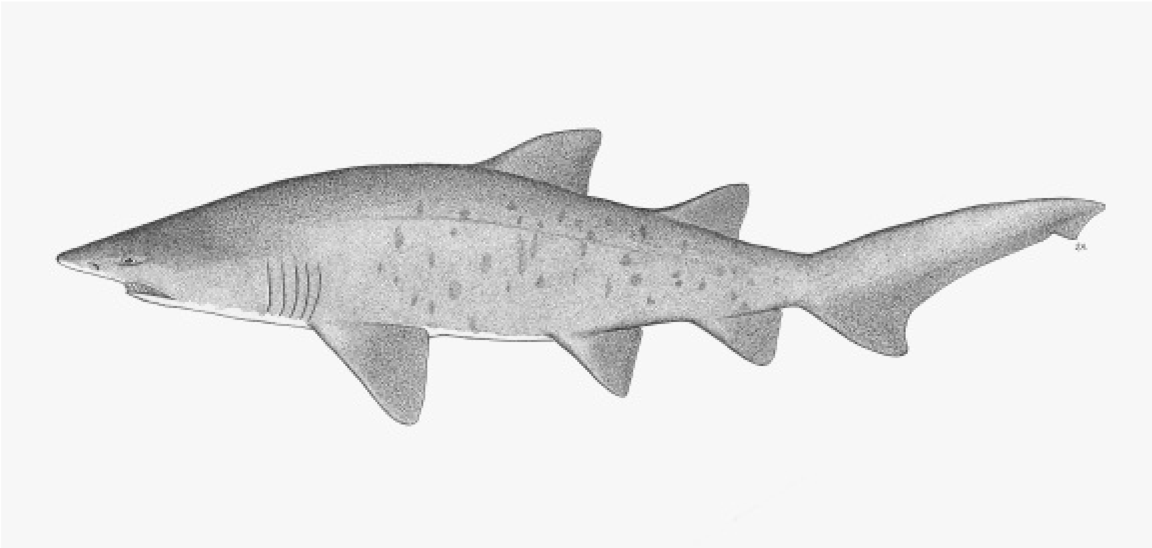

Drawing of Grey Nurse Shark *(Carcharias taurus)* by Jack Hannan, NSW Fisheries

CONSERVATION OVERVIEW and ACTION PLAN for AUSTRALIAN THREATENED and POTENTIALLY THREATENED MARINE and ESTUARINE FISHES

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Addendum: This publication refers to the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (the Wildlife Protection Act). However, since drafting, this legislation has been repealed and its provisions have been incorporated into the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). All references to the Wildlife Protection Act should therefore be read as a reference to the EPBC Act.

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Executive Summary

This Conservation Overview and Action Plan has been prepared for the Natural Heritage Division of Environment Australia by scientists from the NSW Fisheries Research Institute and the Australian Museum. It reviews the biological characteristics and conservation status of 114 species of threatened and potentially threatened Australian marine and estuarine fishes, and outlines some of the constraints encountered in carrying out the task. Work on the project commenced in January 1999. The majority of the work was completed by September 2000, but editing continued until September 2001. A specialist workshop, held in September 1999, brought together approximately 40 experts from government and non-government organisations, private industry and academic institutions in Australia, New Zealand and the USA. The main aims of the workshop were to discuss the proposed Australian conservation status of as many of the identified species as possible, and to attempt to reach consensus on a conservation status for each species. Information from the workshop discussions has been incorporated into the species synopses where appropriate. Comments and advice were also sought from a wide range of individuals and organisations with expertise in fishes throughout the duration of the project.

The Overview and Action Plan analysed in considerable detail 114 species of the approximately 4,100 marine and estuarine fish species known to occur in Australian waters. Of these, we have listed:

- 0 taxa as Extinct (EX)
- 3 taxa as Critically Endangered (CR)
- 6 taxa as Endangered (EN)
- 8 taxa as Vulnerable (VU)
- 16 taxa as Lower Risk, conservation dependent (LR cd)*
- 14 taxa as Lower Risk, near threatened (LR nt)
- 53 taxa as Data Deficient (DD) **
- 15 taxa as Lower Risk, least concern (LR lc)

The conservation status for one commercial species (i.e. eastern gemfish) remains contentious and a final decision on it has been postponed until the Australian Fisheries Management Authority (AFMA) makes its decisions on future management of the species. Species synopses are included for all species listed above as CR, EN, VU, LR (cd), LR (nt), DD and LR (lc) in Australian waters. We looked very briefly at an additional 19 taxa of sharks and rays which will be included by the IUCN Species Survival Commission's Shark Specialist Group (SSC SSG) in its forthcoming publication on the status of chondrichthyan fishes (Fowler *et al*., in prep.). All of these (19 taxa) were provisionally assigned to the Lower Risk (least concern) category in Australian waters, but no species conservation synopses have been included here. Although a number of these sharks and rays have been flagged as having conservation problems in other parts of the world (e.g. North American or European waters), most are widely distributed species and not heavily fished or otherwise significantly threatened in Australian waters. However, in any future assessments of the conservation status of Australian fishes, a more detailed examination of these species may be warranted due to their life-history characteristics and/or their potential susceptibility to capture by fishing operations.

The Overview and Action Plan highlights the main conservation concerns for some of the marine and estuarine fish species in Australia. The main causes include declines in marine and estuarine fishes by overfishing (of both target and non-target or bycatch species), habitat degradation (from urban development and related activities, trawling, dredging, water pollution, etc.), and, to a much lesser extent, exotic species introductions.

This Overview and Action Plan, through both the individual species conservation synopses presented in it and the synthesis of these findings, thus attempts to address the main problems affecting some of the more threatened and potentially threatened species of marine and estuarine fishes in Australian waters. It is the first attempt at broadly assessing the conservation status of the roughly 4100 marine and estuarine fish species that are known to occur in Australian waters, and will hopefully provide the impetus for more research into threatened Australian marine and estuarine fishes in the future.

