal flow rates associated with new and full moon periods in October and November (Williams 1997). Currently reports are being compiled on the latest results from genetic, parasite and allozyme work, which may shed some light on Spanish mackerel stock in northern Australia (Buckworth et al. in prep. a & b, Ovenden et al. in prep., Shaklee in prep.).

Broad-barred mackerel

Broad-barred mackerel is a pelagic species endemic to waters across northern Australia and adjacent Papua New Guinea. The larvae and juveniles are dependent on estuarine and inshore habitats (Cameron & Begg 2002). In the NPA, broad-barred mackerel are usually harvested by commercial net fishers, although commercial line fishers and recreational fishers contribute to the overall harvest. They are a fast-growing species with total length (TL) at first maturity of 75 cm TL for females and 65 cm TL for males at between one and two years of age (Cameron & Begg 2002). The Queensland Fisheries Service acknowledges the biological and distributional data for grey mackerel are limited and is developing a desktop study in collaboration with the NT Department of Business, Industry & Resource Development (DBIRD) to collate existing biological data and to undertake preliminary assessment of the status of grey mackerel across northern Australia. Broad-barred mackerel is being managed in Queensland waters with a precautionary approach by the QFS until this information is compiled.

Longtail Tuna

Longtail tuna are distributed throughout tropical Australian waters and were considered to be characteristically small fish in northern waters (commonly 50–65 cm FL and rarely larger than 75 cm FL; Lyle & Read 1985). However, the average size of longtail tuna encountered in a Queensland offshore gillnet fishery in the NPA was 76 cm FL (ranging from 34 to 106 cm FL, n=568; QFS Fishery observer, unpublished data, 2003). In the NPA, longtail tuna is chiefly a bycatch species. Commercial net fishers usually encounter them, although commercial line fishers and recreational fishers contribute to the catches, with longtail being targeted by recreational sport fishers off Weipa. Longtail rarely survive the trauma of capture by nets.

15. Mackerels and Tunas

Very little current quantitative information is available on this species in the NPA, however some historical information is available from the Taiwanese fishing fleet when it fished northern waters (Lyle & Read 1985). It has been suggested in the literature that longtail tuna undertake longshore migrations but this requires further investigation, particularly as evidence from NSW Fisheries tag data to suggest they may remain in some areas for extended periods (S Griffiths pers. comm.). The average fish size increases in a southerly direction (Wilson 1981). Presumably the larger fish require cooler water temperature in the south to slow metabolism and allow the diversion of energy into gonad development (Sharp 1978). Wilson (1981) hypothesised that a spawning location may exist in northern Australian waters, with particular reference to Aru Island in the Gulf of Papua, to the north of the NPA. The hypothesis was based on size class distributions around Australia and water current/temperature patterns, given that *Thunnus* species require warm water to spawn (between 24 to 28° C, ie northern waters). Thus on the basis of the proposed cool water temperature limits on larger tuna, fish would have to migrate north to the Arafura Sea region during late winter/early spring to spawn, which is the proposed spawning period.

Significance of the species group in the Northern Planning Area

Scombridae as a group are active predators except for the mackerel *Rastrelliger* group, which chiefly prey upon zooplankton. The remaining mackerels, bonitos and tunas form the top of the food chain within the NPA ecosystem. They directly affect stocks of schooling bait fish, crustaceans, cephalopods as well as a diverse range of mainly fish prey (Collette & Nauen 1983).

There is also a well-documented relationships between the feeding of seabirds and the hunting behaviour of scombrids. Somewhat counter-intuitively, a reduction in scombrid populations may lead to a reduction in seabird numbers. In the NPA anecdotal information from fishers suggests that tunas drive schools of baitfish to the surface where seabirds can be seen scooping the jumping baitfish off the surface. Mackerel also drive schools of baitfish towards the surface but these do not break the surface, so only diving seabirds can feed on them. Fishers use this difference in behaviour of the seabirds to distinguish which school of scombrids to target.

The importance of this group to the commercial fishery in the NPA is summarised in Table 15.3. The recreational importance of the species is growing as the charter 'fishing tour' industry becomes more sophisticated and the number of tourist to the NPA increases with improved road access. The importance to the Indigenous community in the NPA is unknown.

Impacts/threats

Virtually all mackerels and tunas are highly prized for their high quality flesh, so the main impacts on these species are commercial and recreational fishing. Mackerels and tunas are midwater or surface species, active predators, and in many cases shoaling and migratory; characteristics making them vulnerable to gill net and line fishing in particular.

Mackerel and tuna in the NPA are considered migratory species, which in terms of the fishery means that catch opportunities may last for only a short period (ie highly seasonal fisheries). Currently there is expanding fishing effort for Spanish and broad barred (grey) mackerel in the NPA, both from the commercial and the rapidly expanding recreational sectors. The pelagic, migratory nature of these species means that many are straddling stocks, having significant components of their life history in a number of management jurisdictions.

Currently the longtail tuna is an Australian Government regulated species and is discarded as bycatch in state-regulated gill net fisheries, hence there is a largely undocumented 'cryptic' mortality to be considered in any stock assessment. Sustainable management of mackerel and tuna stocks will require the integration of management and agreement between several state, Australian Government, and OCS joint authority jurisdictions. A real threat to the sustainability of these groups is an *ad hoc* approach, with the management of difficult species falling through legislative cracks.

Information gaps

Fishery-dependent data is being collected via compulsory commercial fishery catch and effort logbooks and fishery observer programs in the NPA, but currently no fishery independent information is collected on mackerels and tunas. In the past 'traditional' tag/recapture methods have generally produced low recaptures rate and this has been attributed to tag-induced mortality (Begg 1996). Stevens (1989) believed capture stress may be greater in pelagic species due to their higher metabolic rates. For this group of finfish it is believed that capture, handling and tagging all contribute to behavioural changes (eg non-feeding period), loss in condition and physiological changes (eg alterations in blood chemistry, O_2 transfer and osmoregulation) immediately after tagging (Barrett and Connor 1962 and 1964, Hampton 1986).

Alternative approaches include: genetic approaches to determine stocks, stock movement, levels of exchange and exploitation rates (FRDC 98/159, NT, Qld & WA Spanish mackerel; and the recently approved FRDC project 'Genetag: genetic mark-recapture for real-time harvest rate monitoring', Buckworth et al. in prep.); and determination of ecological sustainability indicators such as vulnerability to capture versus the ability of a population/species to recover.

Stock structure for mackerels in the NPA is still largely unknown, particularly for the lesser mackerels. A genotype for mackerel species has been compiled primarily for the taxonomic identification (Robertson, 2002), however general genetic stock boundaries, movements and spawning locations are currently unknown for mackerels, other than Spanish mackerel (Ovenden et al. in prep.). Currently reports are being compiled on the latest results from genetic, parasite and allozyme work, which may shed some light on Spanish mackerel stock in northern Australia (Buckworth et al. in prep. a & b), Ovenden et al. in prep, Shaklee in prep). Sources of information on migration of Spanish mackerel include: the FRDC project *Stock structure of northern and western Australian Spanish mackerel* (98/159), and published work by Lewis (1981), Lyle and Read (1985), McPherson (1981), Tongyai (1970) and Wilson (1981).

The lesser mackerels, including broad-barred or grey mackerel (*S. semifasciatus*), the information needs are:

- collation, mapping and preliminary modelling of existing fisheries information
- targeted (research) surveys of potential grounds, based on local knowledge gained from involvement of commercial/recreational/Indigenous fishers
- a similar study to that carried out for the northern Spanish mackerel stock involving genetic, parasite and allozyme assessment of stock structure of the lesser mackerels

A partial overview of the lesser mackerels for the Queensland coast of the NPA has been published by Cameron and Begg (2002).

Information on tuna species in the NPA is essentially non-existent, except for a small amount on longtail tuna, much of which is currently speculative as there has been no stock assessment of longtail tuna in Australia to date (S Griffiths pers. comm.). The information requirements are:

- collation and mapping of existing fisheries information
- introduction of research logbooks or additional categories in current logbooks to record tuna as bycatch
- targeted (research) surveys of potential spawning and nursery grounds based on local knowledge gained from involvement of commercial/recreational/Indigenous fishers
- an integrated study involving genetic, parasite and allozyme assessment to determine stock structure and migration.

Key references and current research

Key datasets are held at state museums (OZCAM), QFS, CSIRO, NTDBIRD and AFMA. A wide array of published literature exists on scombrids, however there is an absence of literature on most of the species found to occur in the NPA. The species that dominates the literature, in this area, is Spanish mackerel but even information on this species has information gaps.

Research projects include:

- The biological and distributional data for broad-bar mackerel are limited and is developing a desktop study in collaboration with NTDBIRD to collate existing biological data and to undertake preliminary assessment of the status of broad-bar mackerel across northern Australia
- FRDC project 'Stock structure of northern and western Australian Spanish mackerel (98/159)
- Recently approved FRDC project 'Genetag: genetic mark-recapture for real-time harvest rate monitoring
- A current CSIRO study "A preliminary investigation of food web linkages and biology of pelagic fishes in northern Australia"

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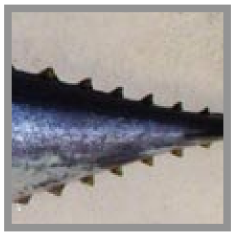

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15. Mackerels and Tunas

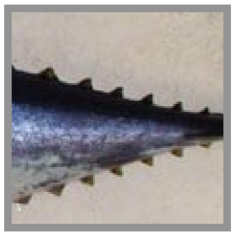


Table 15.1: *Scombrid species known to occur in the Northern Planning Area*

Tribe	Genus	Species	FAO common names	NPA [1]	NPA [2, 3]	ICUN ver 2.3, 1994	Frequency of occurrence in NPA [3, 4]
Thunnini (Tunas)	Thunnus	*T. alalunga*	Albacore			DD	
		T. albacares	Yellowfin tuna	☑	☑		Low
		T. maccoyii	Southern bluefin tuna			CR A1bd	
		T. obesus	Bigeye tuna	☑		CR A1bd	Low
		T. tonggol	Longtail tuna	☑	☑		High
	Katsuwonus	*K. pelamis*	Skipjack tuna	☑			Low
	Euthynnus	*E. affinis*	Kawakawa	☑	☑		Medium
	Auxis	*A. rochei rochei*	Bullet tuna	☑	☑		?
		A. thazard thazard	Frigate tuna	☑	☑		Medium
Sardini (Bonitos)	Allothunnus	*A. fallai*	Slender tuna				
	Gymnosarda	*G. unicolour*	Dogtooth tuna	☑			?
	Sarda	*S. orientalis*	Striped bonito		☑		Low
	Cybiosarda	*C. elegans*	Leaping bonito	☑	☑		Medium
Scombero–morini (Spanish mackerels)	Scombero–morus	*S. commerson*	Narrow–barred Spanish mackerel	☑	☑		High
		S. guttatus	Indo–Pacific king mackerel				
		S. koreanus	Korean mackerel				
		S. lineolatus	Streaked mackerel				
		S. multiradiatus	Papuan mackerel		☑		Low
		S. munroi	Australian spotted mackerel	☑	☑		Low
		S. queenslandicus	Queensland school mackerel	☑	☑		Medium
		S. semifasciatus	Broadbarred mackerel	☑	☑		High
		S. sinensis	Chinese seerfish				
	Acanthocybium	*A. solandri*	Wahoo	☑			Medium
	Grammatorcynus	*G. bicarinatus*	Shark mackerel	☑			?
		G. bilineatus	Double–lined mackerel	☑			?
Scombrini (Primitve mackerels)	Rastrelliger	*R. brachysoma*	Short mackerel	☑	☑		Low
		R. faughni	Island mackerel	☑			?
		R. kanagurta	Indian mackerel	☑	☑		Medium
	Scomber	*S. australasicus*	Spotted chub mackerel	☑			?
		S. japonicus	Chub mackerel				

1. *Carpenter KE & Niem VH 2001*
2. *OZCAM*
3. *Fishery databases and observer records (QFS, CSIRO, NTDBIRD)*
4. *Lyle & Read, 1985*

DD = Data Deficient

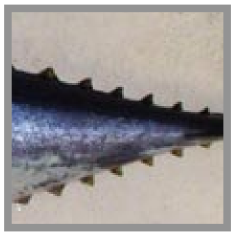
CR A1bd = CR = Critically Endangered, A = Population reduction in the form of either of the following: 1 = An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following: b = an index of abundance appropriate for the taxon, d = actual or potential levels of exploitation.

Table 15.2: *General summary of scombrid life history characteristics*

Tribe	Genus	Species	FAO common names	Common in NPA Fisheries	Global markets	Habitat	Area	School–ing behav–iour	Distribution	Possible spawning season	Diet	Size at first maturity (FL, cm)	Max size (FL, cm)	Temp & Depth
Thunnini	Thunnus	*T. albacares*	Yellowfin tuna	N	Fre, Fro, Can	Ep	Oc	St, Co	PT 40°N to 40°S	Spr – Sum	F, Cr, Ce	60–100	>200	15–31°C 250m
(Tunas)		*T. obesus*	Bigeye tuna	N	Fro, Can	P	Oc	St, Co	PT 40°N to 30°S	Spr – Sum	F, Cr, Ce	130	>200	13–29°C 250m
		T. tonggol	Longtail tuna	Y	Fre, Ds	Ep, Ne,	C	St	IWP 20°N – 38°S	Spr	F, Cr, Ce	60	140	? 10m
	Katsuwonus	*K. pelamis*	Skipjack tuna	?	Fre, Fro, Can	Ep, Me	Oc	St, Co	PT 58°N – 47°S	Spr – Aut	F, Cr, Ce	45	110	15–30°C 260m
	Euthynnus	*E. affinis*	Kawakawa mackerel tuna	Y	Fre, Fro, Can, Ds, S	Ep, Ne	C, Is	Wk, Co	IWP 35°N – 38°S	Spr – Sum	Sf, Cr, Ce, Zo	40	100	18–29°C 50m
	Auxis	*A. rochei rochei*	Bullet tuna	?	Fre, Fro	Ep, Ne	Oc, C, Is	?	Cww 45°N – 47°S	?	Sf, Cr, Ce	35 – 37	40	27.9°C 10m
		A. thazard thazard	Frigate tuna	?	Fre, Fro	Ep, Ne	Oc, C, Is	?	Cww 61°N – 47°S	?	Sf, Cr, Ce, Pl	29 – 35	60	27–28°C 50m
Sardini	Gymnosarda	*G. unicolour*	Dogtooth tuna	N	Fro, Can	Ep, Re	C, Is	Wk, Sol	IWP 35°N – 28°S	Sum	Sf, Ce	65	150	20–28°C 100m
(Bonitos)	Sarda	*S. orientalis*	Striped bonito	?	Fre, Ds	Ep, Ne	C, Is	St, Co	IP 41°N – 40°S	?	Sf, Ce	?	102	14–23°C 30m
	Cybiosarda	*C. elegans*	Leaping bonito	Y	B	Ep, Ne	C	St	Aus, PNG 6°S – 40°S	?	?	?	?	? 50m
Scombero–morini	Scombero–morus	*S. commerson*	Narrow–barred Spanish mackerel	Y	Fre, Fro, Ds	Ep, Ne	C	St	IWP 40°N – 45°S	Spr – Sum	Sf, Cr, Ce	65 – 70	220	? 70m
(Spanish		*S. multiradiatus*	Papuan mackerel	N	–	Ep, Ne	C	?	Gulf of PNG 7°S – 13°S	?	?	?	35	? ?
mackerels)		*S. munroi*	Australian spotted mackerel	Y	Fre, Fro	Ep, Ne	C	St, Co	Aus, PNG 7°S – 35°S	Spr	Sf, Cr, Ce	50 – 55	100	? 100m
		S. queenslandicus	Queensland school mackerel	Y	Fre, Fro	Ep, Ne	C	St, Co	Aus, PNG 5°S – 35°S	Spr – Sum	Sf, Cr, Ce	45 – 50	100	? 100m
		S. semifasciatus	Broadbarred mackerel	Y	Fre, Fro	Ep, Ne	C	St	Aus, PNG 7°S – 30°S	Spr – Sum	Sf, Cr, Ce	55– 60	120	? 100m
	Acanthocybium	*A. solandri*	Wahoo	?	–	Ep	Oc, C	Wk, Sol	Cww 45°N – 38°S	?	F, Ce	?	210	? 12m
	Grammatorcynus	*G. bicarinatus*	Shark mackerel	N	–	Ep, Re	C	St	Aus 10°S – 35°S	?	Sf	?	110	? 15m
		G. bilineatus	Doublelined mackerel	?	Fre, Fro, Can	Ep, Re	C, Is	St	IWP 30°N – 23°S	Spr – Sum	F, Cr	40	100	? 15m
Scombrini	Rastrelliger	*R. brachysoma*	Short mackerel	?	Fre, fro, Can, Ds, S	Ep, Ne	C, Is	St	Central IWP 20°N – 20°S	Aut – Spr	Zo, Pl	16	35	? 200m
(Primitve		*R. faughni*	Island mackerel	?	Fre, fro, Can, Ds, S	Ep, Ne	C, Is	St	Central IWP 30°N – 20°S	?	Zo, Pl	?	20	? 150m
mackerels)		*R. kanagurta*	Indian mackerel	Y	Fre, fro, Can, Ds, S	Ep, Ne	C, Is	St	IWP 35°N – 35°S	Aut – Spr	Zo, Pl	23	35	? 90m
	Scomber	*S. australasicus*	Spotted chub mackerel	?	Fre, fro, Can, Ds, S	Ep, Ne	C, Is	St, Co	PO, IO, RS 42°N – 50°S	?	?	?	40	? 200m

(Sources: Cameron & Begg 2002, Carpenter & Niem 2001, Collette & Nauen 1983, Begg 1996, Lyle & Read 1985, McPherson 1993, Wilson 1981)

15. Mackerels and Tunas



Y	yes	Oc	oceanic	IWP	Indo–West Pacific Ocean	Sum	Summer
Fre	fresh	C	coastal	Cww	cosmopolitan in warm waters	Aut	Autumn
Fro	frozen	Is	around offshore islands	IP	Indo–Pacific	F	fish
Can	canned	Re	reef	Aus	Australia	Sf	small fish
Ds	dried–salted	St	strong	PNG	Papua New Guinea	Cr	crustaceans
S	smoked	Wk	weak	PO	Pacific ocean	Ce	cephalopods
B	bait	Sol	solitary	IO	Indian oceans	Zo	zooplankton
Ep	epipelagic	Co	coexisting with other spp.	RS	Red Sea	Pl	plankton
Ne	neritic	PT	pantropical	Spr	Spring		
Me	mesopelagic						
P	pelagic						

Table 15.3: *Commercial significance of the scombrids in the Northern Planning Area*
Refer to Buckworth and Clarke 2001, Coleman 2000, CFISH, Henry and Lyle 2003, Higgs 2001, Lewis 2002, O'Grady 2002, RFISH, R.C. Buckworth per. com. 2003, Roelofs 2003a&b, Sly 2003a&b, Wilson 1981.

	Fishery / Licences	Target	Byproduct	Bycatch	Total annual catch for mackerel	Total annual catch for tunas (95–00)
Qld	Total Commercial catch	$3.5m/yr			350–580t (96–00)	?
	N3 (90)		☑	☑		
	N9 (6)	☑		☑		
	Line (40)	☑	☑	☑		
NT	Total Commercial catch	~$4.5m/yr			~900t (2003)	2.8–17t
	Spanish mackerel (19)	☑		☑		
	Shark (21)		☑			
	Barramundi (26)		☑	☑		
	Coastal net (14)			☑		
Commonweath & Joint Authority	NPF (102)			☑		
	Fish Trawl (2)			☑		
Fishing Tour Operators	NT 164 Qld see RFISH	☑			?	?
Recreational	NT ~50, 000 visitors + ~42, 000 residents Qld see RFISH	☑			?	?
Indigenous		☑			?	?

Table 15.4: *Contact list of scientist holding sources of mackerel and tuna information applicable to the NPA, Australia.*

State	Contact	Organisation
QLD	Jason Stapley Jason.Stapley@dpi.qld.gov.au	QDPI, QFS, Northern Fisheries Centre
QLD	Neil Gribble Neil.Gribble@dpi.qld.gov.au	QDPI, AFFS, Northern Fisheries Centre
NT	Rik Buckworth rik.buckworth@nt.gov.au	NT DPI Fisheries
QLD	Dr Shane Griffiths Shane.Griffiths@csiro.gov.au	CSIRO, Division of Marine Research
QLD	Dr Helen Larson Helen.Larson@nt.gov.au	NT Museum & Art Gallery
QLD	Geoff McPherson Geoff.McPherson@dpi.qld.gov.au	QDPI, Northern Fisheries Centre

16. Coastal fishes

This chapter should be cited as:
Williams, A, Begg, G, Garrett, R, Larson, H & Griffiths, S (2004). Coastal Fishes. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

Barramundi (Lates calcarifer) ***Source:*** *Marine Harvest*

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Species group name and description

Coastal fishes:

Barramundi,
Lates calcarifer
(Centropomidae)

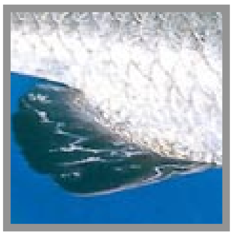
King Salmon,
Polydactylus macrochir
(Polynemidae)

Blue Salmon,
Eleutheronema tetradactylum (Polynemidae)

Black Jewfish,
Protonibea diacanthus
(Sciaenidae)

Queenfish,
Scomberoides commersonianus (Carangidae)

Grunters,
Pomadasys kaakan and P. argenteus (Haemulidae)



There are many species of fish that inhabit the coastal waters and estuaries within the Northern Planning Area (NPA) (Blaber et al. 1994). The species listed above comprise only a small selection of the coastal fish species in the NPA. However, these species are commonly recognised as the most important to a range of coastal fisheries and communities in the NPA (Garrett 1997, Phelan 2002, Williams et al. 2002, Coleman 2003). As such, these species are discussed here as a single group and referred to as the 'coastal fishes'.

The barramundi, king salmon, blue salmon and black jewfish are all single species groups. Queenfish and grunter are common names used to describe a number of species found in tropical Australian waters. In this synopsis, a single species of queenfish, *Scomberoides commersonianus*, and two species of grunter, the banded grunter *(Pomadasys kaakan) and the small-spotted grunter (P. argenteus)*, will be discussed, as they are the most commonly targeted by fisheries in the NPA (Williams et al. 2002, Coleman 2003).

Status

None of the coastal fishes are listed on any international, Commonwealth or state threatened species lists.

Fishing regulations apply to the coastal fishes in both Queensland and the Northern Territory (NT). In Queensland, fishing regulations for coastal fishes differ between the east coast and the Gulf of Carpentaria (GoC). Fishing regulations for coastal fishes in Queensland GoC waters include minimum size limits for the species listed above and maximum size limits for some of them. Minimum size limits were set according to information on the size at maturity, where available, to allow fish to spawn at least once before recruiting to the fishery. Maximum size limits were introduced to allow the larger, potentially more fecund individuals (mostly female in the case of barramundi) to spawn. For recreational fishers, there are also possession limits for all species except queenfish (Table 16.1). In the NT there is a minimum size limit for barramundi and recreational possession limits for barramundi and black jewfish (Table 16.1). Bag limits for barramundi are lower for the Mary River Management Zone, as this area has been subject to the highest levels of recreational fishing in the past.

Seasonal closures for the taking of barramundi, designed to protect spawning individuals, have been implemented in the NT and Queensland. There are no seasonal closures for any other coastal fish, except jewfish in far northern Cape York (see below). In the NT, the closed season for barramundi is between 1 October and 31 January and applies to commercial fishers in all NT waters, and for recreational fishers in the Daly River and the Mary River Management Zone only (Coleman 2003). The NT Barramundi Fishermen's Association is currently lobbying for the extension of the recreational fishing seasonal closures to all Northern Territory waters.

In Queensland GoC waters, the closed season for barramundi, which applies equally to commercial and recreational fishers, varies each year depending on the timing of the full moon, but is usually for a four-month period between October and February (Garrett & Williams 2002a).

Table 16.1: *Summary of legal size limits (total length) for commercial and recreational fishers and recreational possession limits for the capture of coastal fishes in Queensland Gulf of Carpentaria and Northern Territory waters. NA = Not applicable*

Common name	Queensland Gulf of Carpentaria			Northern Territory		
	Minimum size (cm)	Maximum size (cm)	Possession limit	Minimum size (cm)	Maximum size (cm)	Possession limit*
Barramundi	60	120	5	55	NA	5 (2 in Mary River)#
King salmon	60	NA	5	NA	NA	NA
Blue salmon	40	NA	20	NA	NA	NA
Black jewfish	60	120	5 (No more than 2 fish >100 cm)	NA	NA	5
Queenfish	45	NA	NA	NA	NA	NA
Banded grunter	40	NA	10	NA	NA	NA

* *A total recreational possession limit of 30 fish (all species combined) applies in the Northern Territory.*
#*A total of 2 barramundi are allowed in possession within the Mary River Management Zone.*

A self-imposed two-year ban on the taking of black jewfish was implemented by the Injinoo Land Trust and Injinoo Community Council in August 2000 for inshore waters between Crab Island on the west coast and Albany Island on the east coast of Queensland (Phelan 2002). The closure applies to fishers from all fishing sectors.

Habitat and distribution

Barramundi

Barramundi are distributed throughout much of the Indo-West Pacific including the tropical regions of northern Australia (Greenwood 1976, Larson 1999). Within the NPA, barramundi can be found in coastal, estuarine and freshwater habitats along the entire coastline of the NT and Queensland.

Barramundi occupy various habitats at different stages of their life cycle (Figure 16.1). As mature adults, barramundi usually inhabit estuaries and adjacent coastal areas or the lower reaches of rivers (Davis 1985a, 1987). Larvae and early stage juveniles are typically found in temporary coastal swamps and wetlands, close to the spawning sites (Russell & Garrett 1983, 1985, Davis 1985a, 1987). As older juveniles, barramundi disperse into permanent tidal creeks and estuaries, and often make their way upstream into the freshwater reaches of rivers where they remain until they reach maturity (Russell & Garrett 1985). At the onset of the wet season, maturing barramundi typically move back downstream to tidal waters to spawn (Dunstan 1959, Garrett & Russell 1982, Davis 1985a, 1986).

The timing and duration of the spawning season for barramundi vary throughout their range (Davis 1985a, Russell & Garrett 1985, Davis 1987, Garrett 1987). The commencement of the spawning season appears to be strongly associated with environmental variables such as water temperature, salinity and the onset of the wet season (Davis 1985a, Garrett 1987). In the NPA, the spawning season generally occurs between October and March, although there may be small variations in the timing and duration of spawning among river systems and from year to year (Davis 1985a).

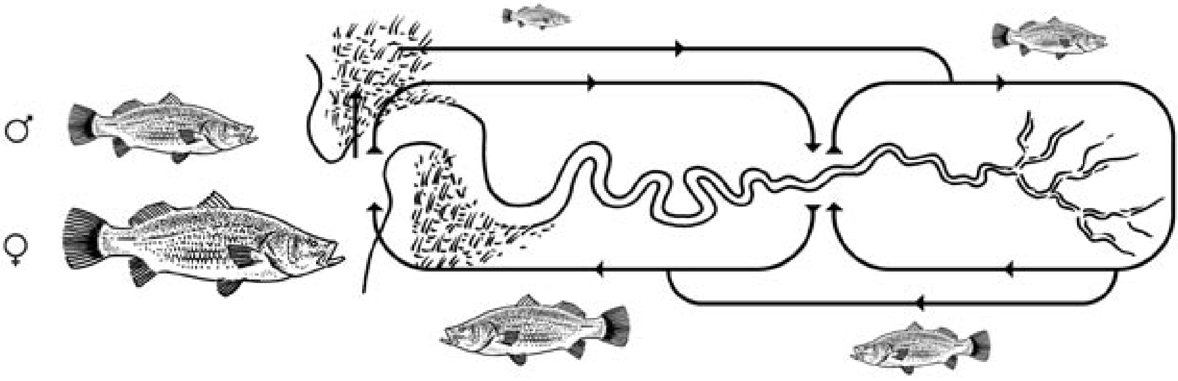
Barramundi are among the most fecund of all fishes. Davis (1984b) estimated that a single female barramundi of 124 cm total length (TL) from the GoC contained approximately 46 million eggs. Early research suggested that barramundi only spawn once during the spawning season (Dunstan 1959). However, there is now some evidence to suggest that at least some barramundi spawn multiple times during the season (eg MacKinnon et al. 1986, Garrett & Connell 1991). Spawning only occurs in saltwater (Garrett 1987), and usually takes place in relatively shallow water near the mouths of creeks and rivers (Garrett & Russell 1982, Davis 1985a). During spawning, barramundi form small male dominated aggregations (MacKinnon et al. 1986), and it is assumed that several males fertilise the eggs from a single female (Moore 1980, Garrett 1987). The peak spawning activity usually occurs at dusk, and coincides with a rising tide so that fertilised eggs are transported by tidal currents into the upper estuarine areas (Garrett & Russell 1982, Davis 1985a, MacKinnon et al. 1986).

Figure 16.1. *Schematic diagram of the typical life cycle of barramundi* ***Source:*** *Northern Territory Fisheries Group*

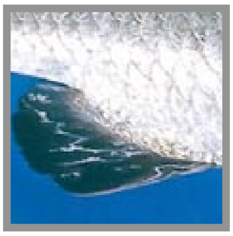
1
Spawning around the river mouths early in the wet season

2
High tides wash eggs and larvae into coastal swamps

3
Juveniles migrate upstream at the end of the wet season



4
Maturing males move downstream at the beginning of the wet season



Barramundi are broadcast spawners and produce pelagic eggs (Dunstan 1959). Under hatchery conditions, MacKinnon et al. (1996) reported that larval barramundi hatch at 1.5 mm after an incubation period of 17 hours in 28°C water, and the duration of the larval stage was approximately 26 days. Barramundi eggs and larvae are passively transported by tidal currents into coastal wetland swamps and tidal pools where they remain until the end of the wet season (Garrett & Russell 1982, Davis 1985a, Russell & Garrett 1985).

The dominant sexual pattern for barramundi is protandry, meaning that individuals mature first as males before changing sex to female at a later stage in their life cycle (Moore 1979, Davis 1982, 1984a). The existence of a small proportion of primary females and a few large males in barramundi populations suggests that not all individuals follow the same sexual pathway (Moore 1979, Davis 1982). The size and age at which maturity and sex change occur has been shown to vary among individuals and locations. For example, within the NPA, male barramundi from the south-east GoC were estimated to mature at approximately 60-65 cm TL (3–5 years of age) and change sex at around 68–90 cm TL (3–7 years of age) (Davis 1982). In contrast, male barramundi in a population in the north-east GoC were found to mature as small as 29 cm TL (1–2 years of age) and change sex at about 49 cm TL (3 years of age) (Davis 1984a). Some of these differences are likely to be a consequence of variations in growth among populations (Davis & Kirkwood 1984), suggesting that maturity and sex change in barramundi populations is related more to age than to size (Davis 1982).

Barramundi are reported to reach a maximum size of over 200 cm TL (55 kg) (Larson 1999), although individuals less than 120 cm are more commonly encountered. Barramundi are a relatively fast growing species, and can reach 100 cm TL (12 kg) at approximately 8 years of age (Davis & Kirkwood 1984).

Barramundi are opportunistic predators. As larvae and small juveniles (less than 50 mm in length), barramundi feed mainly on zooplankton such as insect larvae and small crustaceans (Davis 1985b, Russell & Garrett 1985). As adults, barramundi feed predominantly on fishes and larger crustaceans (mostly prawns) (Davis 1985b, Russell & Garrett 1985). Barramundi are also known to be cannibalistic, eating smaller individuals (Davis 1985b).

Considerable effort to determine the stock structure of barramundi across northern Australia, including within the NPA, has revealed the existence of several genetically discrete stocks (Shaklee & Salini 1985, Salini & Shaklee 1988, Shaklee et al. 1993, Keenan 1994, 1997a). Current knowledge suggests that at least seven genetically discrete stocks of barramundi exist within the NPA (Keenan 1997a). The localised spawning behaviour of barramundi (Garrett & Russell 1982) and the relatively low rates of movement among river systems (Davis 1986) are thought to help maintain genetically distinct populations (Garrett 1987, Shaklee et al. 1993). These populations have also been found to be genetically distinct from Queensland east coast populations (Keenan 1997a).

There have been numerous stock assessments for barramundi populations in the NT and Queensland. A recent stock assessment in Queensland indicated that barramundi stocks in the Queensland GoC have been steadily increasing in biomass since the mid 1980s, and that current levels of fishing effort, which are currently around 12 000 days/year (Williams et al. 2002), are sustainable (Welch et al. 2002a). The apparent increase in stock size is thought to be the result of fishing restrictions and seasonal closures for the barramundi fishery (Welch et al. 2002a). Similarly, a recent assessment in the NT indicates that stocks of barramundi have increased since the 1970s, and that current levels of fishing, about 30 000 hmd/year (hmd=100 m of net set for one day) (Coleman 2003), are sustainable (Coleman 2003).

King salmon

King salmon are distributed along the southern coast of Papua New Guinea from Oetoemboewe to Gulf of Papua, and the tropical and subtropical coasts of Australia from Broome to Brisbane (Feltes 2001). They are found throughout the NPA where they inhabit coastal waters, rivers and estuaries, and occasionally venture into fresh water (Feltes 2001).

King salmon prefer the lower reaches of tidal rivers and mangrove flats and are most commonly found in very shallow turbid waters less than 5 m deep (Kailola et al. 1993, Feltes 2001). They are active predators feeding mainly on fish and crustaceans (prawns and crabs) (Salini et al. 1998, Feltes 2001).

King salmon are reported to live to over 20 years of age and reach a maximum size of 170 cm fork length (FL) and 45 kg (Kailola et al. 1993, Feltes 2001). However, in the south-east GoC, the oldest king salmon sampled was estimated to be 14 years of age, and the largest fish measured was 125 cm FL (Bibby & McPherson 1997). King salmon from the south-east GoC grow moderately fast, reaching about 25 cm FL in their first year (Bibby & McPherson 1997).

King salmon are protandrous hermaphrodites. This means that they mature first as males before changing sex to female at a later stage in their life cycle (Griffin 1990, Garrett 1992, McPherson 1997, Garrett & Williams 2002b). McPherson (1997) estimated the length at which male king salmon from the south-east GoC first mature to be 28 cm FL. In contrast, Garrett (1992) found male king salmon from the south-east GoC did not mature until 60–80 cm FL. Griffin (1990) obtained a similar estimate of male maturity of 70 cm FL for king salmon from NT waters. Sexual transition occurs across a wide size and age range (Griffin 1990, McPherson 1997), with 50% of the population estimated to change sex at approximately 95 cm FL in the south-east GoC (McPherson 1997) at which length they are between 6 and 10 years of age (Bibby & McPherson 1997). Similarly, Griffin (1990) estimated the size at sex change for king salmon to be between 80 and 100 cm FL.

The peak spawning season for king salmon commences in August and continues until at least October in the south-east GoC (McPherson 1997), and occurs between October and March in NT waters (Griffin 1990). King salmon spawn in high-salinity inshore waters, away from the influence of freshwater flows (Garrett & Williams 2002b). Although the factors influencing the timing and duration of the spawning season are unknown, the onset, magnitude and duration of the wet-season freshwater flows into coastal waters are thought to affect adult spawning success and juvenile survival (Garrett & Williams 2002b).

King salmon produce pelagic eggs, but little is known about the larval stage (Kailola et al. 1993). Juvenile king salmon inhabit inshore tidal flats and lower estuary areas (Russell & Garrett 1983). Movement patterns of king salmon are not well known, although there have been reports of long distance movements of up to 550 km along the Australian coastline (Sawynok 1991). King salmon are also known to form large schools at certain times of the year in the south-east GoC (Garrett & Williams 2002b).

Preliminary genetic work has suggested the existence of discrete stocks of king salmon between the eastern GoC and the Queensland east coast, and possibly the presence of sub-stocks within the eastern GoC (Keenan 1997b).

A recent assessment of king salmon stocks in Queensland GoC waters (Welch et al. 2002b) represents the only stock assessment attempted for king salmon in the NPA. Unfortunately, it was not possible to estimate the stock status or sustainability of current levels of fishing effort due to a lack of reliable data to support conventional models (Welch et al. 2002b).

Blue salmon

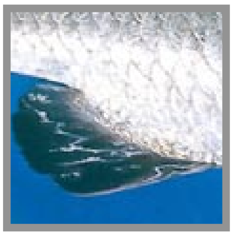
Blue salmon are more widely distributed than king salmon, and can be found throughout the tropical and subtropical regions of the Indo-West Pacific (Feltes 2001). They occur throughout the NPA where they are typically found in coastal and estuarine waters to a depth of at least 30 m (Feltes 2001).

Similar to king salmon, blue salmon are more common in the shallow turbid water of coastal sand and mudflats and in lower river estuaries (Feltes 2001, Garrett 2002a). They also share a similar diet to king salmon, feeding mainly on crustaceans and fish, and occasionally on molluscs and polychaetes (Stanger 1974, Salini et al. 1998).

Blue salmon are reported to reach a maximum size of 200 cm TL and 140 kg in other parts of the Indo-West Pacific (Feltes 2001). However, the largest blue salmon from the south-east GoC was only 88 cm FL (Bibby & McPherson 1997). The oldest fish sampled from the south-east GoC was estimated to be 7 years of age (Bibby & McPherson 1997). The growth rate of blue salmon from the south-east GoC is relatively fast, particularly in their first year when they can reach 30 cm FL (Stanger 1974, Bibby & McPherson 1997).

Blue salmon are protandrous hermaphrodites, maturing first as males before changing sex to female at a later stage in their life cycle (Stanger 1974, McPherson 1997). Male blue salmon can reach sexual maturity at approximately 24 cm FL in the south-east GoC (McPherson 1997) at which length they are approximately 2 years of age (Bibby & McPherson 1997). For blue salmon from the south-east GoC, the size at which 50% of the population change sex from male to female was estimated at approximately 54 cm FL (McPherson 1997) at which size they are around 4 years of age (Bibby & McPherson 1997).

Similar to king salmon, the peak spawning season for blue salmon in the south-east GoC is between July and October (McPherson 1997). Blue salmon spawn in coastal waters away from the direct influence of fresh water (Garrett 2002a). The movement patterns and behaviour of blue salmon during the spawning period are unknown.



Blue salmon produce pelagic eggs, but little is known about the larval stage (Kailola et al. 1993). Juvenile blue salmon inhabit inshore tidal flats and lower estuary areas (Russell & Garrett 1983). Movement patterns of blue salmon are not well known, although there have been reports of relatively large movements of up to 150 km along the Australian coastline (Sawynok 1991).

Preliminary genetic work has suggested the existence of discrete stocks of blue salmon between the eastern GoC and the Queensland east coast, and possibly the presence of sub-stocks within the eastern GoC (Keenan 1997b).

A recent assessment of blue salmon stocks in Queensland GoC waters (Welch et al. 2002b) represents the only stock assessment attempted for blue salmon in the NPA. Unfortunately, it was not possible to estimate the stock status or sustainability of current levels of fishing effort due to a lack of reliable data to support conventional models (Welch et al. 2002b)..

Black jewfish

Black jewfish are distributed throughout the Indo-west Pacific, including the tropical waters of northern Australia (Sasaki 2001). They occur throughout the NPA and typically inhabit coastal waters and estuaries (Sasaki 2001).

Black jewfish commonly inhabit relatively shallow water to a depth of 60 m (Sasaki 2001). They are considered to be opportunistic predators, feeding on a range of fish and crustaceans (mainly crabs and prawns), and occasionally gastropods (Sasaki 2001, Phelan 2002).

Black jewfish have a fast growth rate, and are capable of reaching 100 cm TL in the third year of life (Bibby & McPherson 1997). In the south-east GoC black jewfish can reach a maximum size of more than 150 cm TL and live to at least 12 years of age (Bibby & McPherson 1997). Preliminary age and growth studies of black jewfish from NT waters indicated a similar longevity, but the largest fish were only around 120 cm

Black jewfish *(Protonibea diacanthus)* ***Source:*** *CSIRO*

FL (Hay et al. 1996). This suggests that growth rates of black jewfish may be slower in NT waters than in the south-east GoC.

The sexual pattern of black jewfish is unknown, but the presence of males and females in nearly all size classes (Hay et al. 1996, McPherson 1997) suggests they are likely to be gonochoristic, having separate sexes throughout life. Female black jewfish from far northern Cape York were found to be sexually mature from about 79 cm TL (Phelan 2002). In the south-east GoC, mature female black jewfish were first observed at 92 cm TL, and the size at which 50% of females reached sexual maturity was estimated to be approximately 98 cm TL (McPherson 1997) at which size they are 3–4 years of age (Bibby & McPherson 1997).

The spawning season for black jewfish is not well known. Based on preliminary observations of gonad maturity, the spawning season for black jewfish in NT waters was presumed to occur between October and April (Hay et al. 1996). No estimate of the spawning season for black jewfish was possible from samples collected from the south-east GoC (McPherson 1997) or far northern Cape York (Phelan 2002).

Black jewfish are known to form spatially and temporally predictable aggregations at several locations off far northern Cape York each year (Phelan 2002). Aggregations of black jewfish have also been reported from other locations in northern Australia (eg Bowtell 1995, Newman 1995). The reason for these aggregations is not known, but they may be related to spawning, as ripe gonads were found in mature fish collected from the aggregations (Phelan 2002). A tagging study off northern Cape York demonstrated the movement of one fish between separate aggregations sites (a distance of 36 km) over a period of 13 days, and the persistence of two fish at the same aggregation site over a period of two days (Phelan 2002).

Two separate studies on the stock structure of black jewfish suggest the existence of a single genetic stock within the NPA. Keenan (1997b) was unable to detect a significant genetic difference among populations in the eastern GoC or between populations from the eastern GoC and the east coast of Queensland. Phelan (2002) concluded that populations of black jewfish from the far northern Cape York and the NT were genetically homogenous.

Queenfish

Queenfish are broadly distributed throughout the Indo-West Pacific, including the tropical and subtropical waters of Australia from Exmouth to northern New South Wales (Smith-Vaniz 1999). They can be found throughout the NPA where they inhabit mostly marine waters. Despite their wide distribution, information on the biology of queenfish is very limited.

Queenfish generally inhabit coastal areas and are often found near reefs and offshore islands, and occasionally in estuaries (Smith-Vaniz 1999). They are very common in shallow water less than 5 m deep (Blaber et al. 1994) and can be found alone or in small to large groups. They are active predators feeding mainly on other fish (Brewer et al. 1995, Salini et al. 1998), and occasionally on crustaceans, molluscs and annelids (Brewer et al. 1995, Salini et al. 1998, Smith-Vaniz 1999).

Queenfish are reported to reach a maximum size of 120 cm TL and 16 kg (Smith-Vaniz 1999), although individuals in excess of 100 cm TL and 10 kg are uncommon. Information on the size-at-age for queenfish is not currently available.

Little is known about the reproductive biology of queenfish. It is likely that they are gonochoristic, having separate sexes, which is characteristic of the Carangidae. Currently, there is no information on the spawning season or maturity of queenfish.

Grunters

Grunters are widely distributed throughout the Indo-West Pacific, including tropical and subtropical waters of Australia from Exmouth Gulf to northern New South Wales (McKay 2001). They can be found in coastal inshore waters and estuaries throughout the NPA.

Grunters are tolerant of salinity changes, and may enter the upper tidal reaches of rivers, but rarely enter freshwater (McKay 2001, Garrett 2002b). Grunters are reported to depths of 115 m, but in the NPA they are more common in shallower coastal waters less than 5 m deep. Grunters are opportunistic predators, feeding on a range of small fish and crustaceans (McKay 2001).

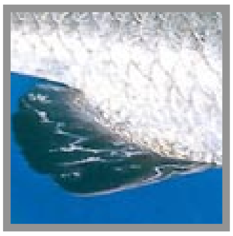
Small-spotted grunters reach a maximum size of approximately 60 cm FL, while banded grunters are reported to grow up to 80 cm FL (McKay 2001). However, in the south-east GoC, the average maximum size of banded grunter was estimated to be approximately 58 cm FL (Bibby & McPherson 1997). Small-spotted grunters have been reported to reach 19 years of age in the Arabian Gulf (Mathews & Samuel 1991), but no estimates of maximum age are available within the NPA. Although banded grunter were estimated to reach 20 years of age in the Arabian Gulf (Al-Husaini et al. 2001), the oldest fish sampled from the south-east GoC was estimated to be 14 years of age (Bibby & McPherson 1997).

Grunters are considered to be gonochoristic (Garrett 2002b) due to the presence of males and females in nearly all size classes (McPherson 1997). Preliminary information suggests that male and female banded grunters from the south-east GoC may reach sexual maturity at 24 and 18 cm FL respectively (McPherson 1997), at which size they are between one and three years of age (Bibby & McPherson 1997). Information on the maturity of small-spotted grunters has not been reported for populations in the NPA, although Bade (1989) demonstrated that, on the east coast of Queensland, they mature at a much smaller size than banded grunter.

The peak spawning season for grunters in the south-east GoC commences in July and continues until at least October, prior to the onset of the annual wet season (McPherson 1997, Garrett 2002b). Grunters appear to spawn close to shore, in areas where salinities are between 31–35 parts per thousand (Garrett 2002b). The onset, magnitude and duration of wet-season freshwater flows into coastal waters are thought to affect the duration of the spawning season for grunter (Garrett 2002b).

Juvenile grunters occupy mangrove and wet-season swamps, and tidal creeks around the margins of estuaries (Russell & Garrett 1983). Consequently, the intensity and scale of the wet season is important for the availability of juvenile habitats (Garrett 2002b). The movement patterns of grunter are not well known, but seasonal aggregations of grunter form inshore around certain major GoC river mouths in the months leading up to the spawning season (Garrett 2002b).

Preliminary genetic work has suggested the existence of discrete stocks of banded grunter between the eastern GoC and the Queensland east coast, and the presence of sub-stocks within the eastern GoC (Keenan 1997b). Currently, there is no equivalent genetic information available for small-spotted grunter.



Significance of the species group in the Northern Planning Area

The ecological roles of the coastal fishes in the NPA are not well understood. However, the coastal fishes are likely to be ecologically important to the NPA as they are some of the most abundant predatory species in coastal waters. The coastal fishes (in particular queenfish) are known to be significant predators of commercially important penaeid prawn species within the NPA (Salini et al. 1990, 1998, Brewer et al. 1995) and also consume a wide range of fish species (Brewer et al. 1995).

The coastal fishes are an important component of the catch from various fisheries that operate partially or wholly within the NPA.

Commercial fisheries

Northern Territory

Commercial fisheries in the NT that operate partially within the NPA and report catches of coastal fishes include the barramundi, coastal net, and coastal line fisheries. The proportion of the catch taken from within the NPA is currently unknown, but NT commercial fishers are required to report their exact fishing location in compulsory logbooks. Therefore, the NT catch from within the NPA could be estimated.

Barramundi and king salmon are the major components of the commercial barramundi fishery in the NT (Coleman 2003). The annual catch of these two species has increased significantly since the early 1990s and reached a peak of 1004 t of barramundi and 394 t of king salmon in 2001 (Coleman 2003). Much smaller quantities of blue salmon, black jewfish and queenfish are also taken in this fishery (Coleman 2003). The gross value of production (GVP) from the NT barramundi fishery was $5.2 m in 2002 (Coleman 2003).

Blue salmon and queenfish are two of the main target species in the NT commercial coastal net fishery. Barramundi and king salmon, among other species, are not permitted to be taken in this fishery (Coleman 2003). The annual catch from the coastal net fishery has remained below 60 t since 1996 and was approximately 40 t in 2002 (Coleman 2003). The majority of the catch from this fishery is blue salmon and mullet (Coleman 2003), although the annual catch of individual species was not reported. The gross value of production (GVP) from the NT commercial coastal net fishery was $0.1 m in 2002 (Coleman 2003).

The black jewfish is an important component of the NT commercial coastal line fishery, and since 1999 has contributed more than 50% to the annual catch (Coleman 2003). The annual catch of black jewfish has also increased from less than 40 t in 1998 to approximately 140 t in 2002 (Coleman 2003). The gross value of production (GVP) from the NT commercial coastal line fishery was $0.5 m in 2002, with the black jewfish catch valued at $0.4 m (Coleman 2003).

Queensland Gulf of Carpentaria

Barramundi and king salmon are the primary target species in the Queensland GoC commercial inshore net fishery (Williams et al. 2002). Barramundi typically contribute between 40 and 57% to the total annual catch from the fishery (Garrett & Williams 2002a), with approximately 720 t harvested in 2001 (Welch et al. 2002a). The annual catch of king salmon has varied between 1990 and 2001, and reached a peak of 463 t in 2001 (Welch et al. 2002b). Prior to 1990, the annual catch of king salmon was mostly between 200–300 t, which was approximately 25% of the annual net fishery catch (Garrett & Williams 2002b). The annual GVP from the Queensland GoC commercial inshore net fishery has increased steadily since 1989 and was $7.3 m in 2000 (Williams et al. 2002).

Although not primary target species, blue salmon, black jewfish, queenfish and grunter are also captured in the Queensland GoC commercial inshore net fishery (Halliday et al. 2001, Williams et al. 2002). Under-reporting of catch through high grading and catch discarding (only keeping and recording the higher value fish) currently presents problems for accurately documenting the catch of these species, particularly for blue salmon and queenfish (Welch et al. 2002b). However, reported annual catches of these species have varied between 1990 and 2000, but on average the contribution of these species to the annual catch has been approximately 6% blue salmon, 1.5% black jewfish (including jewelfish *Nibea squamosa*), 1% queenfish and 2% grunters (both species combined) (Williams et al. 2002). The only significant temporal trend in catch of these species is for the black jewfish (including jewelfish), for which catch has declined significantly from around 20 t in the early 1990s to only 5 t in 2000 (Williams et al. 2002).

16. Coastal fishes

Recreational fisheries

A national survey of recreational and Indigenous fishing (NRIFS) found that more than 90% of recreational angling in Queensland and the NT occurred in estuaries, rivers or coastal waters (Henry & Lyle 2003). Consequently, coastal fishes are especially important to recreational fisheries in the NPA. In particular, barramundi is an icon species of tropical Australia, attracting recreational anglers from all Australian states to the NT and Queensland, as well as international visitors, for its renowned sport fishing appeal and superior eating qualities.

Despite the importance of recreational fishing in coastal areas, there have been relatively few surveys of recreational fishing in the NPA. Quantitative estimates of recreational catch are only available at the state level or from smaller regions within the NPA. At the state level, the NRIFS found that the coastal fishes contribute significantly to recreational catches in the NT and to a lesser extent in Queensland (Henry & Lyle 2003). It should be noted, however, that the contribution of coastal fishes to the Queensland GoC recreational catch is likely to be significantly greater that the NRIFS estimates for the whole of Queensland, as the NRIFS State estimate included very large catches of whiting and bream from south-east Queensland (Henry & Lyle 2003).

The estimated recreational harvest of barramundi from the NRIFS in 2000 was over 105 000 fish in the NT and over 88 000 fish in Queensland (Henry & Lyle 2003). These catch estimates for barramundi correspond to approximately 16% of the total recreational finfish harvest in the NT, but less than 1% of the total recreational finfish catch in Queensland (Henry & Lyle 2003). Similar estimates of the Queensland recreational harvest of barramundi were obtained from RFISH surveys (recreational fishing surveys conducted by Queensland Fisheries Service) in 1997 (Higgs 1999) and 1999 (Higgs 2002). However, the total recreational catch of barramundi is much higher in the NT and Queensland, as more than 50% of the barramundi caught are then released (Higgs 2001, Coleman 2003).

The estimated combined recreational harvest of king and blue salmon from the NRIFS in 2000 was approximately 6% in the NT and less than 1% in Queensland (Henry & Lyle 2003). Recreational catch estimates for the other coastal fishes are not currently available at the state level.