* One species, the eastern gemfish *Rexea solandri*, has been provisionally listed in this category, but may be listed as Vulnerable in the future depending on future management decisions made by AFMA.
** The western stock of gemfish *Rexea solandri* that is listed as Data Deficient is included here

Acknowledgments

The authors wish to thank Environment Australia for funding the preparation of this Conservation Overview and Action Plan through its Natural Heritage Division Consultancy No. 00016388.

This report could not have been prepared without the assistance of many members of the Australian fish and fisheries research and management communities, who generously contributed their specialist knowledge and time in commenting on various parts of the draft manuscript. The authors are extremely grateful to all of those who helped, and especially to those who responded to our many requests for additional information.

The following organisations (including museums, research institutes, universities, government agencies, non-government organisations, etc. and listed alphabetically) have provided information over the course of this project. A complete list of individuals who provided comments and/or attended the Specialist Workshop in Bendigo in September 1999 is included in Appendix 1.

Australian Fisheries Management Authority, Canberra, ACT
Australian Museum, Sydney, NSW
Bureau of Rural Sciences, Canberra, ACT
Centre for Marine Conservation, Washington DC, USA
CSIRO Marine Laboratories, Hobart, Tas and Cleveland, Qld
Environment Australia, Canberra, ACT
Great Barrier Reef Marine Park Authority, Townsville, Qld
Griffith University, Gold Coast Campus, Qld
Inland Fisheries Commission, Hobart, Tas
James Cook University, Townsville, Qld
Marine and Coastal Community Network, Sydney, NSW and Melbourne, Vic
Museum of New Zealand, Wellington, NZ
Museum of Victoria, Melbourne, Vic
Nature Conservation Bureau, Newbury, Berkshire, UK
Museum and Art Gallery of the Northern Territory, Darwin, NT
NSW Fisheries Research Institute, Cronulla and Port Stephens, NSW
Queen Victoria Museum, Launceston, Tas
Queensland Department of Primary Industries, Brisbane, Qld
Queensland Museum, Brisbane, Qld
Queensland Parks and Wildlife Service, Cleveland, Qld
South Australian Museum, Adelaide, SA
University of Sydney, Sydney, NSW
University of Tasmania, Hobart, Tas
Western Australian Museum, Perth, WA
Western Australian Fisheries Research Division, Marine Research Laboratories, Perth, WA
Virginia Institute of Marine Science, Gloucester Point, Virginia, USA
Victorian National Parks Association, East Melbourne, Vic
Zoonetics, Seaford, Victoria

1 Introduction

1.1 Overview of the Australian Marine and Estuarine Fish Fauna

In round figures, Australia has a total of 4400 fish species (4200 described, 200 undescribed), made up of around 200 freshwater and 4200 marine and estuarine species (Hoese *et al*., in press). Our marine fishes are composed of inshore, including estuarine and shelf species, and offshore, including open ocean and deep-sea species. There is some overlap in the categories, but they are useful generalisations nonetheless. It is also useful to divide the inshore fishes into tropical northern fishes, many of which are associated with coral reefs, and temperate southern fishes.

The majority (about 80%) of our temperate southern inshore fishes are endemic to Australian waters (Wilson and Allen, 1987; Jones, 2000), with a significant component also being found in New Zealand. By contrast, the majority of our inshore northern fishes are widespread throughout the tropical Indo-West Pacific, and few species (about 10%) are restricted to Australian waters (Wilson and Allen, 1987; Jones, 2000). Similarly, most of our offshore open ocean species are widely distributed, and few of our deep-sea mesopelagic and bathypelagic species are endemic to Australia. More, but still a minority, of our deep-sea benthic fishes are known only from Australia, but as deep-sea fish collecting increases in other areas of the Indo-Pacific, this proportion will decrease. The second volume on Fishes of the Zoological Catalogue of Australia (Hoese *et al*., in press) will be submitted for publication in 2001, and precise numbers for each of the species groups mentioned above will then be available.

From a conservation viewpoint, our temperate endemic fishes might be considered more important as they are found nowhere else. However, Australia has the world's largest area of coral reefs (Jones, 2000) and coral reef fishes in many parts of the Indo-Pacific are under increasing threat from overfishing and habitat degradation. In such a scenario, the protection of tropical Australian marine fishes assumes increased importance, and cannot be dismissed because these species are often more widespread. Some (e.g. Vincent, 1996) have suggested that northern Australia has a role to play as an important tropical 'sanctuary' in the Asia-Pacific region.

1.2 Conservation of Australian Fishes

The history of fish conservation is relatively short when compared to the conservation of terrestrial vertebrates, in both Australia and the rest of the world. One of the first Australians to express concern about fish conservation was John Lake of NSW Fisheries, who included a chapter on the Future of Australian Freshwater Fishes that grouped different levels of threatened fishes in his book *Freshwater Fishes and Rivers of Australia* (Lake, 1971).

The Australian Society for Fish Biology (ASFB) was founded in 1971 and held its first annual conference in 1974. Concern about the translocation of Australian fishes at the Society's 1977 conference resulted in a resolution from ASFB aimed at all fisheries agencies in the country. At the 1982 conference a presentation on and extended discussion of Australian endangered fish species was led by Fred Reynolds of NSW Fisheries.

In March 1985, the then Australian National Parks and Wildlife Service published a report entitled *Threatened Fish in Inland Waters of Australia* which was commissioned by the Advisory Committee on Live Fish (ACOLF) of the then Standing Committee on Fisheries (Michaelis, 1985), using the categories of Miller (1977). The provisional listing included 24 endemic species: 5 Endangered, 2 Vulnerable, 7 Rare, 1 Out of Danger and 9 Insufficiently Known, not inconsistent with later ASFB listings. The report considered the concentrations of these species in certain drainage divisions, threats to individual species, and the lack of Federal or State legislation to adequately protect native fishes.