A few localised surveys of recreational fishing in Queensland GoC waters have also demonstrated the importance of the coastal fishes to recreational fisheries in the NPA. In a small pilot study of recreational fishing in the Karumba area, Hart (2002) reported that grunters and blue salmon each contributed 23% to the recreational finfish catch. Other coastal species reported were black jewfish (3%), barramundi (1%), and king salmon (<1%) (Hart 2002). Williams et al. (2002) reported that recreational fishers in the Karumba region caught an estimated 40–60 t of grunter in 1998, which was approximately four times the annual commercial harvest of grunter for the whole of Queensland for the same year (Garrett 2002b). Helmke (1999) found that barramundi was the main species targeted and caught during recreational fishing competitions in Normanton and Burketown, but other coastal fishes such as king salmon, blue salmon, black jewfish and grunter were also captured. The Kowanyama Land & Natural Resource Management Office have been surveying recreational and Indigenous fishing in their country for several years, but the data collected have not yet been analysed and are currently not available outside the Kowanyama Community.

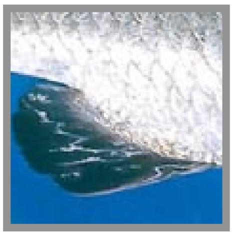
Charter fisheries

For recreational fishers, the popularity of chartering fishing guides has increased significantly in the NT and Queensland in recent years (Coleman 2003, J Higgs pers. comm.). However, the number of charter vessels operating in the NPA is currently unknown. The catch from charter operations in the NT has increased significantly since 1994 to reach a peak of over 35 000 fish in 2002 (Coleman 2003). The most common species captured on fishing charters in the Northern Territory are barramundi, black jewfish and blue salmon, although king salmon, grunter and queenfish are also captured (Coleman 2003). The catch of coastal fishes from Queensland charter operators is unknown, but catch and effort data are collected regularly by the QFS through compulsory logbooks.

Indigenous fisheries

For Indigenous fishers, fishing is not only for food, but also for ceremonial occasions, exchange, trade and barter. In the NT and Queensland, more than 90% of Indigenous fishing occurs in rivers, estuaries and coastal waters (Henry & Lyle 2003). Therefore, coastal fishes are very important components of Indigenous fisheries in the NT and Queensland.

Estimates of indigenous catch in the NT and Queensland are only available at the state level (from the NRIFS). The estimated Indigenous harvest of barramundi from the NRIFS in 2000 was over 44 000 fish in the NT



but less than 6000 fish in Queensland (Henry & Lyle 2003). These catch estimates for barramundi correspond to approximately 11% and 1% of the total Indigenous finfish harvest in the NT and Queensland respectively (Henry & Lyle 2003). Indigenous catches of king salmon were over 8 000 fish in the NT and nearly 12 000 in Queensland, corresponding to 2% and 3% of the total Indigenous harvest in the NT and Queensland respectively (Henry & Lyle 2003). Indigenous catch estimates for the other coastal fishes are not currently available.

A study of the Indigenous black jewfish fishery in the waters of far northern Cape York revealed the significance of this species to the Indigenous communities of Cape York (Phelan 2002). Subsistence fishing for black jewfish by the Indigenous communities of far northern Cape York has occurred for more than 50 years (Phelan 2002).

Impacts/threats

The main potential impacts or threats to coastal fishes within the NPA relate to habitat degradation and over-fishing.

The entire life cycle of coastal fishes is dependent on habitats that are close to and used by human populations. Potential environmental threats to coastal fishes and their habitats include habitat loss and modification from development, sedimentation and nutrification from agricultural runoff, restricted access to habitats due to construction of dams, weirs, flood mitigation and saltwater intrusion works, and pollution from fuel and oil spills and other waste material.

Coastal fishes are easily accessible to fishers from all sectors, and form a significant component of numerous fisheries within the NPA. High levels of localised fishing effort for coastal fishes have been reported from areas within the NPA, particularly near major population centres (eg Phelan 2002, Coleman 2003), which may result in localised depletion of coastal fish populations. Furthermore, there is the potential for species with a number of discrete stocks within the NPA (eg barramundi, king salmon, blue salmon and grunter) to become locally overfished unless the stock structure of these species is incorporated into regional fishery management measures. Although recent stock assessments suggest that harvest levels of barramundi stocks in the NPA are currently sustainable, no equivalent information is currently available for the other coastal fishes.

Many of the coastal fishes are known to form aggregations of various sizes at different times of the year (MacKinnon et al. 1986, Garrett 2002a & b, Garrett & Williams 2002b, Phelan 2002). Some of these aggregations are well known by fishers who deliberately target them. For example, large numbers of recreational fishers travel to Karumba each year to take advantage of the large numbers of grunter that congregate in the south-east GoC (Garrett 2002b). Perhaps the best documented example of targeting coastal fish aggregations is the fishing of black jewfish aggregations off far northern Cape York, which have been exploited for over 50 years (Phelan 2002). There is a real concern that the deliberate targeting of aggregations of coastal fish in Queensland and the NT will result in the collapse of populations, particularly the black jewfish (Phelan 2002, Coleman 2003). The significant decline in commercial catches from Queensland GoC waters since the early 1990s is also a concern for black jewfish in the NPA, as it suggests there may have been a decline in population size. Adding to these concerns is the recent collapse and disappearance of a once-productive fishery for black jewfish on the north-west coast of India, apparently as a result of ove-rfishing (James 1994).

A reduction in reproductive potential is a threat for coastal fish populations in the NPA, particularly king salmon and blue salmon. Protandrous species, such as barramundi, king salmon and blue salmon, are particularly vulnerable to over-fishing, as fishing may remove proportionally more females than male, due to the selectivity of fishing gear towards larger individuals. A maximum size limit for barramundi was introduced in Queensland to protect the larger female barramundi. Currently, there is no maximum size limit for the protection of large female barramundi in the NT or large female king salmon or blue salmon in the NT or Queensland.

The current fisheries regulations in the NT may have important implications for populations of coastal fishes in the NPA. Currently, there are no minimum size limits for any coastal fish species in the NT, except barramundi (Table 16.1). Some of the other coastal fishes, such as king salmon and black jewfish, are known to mature at a relatively large size. Therefore, there is the potential for fishing to remove a significant proportion of immature coastal fishes in the NT. The different management arrangements for coastal fishes in Queensland and the NT also have important implications for stocks of coastal fishes that straddle the Queensland-NT border. There is the potential for a straddling stock to become over-exploited if harvest from all fisheries is not accounted for in

stock assessments. Therefore, it may be necessary for coastal fishes in the NPA to be managed collaboratively between the NT and Queensland to reduce the potential of over-exploitation.

The Northern Prawn Fishery (NPF) that operates in the NPA captures a wide diversity of bycatch species. Of the coastal fishes, the two grunter species, black jewfish and queenfish were reported as bycatch from this fishery (Stobutzki et al. 2001). A large proportion of these coastal fishes captured by prawn trawling are likely to be immature as trawling often occurs in areas where juvenile fish are abundant, and trawl nets are capable of retaining large quantities of smaller fish. Wassenberg and Hill (1989) and Hill and Wassenberg (1990) found that the majority of finfish bycatch from prawn trawling do not survive. However, based on biological and ecological information, Stobutzki et al. (2001) suggested that the four coastal fish species were among the groups of fishes that were likely to be sustainable under current levels of trawl fishing. Also, the amount of finfish bycatch in the NPF is likely to be lessened by the recent introduction of bycatch reduction devices that reduce the initial take of fish species, and hoppers that help to seprate prawns from bycatch and return the unwanted species to the sea alive. However, trawling may still be a potential threat to the sustainability of coastal fishes, as the main target species of the NPF (penaeid prawns) are important prey items for coastal fishes, and often form a large proportion of their diet.[1]

Information gaps

Although the coastal fishes form a significant component of a number of fisheries in the NPA, there are still significant information gaps for coastal fishes that need to be addressed.

The biology of barramundi has been well studied in the NT and Queensland GoC, and many aspects of the species' biology are now understood. However, biological information for the other coastal fish species is more limited. Preliminary biological information for these species was reported by Garrett (1997), but this work needs to be continued and expanded to provide more detailed biological information for all coastal fishes throughout the NPA. In particular, more comprehensive information on age, growth, reproduction, larval and juvenile biology, spawning behaviour, habitat associations, and movement patterns is needed for coastal fishes from locations throughout the NPA. Robust stock assessments are also required to determine resource status over time.

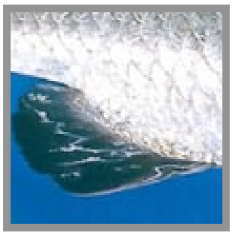
There is a need to obtain better catch and effort data for coastal fishes from all fishing sectors in the NPA. Commercial catch and effort data have been recorded for most coastal fishes in the NT and Queensland for a number of years. In Queensland, however, the reported commercial harvest of grunters and black jewfish include more than a single species. In the NT, there are no reports on the annual commercial catch of blue salmon, grunters or queenfish, and the catch of coastal fishes taken from NT waters of the NPA has not been reported. Observer surveys on commercial vessels in the NPA have provided some estimates of the catch and effort for all coastal species from individual operators. Continuation of these surveys is recommended to monitor trends in the commercial harvest of all coastal fishes in the NPA. The need to demonstrate ecological sustainability under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* is encouraging fishery agencies to invest in these activities.

For recreational, Indigenous and charter fishers in the NPA, there is a lack of information on the catch and effort of coastal fishes. Continuation of recreational surveys like the NRIFS is recommended to determine temporal trends in catch and effort of recreational and Indigenous fishers. Refining such surveys to include more detailed spatial catch and effort data would allow a better estimate of the recreational and Indigenous catch from the NPA. Improving the involvement and partnership with the Indigenous sector will be necessary to realise this goal. Furthermore, analysis of the catch and effort data for the charter fishery in Queensland GoC waters is required to determine trends in the harvest of coastal fishes from this sector.

Preliminary genetic work has revealed the existence of discrete stocks of some coastal fishes in the NPA. Additional genetic research is needed to better define the stock boundaries of coastal fishes in the NPA. Furthermore, the implications of the stock structure of coastal fishes in the NPA for the management of coastal fisheries needs to be determined.

While there have been numerous stock assessments for barramundi in Queensland and the NT, stock assessments for other coastal fish species are lacking. Armed with better information on the biology, harvest and stock structure of coastal fishes in the NPA, it will be possible to carry out reliable stock assessments for all coastal fish species, and determine the sustainability of coastal fish stocks within the NPA. With greater

[1] *See Chapter 24: Trawl Bycatch Species for more information on other species taken as bycatch in the Northern Prawn Fishery.*



biological and ecological data, and the development of ecosystem models, there is an opportunity for agencies to move towards ecosystem-based management to provide a more holistic assessment of all ecosystem processes.

Key references and current research

Current research projects that are relevant to coastal fishes in the NPA include:

- National strategy for the survival of line caught fish: assessment of post-release survival and stress physiology of barramundi (Lates calcarifer). Northern Territory Department of Business, Industry and Resource Development. FRDC funded project No. 2002/039.
- Tropical Resource Assessment Program (TRAP) Phase I and Phase II. Department of Primary Industries Queensland. FRDC funded project No. 1999/125.
- Environmental flows for subtropical estuaries: Understanding the freshwater needs of estuaries for sustainable fisheries production and assessing the impacts of water regulation. Cooperative Research Centre for Coastal Zone Estuary and Waterway Management Department of Primary Industries Queensland. Jointly funded by Coastal CRC and FRDC, project No. 2001/022.

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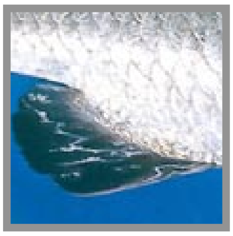

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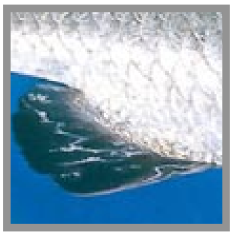

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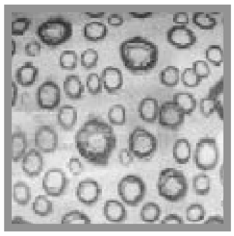

17. Molluscs

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Willan, R & Dredge, M (2004) Molluscs.
In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

Pearl Oyster (Pinctada maxima) ***Source:*** *R Willan*

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Northern Territory

Jim Luong-Van Thinh (Aquaculture Facility, Charles Darwin University, Darwin), Rik Buckworth (Northern Territory Department of Business Industry and Resource Development, Darwin), Andria Marshall (Northern Territory Department of Business Industry and Resource Development, Darwin), Steve Wilmore (Fisheries Group, Northern Territory Department of Business Industry and Resource Development, Darwin).

Species group name and description

The Mollusca is numerically the largest phylum in the world's seas, comprising an extraordinarily diverse array of animals with many different body forms and habitats. The three largest groups (ranked as classes) of molluscs are the gastropods, bivalves and cephalopods. The two former groups are considered in this chapter and the cephalopods (specifically squid) are treated in Chapter 18 of this report. Analyses of fishery statistics relating to molluscs are frequently compromised because of misapplication of common names. In the context of this present chapter, the gastropods comprise the marine shell-bearing snails as Trochus, baler shells, cowries and cone snails. Nudibranchs are also gastropods, but they have no shell when adult. The term 'sea slugs' is not recommended for nudibranchs as it is frequently taken to include Holothurians, which belong to a separate phylum (Echinodermata) and are treated in Chapter 23 of this report. The bivalves comprise oysters, mussels, cockles, clams and mangrove worms, the latter being worm-like bivalves, totally unrelated to bristle worms (polychaetes in the phylum Annelida).

With an estimated 5000 species in the Northern Planning Area (NPA), the Mollusca reaches its richest biodiversity anywhere in the Australian Exclusive Economic Zone (EEZ). This biodiversity comes about through the intermixing of Indo-Pacific and Australian coastal faunas, especially in Torres Strait. Nowhere else in the EEZ does such diversity and intermixing of molluscan faunas occur. Despite this biodiversity, the level of endemicity is the lowest of anywhere in the EEZ with less than 1% of species entirely restricted to the NPA or with a short range distribution confined to northern Australia extending into the NPA. The molluscan fauna of the NPA is wholly tropical, and part

of the wider Northern Australian Biogeographical Region extending from North West Cape in Western Australia to the southern tip of the Great Barrier Reef (Wilson & Allen 1987).

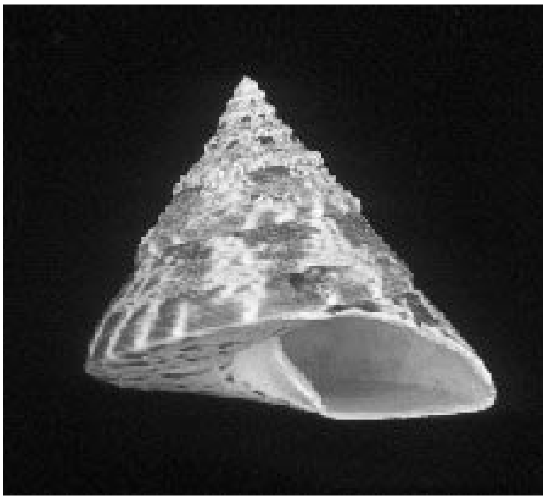
Overall, the most significant publication collating knowledge about Australian molluscs is *Molluscs: The Southern Synthesis* edited by Beesley et al. (1998). An indispensable reference that is highly relevant to the species groups of molluscs covered in this report is the United Nations Food and Agriculture Organisation (FAO) *Species Identification Guide for Fishery Purposes* edited by Carpenter and Niem (1998). Volume 1 of this series includes bivalves and gastropods.

In the context of this report, ten broad species groups of molluscs (four gastropods and six bivalves) are significant:

Trochus

This group comprises only a single species, the trochus/commercial trochus/commercial top (FAO name), *Trochus niloticus* (family Trochidae). Although the genus *Tectus* is sometimes used for this species, that placement is incorrect based on shell architecture and morphology of the animal. That *Trochus* is the correct genus has also been demonstrated by allozyme electrophoresis (Borsa & Benize 1993).

Trochus (Trochus niloticus) **Source:** *R Willan*

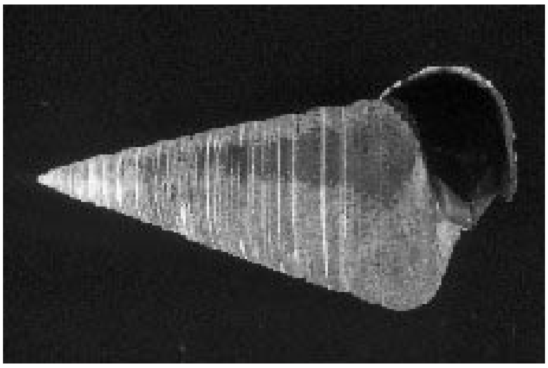


This large, top-shaped gastropod (shell to 150 mm in height) occurs patchily throughout the tropical Indo-west Pacific Ocean and has been introduced by humans beyond its natural range for commercial purposes. The animal lives on coral reefs in clean waters and eats seaweed.

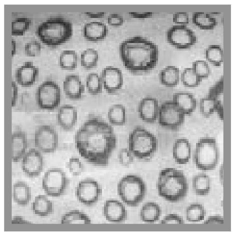
Longbums

Collectively, two species of mangrove snails/mudwhelks are known throughout northern Australia by the peculiar vernacular name of longbum. This name alludes to the long, sinuous trail of faeces left by an animal after it has been feeding on detritus on the surface of mangrove mud. These are the true longbum (*Telescopium telescopium*) and the lesser longbum (*Terebralia palustris*). Both species of longbum occur throughout the Indo-west Pacific Ocean. The family to which lonbums belong, Potamididae, also contains five smaller species in the NPA, but only two of these (*Terebralia semisulcata* and *Cerithidea obtusa*) are ever collected in a minor way along with the larger and more palatable target species.

Longbum (Telescopium telescopium) **Source:** *R Willan*



Houbrick (1991) has investigated the functional morphology, ecology and life history of longbums. Wells (1980, 2003) and Wells and Lalli (2003) have investigated the distribution of longbums within mangrove habitats in northern Australia.

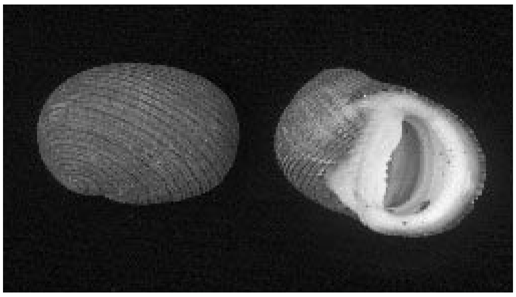


Other Edible Gastropods

Overall, the major species (with family in brackets) comprising the catch of this group in terms of size of shells and numbers collected in the NPA are:

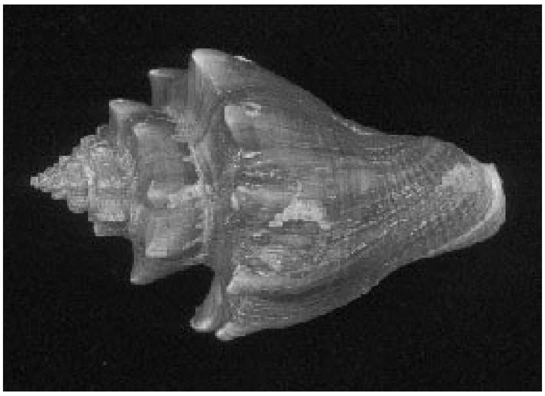
- balers - *Melo*, *Cymbiola* and *Amoria species* (family Volutidae)
- spider snails - *Lambis* species (family Strombidae)
- black nerite - *Nerita balteata* (family Neritidae)
- false trumpet/Australian trumpet (FAO name) - *Syrinx aruanus* (family Turbinellidae)
- spiral melongena (FAO Name) - *Pugilina cochlidium* (family Melongenidae).

Mangrove nerite (Nerita balteata) ***Source:*** *R Willan*



Cowries (families Cypraeidae, Ovulidae) and Olives (family Olividae) are generally not taken because the animals exude too much mucous. However, ear snails (family Ellobiidae) are sometimes taken despite the animal's production of mucous. Cone snails (family Conidae) are seldom taken because they are known to be venomous.

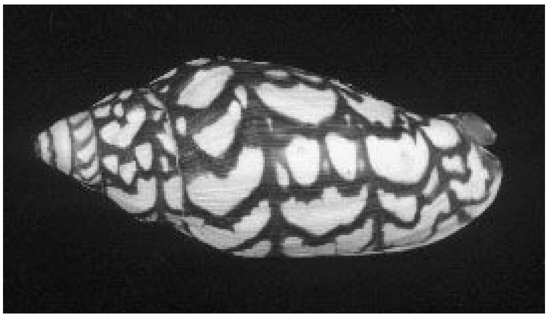
Spiral Melongena (Pugilina cochlidium) ***Source:*** *R Willan*



Commercially valuable gastropods

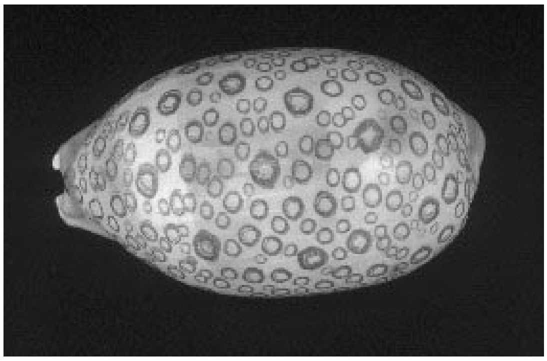
Approximately twenty species of gastropods belonging to four families (Volutidae, Cypraeidae, Muricidae, Conidae) occurring in the NPA are targeted by collectors of specimen shells.

Bednall's baler (Volutoconus bednalli) ***Source:*** *R Willan*



These gastropods live both in rocky and sandy habitats intertidally and subtidally. Some of the more desirable species are also obtained from SCUBA divers and prawn fishermen.

Eyed cowrie (Cypraea argus) ***Source:*** *R Willan*



Collectors also acquire species of several other families (Ranellidae, Bursidae, Ovulidae, Terebridae, Olividae, Naticidae), but not with the zeal with which they collect the principal families, and collectors seldom specialise in these families to the exclusion of the principal families.

Pearl Oysters

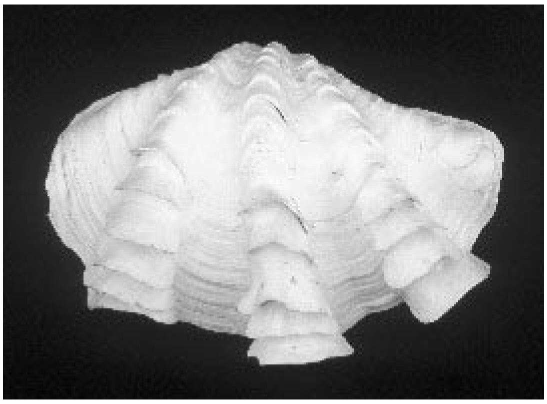
This group comprises the goldlip pearl oyster (FAO name), *Pinctada maxima*, and to a much lesser extent only in Torres Strait, the blacklip pearl oyster (FAO name), *Pinctada margaritifera* (family Pteriidae). The Goldlip is the larger species; its circular shell can grow to 300 mm in maximum diameter. There are (at least) three additional species of smaller "bastard" pearl oysters in the NPA, but only *P. maxima* is used commercially for the manufacture of pearls.

Giant clams

All six species of giant clams (family Tridacnidae) known to occur in Australia can be found in the NPA, particularly the coral reefs in Torres Strait (Harris et al. 1995). These are as follows (with the common names adopted by FAO, as in Carpenter & Niem 1998): Giant clam *Tridacna gigas*; smooth giant clam *T. derasa*; elongate giant clam *T. maxima*; fluted giant clam *T. squamosa*; crocus giant clam *T. crocea*; bear paw clam *Hippopus hippopus*. With maximum length around 1400 mm and weight over 400 kg, the largest species, *Tridacna gigas*, is the largest living bivalve in the world.

All the species of giant clams occurring in Australia formerly had extensive distributions in the tropical Indo-west Pacific Ocean, but nowadays most are seriously depleted.

Fluted giant clam (Tridacna squamosa) ***Source:*** *R Willan*



Mud 'mussels'

A single species of bivalve, *Polymesoda erosa* (also appearing in the literature under the synonyms *Geloina coaxans* and *Cyrena jukesii*), constitutes the most important bivalve consumed by Indigenous communities in the NPA. Its northern Australian common name of "mud mussel" is misleading, as the family to which it belongs (Corbiculidae) is not related to true mussels (family Mytilidae) at all. The names 'mud clam' or 'common geloina' (FAO name) would be more appropriate. Meehan (1982) and Schall (1985) recorded another, similar looking, related species, the violet batissa clam, *Batissa violacea*, as occurring with, and used by Indigenous people alongside *P. erosa* in the area, but that was a misidentification : *B. violacea* only occurs in Australia in the estuarine reaches of the large, eastward-draining rivers in northern Queensland.

Mud mussel (Polymesoda erosa) ***Source:*** *R Willan*

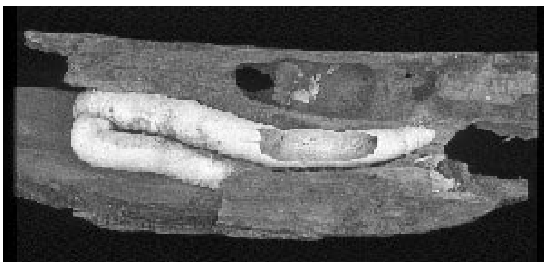
Shells of *Polymesoda erosa* are circular (to 110 mm maximum diameter), heavy and swollen. The species inhabits muds on the inshore fringes of mangrove forests and it also occurs naturally in Asia.

Ricky Gimin and Tony Griffiths of Charles Darwin University (formerly Northern Territory (NT) University), in Darwin, in collaboration with Ray Hall of the Maningrida Community, are currently investigating feeding and the population dynamics of *Polymesoda erosa*.

Mangrove 'worms'

Several species of bivalves (family Teredinidae) constitute the species group known by the misleading common names of mangrove 'worms' or shipworms. This usage has frequently led European scientists to classify them wrongly as members of the worm phylum Annelida (ie Coleman et al. 2003), so that the conclusions of their studies are compromised. A better common name is 'teredos'. Teredos have a small shell at the front end deep inside the wood and very long siphons inside shell-lined bore holes that extend to reach the sea water. Species identification is largely based on the shelly structures (called pallets) on the ends of the siphons that are used to close off the tube. The largest teredo in the NPA, with animals reaching 500 mm in length, are the edible shipworm (FAO name) *Bactronophorus thoracites* and *Dicyathifer manni*.

Mangrove 'worm' (Bactronophorus thoracites) ***Source:*** *R Willan*



Teredos live inside wood or other plant material, eating the wood as they drill through it.

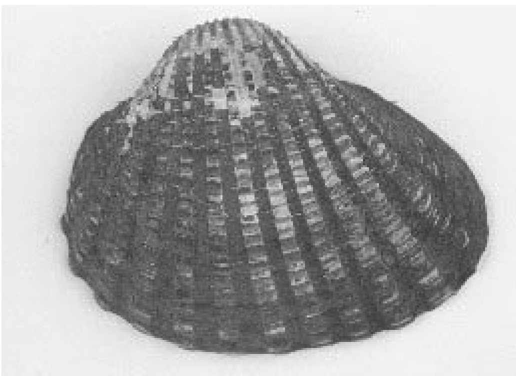
Much of our knowledge of taxonomy and ecology of teredos stems from the studies of Ruth Turner and her colleagues (Turner 1966, 1971, 1998, Marshall & Turner 1974). These studies were aimed at reducing the impact of teredos on submerged wooden structures like wharves, jetties and boat hulls. Subsequent survey work in northern Australia has been done by Marshall-Ibrahim (1981) and Brearley et al. (2003). On the basis of her experiences as a linguist with the Kunibidji people of central Arnhem Land, Carolyn Coleman has produced a photo-book on mangrove worms in the Ndjébbana language for school children (Coleman 1994).

Other Edible Bivalves

Indigenous communities take most of the larger species of bivalves for consumption. Meehan (1982) recorded the consumption of 55 bivalve species (under the western scientific definition of a species) belonging to 22 families by the people of the Gidjingali language group in Arnhem Land, and these numbers must be considered as minima because there are many other species in these families that would surely be gathered serendipitously in the wet season when they are thrown live on the beaches by storms. Harris et al. (1995) estimated 35 tonnes of edible bivalves being taken from the Torres Strait Protected Zone annually.

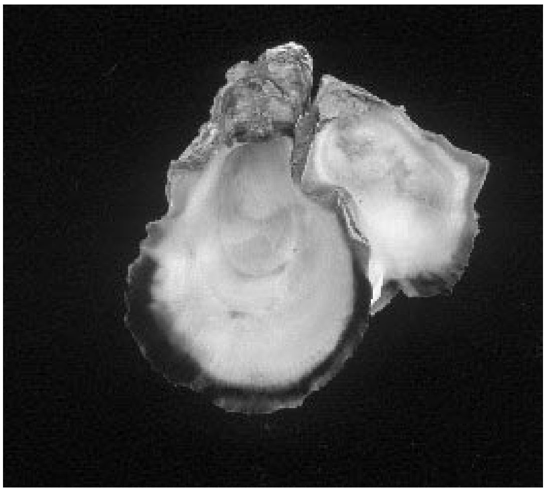
These bivalves are lightly roasted in hot coals to cause the shells to gape open, are allowed to cool and then eaten whole.

Granular ark (Anadara granosa) ***Source:*** *R Willan*



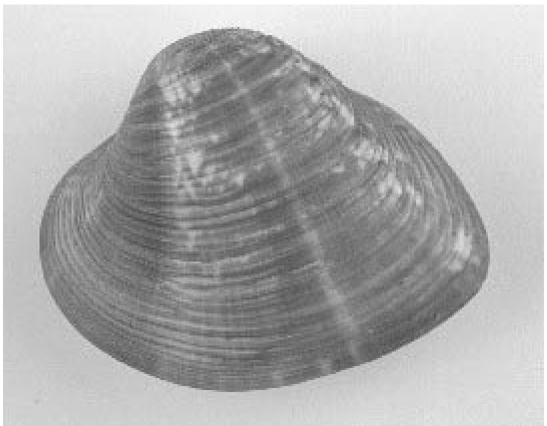
Rock oysters (family Ostreidae), and to a much lesser extent honeycomb oysters (family Gryphaeidae), represent a group of very significant bivalves ecologically. The taxonomy of edible oysters in northern Australia is very confused, and will probably require genetic fingerprinting to delimit species. Joshua Coates of Charles Darwin University in Darwin is currently investigating the biology and potential for aquaculture of one species, the hooded oyster (FAO name), putatively *Saccostrea cucullata* (which is probably the same as *Crassostrea amasa* in the literature), at Borroloola in the western Gulf of Carpentaria (GoC).

Rock oyster (Saccostrea cucullata) ***Source:*** *R Willan*



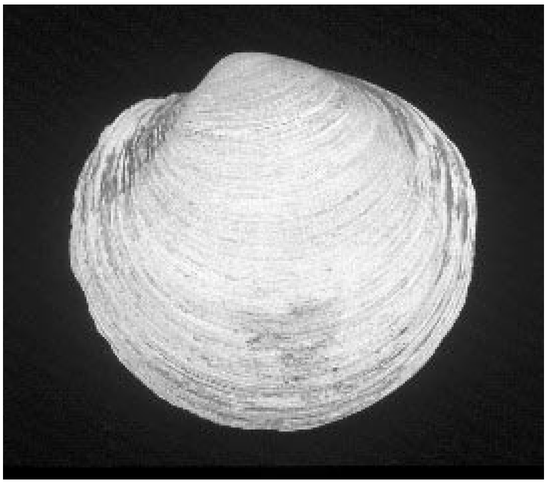
A species of 'cockle', *Marcia hiantina* (family Veneridae) (also sometimes called *Katelysia hiantina*) is the hiant Venus (FAO name). It is a major edible species throughout northern Australia. No research had been undertaken on any aspect of its biology or potential for aquaculture.

Hiant Venus (Marcia hiantina) ***Source:*** *R Willan*



Though difficult to find because it lives buried 30–90 cm deep in mangrove mud, imbao/toothless lucine (FAO name), *Anodontia* sp. (family Lucinidae), is a highly-prized edible bivalve in the NPA.

Imbao (Anodontia sp) ***Source:*** *R Willan*

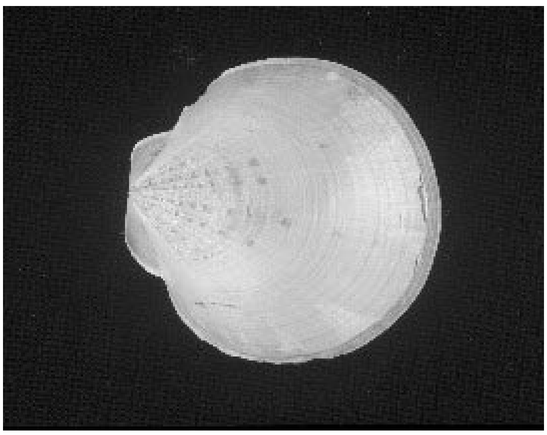


The taxonomy of these hingeless clams is being studied by Emily Glover and John Taylor at the Natural History Museum in London. Jurgenne Primavera of South-east Asian Fisheries Development Ccentre (SEAFDEC) has undertaken studies on the reproductive biology and existing fishery for Imbao at Iloilo in the Philippines.

Mud Scallop

Northern Australian populations of the mud scallop/ Asian moon scallop (FAO name) / delictae saucer scallop, *Amusium pleuronectes* (family Propeamussiidae) are accorded the subspecific name of *A. pleuronectes australiae* because the interior of the valves has relatively fewer longitudinal ribs than Asian populations.

Mud scallop (Amusium pleuronectes) ***Source:*** *R Willan*



Not large by standards of southern Australian scallops, shells of mud scallops can reach 80 mm in maximum diameter. The shell is distinctive in that the upper (left) valve is pink with narrow lines of pale grey that form a rayed pattern towards the beak, whereas the lower (right) valve is entirely white.

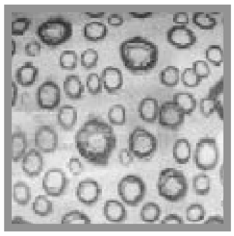
Amusium pleuronectes is fished commercially in the Philippines, Taiwan and Thailand. Data on growth, mortality and recruitment within populations in the Visayan Sea, Philippine Islands, are available in Gabrel-Llana (1988). Dredge (in press) briefly covered the Australian mud scallop in his monograph on the biology and ecology of Australian scallops. Detailed knowledge of *Amusium pleuronectes australiae* comes from research by McDuff (1975) and others undertaken as part of postgraduate degrees at James Cook University, Townsville. None of this research has been formally published. The mud scallop is hermaphrodite (unlike its temperate-water Australian counterpart the saucer scallop, *Amusium japonicum balloti*, which is dioecious), fast-growing and probably annual, and it has an extended spawning season.

Status

International and national

Of all the approximately 5000 molluscs in the NPA, only the six giant clam species are subject to international agreements or conventions. In 1983, the two largest species of giant clam, *Tridacna gigas* and *T. derasa*, were included on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list to regulate the commercial trade. In 1985, all the other species in the family worldwide were included on the list (under the so-called Appendix II) to eliminate problems in identifying products derived from the different species. Therefore, all species of giant clam are currently afforded international recognition as potentially threatened by international trade by listing under CITES. CITES is implemented in this country under the *Environment Protection and Biodiversity Conservation Act 1999*. Wu (1999) has collated information on all the molluscs listed under the CITES convention for general audiences.

No mollusc species group dealt with in this report is regulated as a Commonwealth-managed Fishery.



Queensland State Government legislation

The Queensland Fisheries Service administers the collection of marine molluscs, for commercial and recreational purposes, under the *Fisheries Act 1994* and associated *Fishery Regulation 1995*. Authorities are issued under the Act to take shells for trade or commerce. Separately, specific endorsements may be added to a Queensland boat licence under the *Fisheries Regulation 1995* to authorise the commercial collection of marine shells. Under these regulations a person is limited to taking 50 of any species per day (ie a bag limit of 50 of any species is in force). This bag limit does not apply to Aboriginal and Torres Strait Island persons, so long as their collection is in accord with culture and tradition. Trochus, oysters, pearl oysters, giant clams and scallops are administered under separate arrangements.

No horned helmet (FAO name) *Cassis cornuta* or trumpet triton (FAO name) *Charonia tritonis* can be taken live anywhere in Queensland. This total ban is the result of these gastropods preying on crown-of-thorns starfish *Acanthaster planci*, a large starfish that feeds on corals, outbreaks of which have caused devastation on the Great Barrier Reef.

At the tip of Cape York, the NPA is contiguous with the Far Northern Section of the Great Barrier Reef Marine Park (GBRMP). Therefore, GBRMP Authority regulations relating to molluscs apply. Specifically, no giant clams can be taken. Commercial collection of other molluscs is permitted in 'General' and 'Habitat Protected' Zones subject to permit. Rezoning and review of regulations applying to the entire GBRMP is nearing completion and some specific regulations may change when the new Zoning Plan comes into force in 2004 (Margie Atkinson pers. comm. 2003).

NT Government legislation

Currently one person is licensed by the Fisheries Group, NT Department of Business, Industry and Resource Development (DBIRD) to harvest trochus in NT waters for aquaculture, but this licensee is not collecting animals actively.

There is no legislation (or mandatory bag limit) in the NT relating to collection of any other mollusc for commercial purposes. Presently one person is licensed by DBIRD to undertake such activities, but nothing has been taken to date.

There is no specific legislation in the NT preventing the commercial collection of giant clams (of any size), but as no additional licences are being issued commercial collection cannot take place.

Habitat and distribution

Because the molluscs are so diverse, information on habitat and distribution can be summarised most easily in a table (Table 17.1). None of these species is migratory as an adult, so all the species occupy the same habitat for the duration of their life. Trochus, however, move from the boulder zone on the reef crest where they live as juveniles to deeper water as they mature. The lesser longbum changes its diet as it grows – from detrital feeding as a juvenile to consuming fallen leaves whole as an adult. The larva is the dispersal phase; most molluscs have a larva that feeds in the plankton and drifts for days or weeks until it encounters a habitat suitable for the adult. These species tend to have wide biogeographical ranges. Their life cycles are essentially the same as that illustrated for the giant clams (Figure 17.1). A few gastropods, like the baler shells (Volutidae), have young that hatch directly from the egg case as miniature adults and crawl away. So their possibilities for wide dispersal are non-existent and their biogeographical ranges are consequently narrow.

Table 17.1: Data on habitat and distribution for molluscan species groups in the NPA
Symbols: C = (intertidal and subtidal) coral reefs; I-WP = Indo-west Pacific Ocean; M = mangroves; NA = northern Australia; R = (intertidal and subtidal) rocky reefs; SF = intertidal sand flats; TF = subtidal sandy and muddy substrates; TP = tropical western Pacific Ocean.

SPECIES GROUP	HABITAT	LIFE CYCLE	BIOGEOGRAPHICAL RANGE
Trochus	C	Planktonic larval stage	I-WP
Longbums	M	Planktonic larval stage	I-WP,NA
Other ed. gastropods	C,M,R,SF	Non-planktonic & Planktonic larval stage	I-WP,NA,TP
Comm. val. gastro.	C,M,R,SF, TF	Non-planktonic & Planktonic larval stage	I-WP,NA,TP
Pearl oysters	C,R	Planktonic larval stage	I-WP,NA,TP
Giant clams	C,R	Planktonic larval stage	I-WP,NA,TP
Mud 'mussels'	M	Planktonic larval stage	TP
Mangrove 'worms'	M	Planktonic larval stage	I-WP,NA,TP
Other edible bivalves	C,M,R,SF	Planktonic larval stage	I-WP,NA,TP
Mud scallop	TF	Planktonic larval stage	NA

Significance of the species group in the Northern Planning Area

Basically, the molluscs are divisible into those that are commercially significant (trochus, giant clams, pearl oysters, specimen sea shells, mud scallops), those that serve as food items for Indigenous people (all categories) and those that are culturally significant (baler shells, pearl oysters).

Trochus

The trochus shell is used commercially for the manufacture of mother-of-pearl buttons and the meat of the animal (ie the foot minus the visceral mass) is consumed by Indigenous communities in Torres Strait where it is harvested. Trochus are sold to Islanders acting as middlemen on behalf of purchasers on the Australian mainland (Harris et al. 1995). Gathering trochus is a significant activity for Torres Strait Islanders. In fact, more time is spent harvesting trochus than any other fishing activity, eclipsing even the capture of dugong or sea turtles, or crayfish (Harris et al. 1995).

The history of the trochus fishery in northern Australia has been written by the Department of Commerce and Agriculture, Fisheries Division (1946). Nash (1985) conducted a major study on the biology of trochus and its fishery in the Great Barrier Reef region. Lee and Lynch (1997) have published a monograph on the status, hatchery practice and nutrition of trochus in northern Australia.

Longbums

The animals of *Telescopium telescopium* and *Terebralia palustris* represent dietary staples for Indigenous coastal communities throughout the NPA. Longbums are common in mangrove forests and may be collected in large numbers in a short period of time. Longbums are usually lightly roasted on hot coals, then cracked open one against another to remove the flesh, and then eaten whole. They may also be eaten uncooked, and in fact still alive, and in this state they are an efficient treatment for hangovers (Puruntatameri et al. 2001).

Other edible gastropods

Indigenous communities take most species of shelled gastropods from coastal and estuarine waters for immediate consumption. Terminology in English common names is a stumbling block to assessing what species in this category are taken and how much each contributes to the total molluscan harvest; for example the word 'Periwinkle' used by Harris et al. (1995) is incomprehensible to other researchers. Meehan (1982) recorded the consumption of 21 species (under the western scientific definition of a species) belonging to 10 families by the people of the Gidjingali language group in Arnhem Land.

Unlike southern Australia where the industry contributes more than $97 million a year, abalone (family Haliotidae) form an insignificant part of this Indigenous gastropod harvest because the four species in the NPA are uncommon and small in size. One species, however, is of some aquacultural interest; this is the Asses' Ear Abalone *Haliotis asinina*.

Indigenous people are very knowledgeable about marine habitats. They collect these gastropods by gleaning at low tide or by opportunistic collection of beach-cast specimens after storms. None of these gastropods constitutes a dietary staple. The shell is lightly roasted on hot coals then cracked open, and the flesh inside is removed with a stick or pin and then eaten whole. Harris et al. (1995) estimated 62 tonnes of edible gastropods were taken from the Torres Strait Protected Zone annually.

These gastropods, plus numerous other molluscs (including bivalves, cephalopods and scaphopods), are also collected by Indigenous people throughout the NPA to make shell necklets, necklaces and pendants, hair ornaments, pubic covers, nose ornaments, waist belts, rattles, spear-thrower discs, adzes, scrapers, knives and axes (Schall 1985). In the Cape York region, necklets are manufactured from pearly nautilus *Nautilus pompilius* (family Nautilidae, a cephalopod) and pearl oysters *Pinctada* species (family Pteriidae). Interestingly, wallaby teeth or other shells are used to drill the holes – either sharply pointed chips of the mud clam *Polymesoda erosa* or screw shells *Turritella terebra*. Necklaces are commonly composed of strings of olive shells *Oliva caldania* (Olividae) and, more rarely, tusk shells *Dentalium* species (family Dentaliidae, a scaphopod) (Schall 1985). Large shells of balers *Melo* species (family Volutidae) and false trumpets *Syrinx aruanus* (family Turbinellidae) are used as containers for water and ochres (Meehan 1982, Schall 1985), as well as for baling water out of canoes, scooping ashes, and digging wells and graves.

Commercially Valuable Gastropods

Commercially licensed collectors often specialise in just a single family and try to get a complete representation of all the known species of that family from all over the world. No commercial collector/specimen shell dealer is based in the NPA.

Specimen shell collectors take only the specimens of the commercially valuable gastropods they need from the wild so there is no bycatch associated with their activities. The animals are discarded, and the shells are cleaned and passed to shell dealers, whence they are sold on the national and (predominantly) international market as specimen sea shells where perfect ('gem' quality) specimens can command high prices (Wilson 1986). These specimens go into private collections, are exchanged, or sold on to other collectors. Presently there is one national shell show and about six state-based shell shows every year where specimens are displayed, traded and sold. Thefts of rare species have occurred from private collections in Queensland.

Pearl oysters

Economically, pearl oysters are the most valuable bivalve in Torres Strait; the oysters are collected by the Islanders and kept alive on underwater trays and are then sold to pearl farms around Thursday Island (Harris et al. 1995). There are five pearl shell hatcheries in the NPA. The pearl shells themselves have significance for Indigenous people, particularly as engraved breast plates for ceremonies and trade (Akerman & Stanton 1994).

The official history of the pearl shell industry in northern Australia has been written by the Department of Commerce and Agriculture, Fisheries Division (1946), Bach (1955) and Ganter (1994). Other books explore the human side of the industry, telling the stories of divers and crews from the bygone age of sea harvested pearls. Some comprehensive technical reports on the biology and culture of pearl oysters are publicly available (eg Gervis & Sims 1992) and Gervis (1991) has published an extensive bibliography on this topic. However, much of this detailed information specific to northern Australia is considered too commercially significant to publish by the pearling companies and is therefore not available in the scientific literature.

Giant clams

The really large giant clams cannot be moved whole so they are cut apart on the reef with a large knife and only the muscles of the animal are removed. The rest of the animal is left to decay inside its shell. Smaller specimens are collected whole.

Decimation of natural populations by poachers has spawned great interest in hatchery-reared giant clams, so there is now considerable knowledge about the biology and aquacultural potential of these species, both in Australia and overseas (Beckvar 1981, Braley 1984, Calumpong 1992, Ellis 2000). Norton and Jones (1992) have produced a useful guidebook on the anatomy and histology of *Tridacna gigas*.

Mud 'mussels'

Besides collection for consumption of the flesh, mud clam shells are used by Indigenous people as scrapers and drills (Schall 1985).

Mangrove 'worms'

Mangrove "worms" play an important role in mangrove communities (Nair & Sarasworthy 1971, Barkati & Tirmizi 1991). The large species of teredos are eaten raw by Indigenous people after they have been chopped from branches, stems and roots of mangrove trees. The worm is placed in the mouth head-first, the fingers are then run down the body to squeeze the digested wood out, and finally the head is bitten off and discarded. Teredos have a similar taste to rock oysters. The small species are boiled for 10 to 15 minutes to make a soup that is taken for coughs, colds and congestion, and by nursing mothers to increase milk production (Puruntatameri 2001).

Other edible bivalves

Among these bivalves, four species groups constitute the most significant in terms of densities harvested: ark shells, oysters, Venus shells and imbao. The significance and state of knowledge of each is summarised in the following paragraphs.

Members of the family Arcidae (ark shells/'cockles') are collected from coastal and estuarine mud- and sand-flats at low tide. The principal species is the granular ark (FAO name)/knobbed 'cockle' *Anadara granosa* (Arcidae), which is known locally as akul in Torres Strait. Historically, *A. granosa* was a dietary staple of indigenous people, as evidenced by the extensive, almost monospecific, shell middens throughout the NPA. Today akul is sold by the Indigenous people of Torres Strait to their neighbours on the Australian and Papua New Guinea mainlands. There is considerable research published overseas on *A. granosa* (eg Broom 1985), but none is specific to northern Australia. **Mud scallop**

In the NPA, the Mud Scallop is the one species of commercially exploitable scallop that occurs in the same habitats as prawns and forms part of the bycatch of the Northern Prawn Fishery and Torres Strait Prawn Fishery; in fact it is the only mollusc that can legally be retained as a byproduct of these fisheries.

In the NPA, mud scallops enter the commercial fish market in one of two products; either frozen whole inside their shell, or the animals are "shucked" so that muscles and gonads are removed from the shell, and they are frozen and sold.

Impacts/threats

Trochus

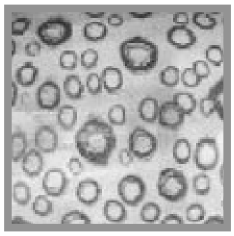
Trochus are subject to small-scale commercial (artisanal) fisheries and are either chronically overfished or comprise "boom-bust fisheries" throughout their range (Bour 1992, Foale & Day 1997, Foale 2000). The larval duration of Trochus is quite short; the larvae can survive for about three days in the plankton until they run out of food (they live entirely off the yolk they inherit from the egg), and must settle and metamorphose (Helsinga 1981). They probably disperse on a scale of hundreds of metres to tens of kilometres, depending on current regimes, bottom topography, and a number of other factors. Therefore populations of trochus, once overexploited, cannot recover quickly, that is they are not resilient to sustained harvesting pressure. Besides over-collection, another possible threat would be sustained disturbance of boulders in the intertidal zone by Indigenous gleaners. The juveniles settle out of the plankton in the intertidal zone and grow under coral slabs. They are killed by desiccation if the coral slabs are overturned and not replaced carefully.

Longbums

Longbums constitute dietary staples for some resident communities and itinerant indigenous people across northern Australia, but others distain them because of their bright green flesh (Meehan 1982). Nothing is known about the duration of the free-drifting larval stage of any longbum, but Houbrick (1991) inferred a long duration in the plankton. No research has been conducted on growth rates, longevity of adults, or resilience to harvesting of longbums. Using longbums as an example, Rik Buckworth of the NT Fisheries Research has prepared a draft strategy for management of such 'data-less' fisheries (Buckworth 1995). longbum populations are potentially threatened by destruction of their mangrove habitats, either naturally by cyclones, or artificially by human reclamation or pollution. Another threat is human ignorance and indifference. This is common across this species group and education about the significance of molluscs in the NPA is needed.

Other edible gastropods

Some general observations emanating from Meehan's (1982) study in Arnhem Land, which have been summarised by Frankiel (1991), are: (a) shellfish are regularly collected by indigenous people (on over half the days of the year); (b) shellfish are collected by a wide variety of people, especially those needing to look after young children who cannot go on longer or more strenuous foraging trips; (c) shellfish can be collected



efficiently: within about two hours women can collect all the shellfish they need, and so have time for other activities; (d) shellfish are reliable, potentially available at all times of the year, provide a guaranteed source of food, where hunting has a greater risk of failure. Juveniles in this species group are not returned to the water. Most species have free-drifting larvae with a long duration in the plankton, but baler shells (Volutidae) have crawl-away juveniles with very limited opportunities for wide dispersal. Populations of these gastropods living in mangrove forests are potentially threatened by habitat destruction, either naturally by cyclones, or artificially by human reclamation or pollution.

Commercially valuable gastropods

Most species of commercially valuable gastropod have free-drifting larvae with a long duration in the plankton, but all baler shells/volutes (family Volutidae) have crawl-away juveniles with very limited opportunities for wide dispersal. Two species groups in this category are potentially threatened: (a) baler shells/volutes, which are targeted both by shell collectors have crawl-away young (therefore limited powers of dispersal). These species are *Volutoconus bednalli*, *V. grossi*, *Cymbiola cymbiola*, *C. flavicans*, *C. sophia*, *C. pulchra craecenta*, *C. rutila*, *Amoria turneri*, *A. damonii ludbrookae*, *A. maculata*, *A. volva*, *Melo* spp.; (b) green cowrie (*Cypraea xanthodon*), a long-range Australia endemic that extends from the GoC and down the eastern Australia coastline (but not the Great Barrier Reef) to northern New South Wales. It has planktonic larvae. Shell collectors operate under self-imposed codes of ethics to return juveniles to the habitat and to replace rocks/coral slabs. Because juvenile shells or 'imperfect' specimens are unsaleable they are not taken by collectors.

Neither of the endemic molluscan species with geographic ranges entirely within the NPA (*Pyrene morrisoni* and *Theora nasuta*) are sold on the commercial shell market. Their shells are small, they are not part of the most sought-after families – indeed the latter is a very small transparent featureless bivalve – and they cannot be obtained reliably.