This report was followed by a more detailed comparison of the conservation status of freshwater fishes (with a revised list being published) with that of aquatic mammals, reptiles and amphibians as well as aquatic invertebrates. The impact of introduced species was discussed and a section included on the legislative and administrative controls to protect aquatic fauna, both nationally and internationally. This report concluded that while the habitat approach to conserving fishes was more difficult than listing and considering the individual species, it was equally necessary (Michaelis, 1986).

A two-day Conference-Workshop devoted to discussion of the conservation problems of Australian threatened fishes was held by the ASFB in Melbourne in 1985. At this workshop a set of conservation status categories and criteria was developed and agreed upon, which resulted in the first comprehensive ASFB threatened fish listings, in which 15 species of threatened Australian fishes and 44 other species of lower risk were identified (Harris, 1987). Following recommendations in that publication, a Threatened Species Committee of ASFB was established at the 1987 conference, which was charged with adding species to, deleting species from, or moving species between the different conservation categories in the List of Threatened Australian Fishes at each subsequent annual conference of the Society. Presently there is a form provided for the nomination of species for listing (Appendix 2), and each nomination is discussed and decided upon at one of the above Committee's meetings. A current listing is published each year in the *ASFB Newsletter*. The 1999 ASFB list included 37 species of threatened fishes and 52 species in lower risk categories (Crook, 1999). Since the early 1980s, these ASFB lists have been sent to both Environment Australia and the IUCN each year for their information and consideration.

Further involvement with fish conservation issues by the has ASFB included:

- resending the Society's 1977 resolution on fish translocation to all Australian fisheries agencies in 1988;
- a 1989 Conference-Workshop on introduced and translocated fishes and their ecological effects (Pollard, 1990a);
- a session devoted to papers on threatened fishes at the 1995 annual conference; and
- a 1996 Conference-Workshop to consider the IUCN conservation categories and criteria.

Currently, the ASFB lists threatened species under both ASFB and IUCN categories, but may adopt the new (2000) revised IUCN categories when they have been finalised (Jackson, 1998).

Worldwide, one of the most important conservation organisations is the IUCN (International Union for the Conservation of Nature), which was created in 1948 and began production of its Red Data Books of threatened species in the 1960s. Today this organisation, more recently renamed the IUCN World Conservation Union, is based in Switzerland and brings together both government and non-government agencies as well as some 10,000 experts. It has six commissions, the largest of which is the Species Survival Commission, with more than 100 specialist groups including the Shark Specialist Group, the Grouper and Wrasse Specialist Group and the Freshwater Fish Specialist Group (http://www.iucn.org/).

The IUCN Red Lists of Threatened Animals (and Plants) are the most important publications on a worldwide basis for species conservation. The Red Lists compile information from national Red Data Books and other lists proposed by various national and/or international groups. Recently, the 2000 IUCN Red List of Threatened Species was published and this is now available on the Internet (http://www.redlist.org/). Prior editions were published in 1996, 1994 and 1990. The Shark Specialist Group has been particularly active, and both an overview and action plan for threatened cartilaginous fishes is currently in the final stages of preparation (Fowler *et al.*, in prep.).

Another organisation active in the area of fish conservation is the American Fisheries Society (AFS). Recently, this Society has been particularly concerned about threatened commercial fishes. The AFS is mentioned here because it, like the IUCN and ASFB, has its own set of conservation categories and criteria that are discussed in Section 3.1.

Up until the last few years, fish conservation has been concerned primarily with freshwater species, both in Australia and overseas. Reasons include that freshwaters are usually of smaller volume and hence more susceptible to degradation than marine habitats, and that many freshwater species have smaller distributions than marine species. The original 1987 ASFB list of threatened species included only one diadromous species and the 1994 IUCN Red List included only three Australian marine species (all sharks), as opposed to about 70 Australian freshwater species. As a result, the first (1993) Action Plan for Australian Threatened Fishes covered only freshwater species (Wager and Jackson, 1993).

Although several marine species were added to the ASFB listings in the late 1980s (e.g. grey nurse shark and black rockcod; see Pollard *et al*., 1990), marine fishes were only first considered seriously at the ASFB's 1995 Conference. It is thus only in the last half decade that declines in marine fishes have prompted serious conservation concerns. The 1999 ASFB list included eight threatened marine and diadromous species (Crook, 1999; and see Harris, 1987 and Pollard *et al*., 1990 for categories). The present publication is the first Australian attempt to redress this balance.

It is important to note that there is currently much activity concerned with the conservation of threatened marine fish species, both in Australia and overseas, and it is difficult to provide up to date summaries. The national list of threatened fishes maintained by Environment Australia increased from 11 endangered (1 marine, 10 freshwater) and 12 vulnerable species (4 marine/diadromous, 8 freshwater) in May 1999, to 13 endangered (1 marine, 12 freshwater) and 17 vulnerable species (6 marine/diadromous, 11 freshwater) in May 2000 (http://www.biodiversity.environment.gov.au/).

1.3 Background and Introduction to the Study

The Commonwealth Government's *Endangered Species Protection Act* was passed in 1992, and the Australian Nature Conservation Agency (now part of Environment Australia) adopted the ASFB's listings as its starting point for classifying the conservation status of Australian fishes. During the first half of the 1990s the Commonwealth's Endangered Species Scientific Subcommittee (ESSS; now the Threatened Species Scientific Committee under the *EPBC Act 1999*) began to consider nominations for various marine fishes. Species initially discussed included some of considerable commercial importance (e.g. southern bluefin tuna, gemfish, school shark), those threatened as a bycatch of commercial fishing (e.g grey nurse shark, great white shark), and more recently several species of freshwater and brackish elasmobranchs (e.g. sawfish, stingray and river shark species). The spotted handfish was given 'emergency' consideration during this time, and was listed as Endangered without the usual lengthy and formal evaluation process being followed.