Pearl oysters

Accessible intertidal populations of the pearl oyster *Pinctada maxima* were probably harvested to near extinction in the NPA many years ago. The same is true for subtidal populations. Clearly, the annual dry season harvest that culminated in 1937 with 4000–5000 tons was too much for these natural beds to survive and too much for the market to bear (Anon 1938, Macgregor 1940). Such massive over-exploitation forced the pearl industry to change from sea harvesting to a cultured pearl industry using captive pearl oysters. Pearl oysters are now routinely implanted with nuclei for pearls as many as four times over.

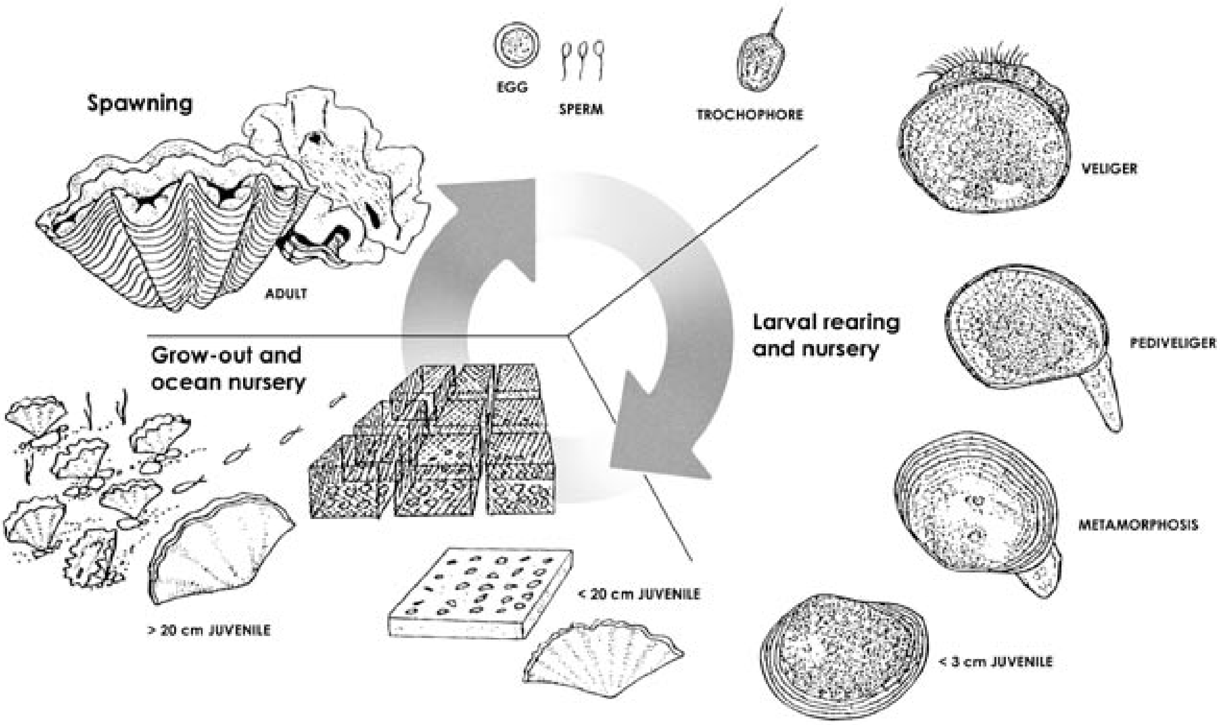
The pearl oyster is now extensively under aquaculture in the NPA with five leases currently operating. *Pinctada maxima* has free-drifting larvae with a long duration in the plankton. Threats to the pearl industry are introduced marine pests and diseases, and interference in genetic integrity of natural populations through accidental crossing with strains selected for aquaculture. Sporadic mass mortality of pearl oyster spat does occur in hatcheries, but the causes are unknown (Alder & Braley 1989).

Giant clams

Large giant clams (*Tridacna gigas*) represent major icons for the dive tourism industry. Small, hatchery-reared clams, particularly *Tridacna squamosa* with its colourful animal and fluted scales on the shell, are grown from hatchery-raised spat for the aquarium trade. The biology of giant clams has been studied extensively. All species have free-drifting larvae with a long duration in the plankton. Figure 17.1 summarises the life cycle of giant clams and techniques for rearing them in culture. Juvenile giant clams living in the intertidal and shallow subtidal habitats are vulnerable to collection for food. The absence of large giant clams on reefs today is testimony to poaching in the past. Queensland has legislation to prevent the collection of giant clams, but there is presently no similar legislation in the NT. For precautionary purposes and to minimise cross-border trade in giant clams, legislation preventing the collection of all giant clams should be introduced in the NT to match that enacted in Queensland.

Sporadic, mass mortality of giant clams affecting up to 54% of individuals has occurred in wild giant clam populations in northern Australia (Alder & Braley 1898). These deaths were caused by an unidentified unicellular organism.

Figure 17.1: The life cycle of giant clams and methods of rearing in culture (after Calumpong 1992)



Mud 'mussels'

Coleman et al. (2003) noted that Mud Mussels (as 'mussels', which they misidentified as true Mytilidae) were the most prominent non-fish group numerically in the Indigenous catch in northern Australia. They recorded a total catch of 586 459 mud mussels being taken in one year and this figure must be an underestimate. Juveniles are not returned to the water. Populations of these bivalves living in mangrove forests are potentially threatened by habitat destruction, either naturally by cyclones, or artificially by human reclamation or pollution.

Mangrove 'worms'

Coleman et al. (2003) recorded 14 361 mangrove "worms" (which they mistook for annelid worms) being taken by indigenous people in northern Australia in one year. This figure must be an underestimate. Most of the information on biology available for teredos has come through attempts to prevent attacks on wooden ships and wharves. Adults do disperse widely inside drifting logs. Species in the genera *Nausitora* and *Bankia*, which are largely found in estuarine habitats, retain the larvae in a special brood pouch in the body of the female until they are ready to settle. Species that have been studied have free-drifting larvae with a long duration in the plankton. Therefore, they do not have extensive ranges. By contrast, species of *Lyrodus* and *Teredo*, which live in oceanic habitats, generally have free-drifting larvae with a long duration in the plankton. *Teredo poculifer* is one notable exception, but it is a brackish water species found well up the rivers of northern Queensland. As far as is known, all species of teredos reach sexual maturity within a short time after penetrating the wood. Turner (1966) cites times as short as eight weeks.

Other edible bivalves

Combining figures for 'Bivalves other' and 'oysters' supplied by Coleman et al. (2003), one arrives at a figure of 346 849 individuals being taken live by indigenous people in northern Australia in one year. This figure must be an underestimate. Juveniles are not returned to the water. Meehan (1982) found bivalves comprised 98% of all molluscs taken by the Anbarra community in Arnhem Land over a year with an estimated combined weight of 6503 kg. Virtually all species have free-drifting larvae with a long duration in the plankton. Populations of these gastropods living in mangrove forests are potentially threatened by habitat destruction, either naturally by cyclones, or artificially by human reclamation or pollution.

Mud scallop

Mud scallops are taken in the bycatch of the prawn fishery from around Melville Island to west of Karumba and in an area around Karumba. Catch data for mud scallops available for the Torres Strait Prawn Fishery for the last four years are highly variable: 1999 = 1855 kg; 2000 = 35 kg; 2001 = 3310.25 kg; 2002 = 1060 kg. Such variability probably represents inaccurate record-keeping for this fishery rather than a decline in stock availability. Catch data for mud scallops from the Northern Prawn Fishery were not available at the time of writing this report.

Information gaps

Levels of scientific knowledge about molluscs in the NPA vary greatly: from well-known for trochus, pearl oysters and giant clams to nil for most other species, particularly those that are taken for human use. It is very clear that enormous numbers of shellfish are taken by Indigenous people for consumption and other purposes. For instance, Meehan (1982) estimated the total weight of shellfish collected for consumption by just one community in Arnhem Land in a single year was 7300 kg, a quantity representing about 234 000 individuals. So Coleman et al.'s (2003) more recent figure of approximately 1.1 million molluscs (as compared to a total of 990 000 for all finfish) being taken annually across northern Australia by indigenous fishers must be regarded as a significant underestimate. This impression is reinforced because the survey technique used by Coleman and co-workers was semi-quantitative, because some communities did not participate in their survey (and no correction factors were applied), and also because the status of mangrove "worms" as bivalve molluscs was not appreciated in that study, so they were not included in the total for molluscs. There are no quantitative data on molluscs taken for other traditional purposes like necklaces, implements, etc. There are no data on molluscs being taken for the specimen sea shell market. Indeed, the population densities and levels of exploitation of molluscs are really not known anywhere in the NPA. Therefore, it is impossible to decide if present levels of exploitation are higher than in the past and are now too high or whether stocks are being depleted, either locally or more generally.

Similarly, there is little or no scientific information on aspects of the life cycle of most molluscan species in the NPA, so the resilience of their populations to sustained collection cannot be known either. Populations of gastropods that have young that develop inside their egg capsules and crawl away will be least resilient because no (or negligible) repopulation can occur. As an example, the yellow baler *Cymbiola flavicans* is known to suffer from local extinctions. Although these species with direct developing young constitute the minority of gastropods (family Volutidae), they are potentially severely threatened because they are targeted by both indigenous people for food and shell collectors for their shells. From a conservation standpoint, the status of these gastropods needs to be surveyed.

Despite the low level of present day exploitation, the numbers of giant giant clams remaining in the NPA is not known, even though it is an iconic species.

Given that the two species of tiger prawns in the Northern Prawn Fishery are currently deemed to be over-fished (Bureau of Rural Sciences 2003), it is timely to consider the stocks and status of other (non-commercial) invertebrate species such as the mud scallop. The effects of benthic trawling on other invertebrates living in the same habitats are unknown. No studies have compared invertebrate densities between unfished (should they exist) and fished sites. Neither the Northern Prawn Fishery nor the Torres Strait Prawn Fishery have accurate species-level data on composition of invertebrate bycatch, let alone information on survival of invertebrate bycatch when it is returned to the sea. Many molluscs, particularly nudibranchs, are unlikely to survive capture in a prawn trawl.

Introduction of pest species as fouling on ships' hulls, in ballast water and by accidental translocation, especially through poor aquaculture practices, poses an enormous threat to commerce, recreation and natural habitats in the NPA. The incursion of black-striped 'mussels' *Mytilopsis sallei* in Darwin in 1999 and Asian green mussels *Perna viridis* in Cairns in 2001 demonstrate the vulnerability of ports in northern Australia to the establishment of marine pests. It cost $2.5 million dollars to eradicate the former from Australia (Willan et al. 2000) and there is an ongoing cost associated with monitoring, but this is good insurance.

The ports at Gove, Bing Bong, Karumba and Weipa all handle international shipping and so potentially could be sites for entry of exotic marine pests. All except Bing Bong have already been surveyed for marine pests within the last five years, with none being found. Fixed monitoring sites, like those currently operated by NT Fisheries at Gove, need to be established at these other ports. There is no knowledge of the natural molluscan diversity at any of the secondary ports in the NPA with domestic trade or their status with respect to marine pests and these gaps need to be filled urgently.

The case of one species, presently considered a serious marine pest in Australian waters, merits special consideration. The Asian green mussel *Perna viridis* is the subject of an intensive and highly productive aquaculture industry in Asia where farms produce up to 8 kg per metre of rope, which works out to 150 tons per hectare in a five month period (Adan 2000). Doubtless this productivity could be duplicated in northern Australia. But the risk of this species escaping from aquaculture facilities and disrupting natural habitats may be too great. This same species of mussel has recently become established in the Caribbean Sea and it is already causing problems there such as blocking the water intake pipes for the nuclear power station at Tampa in Florida (Ingrao et al. 2001).

The activities of shell collectors in the NPA have never been quantified, as they have in other areas (eg, the Great Barrier Reef) (Barnett 1988). One assumes the levels of activity are not significant, because the NT has not passed any legislation relating to the specimen sea shell trade as Queensland has done.

Key references and current research

Ricky Gimin and Tony Griffiths of Charles Darwin University in collaboration with Ray Hall of the Maningrida Community are currently investigating feeding and the population dynamics of *Polymesoda erosa*.

Joshua Coates of Charles Darwin University is currently investigating the biology and potential for aquaculture of the hooded oyster at Borroloola in the western GoC.

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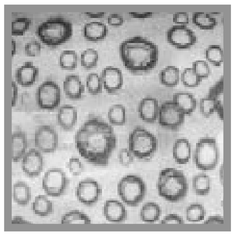

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18. Squid

Loligopealei squid eggs ***Source:*** *J Forsythe, National Resource Centre for Cephalopods, Texas, USA*

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Species group name and description

Cephalopods include octopus, cuttlefish, nautilus and squid. Squid are the most abundant of the cephalopods globally. Squid, order Teuthoidea, are subdivided into two suborders: Myopsida which have skin covering their eyes and occur mainly in inshore waters; and Oegopsida which occur in oceanic waters with eyes that do not have this covering of skin. The most frequently encountered squid in the Northern Planning Area (NPA) belong to the myopsid family Loliginidae (Figure 18.1).

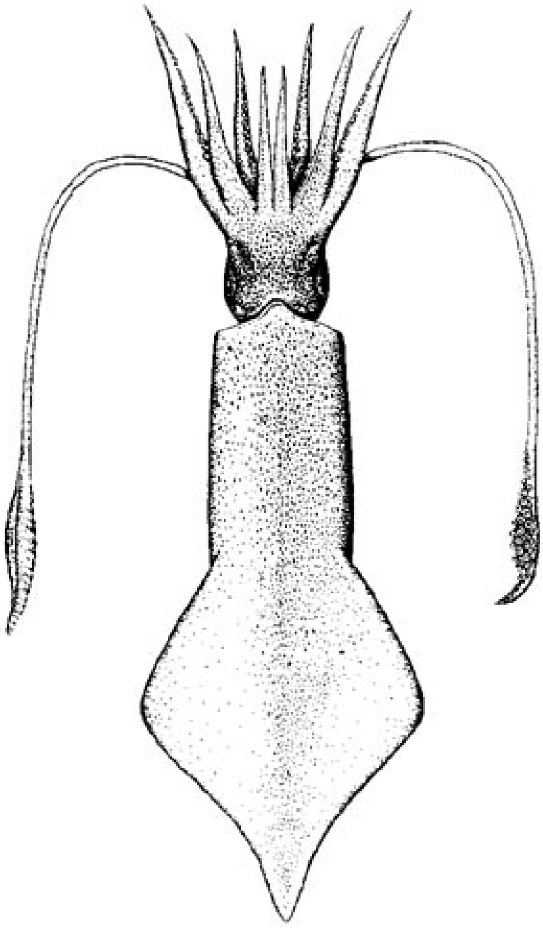
This chapter should be cited as:
Dunning, M & Willan, R (2004). Squid. In: National Oceans Office. Description of Key Species Groups in the Northern Planning Area. National Oceans Office, Hobart, Australia.

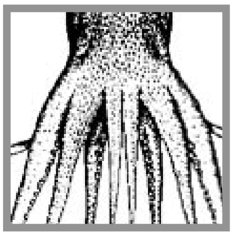
The six squid species commonly caught by commercial prawn trawlers in continental shelf waters of the NPA are:

- slender squid, unnamed species *Photololigo* sp 4 of Yeatman, 1993 (about 320 mm mantle length*)
- broad squid *Photololigo etheridgei* (Berry, 1918) (about 165mm*)
- unnamed species *Photololigo* sp. 1 (about 160 mm*) and sp. 2 (~185 mm*) of Yeatman, 1993 (P. sp.1 reported west of about 136°E only)
- northern calamary or bigfin reef squid *Sepioteuthis lessoniana* Lesson, 1830 (about 240 mm*)
- bay squid *Loliolus noctiluca* Lu, Roper & Tait, 1985 (about 65 mm*).

(*maximum body size reported in the NPA)

Figure 18.1: *Slender squid (Photololigo sp. 4), a common commercially harvested squid from northern Australia*
Source: *from Yeatman, 1993*





Because of their size, all but the bay squid are retained for commercial trade on the domestic and export seafood markets while bay squid (which reaches a maximum of about 10 cm body length) would typically be discarded as bycatch.

The squid fauna of the shallow continental shelf in the NPA also includes several smaller squid species (family Sepiolidae – bobtail squid *Euprymna* cf. *tasmanica* of Norman & Lu, 1997; family Sepiadariidae – tropical bottletail squid *Sepiadarium kochi* Steenstrup, 1881), and one arrow squid species (family Ommastrephidae – *Todarodes pacificus pusillus* Dunning, 1988). It is likely that the two-tone pygmy squid (family Idiosepiidae – *Idiosepius pygmaeus*) also occurs in shallow coastal waters in this region (Lu & Phillips 1985, Dunning 1988, Dunning et al. 1994, Dunning et al. 1998, Norman 2000).

The presence of squid in trawl catches from research surveys of the southeast Gulf of Carpentaria (GoC) in 1963–64 and Torres Strait in 1988 was noted by Rainer and Munro (1982) and Harris and Poiner (1990) without more detailed consideration of the taxa involved. The same was true of the cursory surveys of the Arafura Sea region by CSIRO in the early 1980s (Okera & Gunn 1986). Yeatman (1993) identified broad squid and slender squid from the commercial prawn trawl fishery area in eastern Torres Strait.

There are no reports of the squid fauna of deeper continental shelf waters in the Arafura Sea north of Arnhem Land and in eastern Torres Strait. A suite of oceanic Coral Sea species are likely to occur in the area around Murray Island in eastern Torres Strait.

Status

Squid are not listed as endangered, threatened, protected or vulnerable under any international, Commonwealth, Queensland or Northern Territory (NT) legislation. No assessments of the status of populations of any squid species in the NPA have been undertaken.

While the species differ in distribution and relative abundance, none can be considered rare and some are almost ubiquitous in trawl catches in the NPA. Some species appear to be endemic to the Indo-Australian archipelago (ie Indonesia–New Guinea-Australia) (eg *Photololigo* sp. 2; broad squid), while others have a broader Indo-West Pacific distribution (eg two-tone pygmy squid, northern calamary and the arrow squid *Todarodes pacificus pusillus*).

Habitat and distribution

The suite of squid species occurring in the NPA inhabits almost all of the marine environments represented from inshore mangrove and shallow seagrass habitats (eg bottle squid, two-tone pygmy squid) to coral reefs (eg. northern calamary) and deeper mid-shelf waters greater than 50 m (eg *Photololigo* spp. and *Todarodes*). Given that they are visual predators, it is unlikely that squid are abundant in highly turbid mud environments and, with the exception of *Loliolus* which tolerates salinities as low as 17 parts per thousand, they are not found in estuaries.

While the smaller species are likely to remain associated with the bottom throughout their life cycles and may be solitary or occur in small groups, the larger species are nektonic (swimming) schooling species, typically associated with the bottom during the day but distributed throughout the water column and into surface waters at night. They may travel considerable distances to feed and perhaps to aggregate at spawning sites (reported for some similar members of the Loliginidae family [loliginid squid] elsewhere but not confirmed from northern Australia).

The bay squid is caught in nearshore coastal and occasionally estuarine waters only. This species has been reported from the south-eastern GoC in depths of 3.5 to 7 m (Lu et al. 1985).

Slender squid, the most abundant species in commercial prawn trawl catches, has been caught throughout the fishing grounds in the GoC in depths of 7 to 63 m while broad squid were caught at depths of 7 to 52 m typically closer to the coast. *Photololigo* sp. 2 was more abundant between 12° and 14°S during surveys in the Gulf in 1990 and 1991. This species was trawled in depths of 10.4 to 63 m (Dunning et al. 1994).

The arrow squid, *Todarodes pacificus pusillus*, has been reported only from the Timor Sea in the far north-west of the NPA in 78 m (Dunning 1988).

The northern calamary is typically encountered in coastal waters associated with coral reefs and seagrass areas (Norman 2000).

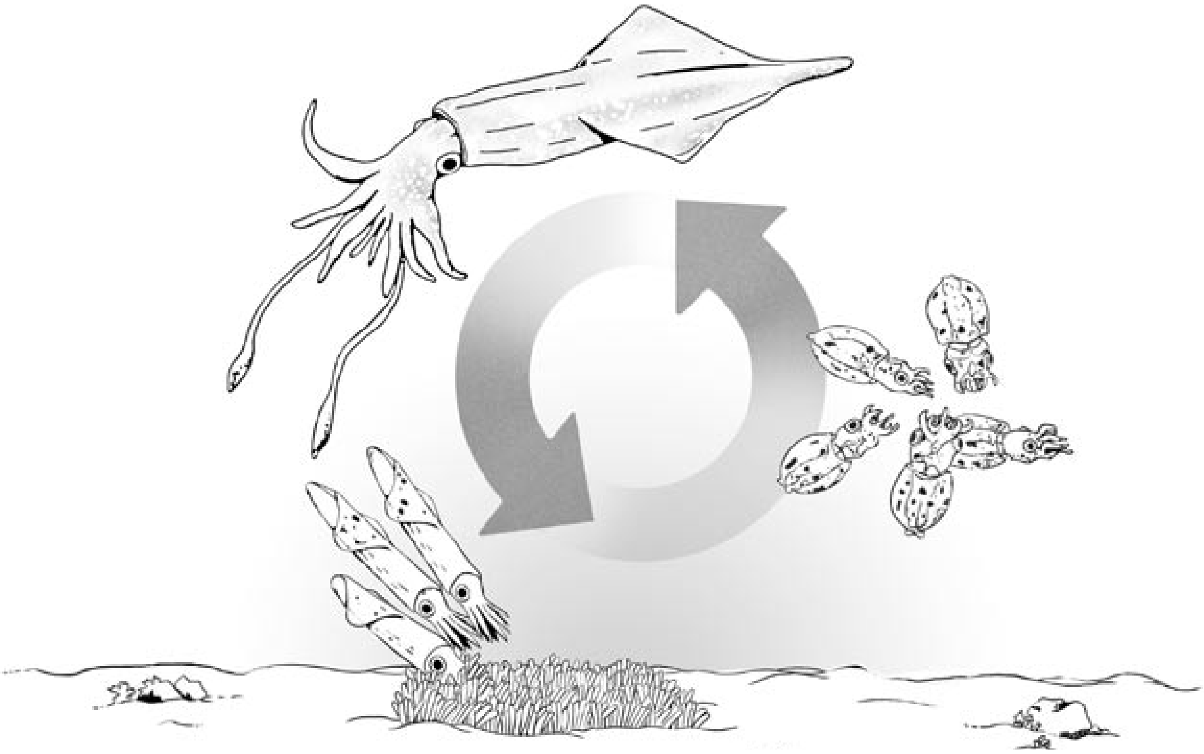
Little is known about the detailed biology and life cycle of the squid species occurring in the NPA.

A growing number of studies have been undertaken on the biology of cool and warm temperate loliginid squids of commercial importance and general life history patterns are known (eg Augustyn 1990, Boyle et al. 1995). However our knowledge of tropical species is poor and indeed some fundamental differences in life history details have been reported between tropical and temperate squids. Based on captive growth studies (eg., Jackson 1990a, b), it is likely that growth rates

in the wild are significantly higher and life spans shorter in tropical species. Species diversity among loliginids is higher in tropical areas with significant overlaps in distributions, whereas in temperate waters often a single species dominates.

Studies to date have shown that, for the few species studied, tropical loliginid squid grow rapidly, are short-lived (a few months), and do not survive beyond a single spawning season. Cannibalism has been reported in some squid species elsewhere, resulting in schools typically containing squid of similar size (Lipinski 1987). Clusters of finger-like egg capsules each containing from 10 large (northern calamary) to more than 100 small eggs (broad squid and probably all *Photololigo* species) are laid attached to the seabed, sometimes resulting from spawning aggregations (Sunilkumar Mohamed 1993). Hatchlings of northern calamary (the only tropical squid species studied) appear about 15 to 30 days later (dependent on ambient water temperature) as miniature replicas of the adults (Segawa 1987). The life cycle of a typical loliginid is shown in Figure 18.2.

Figure 18.2: *The life cycle of a typical loliginid squid*

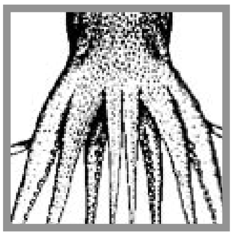


Tropical loliginid species appear to have extended spawning seasons and hence a complex population structure consisting of multiple age and size classes (Chotiyaputta 1990). Significant seasonal migrations are suspected for temperate loliginids, apparently correlated with spawning and water temperature/salinity changes (Roberts & Sauer 1994). Whether such migrations also occur for all squid species in the more homogeneous environment of the tropics remains unknown.

Slender squid were targeted by commercial prawn trawlers at a spawning aggregation off the Western Australian Kimberley coast in 1995 for an extended period (several weeks). The harvest of several hundred tonnes from a small location suggests that these squid are aggregating from a much larger area and spawning migration is likely to be a characteristic of this species.

The life history of the other squid groups in tropical waters is even less well understood than for the loliginids. In temperate waters, Bobtail and bottletail together with pygmy squids (Sepiolidae, Sepiadariidae and Idiosepiidae) typically lay a small number of medium-sized, gelatinous eggs attached to shells, coral and other substrates, similar to cuttlefish (Norman 2000). While these squid may lay perhaps 20–50 eggs in a clutch, arrow squid of the family Ommastrephidae typically lay semipelagic egg masses containing hundreds to thousands of small eggs which drift with the currents, rather than attached eggs.

Squid are important elements of food webs in temperate ecosystems, representing both predators and prey (Morejohn et al. 1978) and loliginid squid perhaps occupy similar positions in the food chain of tropical waters to smaller trevallies and mackerels.



Crustaceans such as penaeid prawns are common in the diets of smaller loliginid squids elsewhere; larger squid add fish to their diets. Sepiolid squids are probably more sedentary and perhaps occupy similar positions in the ecosystem to benthic octopuses and cuttlefish. Cephalopods including the smaller sepiolid squids are eaten by whaler sharks off northern Australia (Stevens & McLoughlin 1991).

No studies of the age and growth of squid from within the NPA have been reported. Jackson (1988) investigated the growth of the pygmy squid *Idiosepius pygmaeus* off Townsville, Queensland. He found that this small species lives for less than three months. A preliminary assessment of the age of broad squid and slender squid from samples from the Queensland east coast was reported by Dunning et al. (2000). The oldest broad squid examined were less than 140 days old and the oldest slender squid 220 days old. This preliminary analysis showed high variability in size at age for both species in east coast waters, and indicated that size may not be a reliable indicator of age for these squid.

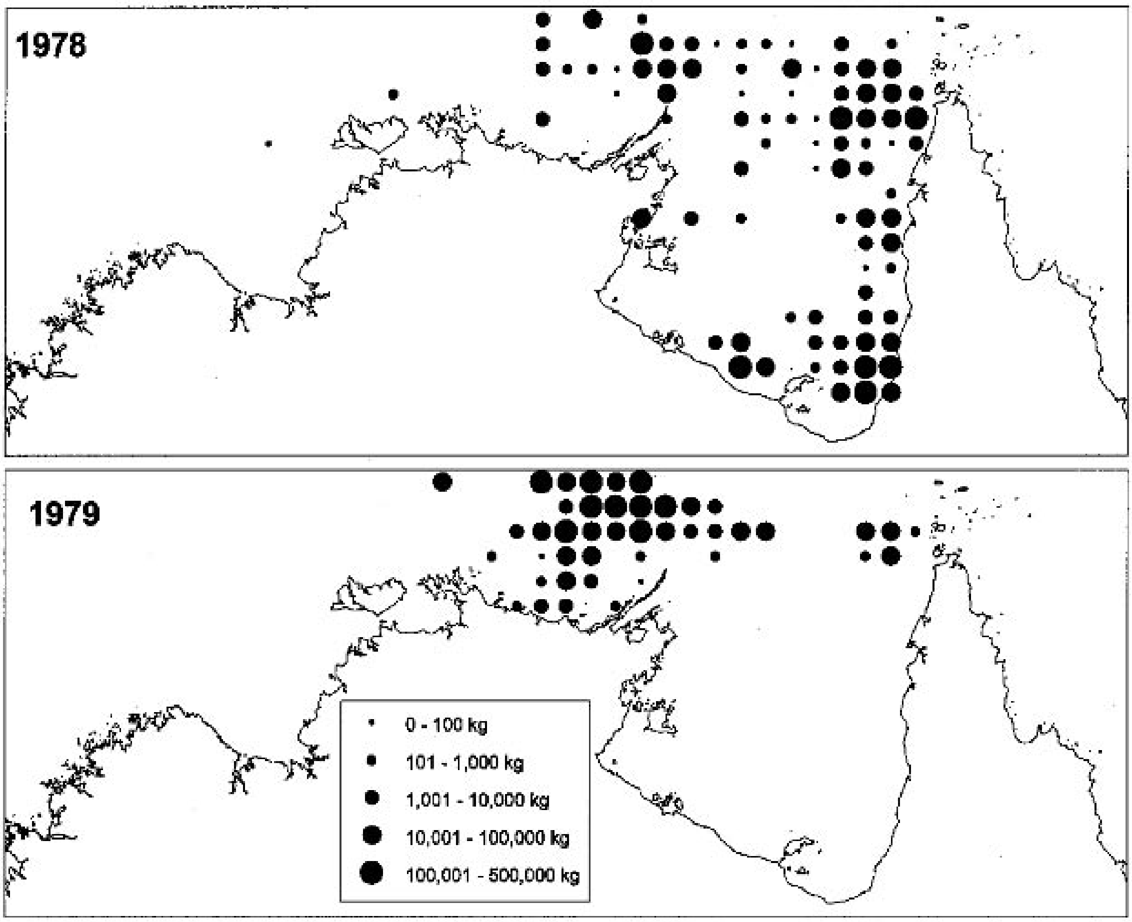
The population structure of the squid species in the NPA remains unknown. A genetic study undertaken in the early 1990s was unable to distinguish differences indicative of discrete populations in samples of commercially harvested *Photololigo* species collected in the Timor Sea, throughout the GoC and from Torres Strait (Yeatman 1993).

Significance of the species group in the Northern Planning Area

Squid catches in the NPA are almost entirely taken by commercial fishing operations, either as a target species or as bycatch.

Squid have historically represented an important by-product and occasionally target species in northern Australian prawn fisheries. They were targeted by foreign trawlers in the Arafura Sea/GoC in the late 1970s/early 1980s (Edwards 1983). Squid represented the major component of Taiwanese trawl catches in the Arafura Sea region, particularly during spring (August to November). Squid represented 24.9% of the total trawl catch in 1978 and reported landings totalled about 2,600 tonnes from the region in 1979 (Figure 18.3).

Figure 18.3: *Reported Taiwanese squid catches from demersal trawling* ***Source:*** *Demersal Fish Research Center 1979,1980*



18. Squid

Recent annual catches of loliginid squid by the domestic prawn trawl fleet are shown in Figure 18.4. The Northern Prawn Fishery (NPF) logbooks have only required the reporting of squid byproduct since implementation of the management plan in February 1995. Catch records prior to that date were voluntarily reported and what proportion of the actual retained catch they represent through time is unknown (Manson 1996). The location of higher catch areas has been variable between years (Figure 18.5).

Figure 18.4: *Reported domestic squid catches from the Northern Prawn Fishery area* ***Source:*** *AFS/AFMA logbooks; Perdrau & Garvey 2003*

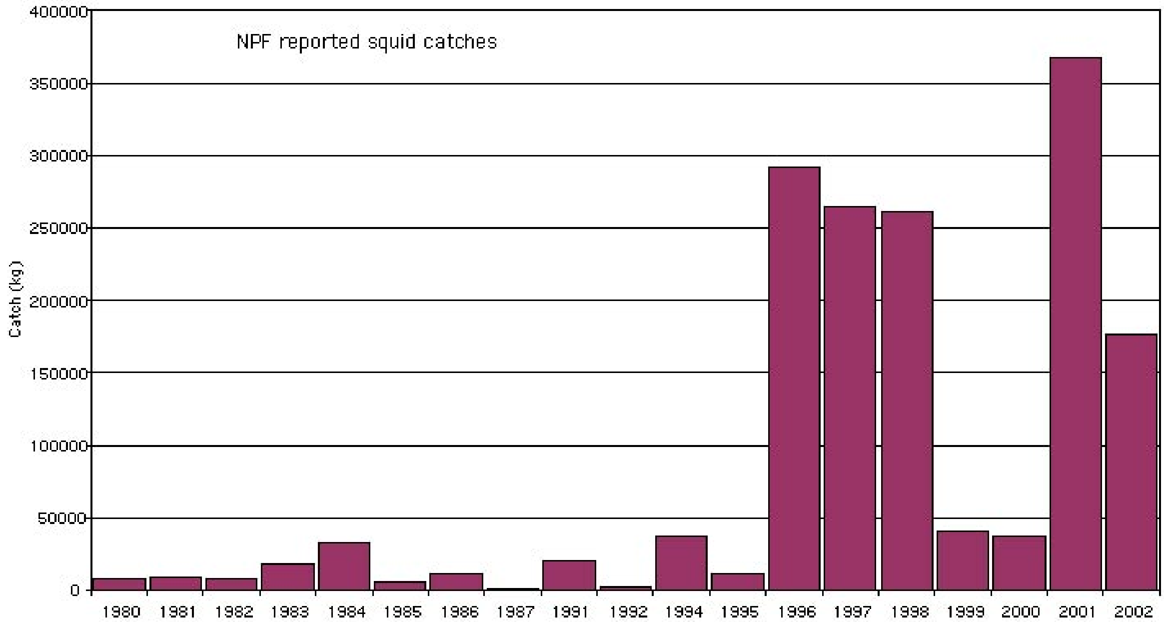
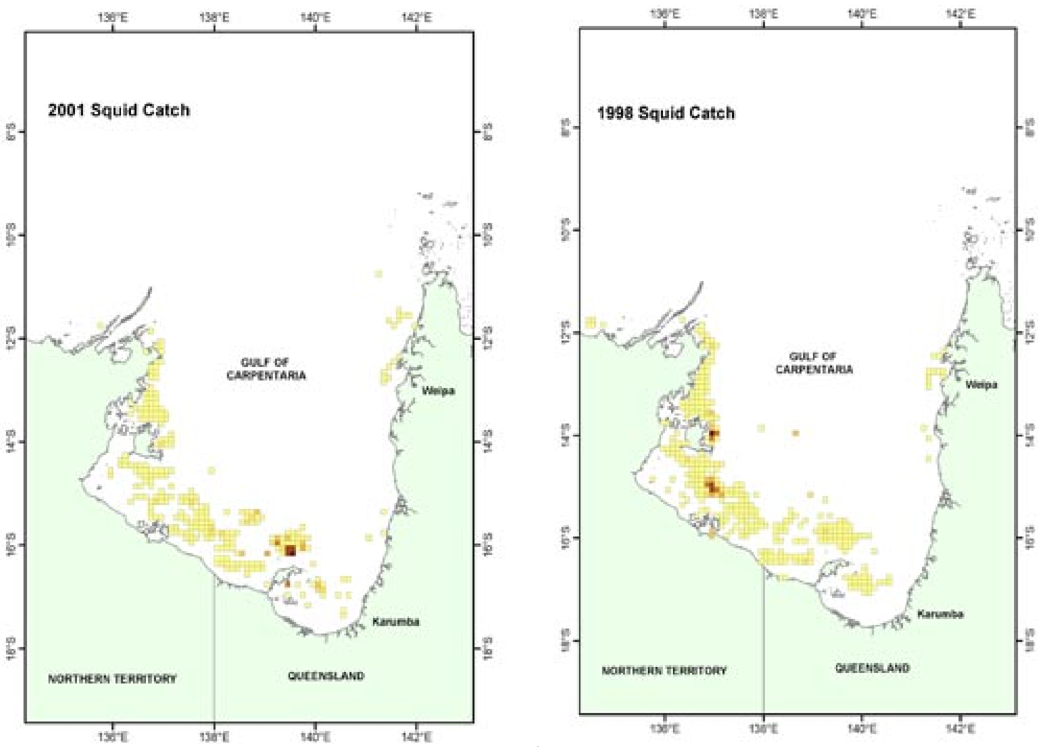
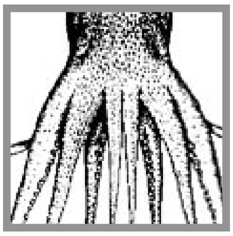


Figure 18.5: *Spatial distribution of reported domestic squid catches from the Northern Prawn Fishery area, 1998 and 2001 Darker colours represent higher catch levels* ***Source:*** *AFMA logbooks*





Impacts/threats

Harvesting of squid using demersal trawls (nets that are trawled along the seabed) in the NPF represents a potential threat to populations, especially of loliginid squid, in the area if it continues without regard for the susceptibility of squid (including egg masses) to capture and mortality, and their biological capacity to recover. Gaps in current knowledge of their biology and distribution include:

- loliginid squid lay eggs attached to the seabed – location of spawning grounds inadequately known, preferred substrate for egg laying unknown, timing of peak spawning activity at a local level unknown, impacts of trawling on the substrate and survival of squid eggs unknown
- spawning stock – recruitment relationships unknown; recruitment strength of succeeding cohorts poorly predicted by spawning stock size except at very low or very high levels in the Southwest Atlantic squid, *Loligo gahi* (Agnew et al. 2000)
- biomass available for harvesting unknown – no assessments undertaken
- squid damaged in capture by trawl are unlikely to survive after being discarded – discard quantities are currently unknown but need to be assessed to obtain a better picture of fishing mortality for any future quantitative resource assessment

Information gaps

Identification

Several abundant squid species taken in commercial fisheries in the NPA remain unnamed and undescribed. While significant preliminary taxonomic work has been undertaken (eg Yeatman 1993), more resources are required to complete publications describing these new species for the scientific community and users of the resource. Accurate identification is important as, based even on our current knowledge, species life history characteristics such as size at maturity and maximum size show considerable variation among species.

Distribution and abundance

Our knowledge of the squid faunal composition, species distributions and life history in northern Australian waters remains limited. Information has been collected opportunistically during fisheries research surveys targeting prawns and finfish, using commercial trawl gear towed often at night and, occasionally, benthic dredges primarily in the major fishing grounds in GoC. Loliginid squids are known to school close to the bottom during the day and disperse throughout the water column at night (Matsuoka et al. 1992). Hence demersal trawls need to be undertaken during daylight to catch squid efficiently.

While we have a broad understanding of the identity and relative abundance of the larger common species present in the GoC, no research effort aimed at improved understanding of squid distribution has occurred in the NPA. Only opportunistic 'snapshots' of spatial and temporal distribution, relative abundance and their life history are available.

Only a handful of isolated reports exist identifying squid (generally only to that taxon) from the Torres Strait and the Arafura Sea/Timor Sea. Systematic surveys of both the demersal and pelagic faunas using a range of sampling devices in these areas are required, to provide a baseline for monitoring any changes in biodiversity.

Squid fisheries management needs

There is a need for more detailed information on the following aspects of squid biology in the NPA for the development of specific fisheries management strategies:

Definition of spawning grounds

Since 1993, target demersal trawling for squid has been occurring on spawning grounds off the Kimberley coast and in the GoC. Loliginid squid lay egg capsules attached to the seabed, potentially vulnerable to direct physical damage from trawling and impacts on survival of eggs. Aggregating behaviour for mating and egg-laying around spawning grounds may be interrupted by trawling. Demersal trawling in known spawning grounds for loliginid squid off southern Japan and South Africa is not allowed under current management regimes there.

As a priority, research should be undertaken to confirm location of spawning grounds initially through documentation by fishers or scientific observers of occurrence of squid eggs in commercial catches and in fishery-independent surveys undertaken in the NPF.

It is possible that spawning grounds are widespread and generally located outside the major trawl grounds. However, if spawning grounds for any species are restricted to only a few areas in the NPF/NPA, additional fisheries closures (seasonal or geographic) may need to be considered as a precautionary management response.

Population (stock) discrimination

No information is available on the boundaries of the distribution of squid populations in the NPA. It is possible that stocks of the commercially important species are shared with Indonesia and PNG. Preliminary genetic studies have not shown any variability in slender or broad squid indicative of stock separation across northern Australia (Yeatman 1993), but higher resolution DNA studies may reveal details of population structure. The level of movement and migration in northern Australian squid species remains unknown.

Population age structure

Focussed studies of the age composition of the major commercially important species (slender squid and *Photololigo* sp. 2) in key areas should be undertaken to assess species-specific, geographical and seasonal variation in life span and to assist in defining major spawning periods.

Estimation of available biomass

Methods applied to temperate squid resources should be assessed for their suitability for estimation of squid population size in the NPA/NPF.

Where feasible, include squid data collection in any future NPF target species / bycatch monitoring programs, noting the need for daylight trawling to efficiently harvest squid.

Fishing methods

Development and introduction of squid-specific, 'environmentally friendly' gears (eg jigs and lift nets) to the harvesting of northern Australian squid should be encouraged, to maximize economic return (jigged squid are of much higher value on the east Asian export markets than trawled squid) and reduce risk of damage to squid egg masses.

Key references and current research

Current research

There is no currently funded research aimed at enhancing our understanding of the taxonomy, distribution, life history or trophic relationships of squid in the NPA. Collections of squid material for taxonomic study exist at various museums (Museum of Victoria, Melbourne; Queensland Museum, Brisbane; Museum and Art Gallery of the NT, Darwin).

There may be opportunities to enhance recently commenced projects investigating seagrass and other inter-reefal ecosystems in Torres Strait by incorporating studies of squid species distribution, life history and trophic interactions. Studies of benthic biodiversity of the GoC and any future NPF Integrated Target Species/ Bycatch Monitoring Program should also incorporate assessment of squid diversity and abundance.

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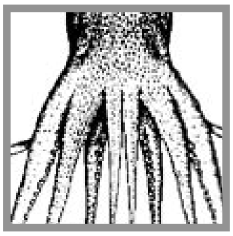

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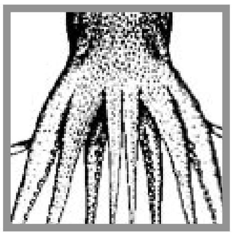

19. Prawns

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A juvenile tiger prawn among seagrass **Source:** CSIRO

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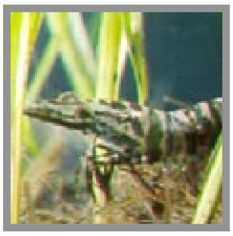
Species group name and description

Within the Northern Planning Area (NPA) commercial prawns of economic significance can be divided into four broad groups:

- tiger prawns
- banana prawns
- endeavour prawns
- king prawns

Many other prawn species are present in the NPA and most of the common ones belong to the family Penaeidae. However, these species are either small, rare or, though common, not found in quantities that would support a fishery. Their common names tend to group several species (eg coral prawns, hardback prawns). They are caught as incidental catch to the prawn fishery in the NPA and some are kept as by-product. Their distribution, habitats and biology are mostly poorly understood, as are the status of their stocks. CSIRO Marine Research has collected data on some of the species, but they have not been analysed.

These species will not be dealt with in detail in this report. They are referred to as a group and use



the name ‘non-commercial’ prawns. Strictly, this is a misnomer, as some are kept and sold. However, for this chapter, they are distinguished from the major commercial species. Their most up to date description can be found in Grey et al. (1983) and a short description of the importance of a few as fishery species can be found in Kailola et al. (1993). A list of the species is provided at the end of this section.

Tiger prawns

Brown tiger prawn, *Penaeus esculentus* Haswell, 1879

Other names: tiger prawn
FAO name: brown tiger prawn

Grooved tiger prawn, *Penaeus semisulcatus* De Haan, 1844

Other names: green tiger prawn, northern tiger prawn
FAO name : green tiger prawn

Tiger prawns are relatively large commercial prawns and are members of the family Penaeidae. They inhabit shallow and inshore waters, have a larval life phase and live to about two years old. They use sub-tidal habitats during their nursery phase and move offshore as they grow.

Brown tiger prawns are endemic to Australia. Grooved tiger prawns are found throughout the Indo-west Pacific, from southern Africa to Japan. In Australia, grooved tiger prawns are restricted to the tropics, while brown tiger prawns are found in both tropical and subtropical latitudes. Brown tiger prawns grow to about 55 mm carapace length (CL) (the carapace is the ‘head’ of the prawn) (50 mm CL = about 85 g) for females and about 47 mm CL (40 mm CL = about 50 g) for males. Grooved tiger prawns are slightly larger; females grow to about 58 mm CL (53 mm CL = 95–105 g) and males to about 47 mm CL (43 mm CL = 55–60 g).

Banana prawns

Banana prawn, *Penaeus merguiensis* De Man, 1888

Other names: white banana prawn (the name used here for clarity)
FAO name: banana prawn

Red-legged banana prawn, *Penaeus indicus* H. Milne Edwards, 1837

Other names: Indian banana prawn
FAO name: Indian white prawn

Banana prawns are relatively large commercial prawns and are members of the family Penaeidae. They inhabit shallow and inshore waters, have a larval life phase and live to about 18 months old. They use inter- and sub-tidal habitats during their nursery phase and move offshore as they grow.

Both the white and red-legged banana prawns are found throughout the Indo-west Pacific. The western range of white banana prawns is the Middle East, while their eastern range is the South China Sea and Oceania. Red-legged banana prawns extend from southern Africa to the South China Sea, New Guinea and Australia. In Australia, white banana prawns are found in both tropical and subtropical latitudes, while the red-legged banana prawn is restricted to the tropics (north of 18° latitude). White banana prawns grow to about 50 mm CL for females and about 45 mm CL for males. In Australia, the size of red-legged banana prawns is not well known. A tagging study of the population in Joseph Bonaparte Gulf in 1997–98 found that the largest female tagged prawn returned had a carapace length of 46.3 mm, while the largest male was 39.4 mm CL. The sizes are indicative only and individuals may be slightly larger.

Endeavour prawns

Blue endeavour prawn, *Metapenaeus endeavouri* Schmitt, 1926

Other names: blue tail endeavour prawn
FAO name: endeavour shrimp

Red endeavour prawn, *Metapenaeus ensis* De Haan, 1844

Other names: red tail endeavour prawn, offshore greasyback prawn
FAO name: greasyback shrimp

Endeavour prawns are relatively large commercial prawns and they are members of the family Penaeidae. They inhabit shallow and inshore waters. Blue endeavour prawns are endemic to Australia and Papua New Guinea (Gulf of Papua). Red endeavour prawns are found throughout the Indo-west Pacific, from Sri Lanka through Australasia to southern China, Japan and Oceania.

They have a larval life history and live to about two years old. In the Gulf of Carpentaria (GoC), female blue endeavour prawns grow to about 47 mm CL and males about 45 mm CL. Female red endeavour prawns grow to about 50 mm CL and males grow to about 40 mm CL. In Torres Strait, blue and red endeavour prawns are about the same size as in the GoC, with both female and male red endeavour prawns being slightly smaller than blue endeavours.

19. Prawns

King prawns

Western king prawn, *Penaeus latisulcatus* Kishinouye, 1896

Other names: blue-legged king prawn
FAO name : western king prawn

Red spot king prawn, *Penaeus longistyus* Kubo, 1943

Other names: red-spotted king prawn
FAO name : red spot king prawn

King prawns are members of the family Penaeidae. They are relatively large commercial prawns and inhabit shallow and inshore waters. Western king prawns are widely distributed in the Indo-Pacific: from southern Africa/Madagascar to Japan and Oceania. In Australia they are ubiquitous around much of the Australian coastline. Red spot king prawns are found in South-east Asian (and Australasian) waters, from Malaysia and Indonesia to the South China Sea and Oceania. In Australia they are found along the coastline of the top-half of the continent. They have a larval life history. Western king prawns live for two to four years (depending on latitude) and red spot king prawns live for 18 months to 2 years. Sizes of about 76 mm CL for females and about 50 mm CL for males have been reported for western king prawns (Kailola et al. 1993). In northern Australia, they commonly grow to 57 mm CL and 45 mm CL, respectively. Red spot king prawns of about 57 mm CL (females) 50 mm CL (males) are regularly recorded in the GoC (CSIRO Marine Research).

Other prawn species in the NPA

Penaeidae

Atypopenaeus formosus Dall, 1957
Atypopenaeus stenodactylus Stimpson, 1860
Metapenaeopsis crassissima Racek & Dall, 1965
Metapenaeopsis lamellate De Haan, 1844
Metapenaeopsis mogiensis MJ Rathburn, 1902
Metapenaeopsis novaeguineae Haswell, 1879
Metapenaeopsis palmensis Haswell, 1879
Metapenaeopsis rosea Racek & Dall, 1965
Metapenaeopsis wellsi Racek, 1968
Metapenaeus demani Roux, 1921
Metapenaeus eboracensis Racek & Dall, 1965
Metapenaeus insolitus Racek & Dall, 1965
Parapenaeopsis arafurica Racek & Dall, 1965
Parapenaeopsis cornuta Kishinouye, 1900
Parapenaeopsis sculptilis Heller, 1862
Parapenaeopsis tenella Bate, 1888
Penaeus canaliculatus Oliver, 1811 (Torres Strait)
Penaeus japonicus Bate, 1888
Penaeus marginatus Randall, 1840 (Torres Strait)
Penaeus monodon Fabricius, 1798
Trachypenaeus anchoralis Bate, 1881
Trachypenaeus curvirostris Stimpson, 1860
Trachypenaeus fulvus Dall, 1957
Trachypenaeus gonospinifer Racek & Dall, 1965
Trachypenaeus granulosus Haswell, 1879

Sicyonidae

Sicyonia cristata De Haan, 1850

Solenoceridae

Solenocera australiana Perez-Farfante & Grey, 1980

Status

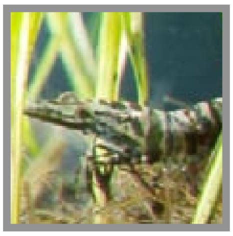
None of the commercial prawn species in the NPA is listed under international, national, Queensland or Northern Territory (NT) environmental legislation. Those measures in place arise from the management of the Northern Prawn Fishery (NPF) and the Torres Strait Prawn Fishery.

Tiger prawns

In the NPF, brown tiger prawns are considered to be over-exploited. The stock is below that needed to achieve the maximum sustainable yield (MSY). Greater yields could be achieved under prevailing environmental conditions if the stock was allowed to recover and the need to reduce fishing effort on brown tiger prawns has been recognised. NPF closure changes in 2002 (the mid-season closure was extended to close both earlier and later) has reduced the pressure on brown tiger prawns, which were traditionally fished in May and August. If effort is kept at the 2002 level, recovery of brown tiger prawn stocks to MSY is expected.

Grooved tiger prawns are considered fully-fished at current levels. Future tiger prawn assessments would benefit greatly from a fishery-independent recruitment index (integrated monitoring currently being undertaken). Rigorous management of the fishery maintains the stocks of both tiger prawn species.

The current stock assessment for the Torres Strait tiger prawn fishery which was recently reviewed by Dr David Die (Miami) indicates that tiger prawn stocks are fully exploited at current levels of fishing effort. Options for reducing latent effort (fishing that could potentially occur in the fishery above that which currently happens) in the fishery are being discussed by industry and management.



Banana prawns

The catch of banana prawns (*P. merguiensis*) is highly variable (eg 260–2230 t in the south-eastern GoC in the last 10 years) and much of the variation prior to the late 1990s can be attributed to the environment (variation in rainfall). However, since the 1990s the deviation of the observed yields from those predicted by the model based on environmental variables has increased. Recent research has identified a stock-recruitment relationship for several stocks within the GoC, using a new model that combines stock recruitment and environmental processes on a regional basis. The model is preliminary and requires further development.

Despite the variation, the mean catch of both species of banana prawns in the NPF has remained much the same over the last three decades (Table 19.1). In the NPF, the banana prawn stocks in some regions are assessed as over-fished, while others are fully exploited. The estimated MSY for each region varies from 55 t to 525 t.