Action Plans for various broad taxonomic groups are usually commissioned from relevant experts by Environment Australia's Natural Heritage Division as a requirement of the legislation, and in order to obtain a broad overview of these taxon groups' conservation status and an assessment of their conservation needs. Individual submissions from the public and other government agencies and non-government organisations are also considered and referred by the Threatened Species Scientific Committee to outside experts for specialist comment. Based on the ASFB's contributions originating from its 1985 Workshop, one of the first Action Plans to be commissioned was that on Threatened Australian Freshwater Fishes. Rob Wager and Peter Jackson wrote this Action Plan with the endorsement of the ASFB's Threatened Fishes Committee and the technical advice of many of its specialist members (Wager and Jackson, 1993).

However, for a number of broad taxonomic groups where the information on individual species was scant or inadequate, more wide-ranging conservation overviews were also commissioned – especially where it was considered that a full-scale Action Plan may be premature (e.g. for terrestrial invertebrates; Yen and Butcher, 1997).

Some of the other higher taxon Action Plans that have since been published are those for Reptiles, Frogs, Birds, Rodents, Cetaceans, Marsupials and Monotremes, and more recently Seals and Bats.

On the advice that a specific and detailed Action Plan for Australian Marine Fishes, along the lines of that already prepared for Australian Freshwater Fishes, was at this stage premature, due mainly to the lack of detailed information on many of the species potentially involved, Environment Australia contracted Dr David Pollard of NSW Fisheries and Dr John Paxton of the Australian Museum to prepare a 'hybrid' Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes. John Pogonoski was appointed as Research Assistant to aid in performing this task, which commenced in January 1999.

1.4 Aims of the Conservation Overview and Action Plan

The main aims of this Conservation Overview and Action Plan are to:

- Provide a national overview of the conservation status of Australian threatened and potentially threatened marine and estuarine fishes, including the assessment of selected taxa using IUCN Conservation Status Categories, the identification of threats to these taxa, and the recommendation of conservation actions to undertake.

- Identify habitats or areas of particular importance for marine and estuarine fishes, including key areas or critical habitats for critically endangered, endangered and vulnerable taxa.

- Identify processes threatening marine and estuarine fishes, and in particular those taxa in the critically endangered, endangered and vulnerable categories, and identify areas where these processes are a problem.

- Recommend conservation priorities, including areas for future research and management actions, with particular emphasis on critically endangered, endangered and vulnerable taxa.

- Initiate nominations for threatened species status for the more threatened, but so far unlisted, species amongst those investigated, at both the State and Commonwealth levels.

2 Methodology

2.1 General Methodology

This study is a synthesis of the information available from literature reviews and other existing sources, including the personal contributions of the authors and numerous other specialist ichthyologists and fisheries biologists (see Appendix 1). The initial task was to prepare detailed species conservation synopses for and to allocate IUCN conservation status categories to the 114 species of Australian marine and estuarine fishes identified as being of some conservation concern. This information was then sent to a wide variety of Australian fish scientists (see Appendix 1) for their technical advice and comments, prior to holding a specialist workshop on this topic (see Section 2.5). Following this workshop, additional advice was again sought from many of these specialists.

2.2 Selection of Taxa for Inclusion in the Conservation Overview and Action Plan

Needless to say, detailed analysis of the conservation status of all of the approximately 4100 marine and estuarine fishes that occur in Australian waters would take a considerable amount of time, and was thus far beyond the scope of this report. The bases for the inclusion of fishes in this report are therefore outlined below, and include:

- Those marine and estuarine (including brackish-water) fishes which occur within Australian marine jurisdiction, but not including freshwater teleosts, or ‘bony’ fishes, that were included in the 1993 Action Plan for Australian Freshwater Fishes by Wager and Jackson.

- Those Australian marine and estuarine fishes listed in the IUCN’s 1996 Red List of Threatened Animals. Note that the 2000 IUCN Red List of Threatened Species was only published in the final stages of this project. Time constraints thus limited the analysis of any new additions to this 2000 IUCN Red List.

- Those marine and estuarine fishes listed in the Australian Commonwealth Government’s Lists of Nationally Threatened Species.

- Those marine and estuarine fishes listed in the Australian Society for Fish Biology’s Threatened Species List.

- Those marine and estuarine fishes on the various Australian States’ and Territories’ Protected Species Lists.

- Most Australian marine and estuarine fishes included in the IUCN Species Survival Commission’s Shark Specialist Group Status Report for Chondrichthyan Fishes (in preparation).

- Those Australian marine and estuarine fishes nominated to the authors as being threatened or potentially threatened by various Australian ichthyologists.

- Selected Australian marine and estuarine commercial fish species which are known to have declined significantly in the last few decades.

- Selected taxonomic groups of fishes that have been identified previously as having conservation problems. These include the handfish family Brachionichthyidae; the seahorse, pipefish, pipehorse and seadragon family Syngnathidae; and the mainly larger groupers and wrasses of the families Serranidae and Labridae, respectively.

2.3 Use of Museum Records in the Analysis of Distributions of Fishes Included

For the species included in this Conservation Overview and Action Plan, records were requested from museums and research institutions in all states and territories of Australia that hold collections of fishes. These records are most often of species identified by the relevant experts in Australia and overseas and provide an outline of the occurrence in collections of Australian fishes collected since about 1870. However, the numbers of specimens listed in fish collections are not always indicative of their relative abundances. Large specimens such as sharks, rays and some larger bony fishes would often potentially occupy too much valuable space in collections, and are thus not always kept when caught. Also, the varying distributions of fishes and habitat diversity in Australian waters can make collecting some fishes difficult, time-consuming and expensive due to the isolation of the area or the difficulties of sampling particular habitats. A number of areas, particularly in the northern half of the continent, but also the south-west, have not been adequately sampled. The coverage of some species in collections may thus be patchy and not accurately reflect their true distributions and/or abundances.

As accurate as most of the identifications of specimens in these collections have been, inevitably the changing state of taxonomy will mean that some specimens are synonymised or have been mis-identified. Some specimens may only be represented in collections by some body parts, e.g. jaws, skin or teeth, which can make accurate identifications difficult once the remainder of the animal has been discarded. Furthermore, specimens are sometimes destroyed or exchanged, leaving just a record in a database for which the identification cannot be checked against the specimen. Also, accurate size and depth ranges are often incomplete due to the fact that not all specimens have been measured and capture depths have not always been recorded. Many institutions have a backlog of specimens to register, which means that some specimens may exist in collections, yet the data may not have been included here as it was not databased (i.e. retrievable) at the time of our data request. We have taken time to overcome many of these problems especially those surrounding suspect identifications, but we cannot discount that some records may be inaccurate.

These museum and research institute records are herein referred to collectively as “Museum Records” in the Species Conservation Synopses. The following museums and research institutions kindly provided collection data that appear in these synopses:

Australian Museum, Sydney, New South Wales
ISR Munro Fish Collection, CSIRO Marine Laboratories, Hobart, Tasmania
Museum of Victoria, Melbourne, Victoria
Museum and Art Gallery of the Northern Territory, Darwin, Northern Territory
Queensland Museum, Brisbane, Queensland
Queen Victoria Museum, Launceston, Tasmania
South Australian Museum, Adelaide, South Australia
Western Australian Museum, Perth, Western Australia
Western Australian Fisheries Marine Research Laboratories, Perth, Western Australia

2.4 Taxonomy Adopted in the Conservation Overview and Action Plan

The taxonomic decisions used in this report follow current systematic practice. Species are listed in phylogenetic order, and follow Nelson (1994) in the arrangement of families within this phylogenetic order. Where possible, the most recent taxonomic works were used. For example, the taxonomy of sharks and rays largely follows Last and Stevens (1994) and the taxonomy of rockcods and groupers largely follows Heemstra and Randall (1993). Often, there are taxonomic studies in progress that are not yet available as published scientific papers. In these cases we have endeavoured to discuss the relevant works with the authors and have included their personal communications in the text and cited the references accordingly. For example, Rudie Kuiter has recently completed a revision of the Australian seahorses (*Hippocampus* spp.), and in many cases we have cited his personal communications in much of the text on this group. We have not attempted to include an exhaustive list of all synonyms for species listed in the text. However, we have included Australian synonyms (i.e. species named by Australian taxonomists), and other scientific names by which individual species are commonly referred to are also occasionally included. The taxonomy of Australian marine and estuarine fishes is dynamic and constantly changing. Although we have tried to use the most up to date information possible, there may be changes in the near future which will override some of the taxonomic decisions we have followed in this publication. Correct alpha taxonomy of Australian fishes is critical in identifying their conservation priorities. In this regard, the current shortage of positions for Australian workers in fish taxonomy and systematics needs to be reversed to allow more detailed study of our Australian fishes by scientists in this country.

2.5 Threatened Marine and Estuarine Fishes Specialist Workshop

A specialist workshop to discuss the conservation status of the 100 or so species that had been analysed by that time was held at Bendigo in September 1999 in conjunction with the ASFB's Annual Conference. Some 40 specialists from government and non-government organisations, private industry and academic institutions attended from around Australia, as well as several from New Zealand and the USA. Species considered at the workshop included around 35 syngnathids, 30 sharks and rays, 10 groupers and 20 or so others, including around a dozen species which are seriously targeted by commercial and recreational fishers and some small 'narrow-range' endemic species of potential conservation concern. The comments made by the workshop participants were recorded and transcribed, but this detailed material is not included as a separate section in this report, as these comments, corrections and additions, etc., were incorporated into the texts of the individual species conservation synopses, where applicable. Feedback from numerous specialists who were unable to attend the workshop has also been incorporated into the individual species synopses throughout the course of this project. The input sought from over 90 specialists, including those at the workshop, included not only their comments on (or additions to) the material in the species conservation synopses, but particularly their comments on our draft conservation category listings. Specific information on critical habitats, threatening processes, and possible future conservation and recovery actions were also sought in relation to the individual species listed. Furthermore, experts were encouraged to nominate additional species for inclusion using the ASFB's formal nomination procedure and proforma (see Appendix 2).

2.6 Analysis of Marine Protected Areas in which Each Species Occurs

A comprehensive analysis of every Marine Protected Area (MPA) in which each species occurs was considered to be too exhaustive and was thus not possible due to time constraints. However, we have included a list of the Marine Parks in which each species is known to occur or is likely to occur (e.g. by having a species distribution that overlaps with the distribution of the appropriately located Marine Park). Therefore, if a species occurs in inshore waters all around Australia, we have included it as being likely to occur in all or most inshore Marine Parks around Australia. However, it should be understood that habitat preferences of different species vary and suitable habitat may not be available for each species within these protected areas, even within their known distributional ranges. For further information on MPAs in Australia, the reader should consult Cresswell and Thomas (1997), who list all of those Australian MPAs which were gazetted before 30 June 1997. This publication is updated every four to five years (Cresswell and Thomas, 1997).