The catch of red-legged banana prawns also is highly variable (262–1000 t in Joseph Bonaparte Gulf over the last 10 years). A tag-release-recapture program in 1997–98 determined population parameters for the fishery and allowed an initial assessment to be undertaken. The fishery has been assessed as fully exploited and that effort levels should not be increased from 1998 levels. The exploitation rate is lower than that for banana prawns in the GoC. The environment plays less of a role in determining the variation in the catch of this species and a stock assessment of *P. indicus* in the Joseph Bonaparte Gulf would likely show a stock-recruitment relationship for the species, as has been shown for regional stocks of *P. merguiensis* (a project to undertake a stock assessment of *P. indicus* has been proposed by CSIRO Marine Research, see Information Gaps below). The amount of fishing for red-legged banana prawns is dependent on the moon phase and catch of common banana prawns in the GoC; if catch there is low, vessels seek prawns elsewhere. In the Joseph Bonaparte Gulf, the current around the full moon (spring tides) is too strong for effective fishing.

Endeavour prawns

The endeavour prawn fishery is essentially an incidental catch to the tiger prawn fishery in the NPA. Thus, the fishery is not specifically managed, but the management practices of the tiger prawn fishery apply to it. In the NPF, the average catch of endeavour prawns during the decade 1980 to 1989 was 1406 t. Since then, the average catch seems to have declined (Table 19.1). Over the past four years, the catch has averaged 740 t.

In the GoC, a stock assessment for both blue and red endeavour prawns has been undertaken for the local populations in Albatross Bay, only. A biological reference point based on effort (boat days) was used in place of maximum sustainable yield to examine the status of the stocks. Depending on the assumed annual increase in the fishing power of NPF vessels (3% or 5%), blue endeavour prawns are considered either under-fished or over-fished, while red endeavour prawns are considered fully fished. No NPF-wide assessment of either species of endeavour prawn has been undertaken and the Albatross Bay assessment suggests that a robust assessment is required. Growth and mortality of blue endeavour prawns have been estimated at Groote Eylandt. In Torres Strait, the estimated of MSY for the blue endeavour stock is about 1000 t. This estimate was made in 1992 using survey data from the late 1980s and early 1990s. No recent stock assessment has been conducted using commercial harvest data in more complex stock assessment models (as have been used for brown tiger prawns in Torres Strait). A recent review of the tiger prawn Torres Strait Stock Assessment recommended the development of a current, comprehensive stock assessment for blue endeavour prawn stocks.

King prawns

In the NPF, logbook data do not discriminate between western and red spot king prawns. Thus, it is difficult to undertake an assessment of either species. However, the combined catch of king prawns has declined drastically since about 1990. The average catch in the decade 1980–89 was 103 t (Table 19.1). The average catch over the last four years was 6 t. One reason for this change is because they were traditionally caught in August and that month is now closed to fishing. The stocks of king prawns may be over-fished and are probably below that needed to achieve MSY, though no rigorous stock assessment has been undertaken to verify their status.

King prawns are caught as incidental catch in the tiger prawn fishery. Consequently, logbook catch data show that, in the past, king prawn catch has roughly increased and decreased with the tiger prawn catch. However, from 1991 to 2002 the logbook data show that the catch of king prawns has declined markedly, with no matching decline in tiger prawn catch or fishing effort (prior to the recent closure) (see Perdrau

& Garvey 2004). The recent NPF-wide closure during August (aimed at protecting brown tiger prawn stocks) may provide protection for the king prawn stocks as well.

King prawns are an incidental component of the tiger/endeavour fishery in Torres Strait. The king prawn catch comprise mainly red spot king (about 93% of the king catch) with western king making up the remaining 7%. The estimate of MSY for the Torres Strait king prawn stock is 180 t. This estimate was made in 1992 using survey data from the late 1980s and early 1990s. No recent stock assessment has been conducted using commercial harvest data in more complex stock assessment models (as has been undertaken recently for brown tiger prawns). The fact that it is an incidental catch makes it difficult to apply these types of stock models which are based on targeted catch and effort data.

Table 19.1: *Average catch of the dominant species groups of commercial prawns in the Northern Prawn Fishery from 1970 to 2003 (by decade) and the catch range from the Northern Prawn Fishery and Torres Strait from 1980 to present.*

	NPF average catch by decade (t)				Catch range 1980–2003 (t)	
Species	1970–1779	1980–1989	1990–1999	2000–2003	NPF	Torres Strait
Tiger prawns	1885	4237	3078	2085	1943–5751	273–965
Banana prawns	5214	3904	3863	4314	2157–7245	na
Endeavour prawns	701	1406	1056	740	411–2124	154–1500
King prawns	22	103	55	6	4–207	23–150

Habitat and distribution

Commercial prawns

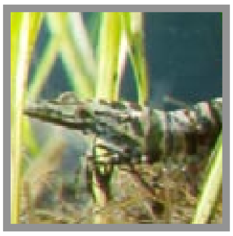
All species of commercial prawns have estuarine/marine phases of their life history (Figure 19.1). The adults live at sea where they spawn, usually in waters less than 50 m deep. Their juvenile phase is spent in coastal habitats, often in estuaries and embayments. Adults shed their eggs into the water column and nauplii hatch after about one day. They develop through three protozoeal and three mysis stages (pelagic stages) and reach near-shore waters about 2–3 weeks after hatching. Larval behaviour is cued to diel cycle, moving into the water column at night to feed. As they grow, postlarvae become tidally clued, moving into the water column on the flood tide which transports them inshore to nursery habitats. Individuals from eggs spawned in a region adjacent to inshore nursery habitat from where larvae/postlarvae may reach coastal habitats on tidal currents, are the only ones that will move inshore and successfully recruit to juvenile habitats.

Outside this region (the advective envelope) larvae are lost offshore. About this time they develop into postlarvae (approx 1.2 mm CL), resembling small prawns, and continue to grow to become demersal at about 1.7 mm CL. Postlarvae must move to inshore nursery habitat. They shelter and grow in the littoral zone until they reach about 8–15 mm CL (depending on the species), when they begin to move into deeper waters (usually from September to April in the GoC). As they grow to adults, they move offshore to depths of at least 15–30 m.

Non-commercial prawns

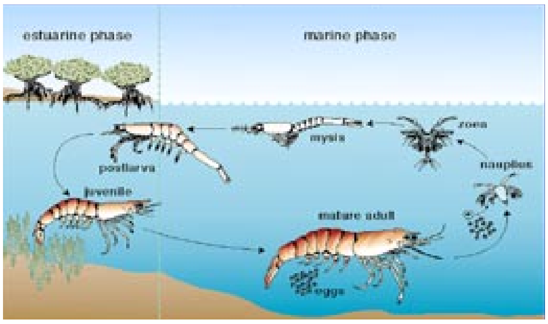
Many of the non-commercial prawns that are penaeids also have an estuarine/marine or inshore/marine life history, although some may complete their life-cycles in inshore environments. Hardback (*Trachypenaeus* sp.) and coral (*Metapenaeopsis* sp.) prawns have an inshore/marine phase as their juveniles are found in inshore embayments while adults are caught as by-catch to commercial operations offshore. Greasyback prawns (*Metapenaeus* sp.) are commonly found in coastal mangroves or seagrass beds as juveniles and offshore in the commercial catch, though some smaller species remain in coastal estuaries or embayments adjacent to their nursery habitats as adults (possibly under brackish conditions).

In the NPA, the habitats of these species are not well understood, particularly those of the juvenile stages. Despite them being caught during the scientific surveys that have investigated the biology of the commercial species, they have not been studied. In some cases, data on the non-commercial species has been taken simultaneously with data on commercial species, but they have not been analysed (e.g. data on juvenile non-commercial species at Groote Eylandt from 1983–85).



Their worldwide distribution has been mapped at a coarse scale (see Dall et al., 1990) and their distribution throughout Australia is broadly known (see Grey et al., 1983). However, the treatment of these species in authoritative publications is meager (see Kailola et al, 1993), reflecting the lack of abundance and habitat data, including incidental catch data. In Australia, reproduction and stock data are meager.

Figure 19.1: *The life cycle of the penaeid prawn Some prawns use littoral seagrass habitats as nursery areas, some use mangroves, while others use bank habitats.* ***Source:*** *CSIRO*



Tiger prawns

Brown tiger prawns are found from Shark Bay in Western Australia across the northern tropics of Australia to mid-New South Wales (Wallis Lake) on the east coast. Grooved tiger prawns are exclusively tropical in Australia. Their western limit is Collier Bay on the Kimberly Coast, Western Australia, and their eastern limit is Yeppoon on the east Queensland coast, including the GoC. Throughout the range of both species, their abundance varies and they are common enough to be commercially fished in part of their range. The regions of high abundance are adjacent to areas of extensive inshore nursery habitats.

Tiger prawn postlarvae move to inshore nursery habitat, usually littoral seagrass beds that form a stable community, but also to algal beds and some seagrasses that may be ephemeral (seasonal and short-lived). They shelter and grow among the seagrasses until they reach about 12 mm CL (often smaller at about 9 mm for *P. semisulcatus*) when they begin to move into deeper waters (usually from November to April annually in the GoC).

In Torres Strait, the seagrass habitat of juvenile tiger prawns (almost exclusively brown tiger prawns) is located in dense seagrass beds on the shallow reef tops of the Warrior Reefs (extensive coral reef platforms). These habitats cannot be described as 'inshore', but they are the shallow seagrass habitats that are crucial to the species. Prawn larvae presumably move to the seagrasses from surrounding deep waters using the tidal current that flow across the reefs. Although the major spawning areas occur to the east of the Warrior Reefs, some spawning also occurs on the south-western side of the reefs.

Juvenile brown tiger prawns use seagrasses in different ways, depending on the morphology of the seagrass and the size of the prawn. Exactly how they utilize their seagrass habitats is not known, though some experimental work has been undertaken. Very small juveniles (less than 4 mm CL) do not bury themselves and rely on the structure provided by the seagrass for protection. Recent work suggests that small juvenile brown prawns (about 5–9 mm CL) often do not bury themselves when among seagrasses, while large juveniles (greater than 10 mm CL) bury themselves in the substrates for differing proportions of the day, depending on the leaf-size of the seagrasses. Like brown tiger prawns, juvenile grooved tiger prawns prefer seagrass habitats over non-vegetated habitats, though their individual behaviour among seagrasses is not as well investigated. In seagrass beds, juvenile tiger prawns have a striped green to green/brown colour pattern which provides camouflage among the seagrasses. As adults, they are brown-striped.

In the NPA, brown and grooved tiger prawns are sympatric (they have a common distribution, though not necessarily at a uniform density) as adults. Each species is consistently more abundant in some regions and at some times of the year. Their distribution is closely related to substrate type; brown tiger prawns favour sandy sediments, while grooved tiger prawns favour sediments with a greater portion of mud (greater than or equal to 50%). For example, in the NPF grooved tiger prawns are abundant north of Groote Eylandt from July to November, while brown tiger prawns are abundant north of Mornington Island from May to August. As adults, brown tiger prawns inhabit waters from approximately 10–30 m depth (mostly 20 to about 30 m). Grooved tiger prawns migrate to waters greater than 50 m depth over winter, then return inshore to spawn.

In the GoC, brown tiger prawns spawn throughout the year, with peak spawning occurring during August to September. Grooved tiger prawns exhibit a peak in spawning in the period August–October, and a minor peak in January–February. Both species are highly fecund and large females may produce 500 000 eggs.

The minimum size at first maturity is about 26 mm CL for brown and 30 mm CL for grooved tiger prawns (about 5–7 months old).

As adults, both tiger prawns bury themselves during the day and emerge to feed at night (when they are fished). Their diet consists of very small, bottom-dwelling shellfish, brittle stars, shrimp and marine worms (eg bivalves, gastropods, ophiuroids, crustaceans and polychaete worms). Bivalves and gastropods are the most common food of juvenile and adult brown and grooved tiger prawns, while crustaceans are also common in the diet of grooved tiger prawns. In turn, they are preyed upon by fish (sharks and teleosts), squid and cuttlefish.

Banana prawns

White banana prawns are found from Shark Bay in Western Australia across the northern tropics of Australia to the Tweed River in northern New South Wales on the east coast. Red-legged banana prawns are exclusive to the north tropical coast of Australia. There are found from their western limit at Broome, Western Australia, across the Kimberly and Arnhem Land coasts to the north-west margin of the GoC. They are not found in the GoC or Torres Strait. Their distribution in the NPA is limited to the north Arnhem Land coast. The only commercially fished populations of red-legged banana prawns are those in the Joseph Bonaparte Gulf and on the western Arnhem Land coast (Melville Island/ Coburg Peninsula).

The habitats and behaviour of juvenile white banana prawn are well know (about 30 years of investigation in the GoC) and are more studied than those of the red-legged banana prawn (one study in 1997–98). Both species use mangrove/mud habitats and, at low tide, are most abundant in small tidal creeks and gutters that drain mangrove forests. Small juvenile banana prawns are more abundant in these small tributaries than in the larger creeks and rivers that they flow into, though as they grow they move to larger water bodies. Experiments have shown that juvenile white banana prawns use the whole mangrove forest at high tide, moving into the forest on the flood tide and retreating from it on the ebb tide. They are more abundant in the near-creek regions of the forest and accumulate in remnant water bodies at low tide. Red-legged banana prawns are found in remnant water bodies among mangroves forests and in mangrove-lined creeks, as well. In all probably, they use the mangrove forest habitats in the same way as white banana prawns. Both species of banana prawn probably gain protection from predators within the forest structure at high tide and among highly turbid near-bank waters at low tide.

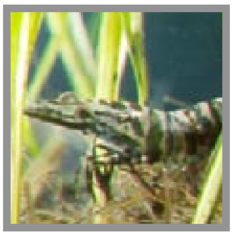
Juvenile white banana prawns grow rapidly in the estuary (about 1.2 mm CL per week). Their emigration from the estuaries is strongly cued by a decline in salinity during flood events and the population offshore is correlated to rainfall (due to flood-cued emigration). Juvenile white banana prawns emigrate at 8 to 14 mm CL; or at a smaller size during flood events. They continue to grow as they emigrate offshore to water more than about 15 m deep. Large adults may move inshore at spawning.

In the GoC, the populations of white banana prawns are adjacent to the extensive mangrove nursery areas that support them; usually less that 50 km separates the juvenile and adult habitats. In contrast, in Joseph Bonaparte Gulf the mangrove habitats that support the red-legged juveniles are 150–240 km to the south and south-east of the distribution of the adult population (in the north-west of the Gulf).

In Australia, red-legged banana prawns live in deeper waters (around 35–90 m) than the common banana prawns (abundant in 15–45 m). They are both found on muddy substrates. Their depth ranges maybe related to their geographic distribution, as red-legged banana prawns are confined to northern areas with deeper waters adjacent to the coastal nursery habitats. In the GoC, white banana prawns aggregate into dense schools (up to 400 t) in waters 15-25 m depth, while in Joseph Bonaparte Gulf red-legged banana prawns aggregate, though not to form the same dense schools as white banana prawns.

Although the white banana prawn occurs along the Papua New Guinea coastline and is a major fishery in the adjacent Gulf of Papua, this species does not occur in the Torres Strait Prawn Fishery.

In the GoC, banana prawns spawn over two main periods, September to November and March to May; the smaller September to November spawning contributes to the following year's recruits. Thus, the stock of adult spawners must survive significant fishing activity in April/May to contribute to the next year's stock. Banana prawns are highly fecund and females may produce 100 000 – 400 000 eggs. The minimum size at first maturity is about 26–34 mm CL (about 6 months old). They live to 12–18 months. The spawning cycles, fecundity and size at first maturity of red-legged banana prawns are unknown.



An adult red-legged banana prawn that has been tagged to measure its movement and growth ***Source:*** *CSIRO*

As adults, common banana prawns bury themselves; though during the day they emerge more often than tiger prawns. Burying and schooling behaviour are their main methods of avoiding predators. The behaviour of red-legged banana prawns has not been studied, though prawns kept in tanks for three months to assess the effect of streamer tags on mortality often buried themselves in the sand substrate of the tanks. The diet of common banana prawns consists of small bivalve molluscs and polychaete worms, while that of red-legged banana prawns is unknown. Adult banana prawns are preyed upon by trevally, sharks, rays and other fish. The predators of red-legged banana prawns are not known, but probably are similar to the common banana prawn.

Endeavour prawns

Blue endeavour prawns are found from Shark Bay in Western Australia across the northern tropics of Australia to northern New South Wales (Ballina) on the east coast. Red endeavour prawns are found from Shark Bay in Western Australia across the northern tropics of Australia to Nowra in southern New South Wales on the east coast.

In the GoC, postlarval blue endeavour prawns settle from the plankton, usually to seagrass beds or algal beds, from October to about January. They shelter and grow among the seagrasses until they move off into deeper waters (usually from November to April). The juvenile distribution, behaviour and offshore migration of blue endeavour prawns have not been well studied. Their appearance in the offshore fishery from October to June (at less than 20 mm CL) suggests that they do not spend a long time in nursery habitats, but move off at a small size. They move to deeper waters as they grow and as adults can be found to depths of about 50–60 m. The majority of the commercial catch is taken in depths between 30–40 m.

Rigorous studies of the distribution and abundance of juvenile red endeavour prawns in the NPF have not been undertaken. Postlarval red endeavour prawns are found on most of the habitats that are available in estuaries, including seagrass, mangroves and channels. They do not favour any one habitat type. They shelter and grow in littoral habitat until they move off into deeper waters (usually from January to June annually in the western GoC). They move to deeper water and as adults are found to depths of 95 m (in the Joseph Bonaparte Gulf, outside the NPA). The majority of the commercial catch is taken in depths between 30 and 50 m.

In Torres Strait, the seagrass habitats of juvenile blue endeavour prawns are located in dense seagrass beds on the reef tops of the Warrior Reefs. Prawn larvae presumably move to the seagrass habitat using the tidal current that flow across the reefs. Although the major spawning areas occur to the east of the Warrior Reefs, some spawning also occurs on the south-western side of the reef.

In the NPF, blue and red endeavour prawns are sympatric as adults. However, each species is consistently more abundant in some regions and at some times of the year. Their distribution is closely related to substrate type; blue endeavour prawns are found on sandy sediments (less than 50% mud), while red endeavour prawns favour sediments with a greater portion of mud (greater than 60% mud).

In the GoC, blue endeavour prawns spawn throughout the year, with peak spawning occurring from September to December in the west, and July to September in the east. In the eastern GoC, red endeavour prawns spawn from September to November. Both species are highly fecund. The size at first maturity for blue endeavour prawns in Albatross Bay (eastern Gulf) is 23 mm CL. In Albatross Bay, the size at first maturity for red endeavour prawns is 21 mm CL. The proportion of mature females increases with size.

A tagging study at Groote Eylandt showed that usually blue endeavour prawns do not move large distances (less than 20 km), though some moved greater than 100 km. Both species move to deeper waters over winter and then migrate shoreward in the spring to spawn. As adults, both blue and red endeavour prawns bury themselves during the day and emerge to feed at night (when they are fished). High temperatures (greater than 30° C) shorten the emergence of red endeavour prawns. Endeavour prawns are carnivorous benthic feeders. Their diet consists of small molluscs, crustaceans, polychaete worms and Foraminifera. In turn, they are preyed upon by fish (sharks and teleosts), squid and cuttlefish.

King prawns

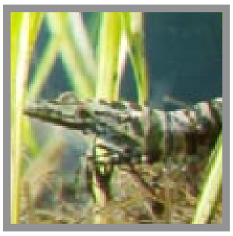
Western king prawns are found from Cape Leeuwin in Western Australia, up the west coast and across the northern tropics of Australia to Ballina in northern New South Wales on the east coast. They are also abundant in Spencer and St Vincent Gulfs and adjacent coasts in South Australia, to Ceduna. In southern Australia, the South Australian and Western Australian populations may extend across the Great Australian Bight, but no surveys have been undertaken. Red spot king prawns are found from Shark Bay in Western Australia across the northern tropics of Australia to Yeppoon on the east coast. There is an isolated population at Lord Howe Island.

In the NPA, the distribution and habits of juvenile king prawns (either species) have not been studied to the extent that juvenile tiger or banana prawns have been. In the south-west GoC, juvenile western king prawns recruit to seagrass habitats during September to December. In Exmouth Gulf, Western Australia, juvenile western king prawns were abundant in sand-substrate habitats and in short-leaved seagrass habitats (*Halodule uninervis* and *Halophila ovalis*). They were not abundant in long broad-leaved seagrass habitats close by (*Halophila spinulosa* and *Cymodocea serrulata*). Similarly, in Moreton Bay, Queensland, among three habitats in close proximity, the co-generic eastern king prawn (*Penaeus plebejus*) used both bare substrates and short-leaved seagrasses as juvenile habitats. They were not abundant in long broad-leaved seagrass habitats. These field data are supported by laboratory experiments on western king prawns caught in South Australia; they preferred to bury themselves in sand substrates than shelter in artificial seagrass habitat. Juvenile red spot king prawns are found in inshore and reef-top habitats from September to May, and on the Queensland coast emigrate from reef-top habitats at 15–20 mm CL. These studies suggest that, within the littoral habitat, king prawns use microhabitats in different ways that are yet to be fully investigated.

Very small western king prawns are nearly translucent in body colour, with a red/brown fleck. This colouration seems to provide camouflage on sandy substrates. As they grow, they become more yellowish in colour. Small and large juveniles bury themselves in the substrate to avoid predators. As adults, they are yellowish in colour. Few studies have been undertaken on the individual behaviour of juvenile king prawns. A rigorous investigation of the microhabitat requirements of juvenile western king prawns and red spot king prawns in the NPA is warranted.

In Torres Strait, the juvenile habitat of western and red spot king prawns is also found on the shallow tops of extensive coral reef platforms and their shallow lagoons, respectively. Though they are not 'inshore', these shallow water habitats are crucial to the species and larvae must move to them from surrounding deep waters.

In the NPF, western and red spot king prawns are sympatric as adults (ie they are closely related species that have overlapping ranges in nature but do



not interbreed) as adults, though the western king prawn makes up 98% of the biomass of king prawns. Western king prawns are found in the southern and western GoC on sandy sediments (less than 50% mud) mostly in waters less than 30 m deep. Red spot king prawns also favour sandy sediments though, as they represent a low portion of the catch, their habits are not well reported. In Torres Strait, both species are found on sandy sediments; red spot king prawns favouring sediment with greater than 80% sand and western king prawns 70–80% sand.

In the GoC, western king prawns spawn in September and between January and March. On the Queensland coast, they spawn between April and August. In the GoC, red spot king prawn larvae are relatively rare and were caught during surveys in June and September, but not during surveys undertaken in November, January, March or April. In Torres Strait, small adults were found in the fishery in December, suggesting they were spawned 3–5 months earlier (August to October). On the Queensland coast, red spot king prawns spawn between May and October.

Both species are highly fecund and large female western king prawns may produce 1.5 million eggs. On the Queensland coast, the size at first maturity for western king prawns is 26–27 mm. In the Torres Strait, red spot king prawns are mature at about 24 mm CL.

As adults, western king prawns exhibit a strong response to light and bury themselves during the day, emerging to feed at night (when they are fished). They begin to bury three hours before dawn, presumably to gain most protection from predators. Red spot king prawns also exhibit a strong burying response during the day. The diet of both species of king prawn consists of small molluscs, crustaceans, polychaete worms and detritus (decaying organic matter). In addition, red spot king prawns are reported to eat Ophiuroids. In turn, they are preyed upon by fish (sharks and teleosts), squid and cuttlefish.

Significance of the species group in the Northern Planning Area

Prawns are a significant commercial species group in the NPA but are not targeted by either recreational fishers or Indigenous peoples.

Tiger prawns

Brown and grooved tiger prawns form a significant portion of the prawn catch in the NPF (Cape Londonderry to Cape York) and the Torres Strait Prawn Fishery. The annual catches of tiger prawns (both species) in the NPF and Torres Strait have varied considerably since 1980 (Table 19.1). From 1970 to 1991, the proportion of brown and grooved tiger prawns in the catch from the GoC was estimated to be about 51:49% (about 1700 t each). Recently, the proportion of brown tiger prawns in the catch has declined as the population of the species has declined.

The tiger prawn catch of the Torres Strait fishery is dominated by brown tiger prawns as grooved tiger prawns form an insignificant component of the catch. Although brown tiger prawns are generally considered to be the primary target species, they comprise only 40% of the catch of the Torres Strait fishery, with the remainder consisting of blue endeavour (about 55%) and red spot king prawns (about 5%).

The market price per kilogram attainable for brown tiger prawns has varied between about $15 and $35, depending on the market (domestic/overseas) and the size of the prawns. The average catch of tiger prawns per NPF vessel in 2002 was 18 t. Thus, they and the other three groups of commercial prawns are a very valuable catch.

In the NPF (operating from 1 April to mid-May and 1 September to 30 November, in 2002–03), brown tiger prawns are caught in conjunction with grooved tiger prawns, though the two species are caught in different areas and at different times during the year. Brown tiger prawns are caught during May and August, though shifts in the closure regimes in the NPF have excluded fishing in August in recent years. Grooved tiger prawns are caught mainly from September to November, depending on the fishing season.

The Torres Strait fishery operates from 1 March to 1 December with peak catches during March/April.

Banana prawns

Banana prawns form a significant proportion of the prawn catch in the NPF (about 50%). No banana prawns are caught in the Torres Strait Prawn Fishery. White banana prawns are the only banana prawn of commercial significance in the NPA.

The annual catch of banana prawns in the NPF has varied from about 2100 t to 7200 t since 1980. Much of the catch is taken off GoC and Arnhem Land coast in the NPA (47% and 83% in those low- and high-catch years respectively). The market price per kilogram attainable for banana prawns can vary between about $8 and $20, depending on the market and the size of the prawns. The average catch of banana prawns per NPF vessel in 2002 was 40 t.

In the GoC, the major portion of the annual catch of banana prawns is caught in the first few weeks of the fishing season (more than 95% of the catch is taken in April). Vessels search for the schools of prawns with electronic depth sounders and the schools are targeted rigorously. The trawls made for banana prawns are short, targeted trawls and catches can exceed 3 tones per net. In the last three years, an average of 4697 vessel-days were spent fishing for both species of banana prawns in the NPF, a high proportion of this in the NPA.

Endeavour prawns

Blue and red endeavour prawns form a significant proportion of the prawns catch in the NPF (13% over the decade 1990–99) and the Torres Strait Prawn Fishery (40–50%). The annual catch of endeavour prawns (both species) in the NPF and Torres Strait has varied by a factor of five and ten, respectively, since 1980 (Table 19.1). The market price per kilogram attainable for endeavour prawns can vary between about $8–20, depending on the market and the size of the prawns.

The market price per kilogram attainable for endeavour prawns can vary between about $8 and 20, depending on the market and the size of the prawns. Thus, they are a very valuable catch.

In the NPF, endeavour prawns are caught as a minor component of the tiger prawn fishery (about 39% of the tiger/endeavour catch). Endeavour prawns are caught mainly from August to November, depending on the fishing season. From 1970 to 1991, the average catch of blue and red endeavour prawns from the GoC was estimated to be 592 and 191 t respectively (about 76%:24%).

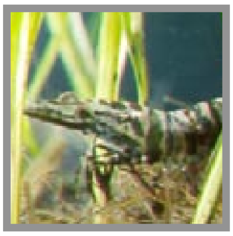
The endeavour prawn catch in Torres Strait is almost exclusively blue endeavour prawn (99.9% of the endeavour catch by weight) with the red endeavour comprising less than 0.1% of the catch. Although endeavour prawns are generally considered to be the secondary target species, they comprise on average 55% of the prawn catch. The proportion of endeavour prawns in the Torres Strait prawn catch varies between years and in the last ten years has ranged between 50 and 69% of the total catch. The Torres Strait fishery operates from 1 March to 1 December with the peak catches of endeavour prawns at the start of the season (March to May), followed by a smaller peak in September.

King prawns

Western king prawns form a minor component of the prawn catch (less than 1%) in the NPF and are an uncommon incidental catch in the Torres Strait Prawn Fishery (about 2–4% of the total king prawn catch). Red spot king prawns form minor components of the prawn catch of both of these fisheries (less than 1% in the NPF). In the Torres Strait fishery they comprise about 98% of the king prawn catch, though all king prawns make up only 1–10% of the total commercial prawn catch.

In the NPF, the annual catch of king prawns (both species) has shown the highest amount of variation of any species group (from 4 t to 200 t) since 1980, while the catch in the Torres Strait has also varied considerably (Table 19.1). In the GoC, the average catch of king prawns from 1970 to 1991 was 100 t and the proportion of western and red spot king prawns in the catch was estimated to be about 98%:2%, respectively. In the NPF in 2002, significant catches of king prawns were made in October and November only. In the Torres Strait the fishery is mainly for red spot king prawns (about 93% of the catch) and most of the catch is taken in March and April.

The market price per kilogram attainable for king prawns can vary between about $10 and $25, depending on the market and the size of the prawns.



Impacts/threats

The management practices of these fisheries have evolved over about 30 years and reflect considerable regime change, notably a steady reduction of fishing effort to a level which is considered sustainable. For example, at peak vessel numbers in 1981, 286 vessels fished the NPF; today less than 100 are licensed. However, the assessment of sustainability in the NPF originates from a target-species-centric view. Although the high-biomass target stocks are likely sustainable, the catch of some incidental stocks (e.g. king prawns) may be declining and they may not be sustainable at current levels of effort. Moreover, Commonwealth legislation requires the fishery to be assessed for the sustainability of both by-product and by-catch species (see Information Gaps below). The scientific consideration of incidental catch is in its infancy. Any changes to fishery management practices in the NPF or Torres Strait as are suggested by some sections of industry (e.g. increased fishing effort) could have a catastrophic impact on prawn stocks.

The fishery stocks of prawn species rely on stable nursery habitats to support their juvenile phase. Thus, threats to littoral seagrass and mangrove habitats, reef platforms and bank and bare substrates, are a threat to the penaeid prawn populations and the fishery. Historically and currently both the GoC and Torres Strait are remote areas with low levels of anthropogenic impacts. However, the low level of infrastructure development in the NPA is beginning to change (Table 19.2). Although some of these infrastructure developments have had a direct impact on nearshore habitats, present infrastructure and activities have had no discernible impact on prawn stocks. In the future, current and proposed resource development, including in river catchments such as mining, farming, ports and water resource development and commercial use of natural resources (fishing) may have an increased impact in both areas. The potential impacts of development proposals on the NPF need to be assessed as part of the planning process and monitored during any construction and operation phases that proceed.

Table 19.2: *Summary of (including possible future) infrastructure development and possible consequence in the Gulf of Carpentaria (and its river catchments) and Torres Strait*

Infrastructure development	Location	Construction/ infrastructure	Possible impact on nearshore habitat
Manganese mine (1966)	Groote Eylandt	Strip mining, port development	Nearshore habitat loss
Bauxite mine (1972)	Weipa	Strip mining, port development	Port dredging, nearshore habitat loss, possible reduction in water table and hence river runoff
MacCarthur River Mine Port Facility (1994)	North west of the MacCarthur River mouth (Bing Bong)	Shipping channel dredged through seagrass community	Direct loss of seagrass habitat, change in local hydrology
Karumba Port enhancement (1998)	Norman River, Karumba	Dredged river channel	Dredging and dumping of spoil, change in hydrology
Proposed cotton farming in river catchments (future)	Cape York	Irrigated farmlands, damming of river	Change in river flow regime, change in nutrient regime of fluvial waters and estuary
Proposed PNG/Australia Gas pipeline (future)	Eastern side of Warrior Reefs	Partially buried seabed pipeline	Some seagrass damage where the pipeline accesses Cape York.

Natural impacts can also greatly reduce the area of productive nursery habitats, for example cyclonic destruction of littoral habitats. In 1985, Cyclone Sandy removed 183 km^2 (20% of Gulf seagrass) of seagrass habitats in the western GoC and a reduction in catch (30%) in the adjacent fishery ground was recorded. By 1995, the seagrass habitat mostly had recovered to pre-cyclone condition. Similarly, in March 1999 Cyclone Vance removed the seagrass habitats from Exmouth Gulf, Western Australia, and the commercial prawn catch declined the following year as nursery habitats for the 1999–2000 juvenile recruitment were affected. For instance, the tiger prawn catch fell to 82 t (26% of the recent five-year average catch), well below the catch range from the previous decade, 250–550 t. The same study, however, suggested that king prawns may not be as vulnerable to some cyclonic impacts (eg removal of seagrasses) as tiger and endeavour prawns. King prawns use shallow sandy substrates and colonising seagrasses as juveniles; therefore the impact of the cyclone which created sandy habitats while removing seagrass habitats was less severe on them. Under natural conditions seagrass ecosystems recover from periodic non-anthropogenic impacts.

Tiger prawns

In the NPF, the stocks of grooved tiger prawns are rated as fully-fished. The average catch of grooved tiger prawns has been relatively stable over the past 10 years. In the NPF, brown tiger prawns are officially rated as over-fished and temporal closures are currently in place to reduce fishing effort on their populations. Traditionally they were fished to the north of Mornington Island during August. For the past two years the fishing season has remained closed until 1 September, resulting in reduced targeting of this species. Their average catch has declined over recent years.

Banana prawns

In the NPF, the stocks of banana prawns fluctuate significantly from year to year. Their catch is correlated to rainfall and in the past about 70% of the variability in catch in the south-east GoC could be attributed to variation in rainfall. However, recent stock assessments have demonstrated a stock-recruitment relationship for many regional stocks and that some stocks are over-fished. Thus, fishing must remain at recent levels or lower if a sustainable harvest is to be achieved.

The potential impacts of development proposals on the NPF need to be assessed as part of the planning process and monitored during any construction and operation phases that proceed. Although not an example from the NPA, the geographic distance between the red-legged banana prawn fishery and its inshore nursery habitats in the Joseph Bonaparte Gulf demonstrates that coastal development may occur more than 200 km from an important fishery, yet still affect that fishery. Furthermore, if impacts in the catchment of large rivers have a negative effect on the estuaries of those rivers, then up-river infrastructure developments many hundreds of kilometres up-river may still affect an ocean fishery.

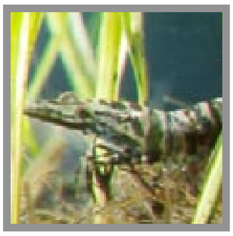
Endeavour prawns

The NPF logbook catch data do not discriminate between blue and red endeavour prawns. In the NPF, the stocks of endeavour prawns are rated as fully-fished. The average catch of endeavour prawns has declined by 50% over the past 20 years; an average of 1406 t over the 10 years 1980–89, and 1056 t over the years 1990–99. In the NPF, the stocks of endeavour prawns are not assessed separately, as are other species. They may be over-fished. Temporal closures are currently in place to reduce fishing on tiger prawns and these may have a positive effect on endeavour prawn populations.

King prawns

In the NPF, the stocks of king prawns are probably over-fished. Logbook data do not discriminate between the two species (western and red spot king prawns), so the data to asses the populations separately are not available. However, data for both species show a dramatic decline in catch over recent years. Over the decades 1970–79 and 1980–89, the catches of king prawns averaged 103 t and 55 t respectively. Over the last five years, the catch has declined from 20 t in 1998 to 5 t in 2002 (with lows of 4 t in 2001 and 2003). Although some of the decline can be attributed to an NPF-wide closure restricting fishing for king prawns in August (when they were targeted in past years), low catches occurred prior to the August closure (eg in 2001).

Fishery management practices in the NPF focus on tiger and banana prawns, and in the Torres Strait the focus is primarily on tiger prawns and, to some extent, endeavour prawns. These effort regimes may not benefit king prawns. As king prawns are considered 'incidental catch', assessments are not undertaken and management is not designed to maintain the sustainability of their stocks.



Information gaps

Tiger prawns

The biology of both brown and grooved tiger prawns was well researched at Groote Eylandt in the early 1980s and at Weipa in the late 1980s and early 1990s. At Groote Eylandt, the juvenile and adult phases were investigated, while at Weipa work was undertaken on the larvae, juveniles and adults. The habitats, behaviour, reproduction and movement of both juveniles and adults are well understood. In Torres Strait, the biology of the brown tiger prawn has been studied extensively in the Australian area of jurisdiction on both sides of the Warrior Reefs. However, there is little information available on the distribution and movement of tiger prawns in the Papua New Guinea waters of the Torres Strait Protected Zone, which is considered to be a single stock.

The effects of large-scale environment and catchment processes on the productivity of tiger prawn fisheries on a local geographic scale (catchment and adjacent fishing grounds) are poorly known. An integrated study of a productive catchment/estuary that develops a model of the contribution of environment and catchment processes on fishery productivity is recommended.

An estimate is needed of the annual catch harvested by PNG vessels in Torres Strait so that this catch can be included in the assessment and catch per unit effort data to develop indices of abundance from the PNG tiger prawn fishery. Liaison with the PNG National Fisheries Authority to incorporate the catch and effort data from PNG vessels into the tiger prawn stock assessment is recommended.

Banana prawns

The biology of juvenile and adult white banana prawns was well researched at Karumba in the 1970s and at Weipa in the late 1980s and early 1990s. The habitat requirements of both juveniles and adults are well understood. Factors affecting the fishery catch have been investigated for nearly two decades. Currently (2002–2004), the distribution and abundance of banana prawn stocks are being monitored over five fishing regions in the GoC (Weipa, Bold/Sweers, Mornington, Limmen and Groote) and these data can be used to improve recently developed stock assessment models. Adjacent to Torres Strait, the biology of the white banana prawn has been studied in the Gulf of Papua by CSIRO and the Papua New Guinea National Fisheries Authority. More research in this fishery is currently planned and will commence in late 2003.

However, the biology of red-legged banana prawns is poorly understood. A tagging study to determine the population parameters for the red-legged banana prawn fishery in Joseph Bonaparte Gulf was undertaken in 1997–98. At the same time, their inshore nursery habitats were investigated. However, these studies were of a short duration and no temporal trends (seasonal or annual) of aspects of their biology could be investigated.

There is a need for a study of the distribution and reproductive biology of red-legged banana prawns. Despite the main fishery these prawns being outside the NPA, the gaps in knowledge about this species are common throughout its range, which includes the western section of the NPA. In 2001, a project proposal was developed to undertake a three-year study on red-legged banana prawns in Joseph Bonaparte Gulf. It was not supported. The project had the following objectives:

- obtain information on the spatial distribution, size structure and reproductive biology of red-legged banana prawns in the Joseph Bonaparte Gulf (JBG)
- develop models of larval advection to establish the size of the effective spawning area for red-legged banana prawns in the JBG and whether it is influenced by changes in flow of the Ord River
- establish sampling programs for catch and landings to obtain information on the size-distribution of red-legged banana prawns and investigate the feasibility of estimating stock-recruitment relationships for this species
- develop a new method of assessing the status of red-legged banana prawns in the JBG that incorporates the new information collected on biology, the potential for a stock recruitment relationship, fleet movements and environmental variation

An integrated study of the effects of large-scale environment and catchment processes on adjacent nearshore banana prawn fisheries would strengthen the ability to sustainably manage fisheries and the understanding of the impact of infrastructure development and changing land use on fishery production.

A proposal to undertake a project that fulfils these criteria is currently being developed by CSIRO Marine Research: Variation in Banana Prawn Catches at Weipa: a Comprehensive Regional Study.

As well, the paucity of knowledge of red-legged banana prawns' behaviour, distribution and reproduction limits our understanding of the species and our ability to sustainably manage its fishery.

The spatial distribution, size structure and reproductive biology of red-legged banana prawns, and their larval movement and effective spawning populations are poorly known. A three-year study of the distribution and reproduction of red-legged banana prawns, including the development of a hydrodynamic model of the waters within their range is recommended.

There is also a lack of information on the individual behaviour, and the effect of habitat on behaviour, of both juvenile and adult red-legged banana prawns, and the food and feeding of both juvenile and adult red-legged banana prawns. It is recommended that a laboratory study be done of the behaviour of red-legged banana prawns in simulated habitats, and analysis of their gut contents.

Endeavour prawns

In the NPA, the biology of the juvenile and adult phases of both blue and red endeavour prawns has not been as well researched as other species. A 1984 tagging study of blue endeavour prawns reported their growth, movement and population parameters at Groote Eylandt in the western GoC. Significant data have been collected on the juvenile and adult of these species and are available in CSIRO databases. These data were collected during studies on other species (eg tiger prawns) and often have not been analysed, or not with a focus on endeavour prawns. In some cases these data have been analysed (eg for blue and red endeavour prawns at Albatross Bay, eastern GoC).

In Torres Strait, the biology of the blue endeavour prawn has been studied extensively in the Australian area of jurisdiction on both sides of the Warrior Reefs. However, there is little information available on the distribution and movement of endeavour prawns in the Papua New Guinea waters of the Torres Strait Protected Zone.

The Species Distribution and Catch Allocation Project (targeting tiger prawns) will undertake an allocation of endeavour prawn NPF logbook data between the two endeavour prawn species (using the same techniques as for tiger prawns). Past and current scientific distribution data for endeavour prawns will be used in the model. The most recent data used will be from the NPF Monitoring Surveys (2002–2004).

An integrated study of the effect of catchment processes on adjacent nearshore fisheries would strengthen the ability to sustainably manage endeavour prawn fisheries and understanding of the impact of infrastructure development and changing land use on fishery production.

The exploitation of blue endeavour prawns stocks in the GoC and Torres Strait is unknown. A stock assessment of blue endeavour prawns in the NPF and Torres Strait is recommended.

The exploitation of red endeavour prawn stocks in the GoC is unknown. A stock assessment of red endeavour prawns in the NPF is recommended.

King prawns

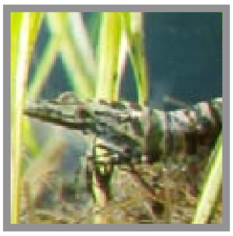
In the NPF (including the NPA) and Torres Strait, the biology of both western and red spot king prawns has not been well researched. Although data are collected on these species simultaneously with data on the major tiger and banana prawn species, stock assessments of king prawn stocks in the NPF have not been undertaken. Similarly, data on the juvenile phase of king prawns were collected during studies on juvenile tiger prawns (mainly). However, these data have never been analysed comprehensively. The raw data exist on CSIRO Marine Research databases.

In Torres Strait, king prawn data (on juveniles and adults) have been collected during research that has targeted tiger and endeavour prawns. The main juvenile habitats of king prawns appear different to those of tiger and endeavour prawns. These habitats were not targeted during research projects in the 1980s, thus crucial king prawn nursery habitats have not been identified. Like data held by CSIRO, the data held by the Queensland Department of Primary Industries and Fisheries have not been analysed.

The dramatic decline in king prawn catch in the NPF over the last decade is of great concern. Fishery management may need to change to include measures to sustain king prawn stocks. A stock assessment of both the western and red spot king prawns is necessary. Models developed during the Species Distribution and Catch Allocation project (using distribution data from the Integrated Monitoring Surveys) could be applied to king prawn catch data to provide separate catch estimates of both species.

The exploitation of western and red spot king prawn stocks in the GoC is unknown. A stock assessment of both in the NPF is recommended.

There is a lack of knowledge of the distribution and abundance and habitat requirements of both juveniles



(and the behaviour of juveniles) and adults of western and red spot king prawns. An analysis of all currently held data on king prawns in the NPF and Torres Strait is recommended to examine the scope of these data and identify data-gaps that field research may need to fill.

Non-commercial prawns

Knowledge of the basic biology of non-commercial prawns is lacking in the NPA. Data on some species have been collected during studies that focused on commercial prawns and, mostly, these data remain unanalysed. A first step to understanding the biology on the non-commercial species in the NPA would be to investigate and collate data sets from the NPA that are currently held by agencies such at CSIRO Marine Research and analyse them. As well, some non-commercial species (or co-generic species) have been studied elsewhere in Australia and knowledge of their distribution and habitats in these areas is transferable to the NPA. These data would probably provide basic information on the abundance and habitats of both the juveniles and adults of some species.

Non-target (by-product) and by-catch species

Whilst targeting key commercial prawn species, other fish and invertebrates are caught. Some species that have value as commercial product are kept as by-product. Much of the non-target catch is discarded as by-catch. Distribution and abundance data and more detailed biological data are scant for by-product and by-catch species. Currently, both by-product and by-catch are the subject of significant research projects in the NPA and elsewhere (eg in the Great Barrier Reef region, with implications for the NPA).

As part of the current project 'Designing, implementing and assessing an integrated monitoring program for the NPF: developing an application to stock assessment (2002–2004)', which focuses on stock assessment of commercial prawns, data on by-product species are being collected. Data are collected on 'bugs' (slipper lobster) (*Thenus indicus* and *T. orientalis*), squid (*Loliginidae*) and cuttlefish (*Sepiidae*), and scallops (*Annachlamys flabellata* and *Amusium pleuronectes*). This is the beginning of the investigation of basic biological data on these species, working towards stock assessments of by-product species. Scallops, squid and bugs are given more extensive treatment in Chapters 17, 18 and 22 of this report respectively and in Dichmont *et al*. (2003).

Similarly, recent and current projects have focussed on the biology and sustainability of by-catch species. Given the large numbers of by-catch species observed in trawl catches (around 390 teleost species, 234 invertebrate taxa, 63 elasmobranch species, 30 seasnake species and six sea turtle species), it is a huge task. Data are also collected on the basic biology and sustainability of benthic species that are impacted by trawls, but are mostly unseen in trawl catches. Currently sea turtles, seasnakes and seahorses are protected under Commonwealth legislation (ie the *Environment Protection and Biodiversity Conservation Act 1999 and Wildlife Protection (Regulation of Exports and Imports) Act 1982*). Recently, the Northern Prawn Fishery was given an authority by Environment Australia to operate for the next five years. This approval stems mostly from the NPF's active support of research to assess the sustainability of its by-catch species, and its willingness to introduce new net technology to protect key species (eg Turtle Exclusion Devices [TEDs] and other Bycatch Reduction Devices [BRDs]). Assessments of the sustainability of all by-catch species are ongoing as demanded under the NPF Bycatch Action Plan (2002). They will further contribute to future legislative assessments of the sustainability of the whole fishery as required by Environment Australia under Commonwealth regulations. The subject of trawl by-catch in the NPA is given more extensive treatment in Chapter 24 of this report.

Key references and current research

Over recent years, the focus of research has been not on the biology of prawns themselves, but on the strategy to optimise the harvest in the fishery and the fishing methods and technology used (including the effects of prawn fishing on species in the incidental catch).

In the last 5 years, prawn research in the NPF has included:

- Designing and trialling and implementing an integrated long-term bycatch monitoring program in the NPF (2002–2005)
- Evaluating new targets and management strategies for the NPF tiger fishery (2001–2003)
- A new approach to fishing power and its application in the NPF (2000–2002)
- Designing, implementing and assessing an integrated monitoring program for the NPF: developing an application to stock assessment (2002–2004)
- Developing a new method of evaluating catch rates of spatially mobile and aggregating prawn resources (2002–2005)

- Species Distribution and Catch Allocation: Data and Methods for the NPF (brown and grooved tiger prawns) (2002–2004)
- Quantifying the effects of trawling on seabed fauna in the Northern Prawn Fishery (2003–2005).

In the GoC, CSIRO Marine Research has suggested the following subjects are important for ongoing understanding and management of the fishery resources of the NPF:

- evaluate the impact of fishery closure areas and MPAs for conservation and biodiversity
- understand the key physical, biological and anthropogenic processes that affect species dynamics and ecosystem productivity and stability
- evaluate management strategies for ecologically sustainable fisheries and their associated bentho-pelagic processes (eg nutrient cycling and trophodynamics)
- effects of fishing on the benthic and associated ecosystems including assessment of effects of trawling on the seabed (physical and biological components)
- knowledge of environmental factors of importance to the fishery (eg rainfall, river flows, sediment and nutrient transport, nutrients cycles, water circulation, productivity, cyclones, etc.)
- understand the effect of the environmental variability on prawn production and maintenance

Specifically, catchment processes have an immediate impact on fishery production. An integrated study of the effect of catchment processes on adjacent nearshore fisheries would strengthen the ability to sustainably manage fisheries and the understanding of the impact of infrastructure development and changing land use on fishery production.

CSIRO Marine Research is currently developing three projects that are relevant to prawns in the NPF:

- Bringing Economic Analysis and Stock Assessment Together in the NPF: a Framework for a Biological and Economically Sustainable Fishery
- Benthic Characterisation of the NPF: Building a Knowledge Base for Ecosystem Sustainability
- Variation in Banana Prawn Catches at Weipa: a Comprehensive Regional Study

Some projects research the biology of the species. Other projects do not directly do this but research the optimal management of the fishery and the effects of fishing methods on benthos.

Enquiries in regard to access to data or reports on prawns in the NPA should be addressed to:

CSIRO Marine Research
PO Box 120
Cleveland QLD 4163
(07) 3826 7200

Fisheries Research and
Development Corporation
PO Box 222
Deakin West ACT 2600
(02) 6285 0400

Australian Fisheries Management Authority
PO Box 7051
Canberra Mail Centre ACT 2610
(02) 6272 5029

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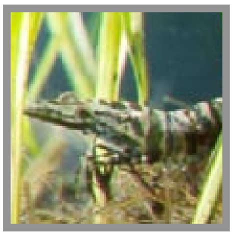

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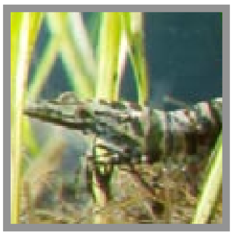

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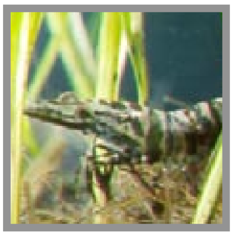

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20. CRABS

(Brachyura: the true crabs)

Grapsid Crabs such as Neosarmatium sp. consume mangrove propagules **Source:** *Keith MacGuinness*

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Species group name and description

True crabs of the infraorder Brachyura invariably look like the familiar image of a crab: their first pair of legs is clawed, antennae are short and their abdomen is reduced and folded underneath the main body. With this general body plan, true crabs are a diverse and varied group of crustaceans and include, for example, the box crabs, fiddler crabs, ghost crabs, spider crabs and swimmer crabs. However, true crabs do *not* include species such as hermit crabs, porcelain crabs and mole crabs: these belong to Anomurids.

We do not know for certain how many species of true crabs there are in the Northern Planning Area (NPA), but publications on specific taxonomic groups and biological surveys have provided some insight into the species richness in the region.

Status

Due to the lack of data, no conservation status can be given to species of crabs found in the NPA. No species of crabs are listed under the Convention on the International Trade in Endangered Species (CITES) or listed under Northern Territory (NT), Queensland or Australian Government environmental legislation.

Habitat and distribution

There are over 950 species of true crabs in Australian waters (Davie 2002) of which 192 species in 24 families and 102 genera occur in NT and/or Gulf of Carpentaria (GoC) waters (Table 20.1). The majority of species have an Indo-west Pacific distribution (100 species, 52%). Species composition within the NPA also shows a transition between the east and west coasts of Australia: the NPA has 131 species in common with NE Queensland and 116 species with the coastal waters of north and north-western Western Australia (WA). The six most families with the most number of species for the NPA are: spider crabs (Majidae, 30 species); Ocypodidae, which includes the ghost crabs (27); swimming crabs (Portunidae, 27); hairy crabs (Pilumnidae, 20); shore crabs (Grapsidae, 17); and black-fingered crabs (Xanthidae, 17).

Four species are found in the NPA which are endemic to Australia: *Halicarcinus bedfordi* (Hymenosomatidae), *Australoplax tridentata*, *Tmethypocoelis koelbeli* (both Ocypodidae) and *Zebridonus mirabilis* (Pilumnidae). *Z. mirabilis* is further restricted to the Queensland coast in the GoC.

Table 20.2 lists the species that are found solely in the NPA or have been recorded from a limited number of localities in adjoining areas (including north and north-western coastal waters of Western Australia, northern NT coast, Arafura Sea, Timor Sea and north-east Queensland). These species have been included because their presence in the NPA is likely. Species that are used for commercial, recreational and/or subsistence use are also indicated in Table 20.2.

Eleven species (Table 20.2) have a limited distribution and are found only in the NPA. However, this listing is complicated by nomenclatural problems. For example, five species which occur in the database of the Museum and Art Gallery of the NT (MAGNT) are not listed by Davie (2002), which reports all crab species known for Australia. A question mark should be placed against these species until taxonomic status is more clearly resolved.