2.7 2000 IUCN Red List of Threatened Species

In October 2000, in the final stages of the preparation of this publication, the 2000 IUCN Red List of Threatened Species was published, and this is now available over the Internet (http://www.redlist.org/). For all fishes with species conservation synopses included herein, we have noted the current (i.e. 2000) Red List category in the text. The 1996 IUCN Red List categories and criteria for individual species are only included in the text of the species synopses if the category or criterion differs from that listed in the 2000 IUCN Red List. Hence, where the 2000 Red List categories and criteria are identical to those used in the 1996 IUCN Red List, only the 2000 IUCN Red List category or criterion is listed.

3 Conservation Categories and Criteria

3.1 History of Conservation Categories and Criteria

Significant discussion at the ASFB's 1985 Threatened Fishes Workshop (Harris, 1987) centred on the categories of threat and the criteria that defined them. Although the classification scheme adopted was similar to that of IUCN at that time, it was not identical. It was considered that some fish conservation issues in Australia required more specific definition. A seven-stage scheme of classification (Table 3.1 and Appendix 2) was thus adopted, with four categories of threatened species requiring action. These included Endangered, Vulnerable, Potentially Threatened, and Indeterminate, with the last category covering species with insufficient data to place them specifically in one of the first three categories, but likely to fall into one of them.

One of the first organisations to develop conservation categories and criteria was the IUCN, now the IUCN World Conservation Union (see section 1.2). The various editions of the IUCN's Red Lists of Threatened Species through the 1994 edition utilised a set of categories and criteria that was considered by some to be too subjective. A new set of categories that utilised primarily numerical criteria involving population sizes, percentage declines, and/or distribution areas was proposed in 1994 and utilised for the 1996 Red List (Appendix 6).

The design of the subjective categories and criteria utilised for the 1996 Red List elicited considerable criticism worldwide. As a result, the IUCN held a series of workshops to discuss the use and applicability of these categories and criteria. One workshop in 1996, which specifically focused on marine fishes, identified problems in considering the conservation status of many marine species, especially marine fishes that are targets of managed fisheries (Hudson and Mace, 1996). As a result of the considerable criticism of the 1996 categories and criteria, the IUCN decided to re-consider the applicability of its criteria in general. The IUCN has since been considering revisions to its guidelines through a series of international workshops. The 2000 IUCN Red List (available on the Internet at http://www.redlist.org/) was published in October 2000 using the categories and criteria of the 1996 Red List. At the International Meeting of IUCN delegates held in Jordan in October 2000, only slight changes were made to the wording of the categories and criteria, but no new categories were introduced and no old categories were omitted.

An analysis of both the ASFB's and IUCN's conservation categories indicated that the two were roughly one step out of phase - the ASFB's highest (Endangered) conservation category roughly coinciding with the IUCN's highest (Critically Endangered) category, and the ASFB's Vulnerable and Potentially Threatened categories corresponding with the IUCN's Endangered and Vulnerable categories, respectively. The ASFB will consider the new IUCN categories at its 2001 Annual Conference in Western Australia.

The American Fisheries Society (AFS) also has a set of categories and criteria (Appendix 7) that are different from those of both the IUCN and the ASFB (Table 3.1 and Appendix 2), and this society is also in the process of revising its categories. At least some of the AFS categories are based on the definitions of the United States Endangered Species Act which protects threatened species in that country (Musick, 1999).

Other sets of categories and criteria have been used at various times for different plant and animal groups (see Reynolds, 1987: Table 1). It is clear, however, that different categories and criteria have different meanings in different contexts, and that conservation planning would be helped considerably by the use of common categories and criteria.

3.2 Conservation Status Categories of Australian Marine Fishes

Prior to considering individual species synopses (in phylogenetic order) in this report, some general points are outlined in relation to the IUCN categories and criteria. The particular case of commercially targeted marine fish species, and some proposed improvements in the use of these criteria as they may apply to marine fishes in general, are also discussed. This latter point takes into account more detail of the life-history parameters of particular groups and species (see Musick, 1999).

Environment Australia requested as part of this contract that the IUCN 1994 Red List categories be used. We noted that the 1994 Red List for Threatened Animals (Groombridge, 1993) used the old categories, but gave notice of possible new categories and criteria currently being developed for future Red Lists. Also, although the Action Plan for Australian Bats utilised the 1994 IUCN categories, these taxa were only subjectively assessed against IUCN criteria (Duncan *et al*., 1999: 2). With around 4100 marine and estuarine fish species present in Australian waters, the vast majority of which are undersampled and incompletely known, a similar subjective analysis was determined to be the most practical method to progress this first overview of our threatened marine and estuarine fishes. A rigorous numerical analysis of population data was attempted for only one species that is the target of a heavily managed fishery, and this is discussed below. Future work on our threatened marine fishes should include application of the new (1996) IUCN criteria, particularly to the 17 species placed here in the formally threatened categories.

We see enhanced value in the 1996 categories, and in particular the Critically Endangered category that allows prioritisation of action plans. The Lower Risk (conservation dependent) category is also very useful for marine fish species. This category is used to flag species for which continued fisheries management or protection in Marine Protected Areas (MPAs) is necessary to prevent the species from becoming more threatened.

In both the pre-workshop analyses and in the workshop discussions, evidence of decline in either abundance or area of occurrence was considered essential for placement in one of the three highest categories of threat, *viz*. Critically Endangered, Endangered or Vulnerable. Because of the lack of knowledge concerning population sizes for virtually all but the most heavily managed commercial species, and even the incomplete knowledge of their areas of occurrence, many of the species analysed were categorised as Data Deficient.