Unique for the NPA are the freshwater crabs found in the catchments between Wenlock and the Archer river; One Mile Creek; and in the vicinity of Coen (Cape York Peninsula). *Austrothelphusa tigrina* is found only in the GoC catchment of One Mile Creek, whereas the other three species of freshwater crab (*Austrothelphusa agassizi*, *A raceki* and *A valentula*) are also found, but in a limited number of places, in north-eastern Queensland (Davie 2002).

The commercially targeted/managed species (green mud crab, *Scylla serrata*; orange mud crab, *Scylla olivacea* and blue swimmer crab, *Portunus pelagicus*) all occur in the NPA (Davie 2002, Keenan 1999, Williams 2002), with the green mud crab and orange mud crab being sympatric (ie occurring in the same or overlapping geographical areas). Both mud crab species are also very similar in appearance, and have only recently been distinguished as two species through genetic studies (Keenan et al. 1998). Nevertheless, Ms Hay (NT Fisheries, pers. comm.) notes that she has never seen the orange mud crab during her mud crab surveys in the GoC or from commercial catches from the GoC. She reports also that the orange mud crab is more common in the coastal waters west of the NPA, in particular from the Adelaide River (just east of Darwin) and further west to Western Australia.

The NPA includes many different marine habitats, ranging from salt marsh, mangroves, mud flats, extensive seagrass beds and soft substrates, scattered coral/rocky reef, sandy beaches and dunes. True crabs are found in all these habitats. In general terms, species diversity is correlated to availability of microhabitats and how well the substrate is developed in three-dimensional terms (Jones & Morgan

1994). For instance, coral and rocky reefs have many crevices, rock pools, loose rocks, etc, and provide refuge areas for many species of crabs. For obvious reasons, mangroves are also species-rich. In contrast, sand flats and beaches have fewer species, given the challenge of adapting to the highly mobile substrate that characterises this environment. In addition, diversity increases where patchiness of substrate/habitat is complex (ie the more habitat/substrate types with a certain area, the higher species diversity).

Within the NPA the amount of collection has been small and the majority of the sampling effort has targeted soft substrates, hence it is not surprising that the expected relationship between habitat and crab species-diversity is not seen clearly for the NPA.

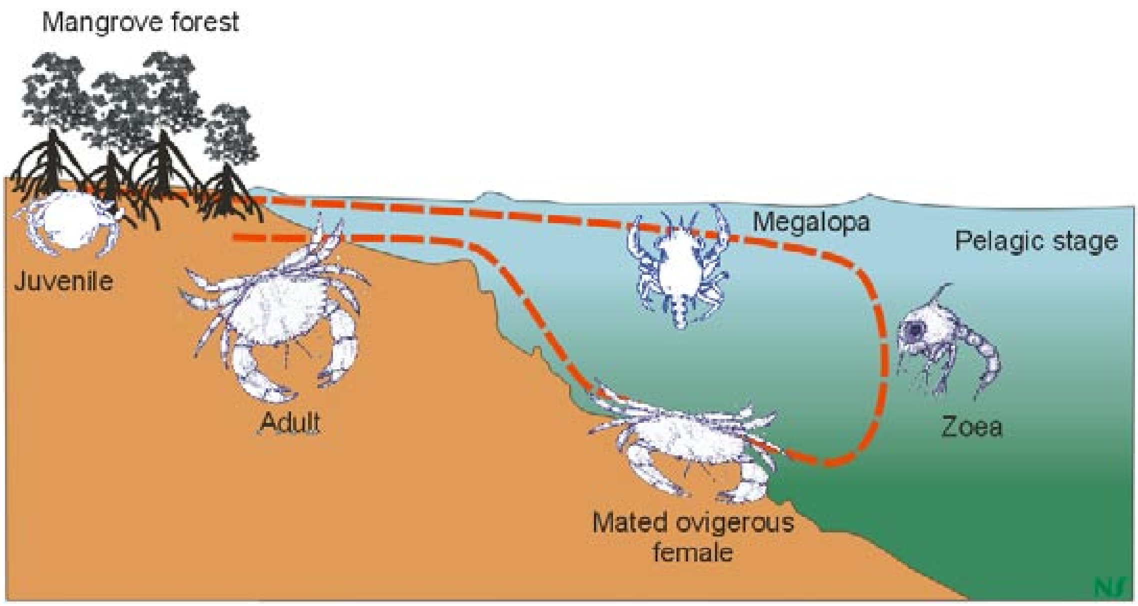
In the NPA, soft substrates are the most species-rich substrate (78 species), followed by reef (56 species), mangrove (48 species) and unconsolidated hard substrate (stones – gravel, rubble, loose rocks etc, 42 species) (Table 20.3). Interestingly, where the substrate has epibenthic fauna (coral, sponges, ascidians and echinoderms) it becomes the second most important substrate (72 species).

In respect to species numbers, intertidal and subtidal areas are of equal importance, although the species composition for intertidal and subtidal substrates differs (Table 20.3), as most species are relatively specialised to one or a few of these environments (ie few species are found over a very broad habitat range).

Mud crab (Scylla serrata and S. olivacea).

Mud crabs inhabit warm temperate to tropical waters near or in mangrove lined coastal habitats and prefer soft-muddy environments. They are carnivorous scavengers living in deep burrows around mangrove roots and in the banks of rivers and tidal creeks. Mating takes place just after mature females have moulted. Sperm is stored in the female's body for up to two to six months, whist the ova mature. Once the ova become fertile, they are fertilised and extruded from the body and deposited under the abdominal flap. Gravid females then migrate offshore to spawn (Figure 20.1).

Figure 20.1: *The life cycle of the green mud crab (Scylla serrata) Adults and juvenile mud crabs live in and near coastal mud flats and mangrove habitats whereas larvae (Zoea and megalopa) are pelagic* ***Source:*** *N Smit*



The eggs hatch into zoeal larvae, which, during their planktonic phase, pass through four zoeal stages. After approximately one month, the zoeal larvae have reached stage-4 and currents have moved the larvae inshore. Here they moult into a demersal megalopal (post-larval) stage. During a period of one to two years they develop into adults within the coastal environment. Adult specimens mature in tropical waters at 18 months (Kailoa et al. 1993) and reach a maximum age of three years.

Females can mate more than once (Knuckey 1999) and can spawn up to three times after mating.

Blue swimmer crab (Portunus pelagicus)

Blue swimmer crabs are found Australia-wide and occur in intertidal areas, bays, estuaries and coastal waters to depths of about 60 m. They prefer muddy or sandy bottoms and seagrass habitats. They are generally found in sandier and deeper habitats than the mud crab. They are scavengers and feed actively on benthic fauna, in particular other crustaceans and shellfish.

Blue swimmer crabs are large animals and can grow up to 22 cm in carapace width and reach a weight of 1 kg. The males are mottled blue, whereas the females are mottled brown. Females are much smaller than the males. Mating takes place shortly after the female moult with females producing up to four batches of eggs between each maturity moult. In the NPA, blue swimmer crabs mate in estuaries and move out to sea when the salinity drops during the wet season. Like mud crabs, they can store sperm for a considerable time before fertilisation and extrusion of eggs. They also have a series of larval stages before they settle out within four to six weeks of hatching. Maturity can be reached within 12 months. Blue swimmer crabs are an important edible crab, mainly caught in traps (pots), but also taken as a bycatch of prawn trawls.

Significance of the species group in the Northern Planning Area

Ecological and ecosystem significance

We know very little about the biology of true crabs (eg species distribution, life cycle or habitat requirements) and the role they play in the existing ecosystems within the NPA. The exceptions are the commercially managed species, although this knowledge is focused on life history and population dynamics.

Studies (eg Robertson 1986, McGuinness 2003) indicate that crabs play an integral role in the trophic and nutrient processes within and between ecosystems and that there are considerable interactions among species. However, most of these processes/interactions are not well understood at present. For example, it is believed that because of the additional breakdown of litter by crabs (such as *Neosarmatium meinerti*, *Clistocoeloma merguiensis*, *Metopograpsus frontalis* and subtidal sesarmid crabs, which all are common in the NPA) detritus is processed much faster than in systems that rely on leaching and fungal decay. Consequently, nutrients are turned over faster and it is suggested that this may lead to higher bacterial and algal productivity, both of which are primary drivers behind trophic systems within aquatic environments. Crabs are also a major link in food chains, being important prey species for higher order animals, including many species of fish, birds and crocodiles in all habitats, including seagrass mangrove and mudflats (Klumpp et al. 1989, Blaber 1997). In the NT, small reef-associated crab species form a large part of the diet of coastal finfish, black jewfish (*Protonibea diacanthus)* and golden snapper (*Lutjanus johnii)* in particular (T Hay pers. comm.).

Besides being a cornerstone of the trophic and nutrient process within and between ecosystems, crabs also have the ability to modify habitat. Studies have shown that Grapsid crabs, in particular *Neosarmatium meinerti*, eat mangrove shoots and limit the growth and survival of *Ceriops tagal* and *Rhizophora stylosa* (McGuinness 1997, K Metcalf, pers. comm.).

Resource use

Indigenous and recreational use

It is well recognised that indigenous people across the Top End have a strong affinity with the marine environment (eg Sharp 2002). Over 90% of the Aboriginal people living in northern Australia rely heavily on coastal and inshore waters for their fishing activities (Coleman et al. 2003).

Indigenous and recreational fishers generally fish near population centres (ie towns, settlements and outstations). The majority of recreational fishers use vessels to fish, whereas Indigenous fishers fish mainly from the shore (Coleman 2003, Henry & Lyle 2003). Both groups harvest crabs, often in conjunction with other fishing activities. Crabs are caught in pots (recreational fishers), or by hand or spear (Indigenous fishers). Hooks are also used in the NT, but these are banned in Queensland. In the NT, recreational fishers target primarily mud crabs (98%); however, Indigenous fishers and Queensland recreational fishers catch a larger proportion of non-commercial species (30–40%).

20. Crabs
(Brachyua: the true crabs)

Table 20.1: *Comparison of Indigenous, recreational and commercial harvest of crabs (numbers of crabs) in the Northern Territory and Queensland in 2000 (data from Henry & Lyle 2003, Coleman 2003, Higgs & McInnes 2003)*

Species		Qld		NT	
		total	NPA	Total	NPA
Mud crab	Commercial	1 250 000	192 500	1 296 250	1 076 000
	Recreational	585 000	58 500	82 371	20 625*
	Indigenous	12 500		86 573	32 350**
	Fishing tour operators			1 000	?
Blue swimmer	Commercial				
	Recreational	140 242	14 000	671	
	Indigenous	882		646	
	Fishing tour operators				
Other brachyuran crabs	Commercial				
	Recreational	483 655	48 350	<1 000	
	Indigenous	2 345		44 146	
	Fishing tour operators				

* *based on FishCount 1995 data (Coleman, 1998)*
** *based on the proportion of Indigenous people living in NPA and total number of people living in coastal communities in the NT*
*** *based on an approximate estimation of 10% of total number of recreational fishers in Qld*

Commercial use

Mud crab fishery

In 2002 there were 843 crab licences in the NT and Queensland (NT: 49, Qld: 794). There are currently 517 (NT: 49, Qld: 468) active licences in both jurisdictions, of which 30 NT fishers and 82 Queensland fishers are working the coastal waters of the NPA.

There are no restrictions of the movement of mud crab operators, and in a worst case scenario they could all decide to fish in the NPA. The total number of operators in the NT is fixed at 49; however, the number of active operators in Queensland varies greatly from year to year as many licence holders also have licences to operate in other fisheries. As the majority of the commercial catch consists of the green mud crab (99%) and the orange mud crab represents only 1% of the total commercial 2002 catch (Anon 2002), the mud crab fishery is managed as a single species fishery. However, mud crab stocks in both jurisdictions are managed separately, even though there is evidence that there is a single mud crab stock in the NPA (Gopurenko et al. 1999, Gopurenko & Hughes 2002). Stock assessment is based on catch and effort data recorded in compulsory fishing activity logbooks and, in the NT, additional fishery-independent data is collected (eg carapace width) by Queensland and NT fishery agencies.

The total catch of the commercial mud crab fishery has increased considerably over the last few years and reached a total of approximately 1000 t per year for each jurisdiction in 2001, with an approximate value of $12 million. Stock assessments indicate that harvest is sustainable (Environment Australia 2002), although it is considered to be very close to its maximum harvest levels in areas fished in the NT (Walters et al. 1999). However, NT and Queensland harvest levels fell in 2002, to a total of approximately 1000 t for both jurisdictions (similar to harvest levels seen in 1999), with fishing effort remaining the same (NT) or slightly lower (Queensland) and new fishing grounds being explored or more heavily used (eg Blue Mud Bay, NT). Further, there is anecdotal evidence that, in the NT, the 2003 harvest is again low (Chris Calogeras, pers. comm. & Iain Smith, NT Seafood Council, pers. comm.).

The reason for the decline in harvest rates is unknown. However, it is believed that there may have been poor recruitment (juveniles reaching the adult stage) in previous years, primarily thought to be caused by natural events (eg high rainfall, long wet season) as barramundi and prawn harvests are also below average (Iain Smith pers. comm.). There is a small possibility that the decline in harvest rates may also be caused by over-harvesting in previous years, which has prompted an independent review by the NT Mud Crab Association and Ian Knuckey (see 'Current research'). Exacerbating the problem, previous mud crab stock assessments have not taken into account harvest levels by recreational and Indigenous fishers and fishing tour operators. Within the NT portion of the NPA, 53 000 individuals were collected by non-commercial fishers in 2000 (Henry & Lyle 2003, Coleman 2003) which accounts for 5% of the total NT harvest and may alter the sustainability of the overall fishery.

Figure 20.2: Northern Territory catch and effort for the commercial mud crab fishery, 1983 to 2002 ***Source:*** *NT DPIF, Coleman 2003*

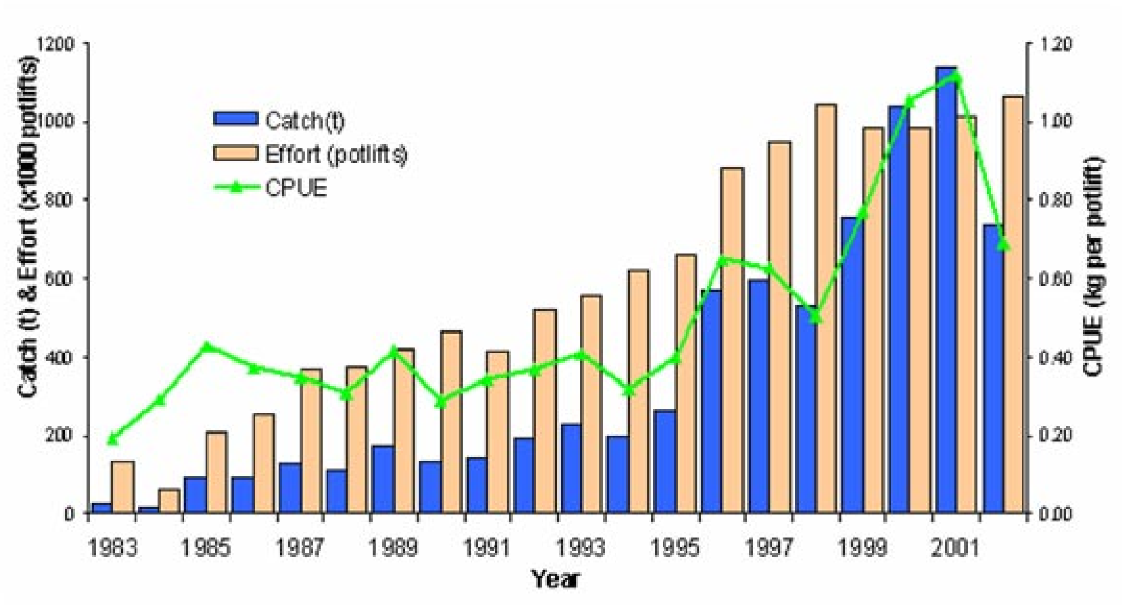
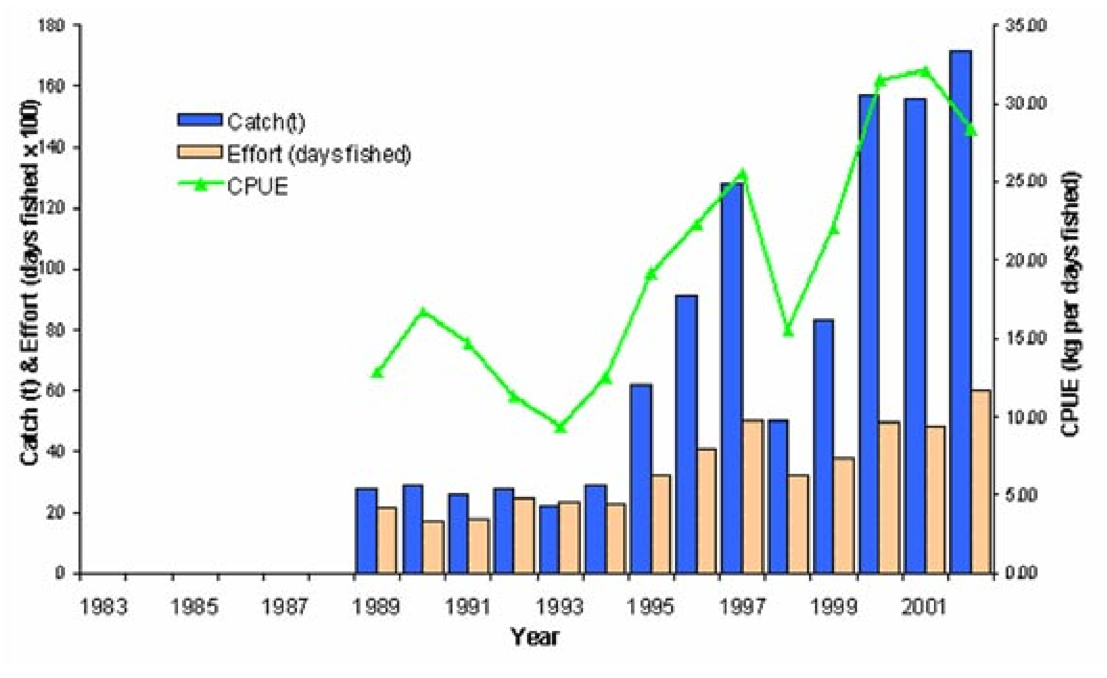


Figure 20.3: Queensland Gulf catch and effort for the commercial mud crab fishery, 1989 to 2002 ***Source:*** *Queensland Fisheries Service*



The NT commercial harvest levels in the NPA accounts for almost 81% of the total NT harvest and is centred around the McArthur and Roper River systems, with new grounds being explored in 1999 (eg Blue Mud Bay, GoC) and in 2002–3. The Queensland commercial harvest level in the NPA is approximately 16% of the total Queensland catch (based on 2001 data, Williams 2002) and is spread over four fisheries management areas.

The management regimes of the NT and Queensland mud crab fishery differ in certain aspects. Queensland has the most restrictive regulations. It has the largest size limit (Qld: 15 cm vs NT: 13 cm males; 14 cm females), and no females can be taken in Queensland at all. It has long been believed that this (ie no take of females) will maximise recruitment. However, this practice needs to be reviewed as studies have indicated that larger females have larger territories; consequently stock density, and thus productivity, is lower. Further,

there is some indication that (a) smaller males cannot mate with large females, and therefore some of the females are not fertilised and do not contribute towards recruitment; and (b) natural mortality of smaller crabs is higher when females are not harvested, due to cannibalism by the larger females.

Bycatch of the Queensland mud crab fishery is considered minimal (Ryan 2003). The dominant bycatch species are: blue swimmer crabs, toadfish, cod, catfish, bream and hermit crabs. The opinion amongst researchers is that most species that are attracted to the bait in the pots are small enough to freely enter and leave the pots.

Blue Swimmer Crab fishery

This fishery is mainly based on the east coast of Queensland. Five licences recorded commercial catches of blue swimmer crabs in Queensland in 2002, although considerably more fishers are licensed to take these crabs. Blue swimmer crabs are abundant in the GoC but they do not reach the size attained in subtropical and temperate waters and therefore few reach the minimum legal size.

There are no commercial blue swimmer crab licences in the NT. A development licence was granted in 2002 but it was not used.

Blue swimmer crabs are caught as bycatch in the mud crab fishery. However, their numbers are low, and they are generally not kept by commercial NT mud crab fishers.

Impacts/threats

There is a wide range of threatening processes/activities within the NPA of which some are driven by human activities and others are the result of natural processes. Although the impacts/threats can be identified, their extent is largely unknown. Given the lack of baseline data, the best method for minimising impacts on crab diversity would be protection/management of their habitats or the species on which crabs depend.

Management

Management remains hampered by lack of knowledge. For example, while authorities considered that there was adequate information to demonstrate the sustainability of the mud-crab fishery in the NT (eg Hay and Calogeras 2000, Hay and Calogeras 2001, Environment Australia 2002), these data related overwhelmingly to only one of the two crab species involved, green mud crab (which comprises 99% of the total commercial catch). The other species included within this fishery, orange mud crab, is treated variably as bycatch or subsumed within the assumed sustainability of the population and capture figures for green mud crab. There are a number of uncertainties in this treatment. For example, it is still not clear whether the low proportion of orange mud crab in the overall catch represents relative rarity or whether it is indicative of pronounced habitat segregation, as suggested by T Hay (pers. comm.), between green mud crab and orange mud crab. If the former, then it is doubtful whether an 'acceptable' harvest proportion for green mud crab would also necessarily be acceptable for orange mud crab. Removal of a high proportion of adults from the population may be more likely to exceed a social threshold (eg because potential mates are already widely separated) and/or because reduction in an already relatively small population may render that species particularly susceptible to other disturbance factors. Currently, there is no research that is specifically investigating this issue.

Fishing practices

Many harvest practices affect crab fauna directly or indirectly. Given that benthic fauna contributes significantly towards crab diversity (Table 20.3), the modification, destruction or loss of habitats – which may be caused, for example, by trawling or by trampling by Indigenous and/or recreational fishers – may lead to a decline of crab biodiversity and numbers. This in turn may have flow-on effects on nutrient and trophic processes. Prawn trawling practices have in the past also led to direct mortality of most bycatch species concerned, though the rate of survival has improved with the recent introduction of hoppers in the fishery.

Currently, road access determines which areas are targeted by mud crab fishers in the NT. However, there are developments occurring within the fishery that will reduce this dependence on road access (Iain Smith, NT Seafood Council, pers. comm.). As a result, it is likely that the fishery will be more evenly spread along the west coast of the GoC. However, it is unclear how this change in behaviour will affect the mud crab stock.

As most Indigenous and recreational fishers harvest crabs near to major population centres, camp sites and outstations, it is possible that localised over-harvesting of crab fauna in these areas could occur.

In more indirect terms, removing fish that consume crabs may lead to an increase in number of crabs, including those species that consume mangrove shoots

and thus partially regulate the growth and survival of mangrove species. On the other hand, the removal of large mud crabs may positively affect crab biodiversity, as the larger aggressive and territorial crabs consume their own and other smaller species of crabs.

Development

Possible impacts may occur from contamination, chemical spills etc, on a local scale in and around mines, ports and population centres. Contaminants are likely to bioaccumulate along the food chain, including within crabs. Oil, oil dispersants and heavy metals are known to be toxic to crustaceans and modify their burrowing behaviour.

With the further development of population centres and ports there will be increasing commercial and recreational vessel traffic, further increasing the risk of introducing aquatic pests. However, currently there are no known marine pests in the NPA.

During an aerial survey of coastal habitats along the west coast of the GoC, scars were observed in soft substrate and seagrass habitats (Smit unpublished data). This was caused by outboard propellers turning through soft substrates, including seagrass substrates, and not by feeding dugongs as originally thought. Although this does not affect crabs directly, it may have a negative impact on the substrate/habitat on which crabs depend. The long-term consequence of scarring on these substrates is unknown.

Natural events

Catastrophic events, such as cyclones, occur in the NPA and are currently the most threatening factor for loss of habitats in shallow coastal waters. In addition, global climate change is expected to lead to raised sea level and sea water temperatures. Such changes may have long-term impacts on habitat distribution/composition and species distribution, particularly in coastal habitats, such as seagrass, mangroves, salt marshes/flats and coral reefs.

It is therefore important that threat assessment and the design of monitoring programs take into account the cumulative effects of threatening anthropogenic and natural processes.

Information gaps

Currently we are unable to identify the conservation status of most species of crabs because there are insufficient data that describe patterns in distribution and abundance. Much of the available spatial data are biased towards deep-water soft-substrates or clustered around a few focal points and listed as '*only recorded from a limited number of sites*' (Davie 2002). More comprehensive and systematic surveys are needed. However, management of crabs cannot be solely based on known patters of richness alone but have to take into account various other aspects of the ecosystem (eg trophic, biogeochemical processes etc). Consequently, studies that investigate linkages between species (eg crab v crab and crab v fish/birds) and their habitats (crab v samphire/mangroves/mud and sand flats/seagrass etc) is also required.

Besides collecting baseline data (ie distributional and abundance data; linkage between species), there is also a need to 'work-up' existing data; for example, many MAGNT voucher specimens still remain to be identified, greatly reducing the usefulness of the collection. Currently there is a lack of local taxonomic expertise.

Commercial mud crab fishery

Although research to develop methods of fishery assessments that do not rely solely on commercial logbooks is under way, more work needs to be done in this area. Further stock assessment needs to be done to take into account (1) harvest by non-commercial fishers and (2) that there is a single genetic stock in the GoC.

Given that the mud crab fishery is managed as a single species, there is need to establish the status of S. *olivacea* in respect to sustainable use.

Key references and current research

Current research

Current research activity is focussed on the commercial crab species, with several large projects currently in progress:

NT mud crab fishery assessment

This program (by Tracy Hay, NT Fisheries Group) collects both fishery-dependent and fishery-independent data for assessment purposes. Long term data sets for assessment purposes are collected for this fishery. Data collected include: biological characteristics such as size, sex, maturity, species composition and shell condition. This information is collected each month from four commercially important regions in the NT (McArthur, Roper, Blue Mud Bay and Adelaide River regions, 1992–present). Changes in fishery dynamics are also monitored through the collection of commercial catch and effort data (1983–present). Information on movement, growth and selectivity is also collected from tagging conducted in the southern GoC (1998–present).

20. Crabs

(Brachyua: the true crabs)

Northern Queensland mud crab stock assessment

This program (by Neil Gribble, Northern Fisheries Centre, Cairns, Queensland) is an integrated response to the need for basic information on the status of green mud crabs stocks in northern Queensland. It includes baseline surveys in Norman River, Staaten River, Mitchell River and Weipa, and an estimation of mud crab abundance in the four Queensland Fisheries management areas.
For further information see
http://www.dpi.qld.gov.au/fisheriesmonitoringprogram.

Methods for monitoring abundance and habitat for northern Australian mud crab Scylla serrata

This collaborative project between NT Fisheries Group and Queensland Department of Primary Industries and Fisheries (led by Tracy Hay and Neil Gribble) aims to identify and quantify the area of critical mud crab habitat in the NT and Queensland and develop and assess methods to estimate the size of northern Australian mud crab stocks.

Independent assessment of the sustainability harvest of Northern Territory mud crabs.

Instigated by the NT Mud Crab Association in collaboration with NT Fisheries Group, this is an assessment of the sustainability of the mud-crab fishery in the NT. This independent assessment was prompted by the decline in catches in the last two years and is being conducted by Ian Knuckey. The final report was expected by the end of 2003.

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20. Crabs
(Brachyua: the true crabs)

Table 20.2: *Species list for Queensland Gulf country (non-marine, Qld Gulf), Gulf of Carpentaria (Qld and NT estuarine and marine waters, GoC) and Northern Territory waters (NT waters: NT coastal, Timor Sea and Arafura Sea), compared with neighbouring regions (Eastern Queensland coast (Qld NE), Western Australia coast (WA N and NW; WA W coasts))*

The listing used only those species that are found only in the Northern Planning Area, or have been recorded from a limited number of neighbouring regions or are used for commercially, recreational or subsistence use. Shaded cells show presence of species – black for within the NPA and grey in adjacent areas. Abbreviations: U, unknown conservation status; C, commercial managed fishery; R, restricted to few localities. Information is based on primary data from the Northern Territory Museums and Art Galleries crustacean database and Davie (2002).

Family	Species group common name	Genus	Species	Common name	Qld NE	NPA			WA N&NW coast	WA W coast	Status	Endemic	Distribution	Comment
						Qld Gulf	GOC	NT waters						
Aethridae		*Drachiella*	*sculpta*										R	Has a Indo-west Pacific distribution
Camptandriidae		*Cleistostoma*	*mcneilli*								U		R	
Dromiidae	Sponge crabs	*Desmodromia*	*griffini*								U		R	Darwin Harbour
Goneplacidae		*Eucrate*	*dorsalis*								U		R	
Grapsidae	Shore crabs	*Perisesarma*	*darwinensis*								U		R	Darwin Harbour
		Perisesarma	*longicristatum*								U		R	
	Mangrove crabs	*Sarmatium*	*hegerli*								U		R	East Alligator River
		Sarmatium	*unidentatus*								U		R	Nungbalgarri Creek
Hymenosomatidae	False spider crabs	*Elamena*	*umerata*								U		R	Darwin Harbour
		Halicarcinus	*bedfordi*								U	E	R	
		Neohynchoplax	*torrensica*								U		R	
		Trigonoplax	*spathulifera*								U		R	
Leucosiidae	Pebble crabs	*Ixa*	*acuta*								U		R	
		Leucosia	*reticulata*								U		R	
Majidae	Spider crabs / decorator crabs	*Naxioides*	*tenuirostris*								U		R	
		Pseudomicippe	*banfieldi*								U		R	
Ocypodidae		*Australoplax*	*tridentata*								U	E	R	record from Samoa doubtful
		Ilyoplax	*strigicarpus*								U		R	
	Sentinel crab	*Macrophthalmus*	*abercrombiei*								U		R	
		Tmethypocoelis	*koelbeli*								U	E	R	South Alligator River
	Fiddler crabs	*Uca*	*capricornis*								U		R	
		Uca	*dampieri*								U		R	Darwin
		Uca	*elegans*								U		R	
		Uca	*flammula*								U		R	
		Uca	*hirsutimanus*								U		R	
		Uca	*mjoebergi*								U		R	
		Uca	*polita*								U		R	
		Uca	*seismella*								U		R	
		Uca	*signata*								U		R	
		Uca	*vomeris*								U		R	
Parathelphusidae	Freshwater crabs	*Austrothelphusa*	*agassizi*								U		R	Archer River

Family	Species group common name	Genus	Species	Common name	Qld NE	NPA			WA N&NW coast	WA W coast	Status	Endemic	Distribution	Comment
						Qld Gulf	GOC	NT waters						
		Austrothelphusa	*tigrina*								U		R	one mile creek
		Austrothelphusa	*valentula*								U		R	from east and west flowing catchments in the vicinity of Coen
Parthenopidae		*Cryptopodia*	*fistulosa*								U		R	
Pilumnidae	Hairy crabs	*Benthopanope*	*estuarius*								U		R	
		Cryptolutea	*arafuraensis*								U		R	Ludmilla Creek
		Cryptolutea	*engulata*											
		Lophopilumnus	*globosus*								U		R	
		Pilumnus	*pulcher*								U		R	
		Pilumnus	*semilanatus*								U		R	
		Pronotonyx	*laevis*								U		R	Arafura Sea
		Rhabdonotus	*pilipes*								U		R	
		Typhlocarcinops	*arcuata*								U		R	Darwin Harbour
		Zebridonus	*mirabilis*								U	E	R	
Plagusiidae		*Euchirograpsus*	*timorensis*								U		R	Timor Sea
Portunidae	Swimmer crabs	*Charybdis*	*jaubertensis*								U		R	
		Charybdis	*yaldwyni*								U		R	
		Portunus	*pelagicus*	Blue swimmer crab									C	Commercial, wide spread
		Portunis	*wilsoni*								U		R	only known from Clarence Strait
		Scylla	*olivacea*	Orange mud crab									C	Commercial, wide-spread
		Scylla	*serrata*	Green or giant mud crab									C	Commercial, wide-spread
Xanthidae	Black-fingered crabs	*Banareia*	*inconspicua*								U		R	
		Hypocolpus	*maculatus*								U		R	

Table 20.3: *Species distribution across substrate/habitat types Shaded cells show presence of species*

Family	Genus	Species	Freshwater	Shore – beach	Shore – rocky	Salt flats	Mangroves	Creek bank	Seagrass	Algae, seaweed	Commensal, sponge, coral	Soft substrate	Mud flats	Sand flats	Sand bank	Reef	Hard substrate – unconsolidated	Shelly	Arboreal	Littoral	Estuarine	Intertidal	Subtidal	oceanic	Continental shelf/slope
Aethridae	Drachiella	sculpta										■					■					■	■		
Camptandriidae	Cleistostoma	mcneilli					■														■	■			
Dromiidae	Desmodromia	griffini																					■		
Goneplacidae	Eucrate	dorsalis																					■		
Grapsidae	Perisesarma	darwinensis					■														■	■			
	Perisesarma	longicristatum				■	■														■	■			
	Sarmatium	hegerli					■	■				■										■			
	Sarmatium	unidentatus					■					■										■			
Hymeno-somatidae	Elamena	umerata																					■		
	Halicarcinus	bedfordi							■			■									■	■			
	Neohynchoplax	torrensica					■				■					■					■				
	Trigonoplax	spathulifera									■					■						■	■		
Leucosiidae	Ixa	acuta																				■	■		
	Leucosia	reticulata									■	■		■		■						■	■		
Majidae	Naxioides	tenuirostris									■	■						■					■		
	Pseudomicippe	banfieldi									■					■						■	■		
Ocypodidae	Australoplax	tridentata					■					■									■	■			
	Ilyoplax	strigicarpus										■									■	■			
	Macrophthalmus	abercrombiei					■						■									■			
	Tmethypocoelis	koelbeli					■	■													■				
	Uca	capricornis					■	■													■	■			
	Uca	dampieri					■	■				■			■						■				
	Uca	elegans				■	■					■									■	■			
	Uca	flammula					■	■													■	■			
	Uca	hirsutimanus					■	■													■	■			
	Uca	mjoebergi					■					■									■	■			
	Uca	polita					■	■				■			■						■	■			
	Uca	seismella					■	■													■	■			
	Uca	signata				■	■	■				■									■	■			
	Uca	vomeris						■				■			■						■	■			
Parathe-lphusidae	Austrothelphusa	agassizi	■																						
	Austrothelphusa	raceki	■																						
	Austrothelphusa	tigrina	■																						
	Austrothelphusa	valentula	■																						
Parthenopidae	Cryptopodia	fistulosa								■	■												■		
Pilumnidae	Benthopanope	estuarius					■				■	■					■	■			■	■	■		
	Cryptolutea	arafuraensis					■															■	■		
?	Cryptolutea	engulata																							
	Lophopilumnus	globosus																				■	■		
	Pilumnus	pulcher									■					■							■		
	Pilumnus	semilanatus									■	■				■							■		
	Pronotonyx	laevis																					■		

Family	Genus	Species	Freshwater	Shore – beach	Shore – rocky	Salt flats	Mangroves	Creek bank	Seagrass	Algae, seaweed	Commensal, sponge, coral	Soft substrate	Mud flats	Sand flats	Sand bank	Reef	Hard substrate – unconsolidated	Shelly	Arboreal	Littoral	Estuarine	Intertidal	Subtidal	oceanic	Continental shelf/slope
	Rhabdonotus	pilipes									■					■							■		
	Typhlocarcinops	arcuata																					■		
	Zebridonus	mirabilis									■												■		
Plagusiidae	Euchirograpsus	timorensis																						■	■
Portunidae	Charybdis	jaubertensis										■								■		■	■		
	Charybdis	yaldwyni										■										■	■		
	Portunus	pelagicus							■			■		■	■							■	■		
	Portunis	wilsoni										■					■	■			■	■	■		
	Scylla	olivacea				■	■					■									■	■	■		
	Scylla	serrata					■													■	■	■	■		
Xanthidae	Banareia	inconspicua									■	■						■					■		
	Hypocolpus	maculatus																					■		
	Total of above		4	0	0	4	22	10	1	1	12	21	1	1	3	7	4	4	0	2	36	30	26	1	1
	Total all spp. in NPA		5	4	6	4	48	15	2	5	72	78	8	3	3	56	42	25	3	7	34	114	119	1	11

21. Lobsters

This chapter should be cited as:
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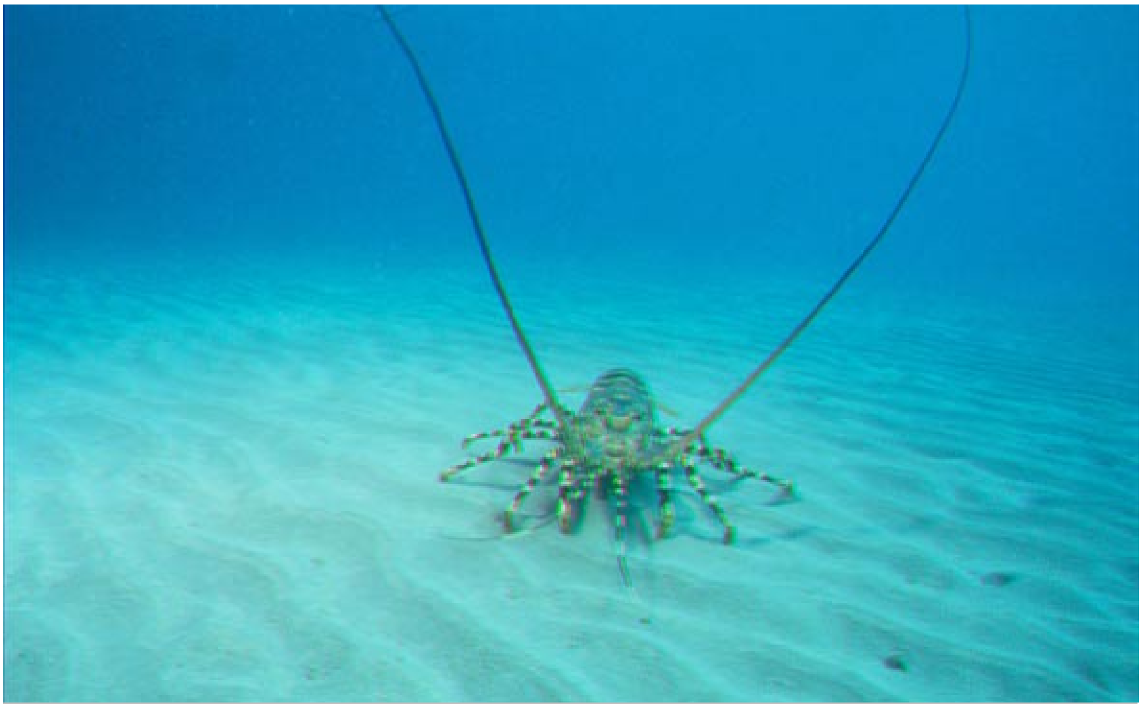
Ornate rock lobster (P. ornatus) ***Source:*** *D Dennis*



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Species group name and description

Common name: spiny lobsters.

Scientific name: superfamily Palinuroidea, family Palinuridae.

Other names by which the species group is known: lobsters, crayfish, rock lobsters.

The spiny lobster group (family Palinuridae) comprises eight genera: *Jasus*, *Justitia*, *Linuparus*, *Palinurus*, *Palinustus*, *Panulirus*, *Projasus* and *Puerulus*. While four of these genera, *Justitia*, *Linuparus*, *Puerulus* and *Palinurus* are likely to occur in the Northern Planning Area (NPA) (Holthuis 1991, CSIRO unpublished data) only *Panulirus* is dealt with in this report as the remaining three genera are poorly known, are probably very rare in the NPA due to their preference for deep habitats (greater than 30 m) and there are no commercial, recreational or Indigenous fisheries based on them. *Justitia japonica* and *J. mauritiana* occur widely throughout the Indo-West Pacific (Holthuis 1991), but their small size, deep habitat (30–200 m) and scarcity has precluded any significant fishery for them. Larvae of *Justitia* spp. were common amongst plankton catches sampled in the north-west Coral Sea in 1997 (Dennis et al. 2001) and adults probably occur in eastern Torres Strait. Similarly *Linuparus sordidus* and *L. trigonus* occur widely in deep habitats throughout the Indo-West Pacific, and *L. trigonus* has been taken commercially by prawn trawling off the north Queensland coast. Whether they occur in the NPA is unknown, but the restricted deep habitat suggests populations would be small. *Puerulus angulatus* and *P. velutinus* also occur throughout the Indo-west Pacific, but again their depth preferences (274–536 m and 520–683 m, respectively) indicate they would be very rare in the NPA.

There are six species from the genus *Panulirus* that occur in the NPA:

- ornate rock lobster *(P. ornatus)*
- painted rock lobster *(P. versicolor)*
- double spined rock lobster *(P. penicillatus)*
- blue spot rock lobster *(P. longipes femoristriga)*
- scalloped spiny lobster *(P. homarus)*
- mud spiny lobster *(P. polyphagus)*

Because of their similarity these species are often grouped as tropical, spiny or rock lobsters when observed in the same locality or taken in a commercial fishery. The contributions of each species to various fishery sectors within the NPA are listed in Table 21.1.

Status

No spiny lobsters in the NPA are listed as endangered under international, Australian (Commonwealth), Northern Territory (NT) or Queensland environmental legislation and management arrangements are in place under state and Commonwealth fisheries legislation.

The ornate rock lobster (*Panulirus ornatus*) supports the only significant commercial lobster fishery in Torres Strait (about 500 t whole weight). The Torres Strait lobster fishery is managed by the Protected Zone Joint Authority (PZJA) in accordance with commonwealth law in the Australian component of the Torres Strait Protected Zone (TSPZ). The TSPZ was established in 1985 as part of the Torres Strait Treaty between Australia and PNG, designed to protect the livelihood of the traditional inhabitants.

Management of the Torres Strait lobster fishery by the Australian Fisheries Management Authority (AFMA) is supported by annual fishery-independent surveys and stock assessments (1989–2003) conducted by CSIRO at Cleveland. During 1999–2001 coincident declines in stock and recruit abundance raised concerns that the fishery was not sustainable. Fishery modelling suggested that the stock was biologically over-exploited relative to several biological reference points, including the stock size that produces half the maximum recruitment and the fishing mortality associated with this point. New management, including an extended closed season (October to January) and increased minimum size (115 mm tail length or 90 mm carapace length) were implemented in 2002 to reduce fishing mortality and allow the stock to recover. There has been significant recovery of the stocks since 2001 and the 2003 stock was amongst the largest for a decade.

The remaining *Panulirus* species do not support significant commercial fisheries in the NPA (Queensland or NT; Table 21.1) and few assessments have been made of the status of these populations. A survey of the recreational and Indigenous lobster catches in NT waters during 2000 found that only 420 lobsters were taken by recreational fishers and 1321 were taken by Indigenous fishers (Henry & Lyle 2003).

21. Lobsters

Table 21.1: Species of spiny lobster taken in separate fishery sectors in the NPA

	Fishery			
Species	Commercial	Recreational	Indigenous	Bycatch
P. ornatus	Torres Strait (500 t) NT Development Fishery	Torres Strait Northern Territory	West Torres Strait Northern Territory	Torres Strait Prawn Fishery (0 take)
P. versicolor	Torres Strait (<1%) NT Development Fishery	East Torres Strait Northern Territory	East Torres Strait	None
P. penicillatus	None	None	East Torres Strait	None
P. longipes femoristriga	None	None	East Torres Strait	None
P. homarus	None	None	None	None
P. polyphagus	None	None	None	GoC Prawn (0 take)

Habitat and distribution

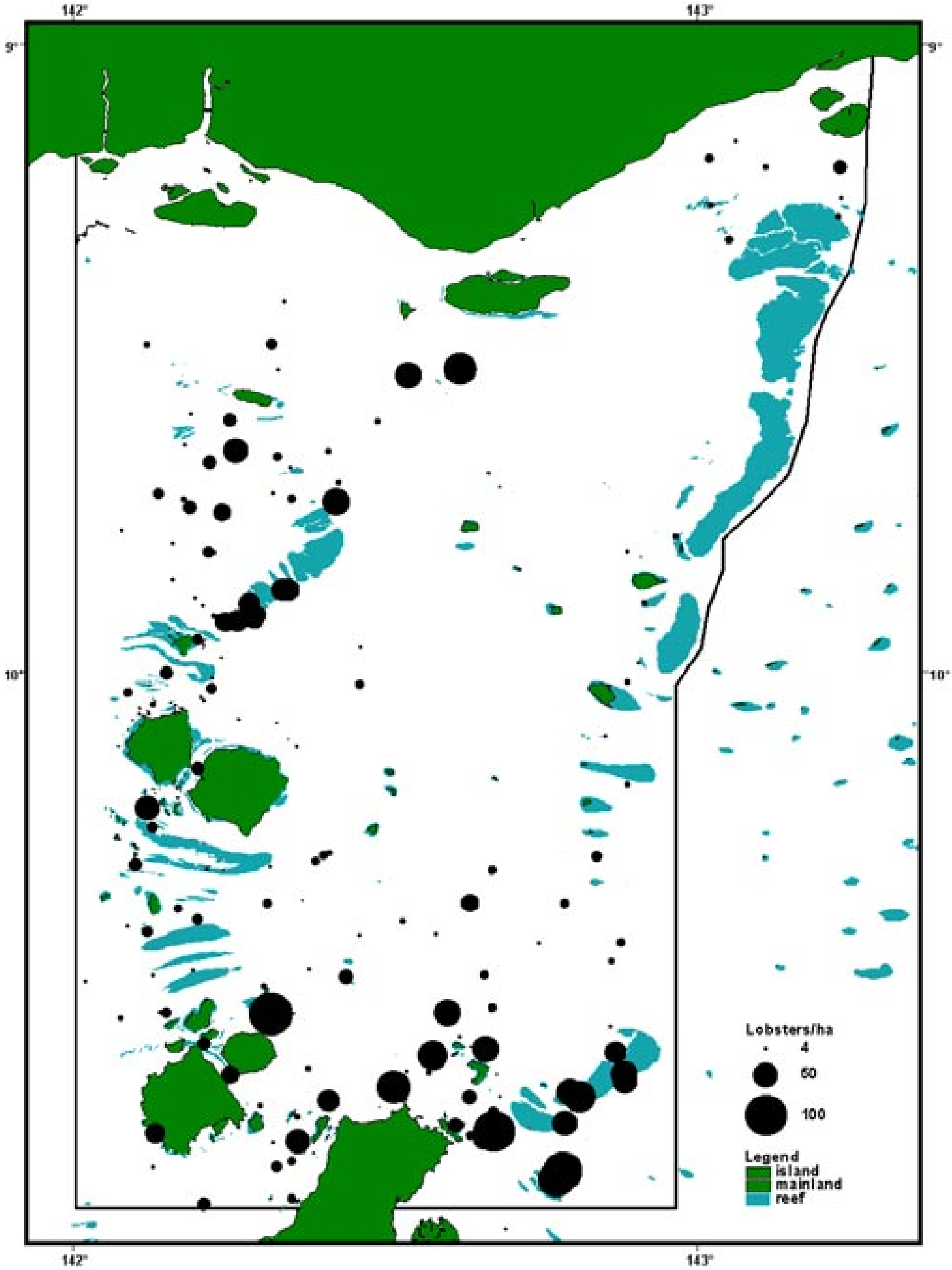
Habitat

Adult spiny lobsters probably occupy a variety of rock/reef habitats within the NPA and the habitat preferences are largely species-specific as outlined below. Most species inhabit shallow (less than 20 m) reef habitats, although ornate rock lobsters have been observed at depths greater than 100 m. Hard substrates are essential for most species, to provide adequate shelter during daytime. Given the distribution of shallow rock/reef habitats in the NPA, spiny lobsters are probably restricted to Torres Strait, hard seabed fringing the Gulf of Carpentaria (GoC) and around islands within the NPA including Wessels, English Company Islands, Sir Edward Pellew group and Groote (Neil Smit pers. comm.). High densities of painted rock lobster were observed around the Wessels Islands by CSIRO staff in November 2003 (Richard Pillans pers. comm.) but the extent of this population is unknown. Habitat of newly-settled and juvenile spiny lobsters is generally similar to that of the adults, and several cohorts may occur in the same vicinity. The newly-settled stages of ornate rock lobster and painted rock lobster settle into solution holes in rock pavement and coral bommies respectively, in adult habitats in Torres Strait (CSIRO unpublished data). The larval phase of the spiny lobster life cycle occurs in oceanic waters, off the continental shelf. Hence few spiny lobster larvae would be found in the bounds of the NPA. This is corroborated by the low catches reported by Rothlisberg et al. (1994) within the GoC. The prolonged larval phase (4–12 months) for spiny lobsters allows widespread dispersal and most of the adult populations within the NPA probably originate from several remote locations.

The most common species in the NPA, the ornate rock lobster, occurs in a wide variety of habitats, although generally preferring turbid, rocky areas with a terrestrial influence (Pitcher 1993). They occur throughout Torres Strait from the continental shelf fringing the NW Coral Sea to western Torres Strait. In western Torres Strait they are most abundant on seabed of the ancient land-bridges between Australia and PNG (Fig. 21.1). It is likely they also occur in rocky areas fringing the GoC, although the absence of commercial catches in NT waters and the very rare occurrence of their larvae in extensive plankton trawls (Rothlisberg et al. 1994) suggest adults are very rare throughout the GoC. Further, the shallow turbid habitat in the GoC is likely to be unsuitable for most spiny lobsters that require oceanic waters during their pelagic larval phase. Although not recorded, a large percentage of the recreational and Indigenous catches by NT fishers probably consist of ornate rock lobster, given their preference for turbid rocky habitats.

Ornate rock lobsters are most common in shallow (less than 20 m) rocky areas although they have been recorded at depths exceeding 100 m off the far northern Great Barrier Reef (Prescott & Pitcher 1991). Newly-settled ornate rock lobsters prefer appropriate sized solution holes in rock pavement with some cover of seagrass or macro-algae (Dennis et al. 1997, Dennis & Pitcher 2001). The only known breeding ground of ornate rock lobsters in Torres Strait is the deeper reefs (greater than 20 m) on the far northern Great Barrier Reef near Murray Island in eastern Torres Strait (CSIRO unpublished data). Since the early to late larval stages occur only in oceanic waters there is no larval habitat in Torres Strait. Nevertheless, the final puerulus stage (see Figure 21.2) that transits the continental shelf from the Coral Sea is found almost exclusively in surface waters prior to settling to assume a benthic life (Dennis et al. 2001).

Figure 21.1: *Map of western Torres Strait showing the distribution and abundance of the ornate rock lobster Panulirus ornatus from diver surveys in May 2002* ***Source:*** *CSIRO*



Painted rock lobsters are found most commonly in coral-rich environments. Though absent in western Torres Strait this species is common in coral-rich habitats in eastern Torres Strait (CSIRO unpublished data). The commercial fishery based around Murray and Darnley Islands in eastern Torres Strait is composed of almost equal portions of painted and ornate rock lobster (Pitcher et al. 1995). This species also occurs on the eastern coast of the GoC (Neil Smit pers. comm.), and is likely to occur on the western coast and around the islands in the NPA.

The double-spined rock lobster exhibits probably the greatest habitat specificity of the species that occur in the NPA. It occurs almost exclusively in the exposed surf zones of oceanic reefs. This species was recorded on exposed coral reefs during diver surveys in eastern Torres Strait in 1992 and 1996 (CSIRO unpublished data) and is probably restricted to this habitat within the NPA.

21. Lobsters

The blue-spot rock lobster is found in habitats similar to those preferred by double-spined rock lobsters, although it occupies a greater depth range. This species was also recorded on coral reefs during diver surveys in eastern Torres Strait in 1992 and 1996 (CSIRO unpublished data) and, like double-spined rock lobsters, is likely to be restricted to this habitat within the NPA.

Scalloped spiny lobsters occupy similar habitats to those preferred by ornate rock lobsters, particularly more turbid rocky areas.

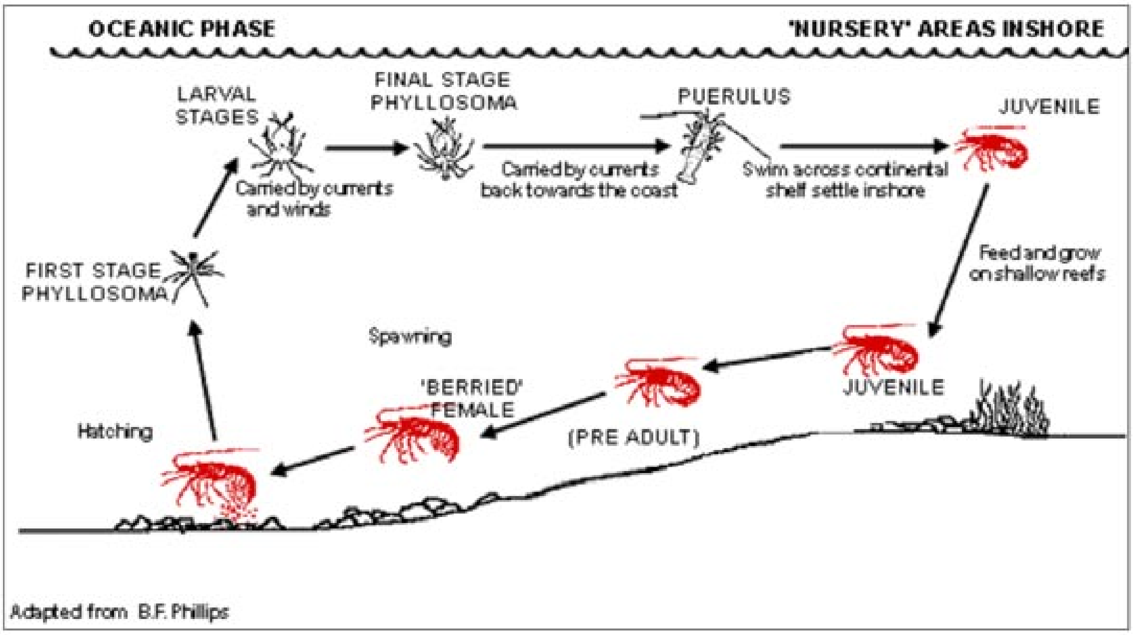
The mud spiny lobster, as its common name suggests, occupies muddy substrates often near river mouths (Holthuis 1991). Its distribution in the NPA is not well documented but the rare occurrence of this species in bycatch samples taken by prawn trawlers in the GoC (CSIRO unpublished data) suggests small populations occur there.

Life cycle and reproduction

The different species of tropical spiny lobster (family Panuliridae) have relatively consistent life cycles involving separate benthic and pelagic phases (Fig. 21.2). The life cycle of the ornate rock lobster is the best known of the species occurring in the NPA due mainly to targeted biological research done by the Papua New Guinea and CSIRO during the 1980s. Mating and reproduction generally occurs during summer, often in deep water near the edge of the continental shelf to facilitate dispersal of the larvae into oceanic waters.

Sub-adult ornate rock lobsters in Torres Strait undertake a migration during March-May to the eastern Gulf of Papua to mate and breed (Moore & MacFarlane 1984). Migrations to the breeding grounds are much less extensive for the remaining species. Once released the larvae (phyllosoma) begin the pelagic phase in oceanic waters. Phyllosomas undergo vertical migrations of up to 100 m during their oceanic existence. Larval movement is primarily via sub-surface ocean currents and surface wind-driven currents in the early phases due to their poor swimming ability. For ornate rock lobsters the delay between the seasonal breeding in Papua New Guinea and subsequent settlement in Torres Strait suggests larval longevity is 4–7 months (Dennis et al. 2001). Larval longevity in the remaining species is likely of similar duration, although species with a more cosmopolitan distribution (ie *P. penicillatus*) may have a longer larval life to facilitate widespread dispersal. The final larval moult involves a dramatic metamorphosis to the puerulus stage, which links the pelagic and benthic phases. The puerulus is a non-feeding stage that seeks appropriate habitat for settlement. In the case of ornate rock lobsters occurring in Torres Strait, the puerulus must traverse about 100 km of continental shelf prior to settlement in suitable habitat. Hence mortality during this phase is undoubtedly high.

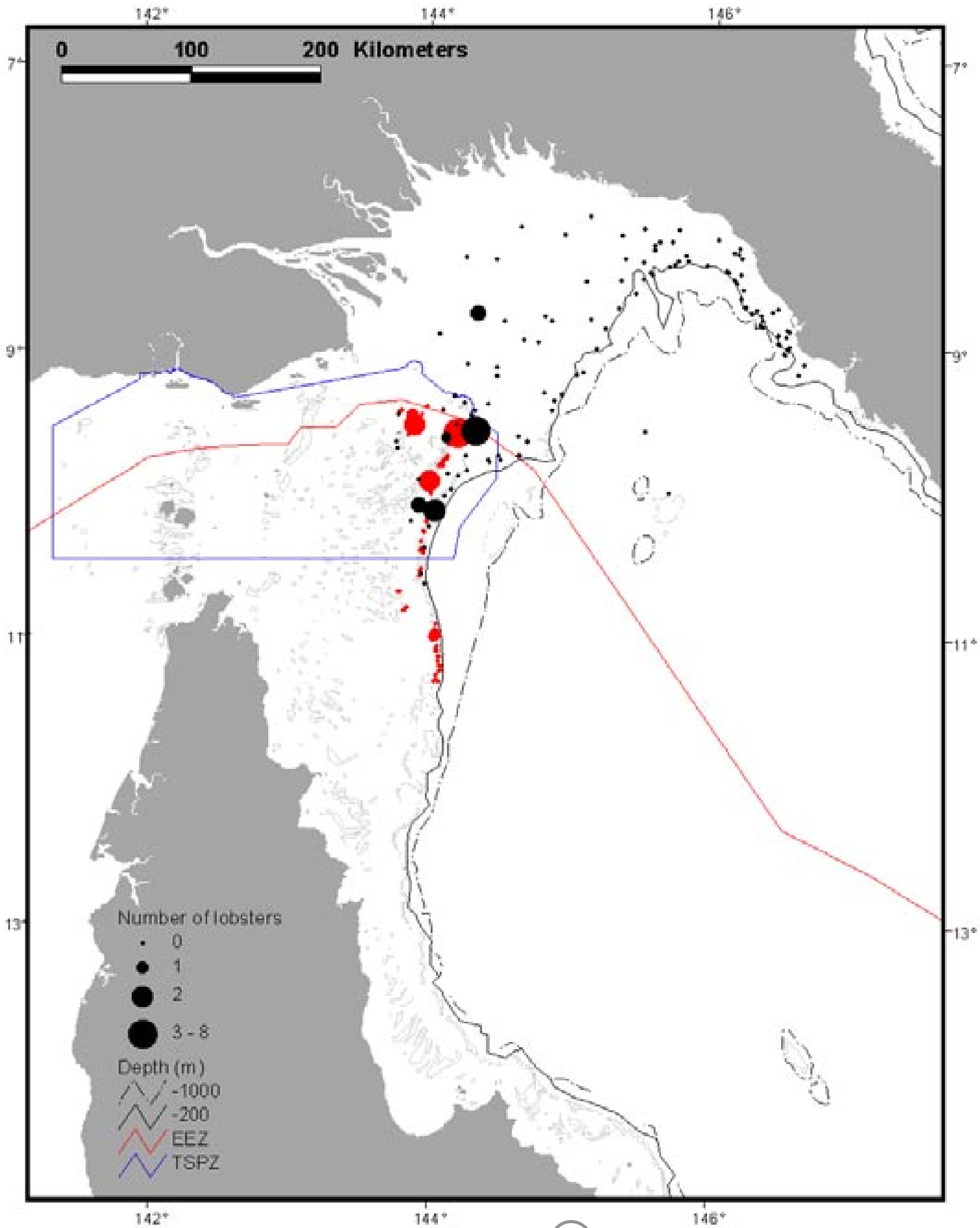
***Figure 21.2:** Life cycle of tropical spiny lobsters showing the benthic and pelagic phases* ***Source:** CSIRO*



Tropical spiny lobsters in the NPA generally reproduce during the summer months (Pyne 1974). Mating involves the male depositing a spermatophoric mass (called a tarspot) onto the underside of the female's carapace. The female lobster then extrudes several thousand eggs from paired pores at the base of the third walking legs and fertilises them by scraping the tarspot and releasing the entrapped sperm. The female carries the fertilised eggs under her abdomen until the larvae are ready for release; usually within one month. For ornate rock lobsters in the eastern Gulf of Papua spawning peaks during November to March (MacFarlane & Moore 1986); a similar season is expected in eastern Torres Strait. In contrast to the remaining species, painted rock lobsters exhibit reproductive activity continuously throughout the year (Pyne 1974).

Some of the breeding grounds of the ornate rock lobster within the NPA are known from shallow and deep-water surveys undertaken by CMR during 1990, 1992 and 1996 (Fig. 21.3; CSIRO unpublished data). Breeding lobsters have been found on the far northern GBR around Murray Island at depths ranging from 10–120 m (Prescott & Pitcher 1991). The size and extent of this population is largely unknown due to the logistical constraints associated with deep-water surveys.

Figure 21.3: *Map of Torres Strait and the northern GBR showing known breeding locations of the ornate rock lobster from deep sites (>50 m) surveyed using a manned submersible, and shallow sites (<30 m) surveyed by divers* ***Source:*** *CSIRO*



Feeding

Spiny lobsters are generally opportunistic and omnivorous benthic scavengers and dietary items vary according to the habitat occupied. Food items preferred by spiny lobsters include benthic molluscs (principally gastropods), crustaceans, echinoderms, algae, polychaetes, seagrass and fishes. The inability to catch tropical spiny lobsters in baited traps has often led to the false conclusion that these species are exclusively herbivorous. The diet of the ornate rock lobster in Torres Strait is essentially carnivorous (Joll & Phillips 1986).

Migrations

Although there is little information about the migratory behaviour of most tropical spiny lobsters, it is likely that migration of most species is limited, particularly species that occur on reefs, due to the ready availability of food and shelter. However, ornate rock lobsters are known to undertake a remarkable breeding migration of up to 500 km from Torres Strait to the eastern Gulf of Papua during March–May (Moore & MacFarlane 1984). This migration culminates in mating and spawning, after which most of the population dies due to the combined physiological stresses (Dennis et al. 1992). Migrations during sub-adult life are far less extensive and most individuals spend their time on reefs.

Significance of the species group in the Northern Planning Area

The restricted distribution (Torres Strait and isolated rock/reef areas) and generally low abundance of spiny lobsters in the NPA indicate that this group is not particularly significant ecologically in this area. However, in Torres Strait where spiny lobsters are one of the most abundant benthic invertebrates (6.5 per hectare; Pitcher et al. 1992) they are key benthic predators (eg of benthic molluscs) and prey of larger fishes.

Indigenous fishers take spiny lobsters in Torres Strait, the GoC and north-eastern NT. In Torres Strait the cultural significance of spiny lobsters to Indigenous inhabitants was recognised as part of a treaty declared between Papua New Guinea and Australia in 1985. The lobster fishery in Torres Strait is managed to conserve the stocks for Indigenous fishers and any expansion of the fishery is reserved for Indigenous fishers. The Torres Strait lobster fishery is of obvious social significance to Torres Strait Islanders as it provides their main source of income and there are flow-on benefits to the local communities. The annual harvest of spiny lobsters by Indigenous fishers in the NT (1321 lobsters; Henry & Lyle 2003), suggests this group is also of some cultural and social significance to Indigenous fishers there.

Spiny lobsters are often the target of recreational fishers due to their attractiveness, size and edibility. However, in contrast to waters to the east of the north Queensland coast, the waters within the NPA are generally not conducive to recreational snorkelling. This is corroborated by the low estimated annual harvest of spiny lobsters by recreational fishers in NT waters (420 lobsters; Henry & Lyle 2003), given that fishers are allowed 10 lobsters in their possession or 30 per boat. In Torres Strait, where lobsters are abundant, the recreational fishing sector is very small in comparison to the Indigenous or commercial sectors, and recreational catches are probably small by comparison. However, recreational fishers are allowed only three per person or six per boat in Torres Strait, which may limit the catches. Fishing charter operators in Torres Strait and on the eastern GoC probably take some spiny lobsters as part of their daily operations.

The Torres Strait lobster fishery provides the main source of income for Indigenous fishers and is the second most valuable fishery in Torres Strait, behind the prawn fishery. Annual catches during the last decade were worth about $7–9 million to approximately 300 Indigenous fishers and about 12 freezer boat operators. The economic benefits of this fishery flow into many sectors including seafood processors, dinghy sales and repairs, and community stores on the outer islands.

Impacts/threats

Due to the prolonged larval dispersal phase for spiny lobsters and hence their widespread distribution, the threats to the populations within the NPA may in fact be remote from the NPA boundaries. For example, the ornate rock lobster population in Torres Strait relies on recruitment from widely distributed breeding grounds including the eastern Gulf of Papua and the north coast of Queensland (Dennis et al. 2001). Hence, fisheries in these locations impact on the subsequent stocks in Torres Strait. Of particular threat in the case of Torres Strait lobsters was the practice of trawling the breeding emigration as it exited the Great North East Channel. This was banned in 1984 but there are concerns that some migrating lobsters are taken illegally in the Gulf of Papua.

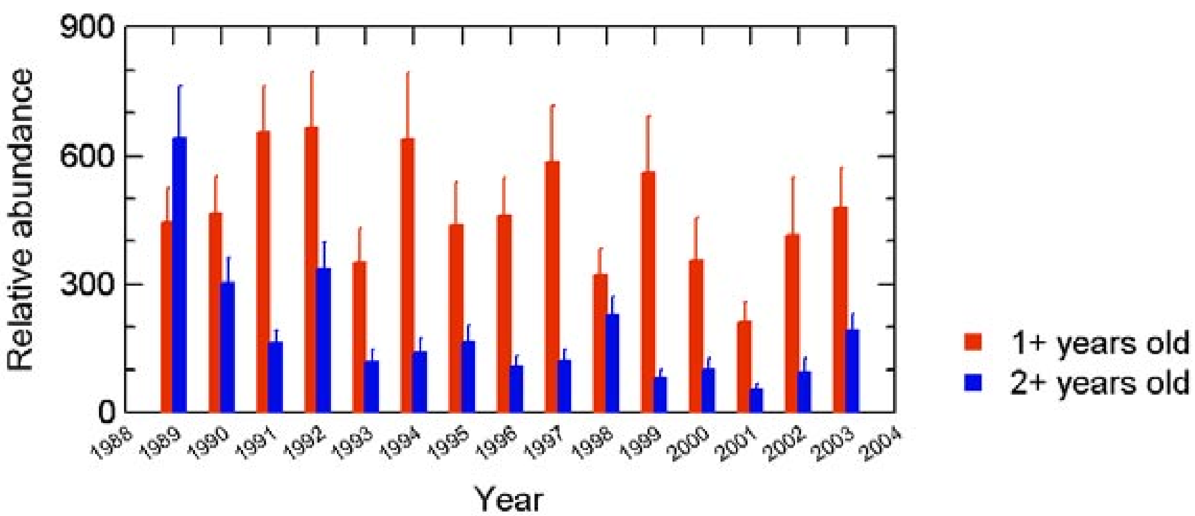
The prolonged larval phase for spiny lobsters also exposes them to changing environmental conditions in oceanic waters, principally ocean currents affected by local events such as cyclones, or large-scale events such as El Niño. Recent oceanographic modelling by CMR has shown that in some years many ornate rock lobster larvae released into the NW Coral Sea are swept south in the East Australian Current and away from suitable habitat. Cyclones passing through the Coral Sea also transport larvae away from suitable adult habitats and in years of weak trade winds pueruli are not transported across the shelf by surface wind-driven currents. The impacts of El Niño on larval transport within the NPA are not well documented but El Niño years are thought to correspond with low settlements of *P. cygnus* in Western Australia (Griffin et al. 2001). The fishery model developed by CSIRO and used to assess the status of the Torres Strait lobster stocks is driven by the estimated stock-recruitment relationship from more than 14 years' survey data. Hence, the impacts of these environmental variables on recruitment are indirectly incorporated into the management strategy formulated for this fishery by AFMA and CSIRO.

The prawn trawl fisheries in the GoC and Torres Strait have little or no impact on spiny lobster populations due to the preference of penaeid prawns for mud seabed and the inability of trawlers to operate on hard seabed. Some lobsters are caught incidentally in Torres Strait but these are released live and previous research has shown high survival rates for these lobsters (CSIRO unpublished data). Some spiny lobsters are also taken in the Northern Prawn Fishery (Roland Griffin pers. comm.) but again survival for these incidental catches is likely to be high.

Several environmental conditions are known to affect the survival of ornate rock lobster juveniles in Torres Strait. In the years 1992–93 and 1999–2000 high mortalities of juvenile lobsters were associated with seagrass dieback events that were caused by an influx of turbid terrestrial run-off. Seagrass diebacks reduce the food available to spiny lobsters and destabilised sediments move across suitable hard seabed and fill in lobster shelters (CSIRO unpublished data).

The principal threat to sustainability of the Torres Strait lobster population is the diver fishery. During 1999–2001 coincidental declines in fished and recruiting year-classes raised concerns that the breeding populations were too small to sustain recruitment. This concern prompted a stock assessment workshop and subsequently a change in fisheries management to allow recovery of the stock. Recent stock and recruit abundance has been higher than in 2001 (Fig. 21.4), alleviating some of the concerns.

Figure 21.4: *Relative abundance of ornate rock lobster fished (2+) and recruit (1+) year classes in Torres Strait from diver surveys undertaken by CMR during 1989–2003* ***Source:*** *CSIRO*



21. Lobsters

The low catches by the recreational and Indigenous fishing sectors in NT waters (Henry & Lyle 2003) suggest, these fisheries are not a serious threat to the spiny lobster populations. Likewise, the failure of development fisheries in NT waters to produce any catches over the last five years or so (Roland Griffin pers. comm.) suggests commercial fishing is not likely to be a future threat. Further, since lobster larvae were rarely found in the GoC by Rothlisberg et al. (1994), it is possible adult populations in the NPA are derived from remote breeding populations.

Information gaps

The biology, ecology and stock status of spiny lobsters has been well documented in Torres Strait due to their economic and cultural significance there. Further, the Torres Strait probably supports by far the largest population of spiny lobsters and the greatest number of species within the NPA, so research efforts should be highest there.

The only known breeding ground of ornate rock lobsters within the NPA is the far northern Great Barrier Reef off Murray Island (Fig. 21.3). However, the size and extent of this population is largely unknown and, more importantly, the relative contribution to overall recruitment by this population (compared with populations in the eastern Gulf of Papua and the north Queensland coast) is unknown. This information is critical for efficient management of the fishery and conservation of the population.

The post-puerulus and juvenile habitat of ornate rock lobsters has been documented in western Torres Strait (Dennis et al. 1997) but the habitat of these stages for the remaining species is largely unknown.

Timing of settlement of ornate rock lobsters into Torres Strait is inferred by analysing size-frequency distributions (Dennis et al. 1997). However, the seasonal and inter-annual variation in settlement timing is unknown as no plankton sampling has been undertaken in Torres Strait. Recent interest in grow-out through aquaculture of puerulus stages, following the success of this practice in Vietnam, may further our understanding of the recruitment processes. The practice of grow-out has great promise as mortality of puerulus during early life in natural conditions is very high (greater than 90%).

There is very little information on the distribution and abundance of spiny lobsters through most of the NPA, including the GoC and northern NT waters and issuing development licences has not significantly furthered our understanding of the populations in these areas. The first reported commercial catch in NT waters was reported in November 2003 (Neil Smit pers. comm.). Whilst the NPA covers a large area, spiny lobsters are probably restricted to isolated rocky areas fringing the mainland and around the inshore islands such as the Wessels and Groote Island (Neil Smit pers. comm.). Hence, targeted surveys could be done in these habitats to document the distribution and abundance of spiny lobsters within the bounds of the NPA. Particularly in the light of very recent commercial interest in NT waters, a baseline study of spiny lobster populations would be critical in determining the sustainability of fishing.

Deep submerged reefs are well known in the GoC from prawn trawling, and two of these were mapped extensively during a Geoscience Australia/CSIRO cruise in the southeast GoC. Whilst no spiny lobsters were sighted during limited recording by towed videos on these reefs, it is possible these habitats support spiny lobster populations. Nevertheless, the low catches of spiny lobster larvae throughout the GoC by Rothlisberg et al. (1994) suggests any population would be negligible.

The genera *Justitia*, *Linuparus* and *Puerulus* are not known to occur within the NPA, although their widespread distribution in deep habitats throughout the Indo-West Pacific, including larvae in the north-west Coral Sea, indicates they are likely to occupy restricted deepwater habitats in the NPA. Specimens of these genera are only likely to be encountered from deep trawls or traps, but their occurrence should be reported and type specimens sent to state museums.

Key references and current research

The CSIRO continues to conduct fishery-independent annual relative abundance surveys in the Torres Strait to support the management of the Torres Strait Rock Lobster Fishery. Other work undertaken to support the fishery includes:

- analysing annual survey data, the size-grade and catch effort data from processors, and catch statistics
- monitoring recruitment fluctuations and changes in age composition of the lobster population and the assessment of stock responses to regulatory measures
- annually updating the stock assessment model to include newly available information and providing evaluation of the stock status and advice on management of the fishery

Commercial fisheries catch and effort data is held by the relevant fisheries agencies. The CSIRO holds data from fisheries-independent surveys, primarily in the Torres Strait.

Although there has been no biological research or stock assessment carried out in NT waters, catch and effort data from developmental lobster licences are reported to DBIRD.

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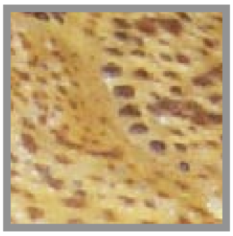

22. Bugs

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Vance, D, Smit, N & Turnbull, C (2004). Bugs.
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Mud bug (Thenus indicus) **Source:** CSIRO

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Species group name and description

Common names: Bugs, Moreton Bay bugs.

Also known in various countries as: flathead lobster, squat lobster, slipper lobster, bay lobster, shovelnose lobster.

Scientific names: Crustacea: Decapoda: Scyllaridae

Bugs are part of the family of Scyllaridae (slipper lobsters). *Thenus* is the most economically important of the scyllarid genera found in Australian waters (Jones 1988, 1993). The species of *Thenus* found in the Northern Planning Area (NPA) are:

- mud bug *(Thenus indicus)*
- reef bug *(Thenus orientalis)*.

It is only recently that mud bugs have been identified in Australia as a separate species to reef bugs (Jones 1990). It is not clear whether the mud bug is endemic to Australia or whether its international distribution follows that of reef bugs.

A further species (*Thenus* sp. nov.) has been reported occasionally in trawl surveys in northern Australia (Ted Wassenberg, CSIRO Marine Research, pers. comm.) However, the taxonomy of the genus *Thenus* is likely to change in the near future as a revision is in progress (Peter Davie, Queensland Museum, pers. comm.). Possibly three other species of the family Scyllaridae (genus *Scyllarus*) have been found in several trawl surveys in northern Australia (Ted Wassenberg pers. comm.). These are quite small non-commercial species with sizes around 60–70 mm total length.

Status

Bugs are caught as incidental byproduct in the Northern Prawn Fishery (NPF) and in the Torres Strait Prawn Fishery (TSPF). In both fisheries there are several regulations regarding the animals that may be retained by fishers:

- a minimum size limit of 75 mm carapace width is in force
- egg-bearing females must not be retained
- removing eggs from egg-bearing females is prohibited

The regulations apply to both commercially valuable species of bug.

Catches of bugs and other byproduct are required to be recorded in logbooks by fishers, but the catches are not separated into species.

None of these species is listed on environmental legislation.

Habitat and distribution

Reef bugs have an Indo-west Pacific distribution: from the east coast of Africa as far north as the Red Sea, to China, southern Japan, the Philippines and tropical Australia (Holthuis 1991).

Very little direct research has been done on the habitat and distribution of bugs in the NPA. However, some knowledge of the same species is available from research carried out on the east coast of Australia and has been documented in Courtney and Williams (2002).

They found that reef bugs tend to occur in water depths of 26–60 m, in sandy or sandy-mud substrates to rocky areas, while mud bugs on the Queensland east coast usually occur in waters shallower than 25 m, in muddy substrates. However, in recent trawl surveys undertaken in the Gulf of Carpentaria (GoC), the dominant bug species was mud bug and it was caught in waters up to 50 m deep (Dichmont et al. 2003). Jones (1993) found only reef bugs in a 12-monthly trawl sampling program conducted around the Wellesley Islands in the southeastern GoC in 1983.

In the recent GoC surveys, mud bugs were found throughout all areas in the Gulf that were surveyed but were most abundant in the south-eastern Gulf and around Mornington Island (Figure 22.1). Densities were lowest in the offshore sites and the size of bugs tended to increase with increasing water depth. The length frequency distribution of all mud bugs caught showed a unimodal pattern (possessing a single maximum value) in August 2002, but there was a clear bimodal pattern of smaller bugs in January 2003 suggesting that recruitment of smaller bugs was occurring at that time (Dichmont et al. 2003).

In contrast, reef bugs were quite rare in trawl samples in these surveys but, proportionally, were more abundant in deeper water than mud bugs (Figure 22.2).

Spawning activity for reef bugs on the east coast of Queensland can be seen throughout the year, but it peaks in the spring and early summer months. Females carry from thousands to tens of thousands of eggs under their abdomen, attached to the swimming legs. After hatching the larvae go through a series of complex metamorphoses in less than a month before settling out as juveniles (Courtney & Williams 2002).

Bugs are active at night and tend to remain buried in the bottom sediments during the day. They are apparently primarily carnivorous scavengers, preferring small benthic invertebrates, including crustaceans, polychaetes (worms) and molluscs (Johnston & Yellowlees 1998). In the laboratory, they have been observed to forage at night by probing or digging the substratum and can open and remove the flesh from small bivalves.

The juvenile biology is less well known. Growth appears to be fairly rapid; animals reach 60 mm carapace width and reach a size that may be legally taken in the fishery at 1–2 years of age.

The annual mortality rate is estimated at about 75% and maximum longevity appears to be about 5–6 years.

There has been no formal assessment of the stock status of bugs in the NPA. Reported catches of bugs in the NPF have been lower in recent years. In 2002, about 35 000 kg of whole bugs were retained in Queensland and the Northern Territory (Perdrau & Garvey 2003), whereas in 1997 and 1998 over 70 000 kg of bugs were retained (Sachse et al. 1998, Sharp et al. 1999). However, this may not necessarily reflect a change in abundance of the bugs as recent management regulations in the NPF have led to a reduction in the number of vessels and fishing gear size, and changes in timing of the fishing seasons. There may have been a redirection of effort away from areas where bugs were caught in previous years. This needs to be investigated.

22. Bugs

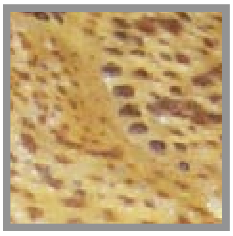


Figure 22.1: Spatial distribution of mud bugs (Thenus indicus) (no/hr) in the survey of (a) August 2002, and (b) January 2003 Note that the January survey included a larger number of sites in the Karumba region and at Weipa. ***Source:*** *CSIRO*

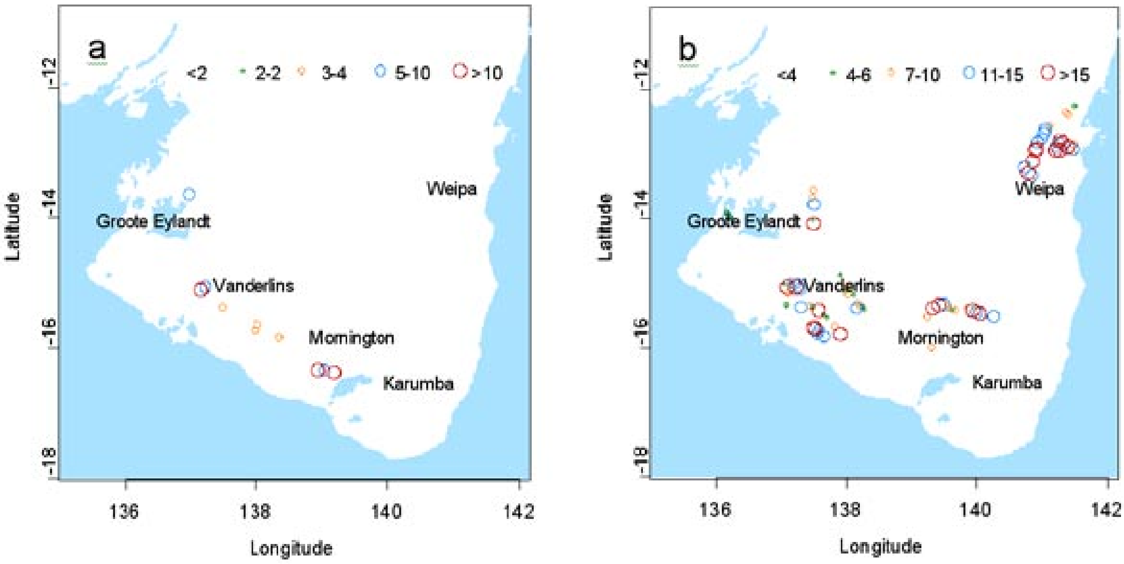
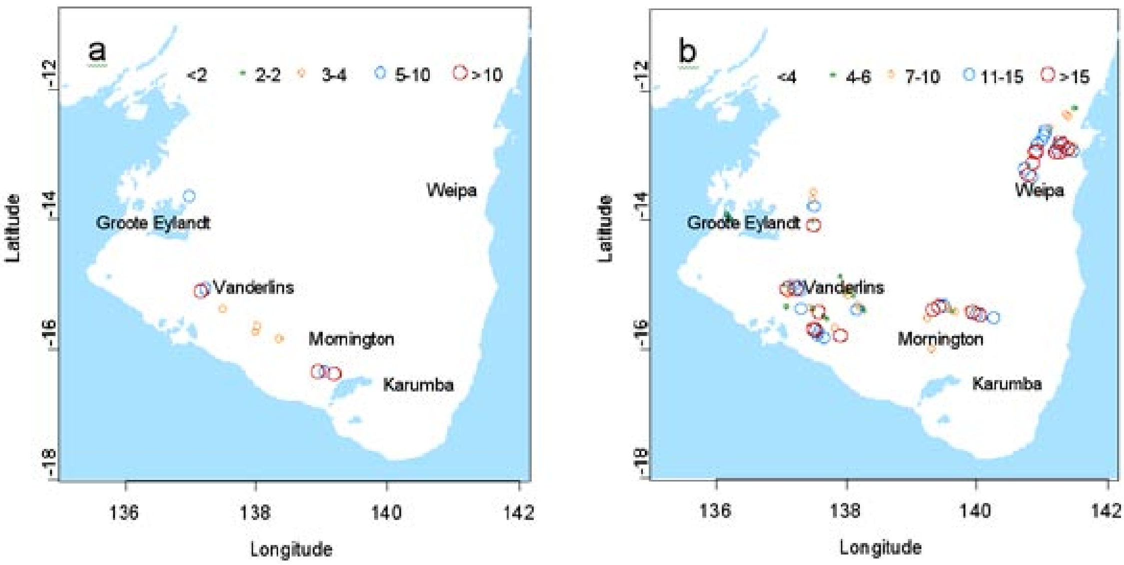


Figure 22.2: Spatial distribution of reef bugs (Thenus orientalis) (no/hr) in the survey of (a) August 2002, and (b) January 2003 Note that the January survey included a larger number of sites in the Karumba region and at Weipa. ***Source:*** *CSIRO*



In the TSPF, the average annual catch of bugs from 1988 to 2002 has been about 44 t (Clive Turnbull, Queensland Department of Primary Industries and Fisheries, pers. comm.), ranging from about 33 t in 2002 to 63 t in 1999. As in the NPF, there have been changes to fishing gear, including the introduction of turtle excluding devices (TEDs) during that time.

Significance of the species group in the Northern Planning Area

Scyllarids are primarily carnivorous scavengers, preferring small benthic invertebrates (molluscs, polychaetes, crustaceans) and are therefore intermediate predators in the food chain. Very little is known about the predators of bugs. Published studies on fish, particularly as predators of animals on the prawn trawl grounds of the NPF, have not noted bugs in the guts of the fish, although they may have been present in very small quantities (Brewer et al. 1991, 1995, Salini et al. 1994).

Bugs of the genus *Thenus* are of minor economic importance in the NPF and the TSPF as byproduct to the prawn catch in those fisheries. There is no fishery for which they are the target species.

Largely because the bugs are caught in offshore waters, there does not appear to be any recreational or Indigenous take of bugs and therefore there is no cultural or recreational significance of bugs in the NPA.

There is no bycatch of bugs associated with other managed fisheries in the NPA apart from the NPF and the TSPF.

Impacts/threats

The main threat to the bug species group is from prawn trawling operations in offshore waters. Mortality of bugs occurs as a result of animals being kept as byproduct. However, undersized animals that are discarded after capture by the trawl nets may also suffer increased mortality as a result of damage incurred during capture. The use of hoppers on vessels in the NPF and TSPF in recent years may help to diminish this mortality as animals spend much less time out of the water when hoppers are in use.

Since the bugs do not seem to utilise estuarine or shallow-water coastal areas during their life cycle, they are not as susceptible to factors affecting the health of these inshore waters as are some other species of crustacean or fish. There are very few human operations apart from prawn trawling in the NPA that may affect bug populations.

In recent years, offshore from Karumba in the south-eastern GoC, a 'roadstead' has been designated for the transhipment of ore from barges to ore-carrying ships. The ore contains a range of heavy metals including lead, zinc and silver and is transhipped from the Port of Karumba by barge. There has been some concern that there may be some spillage of ore during the transfer process and that any spillage may have a detrimental effect on the habitat of marine species in that area. Bugs were abundant in catches taken in this area during a prawn trawl survey in January 2003 (Figure 22.1, Dichmont et al. 2003). Some sampling of prawns from the area has been carried out for heavy metals testing but no assessment of effects on other species has been carried out. Charles Darwin University has done some work in the Bing Bong/McArthur River for McArthur River Mines (western GoC), and is currently involved in a project with NPF and Pasminco Century Mine in the south-eastern GoC. However, it is a confidential study and the data are not to be released under the present arrangements (David Parry, pers. comm.).

Information gaps

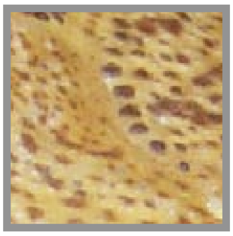
Little information has been published on the distribution of bugs outside the prawn trawling grounds in the NPA. Knowledge of this distribution would be useful in attempting to assess the status of the bug stocks. Some data on this distribution may be available from past surveys carried out by CSIRO research projects into bycatch distribution. It would be useful to analyse the bug catches from these surveys.

Although a substantial amount is known about larval and adult stages of the bug life cycle, there is a real gap in knowledge about the juvenile stage. Research should be done to find out more about the migrations of the larvae and the distribution of the juveniles before they appear on the trawl grounds.

Recent data from a Queensland east coast bycatch project and anecdotal evidence from Torres Strait has suggested that the introduction of TEDs to prawn trawl nets may be decreasing the catch of the largest bugs in the prawn fishery (Courtney 2002). Further research is needed to confirm the effect of TEDs on bug catches.

Many small bugs of the genus *Thenus* as well as smaller non-commercial bug species are discarded after being caught in prawn trawl nets. It is not clear what the survival rate of these animals is. Although many of the animals may be alive when returned to the sea, they may still be more susceptible to predation as they return to the seabed. Research should be carried out to identify the survival rates of the discarded bugs.

Bugs are a byproduct of trawling and fishing effort expended in their capture is rarely aimed at the bugs. Therefore, there is a need to clarify how fishing effort should be quantified with regard to bug catch-per-unit-



effort (CPUE) if logbook-based assessments of stock status are attempted. A prawn monitoring project that has been proposed to continue into the future will continue to collect data on the abundance of bugs in the GoC and the project should provide fishery-independent data to help assess the long-term status of the bug stocks.

A revision of the taxonomy of bugs worldwide, including the Australian species, is in progress and the nomenclature of the Australian species may well change in the near future. Genetic studies of bugs from northern Australia would be most valuable to help identify the northern stocks.

Key references and current research

"Designing, implementing and assessing an integrated monitoring program for the NPF: developing an application to stock assessment". CSIRO Marine Research; Principle Investigator: Dr Yimin Ye.

This a project largely funded by the Northern Prawn Fishing Industry via the Management Committee Initiated Research Fund, the Fisheries Research and Development Corporation and CSIRO, which is mainly aimed at monitoring the abundance of commercial prawn species in the GoC for the year 2003-2004. However, all bugs caught in the survey are also being recorded and measured. Although the survey design is not aimed at bugs, it is hoped that a long-term data set for bugs will be obtained that may be useful in assessing the health of the bug population. Surveys are carried out in August and January.

The monitoring surveys were first begun in 2002–2003 (Dichmont et al. 2003) and it is likely that surveys will be continued annually in the future, although the scope may change.

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23. Holothurians

This chapter should be cited as:
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Holothuria scabra [sandfish] taken from the Warrior Reef, Torres Strait ***Source:*** *T Skewes*

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Species group name and description

Common name: sea cucumbers, sea slugs, bêche-de-mer, trepang.

Scientific name: Echinoderms in the Class Holothuridae.

The sea cucumbers are widespread benthic invertebrates found in all depths and latitudes. Of the 1250 species that have been described worldwide, about two dozen are commercially important in the tropics and most of these occur in the Northern Planning Area (NPA) (Cannon & Silver 1986, Skewes et al. 2004).

Twenty six species have been documented during resource surveys of shallow reefs in Torres Strait (Table 23.1) (Skewes et al. 2002); however, there may be an additional 20 or more species that form the shallow water holothurian fauna if faunal surveys at Ashmore Reef are indicative (Marsh et al. 1993).

Table 23.1: *Large shallow water holothurians documented from reef resources surveys in Torres Strait* ***Source:*** *Skewes et al. 2003.*

Order Aspidochirotida	
Family Holothuriidae	
Holothuria scabra	Sandfish
Holothuria scabra versicolor	Golden sandfish
Holothuria whitmaei	Black teatfish
Holothuria nobilis	White teatfish
Holothuria atra	Lollyfish
Holothuria edulis	Pinkfish
Holothuria fuscopunctata	Elephants trunk fish
Holothuria leucospilota	
Holothuria coluber	Snakefish
Holothuria hilla	
Actinopyga miliaris	Blackfish
Actinopyga echinites	Deep water redfish
Actinopyga mauritiana	Surf redfish
Actinopyga lecanora	Stonefish
Bohadschia argus	Leopardfish, tigerfish
Bohadschia marmorata	Brown sandfish
Bohadschia graeffei	Long stickyfish, flowerfish
Bohadschia similus	Chalkfish
Family Stichopodidae	
Stichopus chloronotus	*Greenfish*
Stichopus hermanni	*Curryfish*
Stichopus vastus	*Curryfish*
Stichopus horrens	*Peanutfish, dragonfish*
Thelenota ananas	*Prickly redfish*
Thelenota anax	*Amberfish*
Order Apodida	
Family Synaptidae	
Euapta godeffroyi	
Synapta maculata	

Only six species have been identified from dredge and prawn trawl samples taken in deep water habitats in the Northern Prawn Fishery in the Gulf of Carpentaria (GoC) (Table 23.2), with a further 27 possible species listed as unidentified, or only partially identified (Hill et al. 2002, CSIRO unpublished data).

Table 23.2: *Holothurians documented from surveys on prawn trawl grounds in the Gulf of Carpentaria*
Source: *Hill et al. 2002, CSIRO unpublished data.*

Order Aspidochirotida
Family Holothuriidae
Holothuria martensis
Holothuria ocellata
Holothuria atra
Family Stichopodidae
Stichupus horrens
Order Dendrochirotida
Family Cucumaridae
Pentacta anseps
Psuedocolochirus axiologus

23. Holothurians

Status

No holothurians are listed under Australian, Queensland or Northern Territory (NT) wildlife conservation legislation.

Ten species of shallow reef holothurians in Torres Strait are listed under Queensland and Australian Government fisheries legislation, and one species of sandfish (*H. scabra*) is listed under NT fisheries legislation with regard to fishery regulation. Three species in Torres Strait, sandfish (*H. scabra*), black teatfish (*H. whitmaei*) and surf redfish (*Actinopyga mauritiana*) are listed as over-exploited and closed to fishing (Table 23.3). The fishery stock status of most other commercial species in the NPA is reasonably well known (Kung 2002, Kelly 2000, Skewes et al. 2004) (Table 23.3).

Table 23.3: *Value category and an assessment of stock status for each species of commercial holothurian (from Kung 2002, Kung pers. comm., Kelly 2000, Skewes et al 2004)*

Species	Value category	Stock status (level of exploitation)
H. scabra	High	Over-exploited, closed, in Torres Strait. Fully exploited in NT. Unexploited in Queensland waters of the GoC.
H. whitmaei	High	Over-exploited, closed in Torres Strait. Unexploited elsewhere.
H. nobilis	High	Fully exploited in Torres Strait. Unexploited elsewhere.
T. ananus	High	Exploited in Torres Strait. Unexploited elsewhere.
T. anax	Low	Unexploited.
A. mauritiana	Medium	Over-exploited, closed in Torres Strait. Unexploited elsewhere.
A. echinites	Medium	Exploited in Torres Strait.
A. lecanora	Medium	Unknown.
A. miliaris	Medium	Exploited in Torres Strait. Unexploited elsewhere.
B. argus	Medium	Exploited in Torres Strait. Unexploited elsewhere.
B. graeffei	Low	Unexploited.
B. marmorata	Low	Exploited in Torres Strait. Unexploited elsewhere.
H. atra	Low	Unexploited.
H. coluber	Low	Unexploited.
H. edulis	Low	Unexploited.
H. fuscpunctata	Low	Exploited in Torres Strait. Unexploited elsewhere.
S. chloronotus	Medium	Exploited in Torres Strait. Unexploited elsewhere.
S. vastus	Low	Unexploited.
S. variegatus	Medium	Exploited in Torres Strait. Unexploited elsewhere.
S. horrens	Low	Unexploited.

The status of deeper water species caught as bycatch by the trawler fleet is less well known; however, they are not considered as vulnerable (either vulnerable to capture or vulnerability of populations to over-depletion by incidental capture) during the recent trawl bycatch sustainability project (Stobutzki et al. 2001).

The CITES secretariat is currently considering the listing of holothurians as an Appendix II protected species group after a submission from the United States of America (discussion document available at http://www.cites.org/eng/cop/12/doc/E12-45.pdf). The submission strongly suggested that sea cucumbers may qualify for listing due to current trade and biological information. The submission identified a number of issues that would need to be addressed before a CITES listing can progress, including taxonomy and identification of species in the catch, population status, population parameters, recruitment parameters and metapopulation characteristics, and developing population models for sustainable exploitation.

Habitat and distribution

Distribution

Holothurians are most likely distributed throughout the NPA, although they are more abundant and diverse in the shallow reefs and coastal regions than in deeper waters. While some species have a wide geographic range and are found in a number of habitats (eg lollyfish), others have narrow habitat preferences that restrict their distribution within the NPA (eg sandfish) (Long et al. 1996). Most shallow reefs species will be restricted to specific reef zones within that habitat. For example, the preferences for reef zones for some species have been well documented as follows (Conand 1993):

- slopes and passes : black teatfish, white teatfish, elephants trunk fish, prickly redfish
- outer reef flats : surf redfish, deep water redfish
- inner reef flats and lagoon : sandfish.

Several ecological factors may influence individual holothurian species distribution. Potential influences include sediment grain size, organic content, intensity of wave action, interspecific competition and juvenile predator/prey interactions, water movement affecting larval dispersal and settlement, relative influences of reef and land-based inputs, and depth, including response to desiccation (dryness resulting from the removal of water) in the intertidal region.

Movement

Holothurians are typically slow moving and sluggish, but they can move, usually by utilising their tube feet to move along the substratum. Movements of individuals are typically of the order of less than 1 m/day to several metres per day (Hamel et al. 2001). This indicates that most holothurians will remain resident of a reef or bank or general area of the bottom once they settle, being constrained by the boundaries of their suitable habitat.

Reproduction

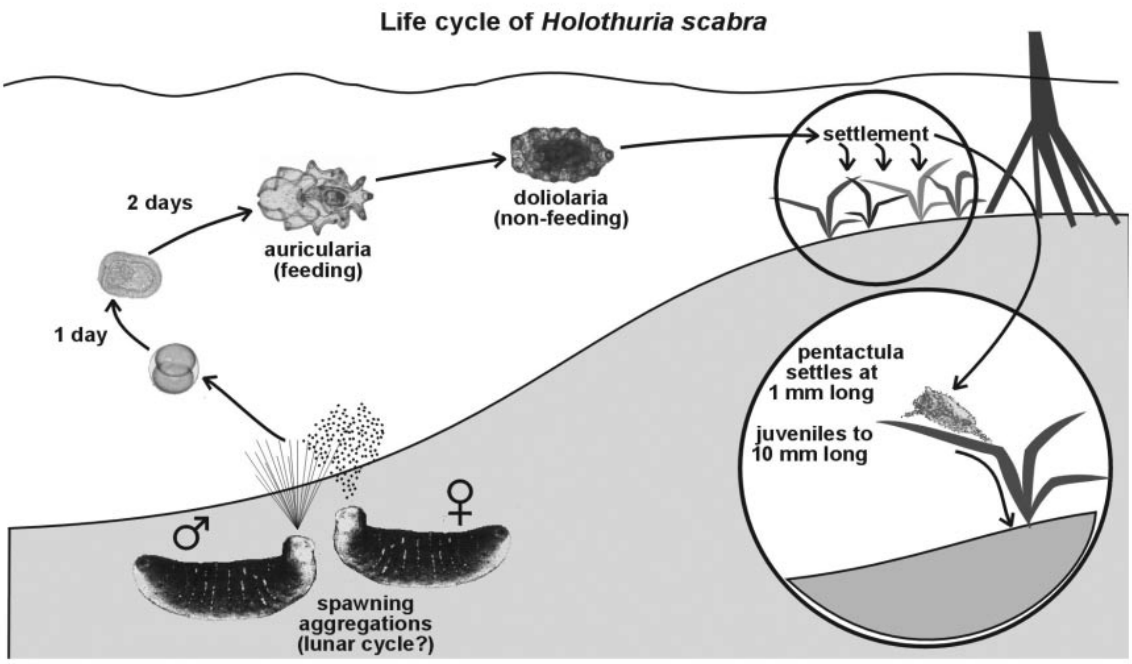
The sexes are separate and fertilisation is external. Most holothurians are broadcast spawners and spawning occurs simultaneously within a population. Maturation and spawning is usually distinctly seasonality, related to seawater temperature; this may be associated with food availability for their planktonic larvae or with optimal conditions for dispersal, settlement and development (Preston 1993).

Most species spawn in the warmer months, with a resting phase during winter (Conand 1989, Preston 1993). However, a few species investigated showed different cycles; the sandfish follows the pattern of spawning in warmer months, but also undergoes a smaller, secondary peak of spawning later in the year; and the black teatfish shows a contrary pattern, with spawning occurring in the cooler months.

Fecundity is relatively high although it varies between species and between seasons (Preston 1993), with estimates ranging from 1–13 million (white teatfish) to 13–78 million (black teatfish). The smaller species, such as deep water redfish, generally have a higher fecundity than the larger species (Conand 1990).

Very little is known about the ecology of holothurian larval stages. Most information comes from work on hatchery production of some commercial holothurians, mostly sandfish. Larval development is planktotrophic, lasting between two and four weeks (Figure 23.1). The egg develops into an auricularia larva within about three days, followed by a doliolaria larvae. Metamorphosis produces a pentactula larva, with the beginnings of adult characteristics. At this stage, the larva settles to the seabed and becomes a juvenile holothurian. For sandfish reared in aquaria, this stage is reached about 13-16 days after spawning (Hamel et al. 2001).

Figure 23.1: *Holothurian life cycle diagram* ***Source:*** *Dr Stephen Battaglene*



Recruitment

There appears to be very little information on recruitment mechanisms and rates in holothurians. Indeed, juveniles are rarely even seen in the adult habitat, possibly because they occupy different habitats or because they are very hard to find (Preston 1993). Juvenile white teatfish have been found attached to calcareous algae on the seagrass *Syringodium isoetifolium* and to the alga *Halimeda sp.* (Gentle 1979), and sandfish also have been found to preferentially settle on seagrass such as *Thallassia hemprichi* (Hamel et al. 2001). Recent studies on released juvenile sandfish have shown that mangrove/seagrass areas were the most suitable habitat for settling juveniles, due mainly to low predation rates (Dance et al. 2003).

Recruitment rates are difficult to estimate and rarely reported. Conand (1993) describes holothurian recruitment as 'low and sporadic'.

Larval dispersal appears to be variable depending on the species, and probably depends on the length of the planktonic larval life cycle, the continuity of population habitats and spawning location in terms of proximity to advection currents. For example, genetic studies on the Australian east coast has suggested that recruitment to black teatfish populations occurs from a wide geographic range (Uthicke & Benzie 2000b), in contrast with sandfish which showed a very restricted gene flow indicating a limited recruitment from within regions (Uthicke & Benzie 2001).

Nutrition

Most commercial species of holothurians are deposit feeders (feeding directly from the seabed), with only a few suspension-feeding species. Sediment is removed from the substrate by the tentacles, and is then pushed into the mouth. Holothurians obtain nutrients from the sediment in the form of organic detritus, faecal material and micro-organisms, particularly bacteria which constitute their major nutritional source (Preston 1993).

Significance of the species group in the Northern Planning Area

Economic and social

The history of holothurian fisheries goes back for thousands of years, and in the NPA for centuries. Bêche-de-mer/trepang is in demand principally in China and South-east Asia, where it is considered a delicacy. The main markets are Hong Kong and Singapore, with smaller markets in Korea, Taiwan and Malaysia. The current high demand for bêche-de-mer now is likely to continue, and may strengthen, due in part to the high economic growth in China.

The modern northern Australian bêche-de-mer/trepang fisheries were re-established in the early 1990s, after a 50-year lull. In Torres Strait, the fishery operates mostly at the community level; Torres Strait Islanders collect the bêche-de-mer and sell to Island and boat-based buyers, who partially process it, usually by boiling or salting, for transport to the mainland for further processing. It provides a substantial source of income and employment for Islander communities with catches peaking at over 1400 t (wet weight) in 1995 (Williams et al. 1999). The current catch estimate is 128 t (gutted wet weight) in 2000/01, valued at over $500 000 (Kung 2002).

The modern NT fishery currently comprises a commercial sector with six licences and a catch of 246 t (whole wet weight) in 2000, with an estimated value of $2.4 million (Kelly 2000). The bulk of the catch is taken from NT waters within the NPA.

Ecological

Studies of coral reef holothurians have found that they play an important role in the nutrient cycle and bioturbation (disturbance of sediment by burrowing and feeding) processes in marine benthic communities by ingesting detritus and bacteria in sediments and excreting nutrients through faeces and respiratory water (Uthicke 2001). Thus, holothurians are important in recycling organic matter from within the sediment. They may also influence the distribution and abundance of meiofauna (ie very small creatures living between grains of sand) and other organisms through the accidental ingestion of recruits settling on or in the sediment although most larger organisms can pass through the gut undigested.

Impacts/Threats

Fishing

About a dozen shallow water species are fished commercially in the NPA. Holothurians are particularly vulnerable to over-fishing due because they are easy to harvest, depend on dense populations for reproductive success and have variable recruitment. For instance, with respect to density dependent reproductive success, holothurians have a low mobility and generally do not aggregate to spawn. The sexes are separate and they are broadcast spawners. Therefore the rate of fertilisation success in the water column is affected by the dilution effect: the lower the density of breeding animals the less chance the gametes (eggs and sperm) have of meeting. If the distance between breeding individuals is too great, fertilisation may not occur at all.