In analysing the decline of some managed commercial fishes, notably the eastern gemfish and the southern bluefin tuna, strict usage of the IUCN numerical criteria resulted in both of these species being listed as Critically Endangered, based on their known population declines. The southern bluefin tuna is so listed in both the 1996 and 2000 Red Lists, and the eastern gemfish comes out as Critically Endangered when analysed using the IUCN criteria and the recently released RAMAS^{R} Red List software analysis program (Akcakaya and Ferson, 1999), which also uses the IUCN criteria. The conundrum facing conservationists is that commercial species have more data available on their population sizes and fluctuations than any other fishes, but significant initial population decline is an accepted part of fisheries management in attempting to reach optimum or maximum sustainable yields. The American Fisheries Society is considering the use of a system of risk criteria that reflects population resilience, specifically the population’s intrinsic rate of increase, the growth coefficient, fecundity, age at maturity and maximum age, in their determinations of conservation status for commercial fish species (Musick, 1999). These characteristics were discussed for some of the commercial species at our specialist workshop, but not for all species.

A small number of marine fishes listed in the 2000 IUCN Red List of Threatened Species have the letter ‘C’ in parentheses after the species name, IUCN category and criteria. This indicates that a caveat formulated at the workshop on categorising marine fishes (Hudson and Mace, 1996) applies in particular to these populations. The text of this caveat is reproduced in the following paragraph:

“The criteria (A-D) provide relative assessments of trends in the population status of species across many life forms. However, it is recognised 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 criteria (A1abd) 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.”

The only Australian species to which this caveat has been applied in the 2000 IUCN Red List of Threatened Species are some tunas (genus *Thunnus*) and the swordfish (*Xiphias gladius*).

The IUCN Red List categories and criteria were specifically designed to be used for all taxa and on a global basis. A draft set of guidelines for use at the national or regional levels has been prepared (Gärdenfors *et al*., 1999). According to these latter guidelines, if species are endemic to a country or are isolated from conspecific populations in other parts of the world (like most Australian temperate marine shore fishes – see Wilson and Allen, 1987), they should be treated as if they were a global population. However, if the species interchanges individuals with external populations such that external populations affect the extinction risk within the region, changes to the regional category should be considered. Such external populations might be expected to influence oceanic species like southern bluefin tuna or basking sharks, or some coral reef species that may migrate. However, in the brief eight hours of discussion at the ASFB's Specialist Workshop, such fine details were not always considered. In the case of the basking shark, for example, significant overseas declines have been documented. However, in Australia the species is so rare that it could be considered a vagrant, and thus Data Deficient was considered to be the most appropriate conservation category for this species in the Australian context.

The use of regional guidelines will be important in Australia where State/Territory agencies have an active involvement in fish conservation. An ongoing, and unresolved, issue is how to establish parity between State (regional) lists of threatened fishes and Commonwealth (national) lists.

Not surprisingly, most of the species analysed were categorised as Data Deficient. It is important to direct research efforts and funding towards these species as well as those in the more threatened categories. This is particularly important when there is a threat that has been identified, such as for the pipehorses, for which there are virtually no available data on population sizes or biological parameters.

Table 3.1: Categories used by various organisations to denote risk of extinction

Organisation	**Risk Categories**							
	Threatened Categories				**Lower Risk Categories**			**Others**
IUCN 1994	Critically Endangered	Endangered	Vulnerable	----------------	Lower Risk (near threatened or conservation dependent)	Lower Risk (least concern)	Data Deficient	--------------------
IUCN pre 1994	--------------	Endangered*	Vulnerable*	Indeterminate*	-----------------	------------	Insufficiently Known	Rare*
EPBC Act 1999	Critically Endangered	Endangered	Vulnerable	----------------	Conservation Dependent	------------	----------------	--------------------
ASFB 1987	Endangered†	Vulnerable†	Potentially Threatened†	Indeterminate†	------------------	------------	----------------	Restricted and Uncertain Status
US *ES Act*	--------------	Endangered	Threatened	----------------	Candidate List	Not listed	----------------	--------------------
AFS (old)	--------------	Endangered	Threatened	----------------	Special Concern	Not listed	----------------	--------------------
AFS (new)	--------------	Endangered	Threatened	----------------	Vulnerable or Conservation Dependent	Not listed	----------------	--------------------

All lists utilise the category Extinct, which has been excluded from this table. The IUCN's 1994 listing and the *EPBC Act 1999* both also utilise the category Extinct in the Wild. The categories of each organisation listed in the columns above do not absolutely correlate in all instances. *†In these cases Indeterminate refers only to those similarly marked categories. ASFB = Australian Society for Fish Biology, *EPBC Act* = Australian Commonwealth Governments' *Environment Protection and Biodiversity Conservation Act 1999*, IUCN = International Union for the Conservation of Nature, AFS = American Fisheries Society, US *ESA* = United States *Endangered Species Act*. Refer to Appendices 2, 6 and 7 for explanations of categories and criteria adopted by each authority.

4 Species Conservation Synopses

4.1 Summary of Species Included Arranged in Order of Conservation Status Using IUCN Categories

<u>Table 4.1:</u> SPECIES INCLUDED IN THE REPORT WITH THEIR IUCN CONSERVATION CATEGORIES AND AUSTRALIAN DISTRIBUTIONS (species distributions in this table are presented in a clockwise arrangement starting from WA and finishing with SA).
Locality key: C = Commonwealth waters (i.e between 3nm and 200nm offshore), E and M = Elizabeth and Middleton Reefs, H = Heard Island, L = Lord Howe Island, MI = McDonald Island, MQI = Macquarie Island, N = New South Wales, NI = Norfolk Island, NT = Northern Territory, Q = Queensland, SA = South Australia, V = Victoria, WA = Western Australia, * = endemic to Australian waters, ** = possibly endemic to Australian waters. **IUCN Status key:** CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LR (cd) = Lower Risk (conservation dependent), LR (nt) = Lower Risk (near threatened), LR (lc) = Lower Risk (least concern), DD = Data Deficient