Species of high commercial value such as black teatfish, white teatfish and sandfish tend to be fished preferentially. Three species (sandfish, black teatfish and surf redfish) are considered to be over-exploited in Torres Strait and are closed to fishing (Skewes et al. 2002). The sandfish population in Torres Strait provided the bulk of the early catches in the Torres Strait fishery, until a survey in 1998 found that the population was severely depleted and it was closed (Skewes et al. 1998). Subsequent surveys in 2000 and 2002 found a small recovery, but the population was still considered heavily depleted. After 1998, the Torres Strait fishery mostly targeted black teatfish, white teatfish and surf redfish. A survey in March 2002 found that black teatfish and surf redfish were also overexploited, and these fisheries were closed in January 2003 (Skewes et al. 2004). Other targeted species were not considered over-exploited, but it was recommended that their catches be restricted and the populations closely monitored.

In the NT, the fishery is primarily focused on sandfish, and the population there is considered to be fully exploited (Kelly 2000).

There is a potential new sandfish fishery being planned for the GoC under the Queensland Government's developmental and exploratory fisheries policy. Under that policy, the Queensland Fisheries Service (QFS) is required to establish that the fishery is 'sustainable, commercially viable and socially acceptable'. The fishery will operate under what the QFS considers is a conservative catch quota, given the size of the fishery, historical fishing levels and virgin status of the stocks. The fishery will operate in two areas, one around the Wellesley Islands, and the other on the north-western coast of Cape York.

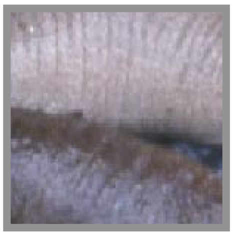
Several species are caught as bycatch by prawn trawlers, although they only make up a small fraction of the total bycatch recorded during studies in the GoC; of 1176 trawls, only 180 had holothurians and over 60% of those had catch rates of less than 1 kg/hr (Stobutzki 2001, CSIRO unpublished data). Studies of the benthic fauna on deeper trawlable bottom in the GoC also yielded low densities of several species of holothurians, with lollyfish and peanutfish being the only species in common with the shallow water fauna (Hill et al. 2002). Other species include holothurians of the family Cucumaridae, such as *Pseudocholochiris axiologus*, and family Mollpadiidae, genus *Paracaudina*. Many species sampled from deeper habitats in the GoC remain unidentified.

Information from the Great Barrier Reef Effects of Fishing study (Pitcher et al. 2002) indicates a low vulnerability to capture by prawn trawls for holothurians. Holothurians were seen at 74% of dredge sample sites, but inonly 48% of prawn trawl and 17% of fish trawl bycatch samples in the GBR lagoon. Estimates of the catchability, being the proportion of holothurians caught in prawn trawls compared with the benthic dredge (the latter considered as an estimate of true abundance) ranged from 0 to 55%, with an overall weighted average of only 9.5%. Besides low catch rates, many characteristics of holothurians make them less susceptible to prawn trawling impacts, eg high fecundity, detrital feeding mode, and being robust in respect to trawl damage (Stobutzki 2001).

Alteration of existing habitats by trawling may have possible impacts on deeper water holothurians. However, the effect of trawl on the substrata may have a lower impact on bycatch populations than over-fishing, since most trawling is undertaken over soft substrata with low habitat complexity.

Cyclones

Cyclones are know to cause large changes in shallow coastal habitats, particularly to seagrass beds in the GoC, which are probably important nursery areas for juvenile sandfish. For example, in 1985, Cyclone Sandy removed 183 km^2 (20%) of seagrass habitats in the western GoC (Poiner et al. 1993). By 1995, the seagrass habitat mostly had recovered to pre-cyclone condition (CSIRO unpublished data).



Coastal processes

Coastal development that increases nutrient and sediment loads into coastal waters may affect adjacent holothurian populations by causing changes to benthic environments, including a loss of seagrass beds, and changes in sediment grain size composition.

Greenhouse changes, changes in coral reef ecology

Possible impacts include changes to coral reef ecosystems caused by high coral mortality related to elevated water temperatures (Wilkinson 2000, Skewes et al. 1999b). While there is unlikely to be a direct impact on most species of holothurians, which do not rely directly on live coral for food shelter, these wider ecological consequences are likely to affect a wide range of species that live on coral reefs.

Information gaps

Taxonomy

The taxonomy of holothurians is not stable. A recent review of the nomenclature listed several changes that affect species names used until recently (Rowe & Gates 1995). For example, the review suggested that black teatfish (commonly identified as *Holothuria nobilis*) be assigned the species name *Holothuria whitmaei* (Bell 1887), and that white teatfish (commonly identified as *Holothuria fuscogilva*) be assigned the species name *Holothuria nobilis* (Selenka 1867). While some researchers and management agencies, including the Australian Fisheries Management Authority (AFMA), have decided, in the case of black and white teatfish at least, to use the most recent nomenclature, others are continuing to use the previous nomenclature pending further review (Uthicke & Benzie 2000a). Other taxonomic uncertainties among the fishery species include the assignment of species names for holothurians covered by the *Stichopus variegatus/hermanni/horrens* group, and the *Bohadschia marmorata/vitiensis/similus* group.

Distribution and abundance

Distribution and abundance of common and commercial species on the shallow reefs in Torres Strait is reasonably well established; however, the list is far from comprehensive. The holothurian populations of the offshore regions of the GoC and NT are not well known.

Stock dynamics and population modelling

Population modelling is required for an understanding of population response to fishing and management actions. This requires long time series abundance and fishery data, especially for modelling that requires a stock recruitment relationship. It includes the selection of suitable biological reference points to assist scientists, managers and other stakeholders interpret the results of population modelling.

Life history parameters

Growth, mortality, size at first maturity and breeding seasonality are essential inputs into robust fisheries yield models and stock assessments. These parameters are either poorly estimated or are taken from research in other parts of the South Pacific. Most are very difficult to determine and require targeted research.

Ecosystem impacts of fishing

Ecosystem impacts of fishing are also likely to be important questions, particularly with the move to ecologically sustainable development and the Australian Government requirements for strategic assessments of fisheries. CSIRO is hosting a postgraduate student who will carry out research on sandfish in Moreton Bay which will be focused on these questions. However, studies in tropical environments are also required.

Burrowing rates

Previous studies have shown that burrowing by sandfish will cause transect survey data to be biased, particularly in dense seagrass beds and during high tide. Actual burrowing rates in areas with moderate to sparse seagrass cover appear to be lower but are poorly understood. As survey data will continue to be important for stock assessments, more study is required to determine burrowing rates, and its variability with habitat, tide, time of day and size.

Key references and current research

Sustainability Assessment of the Torres Strait Sea Cucumber Fishery

The objectives of this project is to:

- conduct surveys of the holothurian population and their habitats in Torres Strait
- provide information on stock status of all commercial species, population dynamics and recovery of depleted species, fisheries ecology and possible environmental effects of fishing
- recommend management strategies for sustainable harvest of sea cucumber in Torres Strait, and optimal sampling strategies for future monitoring

This research will be based on two abundance surveys, one of sandfish on Warrior Reef carried out in early 2004 and a survey of the east Torres Strait fishery planned for early 2005. The survey data would provide estimates of the distribution and abundance of all commercial species in the fishery, and high resolution estimates of trends in abundance for comparison with previous surveys in 1995 and 2002. For the sandfish population, the surveys will complete a series of five undertaken during 1995 to 2004. They will provide information on poorly understood population parameters for input into developing population models. This information will then be used for formulating robust sustainable management strategies, and for designing optimal sampling strategies for future monitoring. Information will also be collected on gross environmental parameters, not only for assessing the effects of fishing, but for mapping and monitoring the environment in general.

Conversion Ratios for Commercial Bêche-de-mer Species in Torres Strait

This research is essential to allow interpretation of catch data that is recorded in various units, dependent on the methods and extent of processing. Accurate conversion ratios are required to determine total catches in a standard unit to relate to set total allowable catches and to assist in monitoring and enforcement in the field. The conversion ratios may also allow for total catch data to be verified using shipping returns, as currently occurs for the Torres Strait rock lobster fishery. It is important that the relationships between measurements of holothurians in different stages of processing be established so that data from different sources can be compared, or converted for use in population models and for setting size limits for processed bêche-de-mer. This will also assist in the design of an appropriate logbook for recording accurate and useful catch data.

Ecosystem impacts of fishing

CSIRO is hosting a postgraduate student, Svea Mara Wolkenhauer, who is carrying out research on sandfish in Moreton Bay that is focused on this question. This research will have direct relevance for this species in the NPA.

Commercial fisheries catch and effort data is held by the relevant fisheries agencies. The CSIRO holds data from fisheries-independent surveys, primarily in the Torres Strait.

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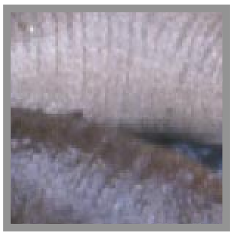

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24. Trawl Bycatch Species

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Trawl bycatch in the Gulf of Carpentaria ***Source:*** *S Griffiths*

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Species group name and description

Trawl bycatch – various tropical teleost fishes and invertebrates, also known as 'trash', 'trash fish' and 'small bycatch'.

'Bycatch' is a loose term defined by the Australian Fisheries Management Authority (AFMA) as '…all living and non-living material (except for the target species) which is caught while fishing, including by-product, discards and that part of the catch which doesn't reach the deck but is affected by interactions with the fishing gear'.

The Northern Planning Area (NPA) comprises part of the Northern Prawn Fishery and the entire Torres Strait Prawn Fishery. Trawl bycatch in these fisheries includes teleosts, invertebrates, elasmobranchs, reptiles and mammals. However, the compulsory use of Turtle Exclusion Devices (TEDs) and Bycatch Reduction Devices (BRDs) since 2000 (NORMAC 2003) has resulted in significant reductions in the capture of turtles, large elasmobranchs and sponges (Brewer et al. 2003). Since other reviews are dedicated to some of the groups caught as bycatch in the NPA, this report only includes teleosts and invertebrates that are not target species or by-product.

The teleost component of trawl bycatch in the NPA is extremely diverse, comprising at least 366 species (spp.) from 91 families (Table 24.1) and 73% of total trawl bycatch by weight (Stobutzki et al. 2000). The families represented by the most species are Carangidae (29 spp.), Apogonidae (24 spp.), Scorpaenidae (17 spp.), Leiognathidae and Platycephalidae (13 spp.). Russell and Houston (1989) reported 474 teleost species from 123 families from the Arafura Sea, although a large portion of the area included in their study is well outside the NPA.

The invertebrate bycatch component comprises at least 234 taxa (Table 24.2) and 20% of total bycatch in the NPA (Stobutzki et al. 2000). The most abundant groups are Crustacea (148 taxa), Mollusca (35 taxa), Porifera (27 taxa) and Echinodermata (11 taxa). Taxa of teleosts and invertebrates that make the greatest contribution to total bycatch by weight are shown in Table 24.3.

Status

Nine species caught as bycatch in the NPA are listed under international, Commonwealth or state legislation or conservation overviews (Table 24.4). Syngnathids (seahorses and pipefishes) and pegasids (seamoths) are the only two teleost groups caught as bycatch in the NPA that are listed by the IUCN, mainly owing to their limited reproductive potential and widespread use in traditional medicines in South-east Asian countries (Vincent 1996, 1997).

Syngnathids are the only teleosts caught as bycatch in the NPA listed under Commonwealth legislation, namely the *Environment Protection and Biodiversity Conservation Act 1999*. Although the IUCN lists *Hippocampus kuda* (spotted seahorse) and *H. hystrix* (spiny seahorse) (species reported from the NPA), the region includes six species of *Hippocampus* (*H. alatus*, *H. dahli*, *H. grandiceps*, *H. hendriki*, *H. multispinus* and *H. procerus*) which have been confused with *H. kuda* and *H. hystrix* (Kuiter 2001). Taxonomic problems with the genus continue, and separate studies are underway by Sarah Lourie (McGill University) and Rudie Kuiter (Zoonetics). Two syngnathid species caught by trawling in the NPA, *Solegnathus lettiensis* (alligator pipefish) and *S. hardwickii* (pallid pipefish), are listed by the Australian Society of Fish Biology.

Two serranids are caught by trawling in the NPA but only *Epinephelus coioides* (estuary cod) is listed under Queensland legislation as having minimum and maximum size restrictions (35 cm min; 120 cm max) and recreational possession limits (10 per person). In the Northern Territory (NT) both *Epinephelus coioides* and *Epinephelus malabaricus* (Malabar groper) have a possession limit of 30 per person and taking any *Epinephelus* species over 120 cm in length is prohibited.

No invertebrate bycatch species caught in the NPA are currently listed.

Although the vast majority of teleost and invertebrate species caught by trawling in the NPA are not listed, it is also important to identify species that were considered by Stobutzki et al. (2001b) and Hill et al. (2002) to be at risk of being unsustainable in the long term at current levels of trawling in the region (Table 24.5). The vast majority of species caught as trawl bycatch in the region are small fish and invertebrates, which are not excluded well by TEDs and BRDs currently used by fisheries in the NPA, namely the NPF (Brewer et al. 2003). The ecological risk assessments undertaken by Stobutzki et al. (2001b) and Hill et al. (2002) used semi-qualitative data to rank the relative sustainability of each bycatch species by their susceptibility to capture in trawls and capacity to recovery if populations were to be depleted. This method provides a relative measure of which species may be most at risk of being unsustainable by trawling, but does not provide a quantitative measure of fishing impact on the population of each species. A more quantitative risk assessment method is currently being developed that aims to validate which species are of highest risk in the NPF (Griffiths et al. 2003).

Habitat and distribution

Little quantitative data is available on the biology and ecology of the vast majority of bycatch species in the NPA. This may be attributed to the high diversity and taxonomic difficulties of fish and invertebrates in the NPA, their general low economic value in Australia, and high costs of undertaking scientific investigations in the NPA owing to the remoteness of the region. Figures 24.1 and 24.2 show the distributions of common teleost and invertebrate taxa caught as trawl bycatch in the NPA, while Figures 24.3 and 24.4 show the distributions of taxa considered by Stobutzki et al. (2001b) and Hill et al. (2002) to be least able to sustain trawling in the NPA.

However, some species representing the dominant families caught as trawl bycatch in the NPA have been well studied both in Australia and in other parts of the world (Jayabalan, 1986, 1988; Thresher et al. 1986; Brewer et al. 1991, 1994; Staunton-Smith et al. 1999). Assuming that some ecological and biological traits

of well-studied species are probably similar for closely related species, some generalisations can be made about the life histories of species within the NPA.

The ecological and biological characteristics of teleosts that are common and considered to be least sustainable to trawling in the NPA are shown in Table 24.6. It is difficult to make generalisations about the life histories of the invertebrates that are trawl bycatch in the NPA since they comprise many different taxonomic levels and have very different life history strategies. However, Table 24.7 shows some common ecological and biological characteristics of common species and those considered to be least able to sustain trawling in the NPA.

In summary, the ecological attributes of teleost and invertebrate species that are both common and considered at risk of being unsustainable generally overlap with areas where commercially important prawns occur, and thus make these species susceptible to capture by demersal trawling. The high reproductive capacity of most of the common bycatch species and their ability to withstand some degree of trawl impact means that these species generally have a high capacity to recover after trawl interactions. In contrast, high risk species generally have a low reproductive capacity and cannot withstand physical interactions with trawl gear, and thus have a lower capacity to recover if populations are depleted.

Significance of the species group in the Northern Planning Area

Fish and invertebrates caught as bycatch by trawling are generally considered of low economic importance in Australia. They are, however, of high ecological importance as tropical fish assemblages of northern Australia are among the most diverse in the world. It is estimated that about 75% of species are considered rare in trawls in the NPA; that is, they occur in less than 10% of trawls (Stobutzki et al. 2001a).

Despite the low economic value of bycatch species in Australia, some species that comprise a large percentage of the total bycatch by weight, such as leiognathids and nemipterids, support commercial fisheries in some underdeveloped countries such the Philippines, India and Indonesia (Table 24.8; FAO, 2003). These fish are used for both human consumption and for feed in aquaculture (Annam & Raja 1981).

Some species important to recreational and commercial sectors in Australia are caught in small quantities by trawling, but they are generally juveniles that are discarded and comprise less than 0.1% of the total bycatch (Stobutzki et al. 2000). These species include a few mackerels (*Scomberomorus munroi* and *S. queenslandicus*), queenfish (*Scomberoides commersonianus*) and snappers (*Lutjanis erythropterus* and *L. malabaricus*). These are particularly important recreational species in the region, particularly queenfish and mackerel, but their pelagic distribution and swift swimming ability generally exclude them from being greatly affected by trawl fisheries in the region.

Impacts/Threats

Because so little is known of the ecology and biology of many bycatch species in the NPA it is difficult to identify specific threats. However, two obvious impacts are over-fishing and habitat alteration by trawling and natural perturbations.

Over-fishing is likely to be the biggest impact upon bycatch species. Nearly all bycatch landed by trawling operations is discarded overboard and it is estimated that 80–90% of teleosts are dead when discarded (Hill & Wassenberg 1990; Wassenberg & Hill 1989, 1993). It was also thought that most sponges torn from the substrata and damaged by trawl nets probably do not survive after being discarded (Wassenberg et al. 2002). Recent anecdotal accounts of large numbers of detached living sponges in the NPA after cyclones and in experimentally trawled areas suggests that at least some species of sponges may withstand some degree of trawl impact. However, more detailed studies are required to determine the actual survivorship of sponges after interactions with trawling. Many common bycatch species have a high capacity to recover if populations are depleted, due to early maturity, high fecundity and rapid growth. However, the populations of species that are less abundant in trawl catches may be most at risk of serious depletion. For many of the rarer bycatch species it is unknown whether they are rare in trawls because they are i) less vulnerable to capture, ii) naturally rare on the trawl grounds but are abundant in unfished areas, or iii) rare both on and off the trawl grounds.

Because some species are so rare in commercial or scientific trawl catches, it is difficult to collect enough specimens to undertake biological analyses to determine whether the species is capable of tolerating current fishing mortality rates. Until a large-scale survey is undertaken across the entire NPA to map the distributions of bycatch species and collect specimens for biological studies, the impact of current fishing mortality on these rarer species remains unknown.

Alteration of existing habitats by trawling and natural perturbations, namely cyclones, may be other possible impacts on trawl bycatch species. Since so little is known of the life histories of trawl bycatch species in the NPA it is difficult to predict the effect that alteration of particular habitats may have on bycatch populations. However, the effect of trawl on the substrata may have a lower impact on bycatch populations than over-fishing, since most trawling is undertaken over soft substrata with low habitat complexity. During cyclones and in regions of high fishing effort, disturbance of sediments may cause localised increases in turbidity, which may affect the abundance of seagrasses and corals and bury other benthic organisms when the sediment eventually settles.

Syngnathids and pegasids are two groups of teleosts common in the NPA that have high cultural and social significance in South-east Asian countries, particularly China, where they are used in traditional medicines (Vincent 1996, 1997). Although there is no evidence of decline of Australian populations, they may come under increasing pressure once populations become fully exploited in tropical South-east Asia. Their limited reproductive potential and complex social structuring suggest that populations of these species may have a low capacity to recover once depleted (Kuiter 2000).

Information gaps

CSIRO, NT and Queensland Departments of Primary Industry and Fisheries and state museums have considerable data sets on the spatial and temporal distribution of bycatch species in the NPA. Despite some of the information being published over the past 30 years, no attempt has been made to combine these data and undertake detailed mapping of species distributions in northern Australia. It is recommended that existing data be collated and maps be produced to show the distribution of each trawl species found in the region. This would help identify areas where additional data needs to be collected. OZCAM (Australian Museum Collections On-line) has a pilot web site which maps fish collection data from all state museums; it is hoped that this site will go public shortly.

Despite there being voluminous data on trawl bycatch in northern Australia, it has mostly been collected from the commercial prawn trawl grounds in the Gulf of Carpentaria (GoC). Little is known of the bycatch composition inshore (less than 15 m depth) and offshore (greater than 40 m) from the commercial trawl grounds in the GoC or in regions outside the GoC, particularly west of the Wessel Islands including the Joseph Bonaparte Gulf. It is recommended that surveys be undertaken in regions inshore (less than 15 m depth) and offshore (greater than 40 m) from the trawl grounds. Such surveys are critical for improving bycatch risk assessments as these regions may provide refuge areas for some species that are currently considered at risk of being unsustainable.

Little quantitative biological data exists for the vast majority of species caught as trawl bycatch in the NPA. This information gap mainly stems from the high diversity of species in the region, the remoteness of the region and high costs of collecting data on many species that have no economic value. It is recommended that biological and ecological studies be undertaken for bycatch species known to be data deficient, particularly those sessile (those attached to the seabed) or slow-moving benthic species and fragile invertebrate species that are currently considered least likely to be sustainable to trawl impacts. This would increase our understanding of the role each species plays in the ecosystem and how well species can cope with anthropogenic impacts such as trawling.

Two species of lizardfish, *Saurida undosquamis* and *Saurida* sp. 2, can only be distinguished using genetics: they are indistinguishable by external features using current identification keys. Although the two species may have similar life histories, only *Saurida undosquamis* is currently regarded as at high risk, possibly due to a lack of knowledge of its distribution. It is recommended that further taxonomic work be done to update current identification keys to allow these species to be distinguished using external features. This will allow the distributions of these species to better documented in future studies and allow an update of bycatch risk assessments.

Sponges (Porifera) are an extremely common and conspicuous component of trawl bycatch; however, almost nothing is known of the species that occur in the NPA, mainly owing to taxonomic difficulties. Most sponges can only be identified by inspecting a combination of characteristics including growth form, skeletal arrangement, morphology of spicules, colour, and life history. Furthermore, the survivorship of sponges that are detached and damaged by trawling is largely unknown. A detailed study of the taxonomy, distribution and survivorship of sponges in trawls in the NPA is required to begin to understand the long-term sustainability of this group in the region.

24. Trawl Bycatch Species

Key references and current research

Several large datasets of trawl bycatch are held by CSIRO, state fisheries departments and museums, which cover significant periods of time extending back to at least the late 1800s.

CSIRO are currently undertaking two three-year projects in the NPA, mainly the GoC. The first project (FRDC 2002/035) aims to compare possible bycatch monitoring methods. However, most of the data will be collected from commercial vessels from the trawl grounds and is not likely to improve our knowledge of the distribution of bycatch species in the NPA.

A second project (FRDC 2002/102) aims to assess the rate of depletion and recovery of the seabed biota after repeated trawling. This study is being undertaken at Groote Eylandt and Mornington Island.

There is also a possibility of CSIRO undertaking a seafloor habitat survey in the Torres Strait in conjunction with the new Torres Strait Cooperative Research Centre, which will utilise trawl gear. This project commenced in January 2004.

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24. Trawl Bycatch Species

Table 24.1. *List of families and species of teleosts recorded from scientific surveys using prawn trawl, fish trawl and dredge in the NPA Primary references include Stobutzki et al. (2000) and references within, and records from the Museum and Art Gallery of Northern Territory (MAGNT)*

Family/Scientific Name	Family/Scientific Name	Family/Scientific Name	Family/Scientific Name
Muraenidae	**Synodontidae**	**Veliferidae**	**Aploactinidae**
Gymnothorax minor	*Synodus hoshinonis*	*Velifer hypselopterus*	*Adventor elongatus*
Muraenesocidae	*Synodus sageneus*	**Fistulariidae**	**Platycephalidae**
Muraenesox cinereus	*Trachinocephalus myops*	*Fistularia commersonii*	*Cociella hutchinsi*
Nettastomatidae	**Ariidae**	*Fistularia petimba*	*Elates ransonnetii*
Nettastoma parviceps	*Arius argyropleuron*	**Centriscidae**	*Inegocia japonica*
Congridae	*Arius nella*	*Centriscus scutatus*	*Onigocia macrolepis*
Ariosoma anago	*Arius thalassinus*	*Centriscus cristatus*	*Onigocia spinosa*
Conger cinereus	**Plotosidae**	**Syngnathidae**	*Papilloculiceps bosschei*
Gnathophis nasutus	*Euristhmus nudiceps*	*Haliichthys taeniophorus*	*Papilloculiceps nematophthalmus*
Lumiconger arafura	*Plotosus lineatus*	*Hippocampus histrix*	*Platycephalus endrachtensis*
Uroconger lepturus	**Batrachoididae**	*Hippocampus kuda*	*Platycephalus indicus*
Clupeidae	*Batrachomoeus trispinosus*	*Solegnathus hardwickii*	*Rogadius asper*
Amblygaster sirm	**Antennariidae**	*Solegnathus lettiensis*	*Sorsogona tuberculata*
Anodontostoma chacunda	*Antennarius hispidus*	*Trachyrhamphus longirostris*	*Suggrundus macracanthus*
Dussumieria elopsoides	*Antennarius nummifer*	**Scorpaenidae**	*Suggrundus rodericensis*
Escualosa thoracata	*Antennarius pictus*	*Apistus carinatus*	**Dactylopteridae**
Herklotsichthys koningsbergeri	*Antennarius striatus*	*Brachypterois serrulatus*	*Dactyloptena papilio*
Herklotsichthys lippa	*Tathicarpus butleri*	*Cottapistus cottoides*	**Pegasidae**
Pellona ditchela	**Tetrabrachiidae**	*Cottapistus praepositus*	*Eurypegasus draconis*
Sardinella gibbosa	*Tetrabrachium ocellatum*	*Dendrochirus zebra*	*Pegasus volitans*
Engraulidae	**Bregmacerotidae**	*Erosa erosa*	**Centropomidae**
Thryssa hamiltonii	*Bregmaceros mcclellandi*	*Inimicus sinensis*	*Psammoperca waigiensis*
Thryssa setirostris	**Ophidiidae**	*Minous trachycephalus*	**Serranidae**
Chirocentridae	*Sirembo imberbis*	*Minous versicolor*	*Centrogenys vaigiensis*
Chirocentrus dorab	**Carapidae**	*Neomerinthe amplisquamiceps*	*Cephalopholis boenak*
Sternoptychidae	*Onuxodon margaritiferae*	*Neomerinthe megalepis*	*Epinephelus areolatus*
Polyipnus elongatus	**Exocoetidae**	*Paracentropogon longispinus*	*Epinephelus coioides*
Melanostomiidae	*Cypselurus oligolepis*	*Pterois russelli*	*Epinephelus heniochus*
Bathophilus nigerrimus	**Hemiramphidae**	*Scorpaena cardinalis*	*Epinephelus malabaricus*
Eustomias multifilis	*Euleptorhamphus viridis*	*Scorpaenopsis diabolus*	*Epinephelus quoyanus*
Bathysauridae	*Hemiramphus robustus*	*Scorpaenopsis neglecta*	*Epinephelus sexfasciatus*
Saurida undosquamis	*Hyporhamphus affinis*	*Scorpaenopsis venosa*	*Plectropomus leopardus*
Saurida longimanus	**Holocentridae**	**Triglidae**	*Plectropomus maculatus*
Saurida argentea	*Myripristis botche*	*Lepidotrigla argus*	
Saurida grandisquamis	*Myripristis hexagona*	*Lepidotrigla cf japonica*	
	Myripristis murdjan	*Lepidotrigla* sp. 2 [in Sainsbury et al, 1985]	
	Sargocentron rubrum	*Lepidotrigla russelli*	
Pseudochromidae	*Siphamia roseigaster*	*Scomberoides tol*	*Lutjanus quinquelineatus*
Pseudochromis quinquedentatus	**Sillaginidae**	*Selar boops*	*Lutjanus* sp. (in Yearsley, Last & Ward, 1999)
Glaucosomatidae	*Sillago analis*	*Selar crumenophthalmus*	*Lutjanus sebae*
Glaucosoma magnificum	*Sillago burrus*	*Selaroides leptolepis*	*Lutjanus vitta*
Terapontidae	*Sillago ingenuua*	*Seriolina nigrofasciata*	*Symphorus nematophorus*
Pelates quadrilineatus	*Sillago lutea*	*Ulua aurochs*	**Nemipteridae**
Pelates sexlineatus	*Sillago sihama*	*Uraspis uraspis*	*Nemipterus celebicus*
Terapon jarbua	**Lactariidae**	**Menidae**	*Nemipterus furcosus*
Terapon puta	*Lactarius lactarius*	*Mene maculata*	*Nemipterus hexodon*
Terapon theraps	**Rachycentridae**	**Leiognathidae**	*Nemipterus nematopus*
Priacanthidae	*Rachycentron canadum*	*Gazza minuta*	*Nemipterus peronii*

Family/Scientific Name	Family/Scientific Name	Family/Scientific Name	Family/Scientific Name
Priacanthus tayenus	**Echeneidae**	*Leiognathus aureus*	*Pentapodus paradiseus*
Apogonidae	*Echeneis naucrates*	*Leiognathus bindus*	*Pentapodus porosus*
Apogon albimaculosus	**Carangidae**	*Leiognathus decorus*	*Scolopsis affinis*
Apogon aureus	*Alectis ciliaris*	*Leiognathus elongatus*	*Scolopsis monogramma*
Apogon brevicaudata	*Alectis indicus*	*Leiognathus equulus*	*Scolopsis taeniopterus*
Apogon carinatus	*Alepes apercna*	*Leiognathus fasciatus*	*Scolopsis vosmeri*
Apogon cavitiensis	*Atule mate*	*Leiognathus leuciscus*	**Gerreidae**
Apogon fuscomaculatus	*Carangoides caeruleopinnatus*	*Leiognathus moretoniensis*	*Gerres baconensis*
Apogon truncatus	*Carangoides chrysophrys*	*Leiognathus ruconius*	*Gerres filamentosus*
Apogon fasciatus	*Carangoides fulvoguttatus*	*Leiognathus longispinis*	*Gerres macrosoma*
Apogon melanopus	*Carangoides gymnostethus*	*Leiognathus sp.* *[in Sainsbury et al, 1985]*	*Gerres subfasciatus*
Apogon nigripinnis	*Carangoides hedlandensis*	*Leiognathus splendens*	*Pentaprion longimanus*
Apogon nigrocincta	*Carangoides humerosus*	*Secutor insidiator*	**Haemulidae**
Apogon notatus	*Carangoides malabaricus*	**Caesionidae**	*Diagramma labiosum*
Apogon poecilopterus	*Carangoides talamparoides*	*Caesio caerulaurea*	*Pomadasys argenteus*
Apogon semilineatus	*Caranx bucculentus*	*Caesio teres*	*Pomadasys kaakan*
Apogon septemstriatus	*Caranx kleinii*	*Pterocaesio chrysozona*	*Pomadasys maculatus*
Apogon sp. 1 [in Sainsbury et al, 1985]	*Decapterus macrosoma*	*Pterocaesio digramma*	*Pomadasys trifasciatus*
Apogon sp. 2 [in Sainsbury et al, 1985]	*Decapterus russelli*	**Lutjanidae**	**Lethrinidae**
Cheilodipterus artus	*Gnathanodon speciosus*	*Lutjanus argentimaculatus*	*Gymnocranius elongatus*
Pseudamia amblyuroptera	*Megalaspis cordyla*	*Lutjanus carponotatus*	*Lethrinus genivittatus*
Siphamia argyrogaster	*Pantolabus radiatus*	*Lutjanus erythropterus*	*Lethrinus laticaudis*
Siphamia fuscolineata	*Parastromateus niger*	*Lutjanus johnii*	*Lethrinus lentjan*
Siphamia guttulatus	*Scomberoides commersonnianus*	*Lutjanus lutjanus*	*Lethrinus miniatus*
Siphamia majimae	*Scomberoides tala*	*Lutjanus malabaricus*	
Sparidae	**Mugilidae**	*Dactylopus dactylopus*	**Paralichthyidae**
Argyrops spinifer	*Valamugil cunnesius*	*Orbonymus rameus*	*Pseudorhombus argus*
Sciaenidae	**Sphyraenidae**	**Gobiidae**	*Pseudorhombus arsius*
Johnius amblycephalus	*Sphyraena barracuda*	*Acentrogobius caninus*	*Pseudorhombus diplospilus*
Johnius borneensis	*Sphyraena flavicauda*	*Amoya spp*	*Pseudorhombus dupliciocellatus*
Protonibea diacanthus	*Sphyraena forsteri*	*Bathygobius* n. sp.	*Pseudorhombus elevatus*
Mullidae	*Sphyraena obtusata*	*Lobulogobius morrigu*	*Pseudorhombus jenynsii*
Parupeneus heptacanthus	*Sphyraena putnamae*	*Lubricogobius ornatus*	*Pseudorhombus spinosus*
Upeneus asymmetricus	*Sphyraena qenie*	*Priolepis spp*	**Pleuronectidae**
Upeneus bensasi	**Polynemidae**	*Sueviota larsonae*	*Samaris cristatus*
Upeneus luzonius	*Polydactylus multiradiatus*	*Oxyurichthys auchenolepis*	**Soleidae**
Upeneus moluccensis	**Labridae**	*Oxyurichthys sp.*	*Aseraggodes melanostictus*
Upeneus sp. 1 [in Sainsbury et al, 1985]	*Choerodon cephalotes*	*Parachaeturichthys polynema*	*Brachirus muelleri*
Upeneus sulphureus	*Choerodon monostigma*	*Trimma taylori*	*Pardachirus pavoninus*
Upeneus sundaicus	*Choerodon schoenleinii*	*Yongeichthys nebulosus*	*Strabozebrias cancellatus*
Upeneus tragula	*Choerodon sugillatum*	**Siganidae**	*Zebrias craticula*
Pempherididae	*Paracheilinus filamentosus*	*Siganus argenteus*	*Zebrias quagga*
Pempheris analis	*Xiphocheilus typus*	*Siganus canaliculatus*	**Cynoglossidae**
Drepanidae	**Scaridae**	*Siganus nebulosus*	*Cynoglossus arel*
Drepane punctata	*Scarus ghobban*	*Siganus lineatus*	*Cynoglossus bilineatus*
Ephippidae	**Opistognathidae**	**Trichiuridae**	*Cynoglossus kopsii*
Platax batavianus	*Opistognathus latitabundus*	*Trichiurus lepturus*	*Cynoglossus macrophthalmus*
Platax teira	**Pinguipedidae**	**Scombridae**	*Cynoglossus maculipinnis*
Zabidius novemaculeatus	*Parapercis diplospilus*	*Cybiosarda elegans*	*Paraplagusia bilineata*
Scatophagidae	*Parapercis nebulosa*	*Rastrelliger kanagurta*	*Paraplagusia longirostris*

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Family/Scientific Name	Family/Scientific Name	Family/Scientific Name	Family/Scientific Name
Scatophagus argus	*Parapercis stricticeps*	*Scomberomorus munroi*	**Triacanthidae**
Chaetodontidae	**Pholidichthyidae**	*Scomberomorus queenslandicus*	*Trixiphichthys weberi*
Chaetodon aureofasciatus	*Pholidichthys anguis*	**Centrolophidae**	**Balistidae**
Chelmon marginalis	**Uranoscopidae**	*Psenopsis humerosa*	*Abalistes stellatus*
Chelmon muelleri	*Uranoscopus cognatus*	**Psettodidae**	**Monacanthidae**
Chelmonops truncatus	*Uranoscopus* sp. 1 [in Sainsbury et al, 1985]	*Psettodes erumei*	*Aluterus monoceros*
Coradion chrysozonus	*Uranoscopus terraereginae*	**Citharidae**	*Anacanthus barbatus*
Parachaetodon ocellatus	**Congrogadidae**	*Brachypleura novaezeelandiae*	*Monacanthus chinensis*
Pomacanthidae	*Congrogadus amplimaculatus*	**Bothidae**	*Paramonacanthus choirocephalus*
Chaetodontoplus duboulayi	**Callionymidae**	*Arnoglossus waitei*	*Paramonacanthus filicauda*
Pomacanthus sexstriatus	*Pseudocalliurichthys goodladi*	*Asterorhombus intermedius*	*Paramonacanthus oblongus*
Pomacentridae	*Calliurichthys grossi*	*Engyprosopon grandisquamum*	*Pseudomonacanthus elongatus*
Pristotis jerdoni	*Calliurichthys afilum*	*Engyprosopon maldivensis*	*Pseudomonacanthus peroni*
Cepolidae	*Repomucenus belcheri*	*Grammatobothus polyophthalmus*	
Acanthocepola abbreviata	*Repomucenus meridionalis*	*Laeops parviceps*	
Ostraciidae	**Diodontidae**		
Ostracion nasus	*Cyclichthys orbicularis*		
Lactoria gibbosus	*Lophodiodon calori*		
Tetraodontidae	*Tragulichthys jaculiferus*		
Arothron stellatus			
Chelonodon patoca			
Feroxodon multistriatus			
Lagocephalus inermis			
Lagocephalus lunaris			
Lagocephalus sceleratus			
Lagocephalus spadiceus			
Torquigener hicksi			
Torquigener pallimaculatus			
Torquigener tuberculiferus			
Torquigener whitleyi			

Table 24.2. List of invertebrate taxa recorded from scientific surveys using prawn trawl, fish trawl and dredge in the NPA Primary references include Stobutzki et al. (2000) and references within and Hill et al. (2002)

Taxa	Taxa	Taxa	Taxa
PORIFERA	*Sphaenopus marsupialis*	*Diogenes sp 3*	*Myrodes eudactylus*
Ancorinidae	*Sphaenopus sp*	**Paguridae**	*Pariphiculus marianne*
Aplysinidae	Scleractinia	*Spiropagurus sp 1*	**Majidae**
Geodiidae	Hard coral sp 2	**Porcellanidae**	*Camposcia retusa*
Tetillidae	*Duncanopsammia*	*Porcellanidae sp 3*	*Chlorinoides aculeatus*
Darwinellidae	*Fungia sp 4*	*Porcellanidae sp 4*	*Hyastenus cambelli*
Dysideidae	*Antipatharia*	**Thallasinidea**	*Hyastenus sp*
Irciniidae	Cubomedusae	*Thalassinia sp 1*	*Hyastenus sp 1*
Spongiidae	*Chironex fleckeri*	*Thalassinia sp 2*	*Hyastenus sp 3*
Spirastrellidae	**CTENOPHORA**	**Upogiibidae**	*Hyastenus sp 4*
Suberitidae	**POLYCHAETA**	**Corystidae**	*Micippa excavata*
Axinellidae	**ECHIURA**	*Gomeza bicornis*	*Micippa sp*
Desmoxyidae	**SIPUNCULA**	*Xenophthalmu pinnotheroides*	*Phalangipes australiensis*
Halichondriidae	**CRUSTACEA**	**Dorippidae**	*Phalangipes longipes*
Callyspongiidae	**Penaeidae**	*Dorippe quadridens*	*Schizophrys dama*
Niphatidae	*Atypopenaeus spp*	*Paradorippe australiensis*	**Parthenopidae**
Petrosiidae	*Metapenaeopsis spp*	**Dromiidae**	*Cryptopodia sp 1*
Phloeodictyidae	*Parapenaeopsis spp*	*Conchoecetes artifisciosus*	*Cryptopodia sp 3*
Coelosphaeridae	*Parapenaeus spp*	*Dromia dehaani*	*Cryptopodia sp 5*
Desmacellidae	*Trachypenaeus spp*	**Calappidae**	*Parthenope harpax*
Microcionidae	*Metapenaeus endeavouri*	*Calappa terraereginae*	*Parthenope hoplonotus*
Mycalidae	*Metapenaeus ensis*	*Calappa gallus*	*Parthenope longimanus*
Myxillidae	*Penaeus esculentus*	*Matuta inermis*	*Parthenope longispinus*
Phoriospongiidae	*Penaeus latisulcatus*	*Matuta granulosa*	*Parthenope sp 3*
Raspailiidae	*Penaeus longistylus*	***Leucosidae***	*Parthenopus nodosus*
Druinelliidae	*Penaeus merguiensis*	*Arcania novemspinosa*	**Portunidae**
Ianthellidae	*Penaeus monodon*	*Arcania septemspinosa*	*Charybdis anisodon*
unidentified Porifera	*Penaeus semisulcatus*	*Ebalia sp*	*Charybdis callianassa*
CNIDARIA	**Sicyonidae**	*Iphiculus spongiosus*	*Charybdis feriatus*
Hydrozoa	**Solenoceridae**	*Ixa inermis*	*Charybdis jaubertensis*
Anthozoa	**Diogenidae**	*Ixoides cornutus*	*Charybdis miles*
Pennatulacea	*Dardanus asperus*	*Leucosia anatum*	*Charybdis natator*
Gorgonacea	*Dardanus hessii*	*Leucosia magna*	*Charybdis truncata*
Alcyonacea	*Dardanus imbricata*	*Leucosia ocellata*	*Charybdis yaldwin*
Actiniaria	*Dardanus pedunculatuss*	*Leucosia sp 1*	*Libystes edwardsii*
Zoanthiniaria	*Dardanus sp nov.*	*Myra biconica*	*Lupocyclus rotundatus*
Lupocyclus tugelae	*Ceratoplax sp 2*	*Meiosquilla sp 1*	Tonnidae
Podopthalmus vigil	*Ceratoplax sp 3*	*Oratosquilla inornata*	Trochidae
Portunus acerbiterminalis	*Cryptocoeloma haswelli*	*Oratosquilla interupta*	Turbinidae
Portunus argentatus	*Lophopilumnus globosus*	*Oratosquilla nepa*	Turritellidae
Portunus gladiator	*Pilumnus semilanatus*	*Oratosquilla quinquendentata*	Volutidae
Portunus gracilimanus	*Pilumnus sp 1*	*Oratosquilla woodmasoni*	Xenophoridae
Portunus pelagicus	*Pilumnus sp 4*	*Carinosquilla carinata*	Nudibranchia
Portunus rubromarginatus	**Alpheidae**	*Carinosquilla multicarinata*	Opisthobranchia
Portunus rugosus	**Crangonidae**	*Dictyosquilla foveolata*	Sepiidae
Portunus sanguinolentus	*Crangon sp 1*	*Lenisquilla lata*	*Sepia pharaonis*
Portunus sp 1	*Crangon sp 2*	**Cirripedia**	*Sepia elliptica*
Portunus spinipes	**Caridea**	**MOLLUSCA**	*Sepia opipara*
Portunus tenuipes	*Palicoides longimanus*	Bivalvia	*Sepia papuensis*
Scylla serrata	*Zebra sp*	Arcidae	*Metasepia pfefferi*

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Taxa	Taxa	Taxa	Taxa
Thalamita intermedia	**Palinuridae**	Arcticidae	*Sepia smithi*
Thalamita sexlobata	*Panulirus ornatus*	Cardiidae	*Sepiodarium kochii*
Thalamita sima	*Panulirus polyphagus*	Cultellidae	Sepiolidae
Thalamita sp 2	**Scyllaridae**	Glycymerididae	Teuthoidea
Thalamita spinifer	*Scyllarus* sp	Limidae	Octopoda
Raninidae	*Thenus* sp. nov.	Mactridae	**ECTOPROCTA**
Jonas luteanus	**Stenopodidae**	Malleidae	Bryozoa
Xanthidae	*Stenopus hispidus*	Mytilidae	**ECHINODERMATA**
Demania cultripes	**Pleocyemata**	Pectinidae	Loveniidae
Demania sp	**Eurysquillidae**	Amussiidae	Spatangoida
Galene bispinosa	*Manningia notalis*	*Amusium pleuronectes*	Crinoidea
Liagore rubromaculata	**Lysiosquillidae**	Solecurtidae	Clypeasteroida
Liomera rubra	*Lysiosquilla tredecimdentata*	Solemyidae	Echinoidea
Neoxanthops sp	*Odontodactylidae*	Solenidae	*Chaetodiadema granulatum*
Gonoplacidae	*Odontodactylus cultrifer*	Spondylidae	Holothuroidea
Carcinoplax purpurea	**Harpiosquillidae**	Trigonioida	Asteroidea
Eucrate dorsalis	*Harpiosquilla annandalei*	Veneridae	Ophiuroidea
Eucrate sp 2	*Harpiosquilla harpax*	Gastropoda	Gorgonocephalidae
Eucrate sp 4	*Harpiosquilla melanoura*	Acteonidae	Unidentified Echinodermata
Eucrate sp 5	**Squillidae**	Bursidae	**CHORDATA**
Eucrate sp 6	*Acanthosquilla multifasciata*	Conidae	Ascidiacea
Ommatocarcinus macgillivrayi	*Clorida chlorida*	Cypraeidae	
Pilumnidae	*Clorida decorata*	Fasciolariidae	
Actumnus dorsipes	*Clorida granti*	Melongenidae	
Bathypilumnus nigrispinifer	*Clorida latispina*	Muricidae	
Bathypilumnus pugilator	*Clorida latreillei*	Olividae	
Ceratoplax sp 1	*Clorida malaccensis*	Ranellidae	

Table 24.3. Families and species of fish and invertebrates comprising the majority of prawn trawl bycatch by weight in the NPA Species within families are listed in decreasing order of contribution to total bycatch by weight. Data summarised from Stobutzki et al. (2000).

Teleosts			Invertebrates		
Family	**Species**	**Common Name**	**Phylum**	**Taxa**	**Common Name**
Synodontidae	*Saurida undosquamis /S. sp. 2* *Saurida micropectoralis* *Trachinocephalus myops* *Synodus hoshinonis* *Saurida longimanus*	Checkered lizardfish Short-finned lizardfish Painted saury Black-shouldered lizardfish Long-finned lizardfish	Crustacea	*Portunis pelagicus* *P. rubromarginatus* *Thenus sp. nov.* *Metapenaeopsis* spp *Charybdis truncata*	Blue swimmer fish Swimming crab Moreton Bay bug Penaeid prawn Blunt-toothed crab
Leiognathidae	*Leiognathus splendens* *L. bindus* *L. moretoniensis* *L. equulus* *L. leuciscus* *L. sp.* *Secutor insidiator.*	Black-tipped ponyfish Orange-tipped ponyfish Zig-zag ponyfish Narrow-banded ponyfish Whipfin ponyfish Vermiculated ponyfish Pugnose ponyfish	Echinodermata	Loveniidae Spatangoida *Chaetodiadema granulatum*	Heart urchin Heart urchin Sea urchin
Nemipteridae	*Nemipterus hexadon* *N. nematopus* *N. peronii*	Ornate threadfin bream Yellow-tipped threadfin bream Notched threadfin bream	Porifera	Unidentified Porifera Irciniidae	Sponge Sponges
Carangidae	*Selaroides leptolepis* *Caranx bucculentus* *Carangoides humerosus* *C. talamparoides* *C. malabaricus* *C. caeruleopinnatus*	Yellow-striped trevally Blue-spotted trevally Epaulet trevally White-tongued trevally Malabar trevally Onion trevally	Mollusca	*Amusium pleuronectes* Sepiidae Teuthoidea	Northern saucer scallop Cuttlefishes Squids
Haemulidae	*Pomadasys maculatum* *P. trifasciatus* *P. kaakan*	Blotched javelinfish Silver javelinfish Yellow-finned javelinfish			
Mullidae	*Upeneus sulphureus* *U. asymmetricus*	Sunrise goatfish Asymmetrical goatfish			

Table 24.4: Teleost species recorded in trawl bycatch in the NPA that are listed by the International Union for the Conservation of Nature (IUCN), the Environment Protection and Biodiversity Conservation Act 1999, the Australian Society for Fish Biology (ASFB) or the states Northern Territory (NT) and Queensland (QLD)

VU = Vulnerable, DD = data deficient, LR = lower risk (least concern).

Scientific name	Common Name	ICUN	ASFB	EPBC	NT	QLD
Haliichthys taeniophorus	Ribboned sea dragon	-	-	Listed	-	-
Trachyrhamphus longirostris	Straight stick-pipefish	-	-	Listed	-	-
Hippocampus hystrix	Spiny seahorse	VU	-	-	-	-
Hippocampus kuda	Spotted seahorse	VU	-	Listed	-	-
Solegnathus hardwickii	Pallid pipefish	VU	DD	-	-	-
Solegnathus lettiensis	Alligator pipefish	VU	DD	-	-	-
Eurypegasus draconis	Short seamoth	DD	-	-	-	-
Pegasus volitans	Slender seamoth	DD	-	-	-	-
Epinephelus coioides	Estuary cod	-	LR	-	Size & bag limits	Size & bag limits
Epinephelus malabaricus	Malabar groper	-	LR	-	Size & bag limits	-

24. Trawl Bycatch Species

Table 24.5. *Taxa of teleosts and invertebrates considered by Stobutzki et al. (2001) and Hill et al. (2002) to be least sustainable under current levels of prawn trawling in the NPA*
Sustainability of trawl species was assessed by ranking species using a number of criteria describing their vulnerability to capture in trawls and their capacity to recover if populations were depleted.

Teleost Fishes			Invertebrates		
Family	**Species**	**Common Name**	**Phylum**	**Taxa**	**Common Name**
Ariidae	*Arius proximus*	Salmon catfish	Mollusca	Octopodidae (Cephalopoda)	Octopuses
	Arius bilineatus	Bronze catfish		Olividae (Gastropoda)	Ancillas
	Arius nella	Smooth-headed catfish		Sepiolidae (Cephalopoda)	Dumpling squids
Plotosidae	*Euristhmus lepturus*	Long-tailed catfish		Solemyidae (Bivalvia)	Date shells
Apogonidae	*Rhabdamia gracilis*	Slender cardinalfish		Solenidae (Bivalvia)	Fingernail clams
Diodontidae	*Cyclicthys orbicularis*	Short-spined porcupinefish		Teuthoidea (Cephalopoda)	Squids
Synodontidae	*Saurida undosquamis*	Checkered lizardfish	Cnidaria	Alcyonacea	Octocorals
	Synodus macrops	Triplecross lizardfish		Pennatulacea	Seapens
Callionymidae	*Callionymus belcheri*	Flathead dragonet	Crustacea	Palinuridae	Spiny lobsters
	Callionymus sublaevis	Multifilament dragonet		Parthenopidae (Brachyura)	Crabs
Congridae	*Poeciloconger kapala*	Conger eel	Echinodermata	Echinoidea	Sea urchins
Labridae	*Leptojulis cyanopleura*	Shoulder-spot wrasse			
Tetraodontidae	*Arothron manilensis*	Narrow-lined pufferfish			
Opisthognathidae	*Opistognathus latitabundus*	Blotched jawfish			

Table 24.6: *A summary of the general ecological and biological characteristics of teleosts in trawl bycatch that are common or considered least sustainable to prawn trawling in the NPA*
Characteristics have been partially summarised from ecological and biological criteria used for an ecological risk assessment for teleosts by Stobutzki et al. (2001) for the Northern Prawn Fishery.

Common teleost bycatch species	Teleosts considered to be least sustainable to trawling
Ecological characteristics	
• Benthic or demersal	• Benthic or demersal
• Prefer soft or muddy substrata	• Prefer soft or muddy substrata
• Prefer water depths of less than 50 m	• Prefer water depths of less than 50 m
• Prey upon benthic or demersal organisms such as small fishes and crustaceans, including commercially important penaeid species	• Prey upon benthic or demersal organisms such as small fishes and crustaceans, including commercially important penaeid species
Biological characteristics	
• Generally have a moderate to small maximum size <80 cm	• Generally have a moderate to small maximum size <80 cm
• Fast-growing and short-lived	• Slow-moving
• Reach sexual maturity quickly	• Slow-growing and long-lived, or are susceptible to capture at a young age
• Dioecious	• Reach sexual maturity late in life and have a low probability of breeding before being susceptible to being caught by trawls
• Broadcast spawners that produce many thousands of offspring	• Produce few young and undertake parental care of offspring (eg mouth brooding in ariids and apogonids (*Rhabdamia*))
	• Possess morphological features that decrease the chances of escape from a trawl net, such as large rigid fin spines that entangle in the meshes

Table 24.7: *A summary of the general ecological and biological characteristics of invertebrates in trawl bycatch that are common or considered least sustainable to trawling in the NPA*
Characteristics have been partially summarised from ecological and biological criteria used for an invertebrate risk assessment by Hill et al. (2002) for the Northern Prawn Fishery.

Common invertebrate bycatch species	Invertebrates considered to be least sustainable to trawling
Ecological characteristics	
• Benthic or demersal	• Benthic or demersal
• Sessile or slow-moving	• Sessile or slow-moving
• Prefer soft or muddy substrata	• Prefer soft or muddy substrata
• Prefer water depths of less than 50 m	• Prefer water depths of less than 50 m
• Prey upon benthic or demersal organisms such as small fishes and crustaceans, including commercially important penaeid species	• Prey upon benthic or demersal organisms such as small fishes and crustaceans, including commercially important penaeid species
Biological characteristics	
• Generally have a small maximum size <50 cm	• May attain a large maximum size >50 cm
• Fast-growing and short-lived	• Slow-growing and long-lived, such as corals
• Reach sexual maturity quickly	• Fragile with respect to trawl impacts
• Produce many thousands of offspring	• Cannot regenerate body parts or grow from body fragments
• Can withstand being temporarily removed from preferred habitat and able to spend some time out of water	• Reach sexual maturity late in life and have a low probability of breeding before being susceptible to being caught by trawls
	• Produce few young and undertake parental care of offspring (eg parental care of eggs by portunids and bugs)
	• Have morphological features that increase their susceptibility to capture by a trawl net, such as large appendages that extend off the seafloor that easily entangle in net meshes

Table 24.8: *Major families and species of teleosts common in trawl bycatch in the NPA that are economically important in other countries*
FAO catch statistics (FAO 2003) were used to determine economic significance of trawl species

Family	Common name	Species	Countries
Leiognathidae	Ponyfishes	*Leiognathus bindus* *L. splendens* *Secutor insidiator.*	Philippines, India, Indonesia
Nemipteridae	Threadfin breams	Undifferentiated	Thailand, Philippines, Indonesia, China
Synodontidae	Lizardfishes	*Saurida micropectoralis* *S. undosquamis* *Trachinocephalus myops,*	Thailand, Philippines, India, China
Priacanthidae	Large-spined big-eye	*Priacanthus macracanthus*	Thailand, Indonesia, China
Carangidae	Malabar trevally	*Carangoides malabaricus*	Thailand, Indonesia, Philippines, Malaysia

24. Trawl Bycatch Species

Figure 24.1: *Distribution of common fish species comprising the majority of trawl bycatch by weight in the NPA*
Black and grey dots indicate if the species was present or absent respectively. Data have been pooled for all CSIRO research surveys in the NPA using prawn trawl, fish trawl and dredge.

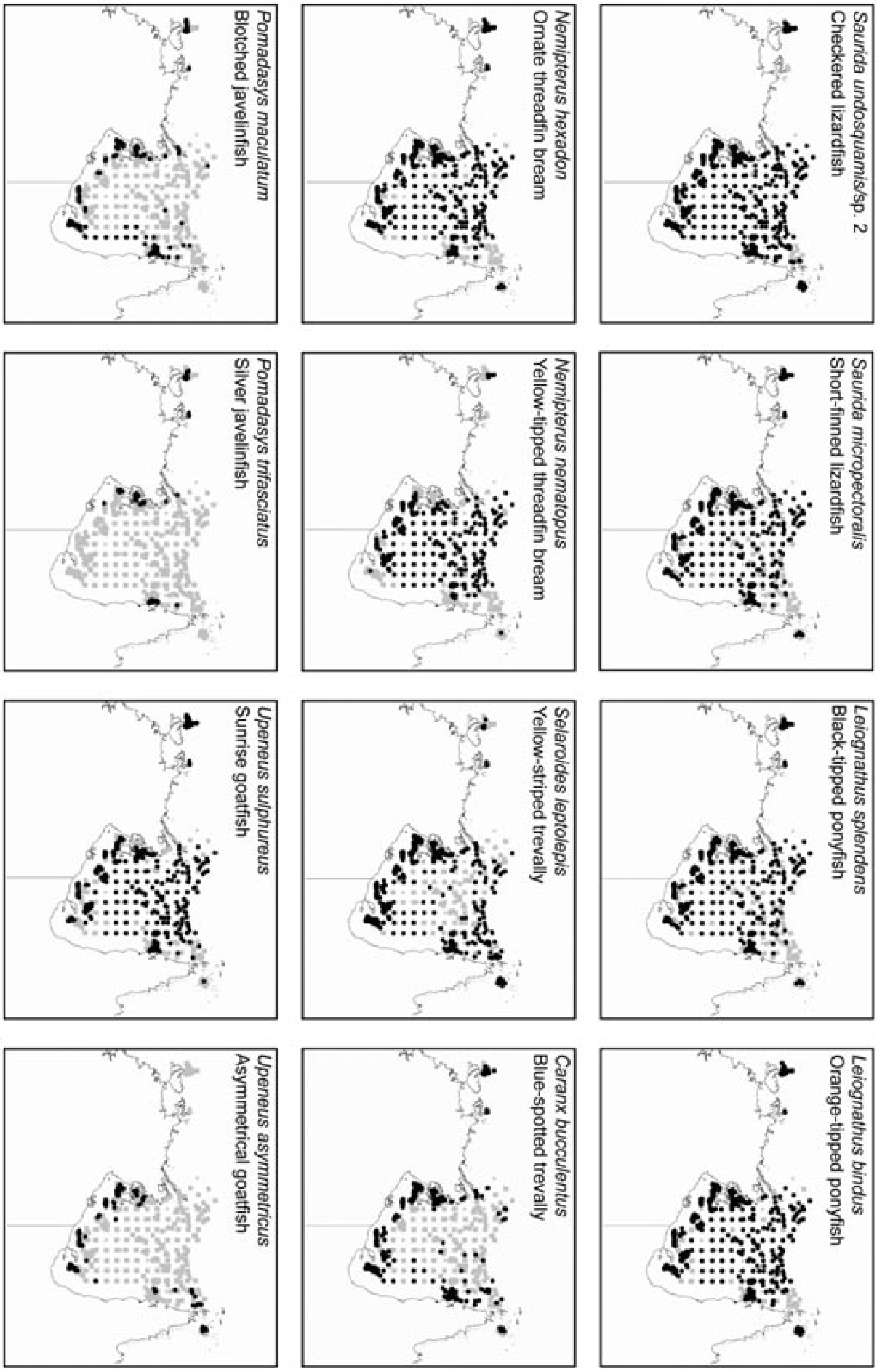
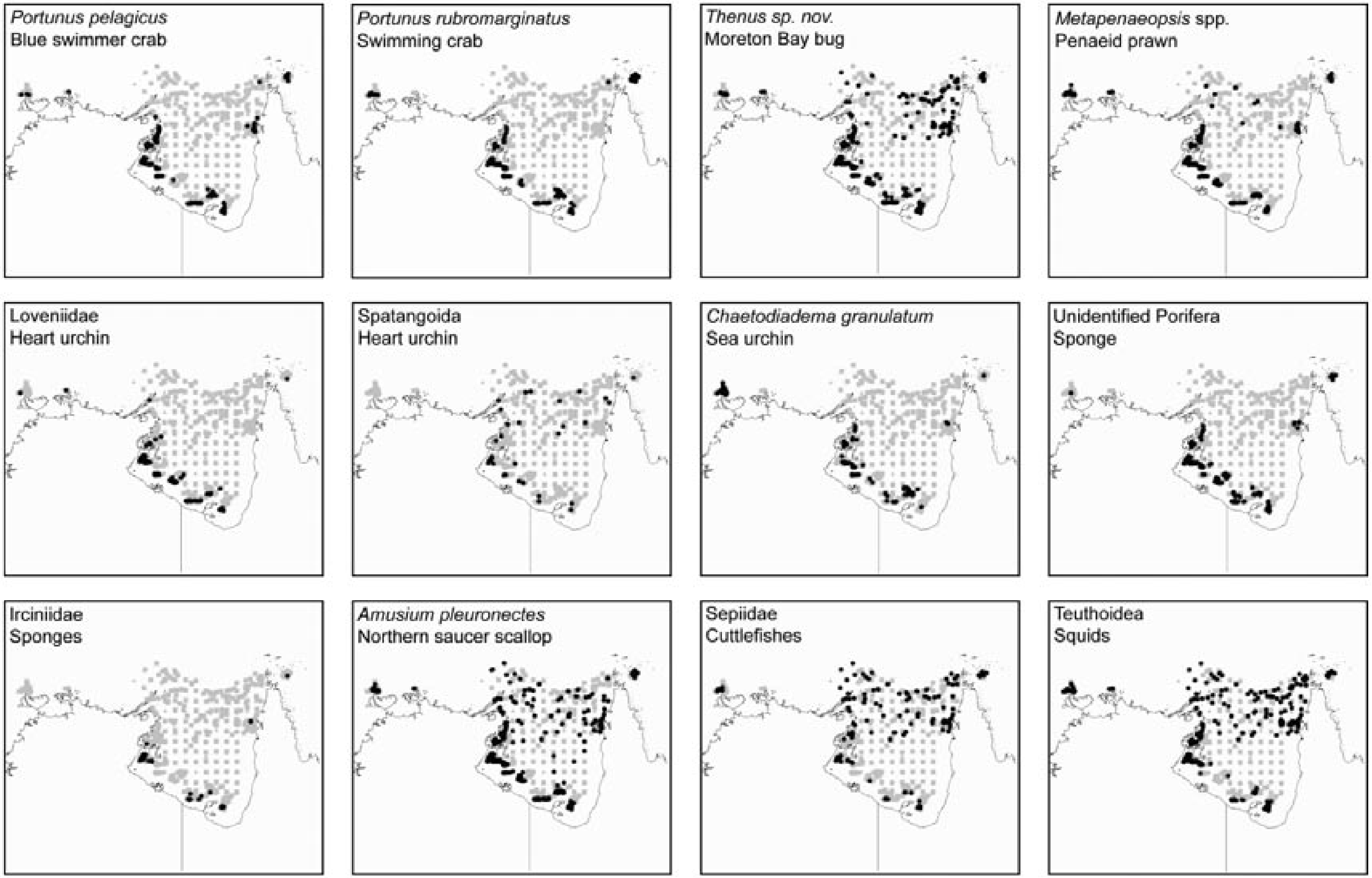


Figure 24.2: *Distribution of common invertebrate species comprising the majority of trawl bycatch by weight in the NPA*
Black and grey dots indicate if the species was present or absent respectively. Data have been pooled for all CSIRO research surveys in the NPA using prawn trawl, fish trawl and dredge.



24. Trawl Bycatch Species

Figure 24.3: *Distribution of teleost bycatch species that are considered by Stobutzki et al. (2001b) to be least sustainable to trawling in the NPA*
Black and grey dots indicate if the species was present or absent respectively. Data have been pooled for all CSIRO research surveys in the NPA using prawn trawl, fish trawl and dredge.

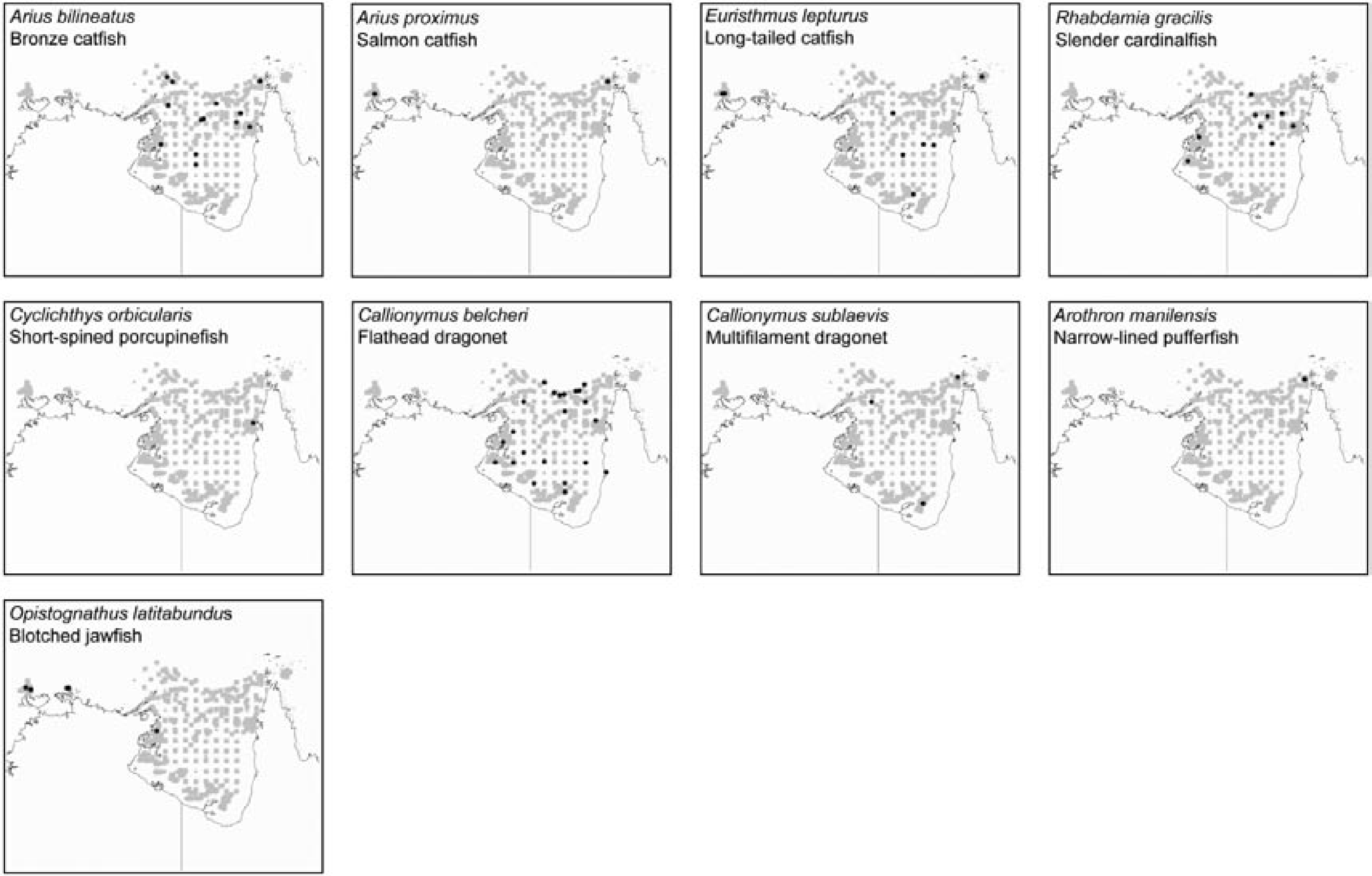
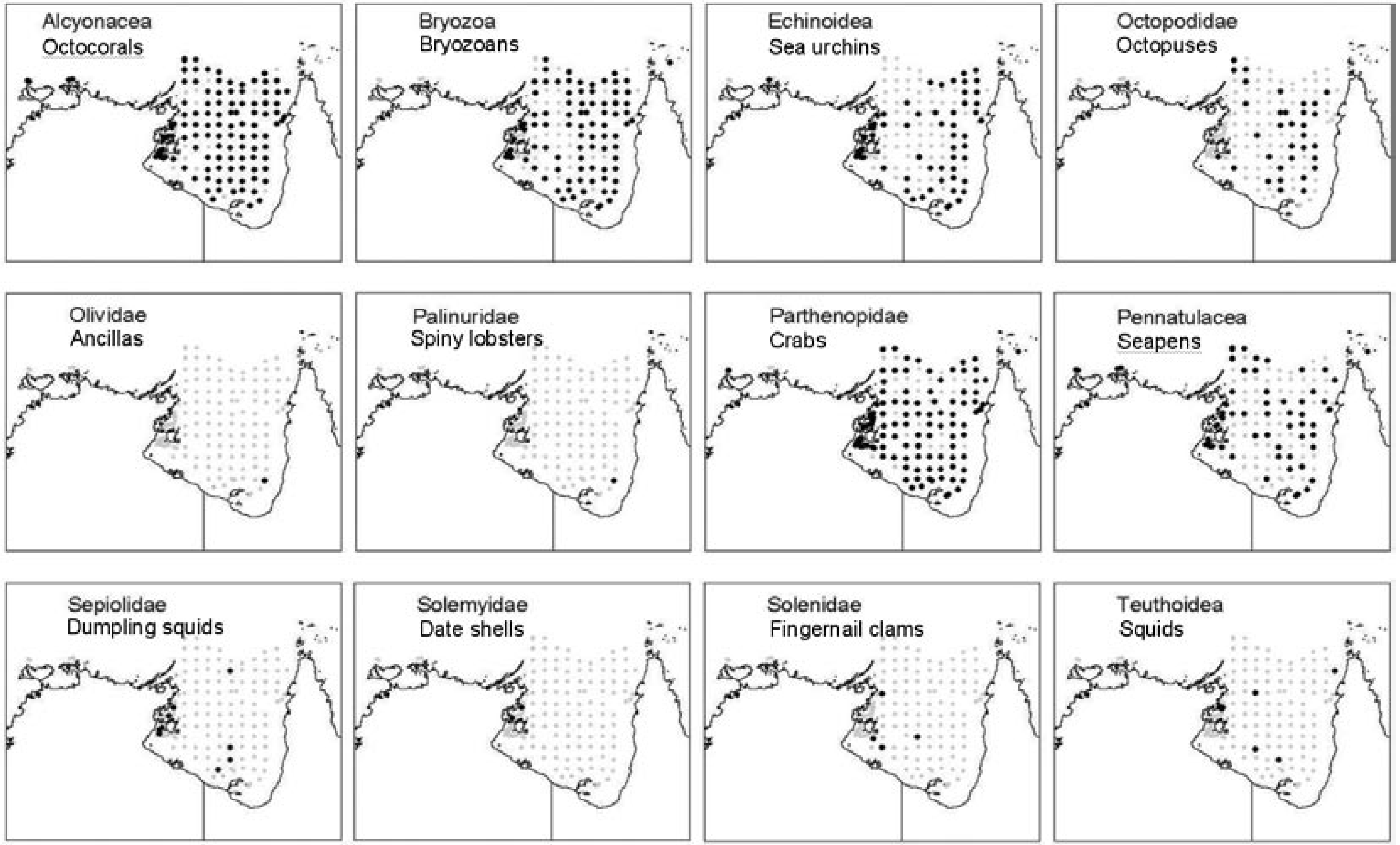


Figure 24.4: Distribution of invertebrate bycatch species that are considered by Hill et al. (2000) to be least sustainable to trawling in the NPA Black and grey dots indicate if the species was present or absent respectively. Data have been pooled for all CSIRO research surveys in the NPA using prawn trawl, fish trawl and dredge.



25. Summary of impacts and threats

The remote and harsh environment in this part of tropical Australia is likely to be primary reasons why human population expansion, and subsequent development, have not (yet) occurred to any great extent compared with other parts of the Australian coast. Much of the wildlife habitat of the Northern Planning Area (NPA) remains relatively undisturbed. This, of course, may not always be the case, and is no reason to be complacent. Within this area we are in the enviable position of being able to document and look after important sites before they begin to be detrimentally affected, and to use past lessons from other parts of Australia for the future management of species and/or areas.

Most of the frequently documented impacts/threats[1] to marine species and their habitats around Australia apply to the NPA, but in many cases they are still probably minimal compared to other more populated coastal areas of Australia. Although impacts and threats can be identified, the extent and long-term consequences are largely unknown. The cumulative impacts (eg one impact may have been studied but it is rarely the only impact acting upon a species) on species are particularly threatening and are also understudied.

It should also be kept in mind that we are managing many **species that migrate** in and out of the NPA and, in some cases, Australia. Consideration should therefore be given, where possible, to threats in parts of their ranges outside of Australia. Lobsters, snappers and holothurians each have free-drifting larvae with a relatively long planktonic stage. Highly migratory species such as turtles, some sharks and tunas also freely swim across local, regional and national marine boundaries.

Cyclones pose one of the major natural threats to all species groups. This threat may be intensified with global climate changes such as global warming and El Niño. Cyclones have been known to alter inshore habitat through increased turbidity from increased runoff. Substrate is reworked and buried, corals killed, seagrass and algal beds can be uprooted or smothered by sediments. Cyclones and other extreme natural events have the potential to cause severe impact (at least regionally) especially if species are additionally under stress from anthropogenic (man-induced) threats.

Another common impact or threat across key species groups in the NPA is **fishing** – commercial (legal and illegal), recreational and traditional. These impacts may be due to direct or indirect mortality and/or disturbance of habitat upon which species rely. Depending upon the species, location and life cycle stage, the nature of the impact and the sector(s) causing the impact may be different.

Unlike many areas of the Australian coastline the impacts of **infrastructure development** (eg ports, community structures, tourism and aquaculture developments) are very localised and sparsely spread across the NPA. However, such developments are expanding, albeit from a low base. With coastal development generally expanding human residence along the coast, there will be an increased risk to the integrity of inshore seagrass pastures and coral reefs resulting from increased turbidity and agricultural and industrial pollution outflow. This will then have flow-on effects on species that depend on these habitats at stages of their life cycle.

Nearly all contributors have noted the **lack of information and knowledge** on the key species groups and the impacts acting upon them. This lack of information and knowledge obliges us to take a more precautionary approach to the management of the impacts on the key species groups.

A summary of impacts, or issues associated with impacts, across each of the species groups is presented in Table 25.1 below. This table does not attempt to prioritise the impacts or threats either within a species group or between groups. The authors have generally provided their own judgments of the degree of the impact or threat. The National Oceans Office is also undertaking further work on impacts on the environment in the NPA with a longer-term aim of assessing cumulative impacts in the region. The information in this report will feed directly into this longer term analysis. For a more extensive initial analysis of impacts of activities on the environment in the NPA please refer to the report entitled *'Preliminary Identification of Impacts of Current Activities in the Northern Planning Area'* at www.oceans.gov.au.

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[1] *Impacts are those events currently happening and known to have an effect on key species while threats are those events that may happen to key species groups (eg have happened in the past and may happen again, anticipated changes make an event likely in the future etc).*

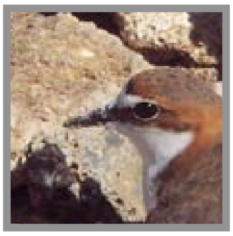
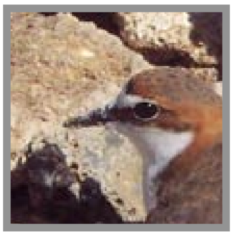


Table 25.1: *Summary of impacts and threats on key species groups in the NPA*

Species Group	IMPACTS / THREATS
Seagrasses	• Natural cyclical events (cyclones, increased turbidity from increased runoff). • Infrastructure, including eco-tourism and aquaculture facilities and ports in seagrass areas. • Seagrass exposed at low tide is likely to be threatened by climate change. • Port and shipping accidents. • Introduced marine pests. • Increase in cyclone activity with climate change. • Potential threat from increased land-based activities (mining, pastoral). • Insufficient information on seagrass meadows in some areas on which to determine likely impacts and threats.
Mangroves	• Minor localised clearing has occurred in some areas near ports, communities and outstations. • Possible future negative effects from the near-coastal 'settling ponds' and concentration plants of the Nuhulunbuy and Groote Eylandt mining operations and ponded pastures. • The main threat to mangrove communities relates to the loss of traditional Aboriginal knowledge diversity rather than the loss of biodiversity. • Climate change / changes in water temperature and sea level rise.
Corals	• Global warming and El Niño events pose major long-term threats to shallow water corals. • Human impact in the region, including coral harvest, may be small although this has not been assessed. • Oil spills, groundings and bottom scouring from shipping accidents.
Seabirds & shorebirds	• Naturally occurring inclement weather conditions (excessive heat, cyclones). • Human disturbance to breeding sites – tourism boats, recreational fishing, 4WD along beaches. • Fishing lines and hooks, discarded or lost nets and other rubbish. • Introduced animals such as cats, dogs, pigs, rats and cane toads can cause considerable damage to seabirds nesting sites. • Introduced vegetation (weeds) invading nesting sites. • Pollution, including oil spills. • Shipping/aircraft noise disturbance, occasional bird strike. • Potential spillages in the upper catchment that make their way to the sea or at coastal loading ports from mining operations. • Fishing discards – population changes as a result of increased food to some species. • Traditional hunting (seabirds) and burning. • Aquaculture operations having the potential to cause problems if poorly managed.
Sharks	• Targeted fishing pressure, especially the commercial catch, is significant for some sharks. • Deliberate post-capture mortality (eg finning) is a potential threat to populations under pressure. • Gill netting and line fishing incidental catch. • Cyclone activity resulting in habitat changes.
Rays	• Few reliable data available on population structures, fishery catch and bycatch of rays, and commercial and Indigenous fishing impacts are unknown. • Foreign fishing impacts outside Australian waters unknown. • Freshwater stingrays with limited distributions are vulnerable to exploitation and habitat degradation, such as inappropriate agricultural practices in river catchments. • Species dependent upon reefs and corals may be threatened by habitat loss (eg coral bleaching).
Sawfish	• Species inability to adapt (due to its biology) to changes within its environment. • Fishing, including commercial net fisheries, demersal prawn trawling in the NPF, recreational line/net fisheries and Indigenous fisheries. • Habitat degradation due to poor land resource management, water extraction, mining and urbanisation. • Short-term and long-term fluctuations in temperature, oxygen level, mineral content, turbidity, water flow, rainfall, and major changes in river and lake beds.
Cetaceans	• The primary threat to cetaceans is incidental mortality as a result of fishing activities, particularly set mesh nets. • Potential threats include seismic testing and the use of sonar by naval vessels.

25. Summary of impacts and threats

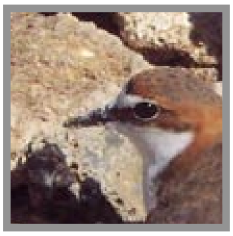
Species Group	IMPACTS / THREATS
Dugong	• Habitat loss has been identified as a potential source of localised declines in dugong populations – particularly due to cyclone activity (eg increased siltation, mechanical damage and freshwater influx). • Potential impact on local habitats from coastal development around ports (eg ore spillage - could affect the ability of dugongs to move between feeding grounds in the south-east GoC). • Threat from additional/new forestry, mining and petroleum activities in, and adjacent to the Torres Strait (eg impact on seagrass beds through terrestrial runoff, direct disturbance of habitat, seismic activities). • Fishing activities (eg commercial barramundi fishing using set nets, inshore shark fishing using pelagic nets, bait fishing using nets to catch bait for mud-crabbing and staked coastal nets used by coastal net fishery, PNG coastal fisheries, illegal Taiwanese and Indonesia vessels). • Indigenous use and hunting – particularly in the Torres Strait (including the Northern Peninsula Area). • Several other threats to dugong populations have been identified, including mortality associated with boat strikes.
Turtles	• Trawl bycatch mortality – primary cause of the recent decline in east Australian loggerhead turtle breeding numbers – with theuse of TEDs now required by regulations this mortality has reduced considerably. • With increasing coastal development throughout the NPA, the current low level of kill of turtles from boat strike and port dredging activities can be expected to increase. • Indigenous harvest across northern Australia, Papua New Guinea, eastern Indonesia and other areas must be considered when assessing the sustainability of the harvest for a particular stock. • Gill net fisheries within the NPA kill an unquantified but possibly low number of turtles annually. • There is a large kill of green turtles annually throughout the Gulf of Carpentaria from entanglement in lost or discarded net (ghost nets). • Threat to key turtle habitat from increased turbidity and agricultural and industrial pollution outflow. • Vehicle traffic on beaches is now commonplace on the nesting habitat of beaches bordering the NPA and there can be an expected increased mortality of turtle eggs. • Unsustainable harvest of turtle eggs within the NPA – egg harvest is only sustainable at low levels. • Predation of turtle rookeries by native wildlife including varanids (goannas) as well as pigs and dogs may need to be managed to ensure an availability of eggs for human consumption.
Marine snakes	• Trawling appears to be the largest and most obvious threat to sea snakes in the NPA. • Being air-breathers, sea snakes are particularly susceptible to the negative impacts of oil spills. • As specialist feeders, any increase in turbidity that impacts on either their prey or their ability to detect their prey would impact negatively on sea snake populations. • Dredging or increased boat traffic has the potential to disrupt normal feeding activities. • Noise generated by increased boat traffic and associated machinery is a source of potential disruptive noise pollution capable of forcing sea snakes out of an area. • Boat strikes are a common cause of sea snake mortality in areas where sea snakes and small boats share the same waterways. • Aquaculture – habitat removal and nutrient influx.
Groupers	• The main potential impacts or threats relate to habitat degradation and overfishing. • Groupers are generally more abundant on coral reefs. Threats to coral reefs in the NPA include coral bleaching, nutrification, sedimentation, cyclones, disease and crown-of-thorns starfish outbreaks. • Virtually nothing is known about populations in the NPA. • Difficulty of surveillance of fishing activities and enforcement of fishing regulations due to remoteness of the NPA coupled with the high value of groupers. • Potential capture of immature groupers by trawling. • Potential for trawling in the NPA to reduce available food resources for grouper. • Potential for fishing to remove a significant proportion of immature fish from populations in the Northern Territory.

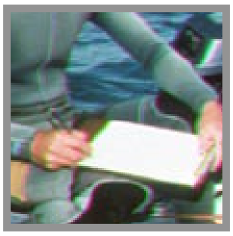


Species Group	IMPACTS / THREATS
Snappers and emperors	• The main potential impacts or threats within the NPA relate to habitat degradation and over-fishing. • Threats to these habitats in the NPA include pollution incidents such as fuel and oil spills, nutrification, physical damage from benthic trawling, maritime accidents or cyclones, and damage to coral reefs through coral bleaching, disease, sedimentation, and crown-of-thorns starfish outbreaks. • Snappers and emperors are likely to be vulnerable to over-fishing due to their life history characteristics and behaviour. • Illegal fishing. • Potential for trawling in the NPA to reduce available food resources for snappers and emperors. • Lack of minimum size limits for the possession of any snapper or emperor species in the Northern Territory.
Mackerels and tunas	• Vulnerable to fishing gear types (gill net and line fishing) – potential over-fishing • Lack of effective management and monitoring (eg longtail tuna).
Coastal fishes	• Potential environmental threats to coastal fishes and their habitats include habitat loss and modification from development, sedimentation and nutrification from agricultural runoff, restricted access to habitats due to construction of dams, weirs flood mitigation and saltwater intrusion works, and pollution from fuel and oil spills and other waste material. • Some species of coastal fishes may also be vulnerable to over-fishing in the NPA - particularly near major population centres, which may result in localised depletion of coastal fish populations. • Potential for species with a number of discrete stocks within the NPA to become locally over-fished unless the stock structure of these species is incorporated into regional fishery management measures. • A reduction in reproductive potential is a threat for coastal fish populations in the NPA as fishing may remove proportionally more females than males from a protandrous population, due to the selectivity of fishing gear towards larger individuals. • Potential for fishing to remove a significant proportion of immature coastal fishes in the Northern Territory due to lack of minimum size limits for many species. • Bycatch of immature fishes from trawling. • The main target species of the NPF (penaeid prawns) are important prey items for coastal fishes, and often form a large proportion of their diet – trophic implications from prawn harvest.
Molluscs	• Over-collection or over-fishing/harvesting. • Sustained disturbance of boulders in the intertidal zone by Indigenous gleaners – juveniles killed by desiccation if the coral slabs are overturned and not replaced carefully. • Destruction of habitats, either naturally by cyclones, or artificially by human reclamation or pollution. • Human ignorance and indifference. • Introduced marine pests and diseases, and interference of genetic integrity of natural populations through accidental crossing with strains selected for aquaculture. • Sporadic, mass mortality of giant clams affecting up to 54% of individuals has occurred in wild giant clam populations in northern Australia; these deaths were caused by an unidentified unicellular organism, apparently a ciliated protozoan.
Squid	• Harvesting of squid using demersal trawls represents a potential threat due to the susceptibility of squid (including egg masses) to capture and mortality, their biological capacity to recover and gaps in current knowledge of their biology and distribution. • Loliginid squid lay demersally attached eggs – location of spawning grounds inadequately known, preferred substrate for egg laying unknown, timing of peak spawning activity at a local level unknown, impacts of trawling on the substrate and survival of squid eggs unknown. • Spawning stock – recruitment relationships unknown. Recruitment strength of succeeding cohorts generally poorly predicted by spawning stock size. • Biomass available for harvesting unknown – no assessments undertaken. • Squid damaged in capture by trawl unlikely to survive discarding. Discard quantities currently unknown but need to be assessed to obtain a better picture of fishing mortality for any future quantitative resource assessment.

25. Summary of impacts and threats

Species Group	IMPACTS / THREATS
Prawns	• Any changes to fishery management practices in the NPF or Torres Strait (eg increased fishing effort) could have a catastrophic impact on prawn stocks. • Over-fishing – lack of stock information. • Threats to littoral seagrass habitats are a threat to the tiger prawn populations and the fishery. • Current and proposed resource development (including in river catchments) (mining, farming, ports), water resource development and commercial use of natural resources (fishing) may have an increased impact. • Natural impacts can also greatly reduce the area of productive nursery habitats, for example cyclonic destruction of littoral habitats. • Some commercial fishing logbooks do not provide enough discrimination to manage and assess individual species.
Crabs	• Lack of baseline data and knowledge on crab diversity and species needs. • Not clear whether the low proportion of S. olivacea in the overall catch represents relative rarity or whether it is indicative of pronounced habitat segregation between S. serrata and S. olivacea. • The modification, destruction or loss of habitats, which may be caused, for example, by trawling, or trampling by Indigenous and/or recreational fishers, may lead to a decline in crab biodiversity and numbers. • Prawn trawling practices could lead to direct mortality of most by-catch species concerned. • Localised over-harvesting of crab fauna in areas close to major population centres, camp sites and outstations. • Possible impacts may occur from contamination, chemical spills etc, on a local scale in and around mines, ports and population centres. Contaminants are likely to bioaccumulate along the food chain, including within crabs. Oil, oil dispersants and heavy metals are known to be toxic to crustaceans and modify their burrowing behaviour. • Potential introduction of aquatic pests. • Impacts on the substrate/habitat in on which crabs depend (eg propeller scarring). • Catastrophic events, such as cyclones. • Global climate change is expected to lead to raised sea level and sea water temperatures. Such changes may have long-term impacts on habitat distribution/composition and species distribution, particularly in coastal habitats, such as seagrass, mangroves, salt marshes/flats and coral reefs.
Lobsters	• Due to the prolonged larval dispersal phase for spiny lobsters and hence their widespread distribution, the threats to the populations within the NPA may in fact be remote from the NPA boundaries. • The prolonged larval phase for spiny lobsters also exposes them to changing environmental conditions in oceanic waters; principally ocean currents affected by local events such as cyclones, or large-scale events such as El Niño. • Changes to environmental conditions such as seagrass dieback. • Over-fishing – diver fishery.
Bugs	• Prawn trawling – byproduct, incidental mortality.
Holothurians	• Fishing/harvesting – especially higher value species. • Cyclones may cause damage to seagrass beds (nursery areas for juveniles). • Coastal processes – increased nutrient and sediment loads. • Greenhouse changes – changes in coral reef ecology.
Trawl bycatch species	• Lack of knowledge – some threats difficult to identify. • Over-fishing – lack of knowledge, management issues, market changes. • Habitat alteration by trawling and natural perturbations such as cyclones – increased turbidity.





26. Summary of key information gaps

The isolation of the Northern Planning Area (NPA) from major population centres makes research expensive due to the need for additional travel time and careful logistical planning. The relatively high cost of research and the extensive information needs across species groups in the NPA requires **research and management agencies to coordinate their efforts** and cooperate in survey design, operation and costs to maximise the benefits from research in the region. Recent work by CSIRO on the benthic characterisation of the area of the Northern Prawn Fishery to build a knowledge base for ecosystem sustainability is an example of research which both collects and requires extensive data. This sort of research can draw on information gathered by, and the expertise of, other agencies in building a knowledge base across the region. Such research can also provide valuable information to support research on other species groups in the NPA.

Our knowledge of key species groups within the NPA has primarily come from research and monitoring of commercial fishing operations. Fisheries such as the Northern Prawn Fishery and the Queensland Inshore Net Fishery have provided invaluable information not only on the target species and their habitats but also bycatch and other ecologically related species. Information collected through logbooks, fisheries observers and dedicated research to support ecologically sustainable fisheries (often fully or at least partly funded by the fishing industry) will continue to be prime resources for the collection of species information in the NPA. However, input from the contributors to this report has demonstrated that, for multi-species fisheries where many species groups are taken in small quantities or not at all, logbooks are inadequate and other fishery-independent research and monitoring methods are required.

Our reliance on the collection of information through research and monitoring of commercial fishing operations also presents challenges. Understandably, **research has tended to focus on areas where the fishery operates.** Large areas such as the Arafura Sea are relatively under-surveyed, with the greatest information base for the NPA derived from the Northern Prawn Fishery. In addition, many fisheries are undergoing a period of rationalisation to achieve a more sustainable basis. This is leading to a decline of commercial fishing licences and often in the overall areas of operation. This will lead to more reliance upon fishery independent research and monitoring for those areas where fishing no longer takes place.

Research and monitoring effort on inshore species and habitats has been concentrated in and adjacent to ports, such as Weipa, Karumba and Nhulumbuy. This focused research approach is partly due to ease of access but mainly due to the monitoring of impacts of port operations on adjacent environments. For many species, critical habitats for spawning and juvenile development are unknown. Many of these areas are likely to be inshore in estuarine/mangrove, seagrass or other areas which, although relatively undisturbed across the planning area to date from anthropogenic influences, require further basic survey information to assist in ensuring that activities in these areas are sustainable. For most species groups in the NPA, basic information is needed to create a baseline from which future impacts and trends in populations can be monitored.

Seagrass monitoring, Thursday Island, Torres Strait ***Source:*** *Marine Ecology Group, QDPIF*

Information on marine species stocks that are shared with Indonesia and PNG is particularly important for developing cross-jurisdictional management tools in the NPA. Australia is obligated to cooperate with adjacent countries to manage these species groups sustainably. For species such as turtles, where the harvest by other countries is having a significant impact on populations across northern Australia, these information needs (and effective management) become paramount.

The reliance on research and monitoring to support commercial fishing has also meant that **information collected to date has focused on high-value commercial species** (prawns, mud crab, Spanish mackerel). More information is required on iconic species such as turtle, dugong and barramundi, which have great importance to traditional and recreational fishers. For other species, such as corals, groupers and crab, there are generally insufficient data that describe basic distribution, stock structure, abundance and biology.

Measuring an ornate rock lobster ***Source:*** *Darren Dennis*

Indigenous take of species, such as sharks, rays, molluscs, turtles and dugong, needs to be better understood, particularly where this take is a significant part of the mortality of those species. The gathering and application of **Indigenous knowledge** has also been identified by authors as important for effective management of marine species in the region. For instance, Indigenous knowledge of environmental factors that are of importance to the sustainability of species (eg rainfall, river flows, sediment and nutrient transport, nutrients cycles, water circulation, productivity, cyclones), could be extremely important in ensuring their long-term sustainability. The mangrove chapter also highlights the importance and timeliness of recording Indigenous knowledge of mangrove communities and species.

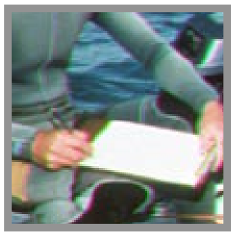
One of the outcomes of this project has been the **identification of important information that has not been widely available**, even to other researchers with expertise in the same species group. Recent initiatives, such as the soon to be introduced OZCAM (Australian Museum Collections On-Line), are now making information on marine species more accessible. Increased collaboration between agencies in broader ecosystem studies is also requiring cross-agency information and resource sharing. This report, by assisting in the identification and collation of available data and other information on each of the species groups, will assist in the sharing of knowledge of marine species in the NPA.

The chapters of this report highlight our need to **increase our understanding of the role each species plays in the ecosystem** and how well species can cope with anthropogenic impacts such as trawling and coastal development, particularly when combined with major natural events such as cyclones and climate change.

The NPA is noteworthy for its **cyclonic activity** which has been shown to induce major and rapid ecological changes to coastal areas and seagrass beds in particular. The importance of the development of models and management arrangements which cater for these catastrophic events has been identified across numerous chapters.

The report also highlights our **lack of knowledge of the extent of impacts and threats on key species groups** (see previous chapter for a summary of the impacts and threats). For instance, the turtle chapter highlights the need for more information on the impacts on turtle rookeries of predation by feral and native animals and on nesting beaches by vehicle traffic. This is similar to one of the information gaps expressed in the seabird and shorebird chapters which discuss the importance of **monitoring of threatening processes** on these species and their rookeries.

The following table (Table 26.1) provides an overview of the information gaps across each species group. It does not attempt to provide a formal analysis of the relative importance of the information gaps across all of the species groups, though some of the readily identifiable areas common across species groups have been mentioned in the text above. A formal analysis



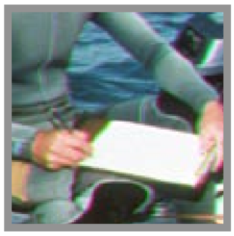
should be undertaken, including an assessment against the key impacts on and threats to key species groups in the NPA. However, this is beyond the scope of this report and will need to be assessed against the objectives developed during the regional marine planning process and other resource management processes (eg Natural Heritage Trust Natural Resource Management Plans).

The table has been divided, where possible, into inshore (less than 15 m depth) and offshore (greater than 15 m depth) to differentiate between shallow water/coastal information needs and research to address them, and the deeper water information needs (which tend to be filled by larger-scale surveys).

Table 26.1: *Summary of Inshore (<15 m depth) and offshore (>15 m depth) information requirements*

Species Group	Inshore waters (<15m)	Offshore waters (>15m)
Seagrasses	• Extension of surveys to areas other than ports. • There are little or no data from the area Nhulunbuy to Goulburn Islands. • A lot of data are old and broad scale. • Nutritional, ecological network analysis and short and long-term change studies required.	• Complete lack of information on distribution.
Mangroves	• Lack of recorded information relating to traditional Aboriginal knowledge of mangrove communities and species. • Distributional data required for mangrove plant species for the southern Gulf of Carpentaria area. • Information relating to the effects of climate change on mangroves is needed. • Cross jurisdictional definition of a mangrove, and what species to include in a joint mangrove species list should be established.	N/A
Corals	• Almost total information gap except for the Torres Strait, parts of the Gulf and results from the recent (Dec 2003) cruise off Arnhem Land.	• Almost total information gap apart from recent Geoscience Australia cruise in southern Gulf
Seabirds	• Surveys are required along Queensland coast of Gulf – which seabirds are present, monitoring of populations and threats.	• Survey work required of offshore seabird activities
Shorebirds	• Surveys are required along Queensland coast of Gulf – which shorebirds are present, monitoring of populations and threats.	N/A
Sharks	• Basic biological information needed, plus habitat preferences, distribution, migration patterns and other ecological requirements. • Knowledge of Traditional Inhabitant usage and fishing activities needs to be increased.	• Basic biological information needed, plus habitat preferences, distribution, migration patterns and other ecological requirements.
Rays	• Lack of specimens – poor taxonomy and basic biology. • Knowledge of habitat requirements is needed.	
Sawfish	• Data gaps in species distribution and range, specific habitat requirements, biology and general life history. • Lack of information in Northern Territory coastal area. • Monitoring of sawfish catches from Indigenous and recreational line and net fishing is needed.	• Data gaps in species distribution and range, specific habitat requirements, biology and general life history.
Cetaceans	• Insufficient information available about all species to enable an assessment of conservation status to be made with confidence – in most cases the extent of population structure within species is not well understood. • Data on fishing effort and incidental mortality should be collected for all fisheries. • Information about the distribution of cetacean species in the Northern Planning Area is lacking.	
Dugong	Information needed: • Accurate and up-to-date data on dugong distribution and abundance. • Accurate data on anthropogenic mortality from all causes. • Information about the customary laws limiting dugong harvest. • Maps of seagrass, biomass and community structure. • The extent and range of dugong movements and habitat use within the NPA.	• Dugong use of potential 'deep-water' seagrass areas of the Northern Territory coast

<table>
<tr><th>Species Group</th><th>Inshore waters (<15m)</th><th>Offshore waters (>15m)</th></tr>
<tr><td>Turtles</td><td>• There is a dearth of data on distribution, size and demographic characteristics (species, sex, maturity, genetic stock composition) of turtle harvest within the NPA.
• Spatially quantified egg loss for each turtle species and stock from egg harvest, feral predation and excessive native animal predation.
• Impact of nesting beach vehicle traffic on egg mortality needs to be studied.
• Information is required on the collective impact of inshore gill net fisheries on marine turtle populations.
• There is an incomplete knowledge of the distribution and size of turtle rookeries across northern Arnhem Land.
• There are no long-term census studies for any marine turtle population in the NPA.
• There are no studies to quantify critical demographic parameters (eg population size at a key life history stage, years between breeding seasons) for any marine turtle species/stock in NPA.
• Need to develop a strategy to break the current barriers to effective collaboration in conservation management of stocks of marine turtles across their range.</td><td>• There are no long-term census studies for any marine turtle population in the NPA.</td></tr>
<tr><td>Sea snakes</td><td colspan="2">• Little is known of ecology and life history.
• Areas outside the trawled areas, apart from a couple of local studies (eg Weipa) have not been surveyed at all.
• Basic lack of information on habitats in the NPA is an issue for stock delimitation.
• Need for a regionally specific management plan for the sea snakes.</td></tr>
<tr><td>Groupers</td><td>• Large information gaps relating to species populations and stock structure, distribution, basic biology and ecology, environmental and habitat associations, recruitment patterns, early life history, productivity of populations and take of cods and groupers in fisheries (commercial, recreational, Indigenous).</td><td>• Large information gaps relating to species populations and stock structure, distribution, basic biology and ecology, environmental and habitat associations, recruitment patterns, early life history, productivity of populations and take of cods and groupers in fisheries (commercial).</td></tr>
<tr><td>Snappers and emperors</td><td colspan="2">• Large information gaps for both snappers and emperors relating to species populations and stock structure, distribution, basic biology and ecology, environmental and habitat associations, recruitment patterns, early life history, productivity of populations and further identification of snappers and emperors taken in fisheries (commercial, recreational, Indigenous).</td></tr>
<tr><td>Mackerels and tunas</td><td colspan="2">• Stock structure for lesser mackerels largely unknown.
• Important habitats/areas for spawning and juvenile development unknown.
• Collation, mapping and preliminary modeling of lesser mackerels from existing fisheries information is required.</td></tr>
<tr><td>Coastal fishes</td><td>• More detailed biological information is needed for all coastal fishes other than barramundi throughout the NPA – ie age, growth, reproduction, larval and juvenile biology, spawning behaviour, habitat associations, and movement patterns from locations throughout the NPA.
• More catch and effort data for coastal fishes from all fishing sectors in the NPA.
• Additional genetic research is needed to better define the stock boundaries of coastal fishes in the NPA.
• Implications of the stock structure of coastal fishes in the NPA for the management of coastal fisheries needs to be determined.
• Stock assessments for coastal fish species other than barramundi.</td><td>• N/A</td></tr>
<tr><td>Molluscs</td><td>• Virtually nothing known about molluscs apart from trochus, pearl oysters and giant clams, including population densities levels of exploitation and aspects of their life cycles.
• Status of gastropods which develop young inside their egg capsules needs to be surveyed.
• Number of giant clams in the planning area is not known.
• No knowledge of the natural molluscan diversity at any of the secondary ports in the planning area or their status with respect to marine pests.
• Activities of shell collectors in the planning area need to be quantified.</td><td>• Virtually nothing known about molluscs apart from trochus, pearl oysters and giant clams, including population densities levels of exploitation and aspects of their life cycles.
• Status of gastropods which develop young inside their egg capsules needs to be surveyed.
• Number of giant clams in the planning area is not known.</td></tr>
</table>



26. Summary of key information gaps

Species Group	Inshore waters (<15m)	Offshore waters (>15m)
Squid	• Description of unnamed and undescribed species in region is required. • Distribution, life history and abundance need to be established. • As a priority, research should be undertaken to confirm location of spawning grounds. • Information is needed on population (stock) discrimination, including possible sharing of stocks of the commercially important species with Indonesia and PNG. • The level of movement and migration in northern Australian squid species remains unknown. • Data are required on population age structure. • Definition of major spawning periods. • Estimation of available biomass. • Squid-specific, 'environmentally friendly' gear (eg jigs and lift nets) to the harvesting of northern Australian squid resources needs to be developed and introduced.	
Prawns	Data needed: • Distribution, movement and catches of tiger prawn in PNG waters of the Torres Strait. • Effects of large-scale environment and catchment processes on the productivity of tiger prawn fisheries on a local geographic scale (catchment and adjacent fishing grounds). • Spatial distribution, size structure, reproductive biology, larval advection and effective spawning populations of red-legged banana prawns. • Individual behaviour and effect of habitat on behaviour of both juvenile and adult red-legged banana prawns. • The distribution and abundance and habitat requirements of both the juveniles (and the behaviour of juveniles) and adults of western and red spot king prawns.	Data needed: • Distribution, movement and catches of tiger prawn in PNG waters of the Torres Strait. • Effects of large-scale environment and catchment processes on the productivity of tiger prawn fisheries on a local geographic scale (catchment and adjacent fishing grounds). • Exploitation of blue and red endeavour prawns and western and red spot king prawns in the Gulf. • Exploitation of blue endeavour prawns in the Torres Strait. • Individual behaviour and effect of habitat on behaviour of adult red-legged banana prawns. • The distribution and abundance and habitat requirements of adult western and red spot king prawns.
Crabs	Data needed: • Basic distribution and abundance patterns, behaviour of species and linkages between species. • Juvenile mud crab distribution and use of available habitat.	Data needed: • Basic distribution and abundance patterns, behaviour of species and linkages between species.
Lobsters	• Post puerilus and juvenile habitat for non-*P.ornatus* species in western Torres Strait needs to be studied. • Information is required on seasonal and inter-annual variation in *P.ornatus* settlement timing in the Torres Strait. • Little information on distribution and abundance of spiny lobsters through most of the planning area.	• Relative importance to overall recruitment of P.ornatus breeding ground/population off Murray Island needs to be established. • Post puerilus and juvenile habitat for non-P.ornatus species in western Torres Strait needs to be studied. • Information is required on seasonal and inter-annual variation in P.ornatus settlement timing in the Torres Strait. • Little information on distribution and abundance of spiny lobsters through most of the planning area.
Bugs	• Distribution of bugs outside trawl fishing grounds needs to be known to assess the status of the bug stocks. • Genetic studies are required to help identify northern stocks.	• Distribution of bugs outside trawl fishing grounds needs to be known to assess the status of the bug stocks. • Genetic studies are required to help identify northern stocks. • Clarification of how fishing effort should be quantified is needed with respect to bug catch per unit effort. • Need to confirm the affects of TEDs on bug catches, particularly with respect to possible decrease in catch of the largest bugs. • Need to identify the survival rates of discarded (small and non-commercial) bugs from prawn trawls.

Species Group	Inshore waters (<15m)	Offshore waters (>15m)
Holothurians	• Population modeling is required for an understanding of population responses to fishing and management actions. • Targeted research required for information on growth, mortality, size at first maturity and breeding seasonality. • More study on sandfish (*H.scabra*) burrowing rates and its variability with habitat, tide, time of day and size.	• Holothurian populations of the offshore regions are not well known.
Trawl bycatch species	• Detailed mapping of species distributions is required. • Little known of bycatch composition inshore. • Little quantitative data exists for the vast majority of species. • Need to increase our understanding of the role each species plays in the ecosystem. • Further taxonomic work required to differentiate between *Saurida undosquamis* and *Saurida* sp. 2.	• Detailed mapping of species distributions is required. • Little known of bycatch composition offshore outside fishing grounds, particularly west of the Wessel Islands. • Need to increase our understanding of the role each species plays in the ecosystem. • Further taxonomic work required to differentiate between *Saurida undosquamis* and *Saurida* sp. 2. • Biological and ecological studies should be undertaken for bycatch species known to be data-deficient, particularly those sessile or slow-moving benthic species and fragile invertebrate species that are currently considered least likely sustain trawl impacts.