Common Name	Scientific Name	IUCN Status	Australian Distribution
Bizant river shark**	*Glyphis* sp. A	CR	Q
Freshwater sawfish	*Pristis microdon*	CR	WA, NT, Q
Spotted handfish*	*Brachionichthys hirsutus*	CR	T
Grey nurse shark	*Carcharias taurus*	EN	WA, NT, Q, N
Northern river shark**	*Glyphis* sp. C	EN	NT
Harrisson's deepsea dogfish*	*Centrophorus harrissoni*	EN	N, V, T, C
Dwarf sawfish**	*Pristis clavata*	EN	WA, NT, Q
Green sawfish	*Pristis zijsron*	EN	WA, NT, Q, N
Maugean skate*	*Raja* sp. L	EN	T
Great white shark	*Carcharodon carcharias*	VU	All states, C
Colclough’s shark*	*Brachaelurus colcloughi*	VU	Q
Southern dogfish**	*Centrophorus uyato*	VU	WA, N, V, T, SA, C
Narrow sawfish	*Anoxypristis cuspidata*	VU	WA, NT, Q
Freshwater whipray	*Himantura chaophraya*	VU	NT, WA, Q
Red handfish*	*Brachionichthys politus*	VU	T
Ziebell’s handfish*	*Sympterichthys* sp.	VU	T
Black rockcod	*Epinephelus daemelii*	VU	Q, N, NI, E&M, L, C
Whiskery shark*	*Furgaleus macki*	LR (cd)	WA, V, T, SA, C
School shark	*Galeorhinus galeus*	LR (cd)	WA, Q, N,V,T,SA,L,C
Common sawshark*	*Pristiophorus cirratus*	LR (cd)	WA, N, V, T, SA, C
Orange roughy	*Hoplostethus atlanticus*	LR (cd)	WA, SA, C
Southern potbelly seahorse**	*Hippocampus bleekeri*	LR (cd)	V, T, SA
Leafy seadragon*	*Phycodurus eques*	LR (cd)	WA, V, SA
Weedy seadragon*	*Phyllopteryx taeniolatus*	LR (cd)	WA, N, V, T, SA
Barramundi cod	*Cromileptes altivelis*	LR (cd)	WA, NT, Q, N
Queensland grouper	*Epinephelus lanceolatus*	LR (cd)	WA, NT, Q, N
Potato cod	*Epinephelus tukula*	LR (cd)	WA, NT, Q
Eastern blue devil**	*Paraplesiops bleekeri*	LR (cd)	Q,N
Western blue groper*	*Achoerodus gouldii*	LR (cd)	WA, V, SA
Eastern blue groper*	*Achoerodus viridis*	LR (cd)	Q, N, V
Humphead maori wrasse	*Cheilinus undulatus*	LR (cd)	WA, NT, Q, E&M
Double-header*	*Coris bulbifrons*	LR (cd)	N, NI, E&M, L
Gemfish (eastern stock)	*Rexea solandri*	LR (cd)[1]	N, V, T, C

[1] Or Vulnerable, depending on future management decisions

<u>Table 4.1 (continued):</u>

Common Name	Scientific Name	IUCN Status	Australian Distribution
Herbsts nurse shark	*Odontaspis ferox*	LR (nt)	WA, N, V, C
Dusky shark	*Carcharhinus obscurus*	LR (nt)	All states and C
Sandbar shark	*Carcharhinus plumbeus*	LR (nt)	WA,NT,Q,N,C
Estuary stingray**	*Dasyatis fluviorum*	LR (nt)	Q, N
Porcupine ray	*Urogymnus asperrimus*	LR (nt)	WA, NT, Q
Sculptured frogfish*	*Halophryne queenslandiae*	LR (nt)	Q, N
Bighead seahorse*	*Hippocampus grandiceps*	LR (nt)	Q
False-eyed seahorse*	*Hippocampus biocellatus*	LR (nt)	WA
Low-crown seahorse*	*Hippocampus dahli*	LR (nt)	NT, Q
Verco's pipefish*	*Vanacampus vercoi*	LR (nt)	SA
Bluefish	*Girella cyanea*	LR (nt)	Q,N, NI, E & M, L
Braun's wrasse*	*Pictilabrus brauni*	LR (nt)	WA
Ballina angelfish*	*Chaetodontoplus ballinae*	LR (nt)	Q, N, L
Southern bluefin tuna	*Thunnus maccoyii*	LR (nt)	WA, Q, N, V, T, SA, C

White-spotted spurdog	*Squalus acanthias*	LR (lc)	WA, V, T, SA
Australian handfish*	*Brachionichthys* sp.	LR (lc)	Q, N, V, SA
Banded pipefish	*Dunckerocampus dactyliophorus*	LR (lc)	WA, NT, Q
Ladder pipefish*	*Festucalex scalaris*	LR (lc)	WA
Shortkeel Pipefish	*Hippichthys parvicarinatus*	LR (lc)	NT
Prophet's pipefish*	*Lissocampus fatiloquus*	LR (lc)	WA
Sculptured seamoth*	*Pegasus lancifer*	LR (lc)	WA, V, T, SA
Estuary rockcod	*Epinephelus coioides*	LR (lc)	WA, NT, Q, N
Purple rockcod	*Epinephelus cyanopodus*	LR (lc)	WA, NT,Q, N, NI, L
Flowery cod	*Epinephelus fuscoguttatus*	LR (lc)	WA, NT, Q, E & M
Malabar grouper	*Epinephelus malabaricus*	LR (lc)	WA, NT,Q, N
Camouflage grouper	*Epinephelus polyphekadion*	LR (lc)	WA, NT, Q, L, E&M
Greasy grouper	*Epinephelus tauvina*	LR (lc)	WA, NT, Q, N
Elegant wrasse	*Anampses elegans*	LR (lc)	Q, N, NI, E & M,L
Baldchin groper*	*Choerodon rubescens*	LR (lc)	WA

Species with no synopses in the report: all are elasmobranch species of Lower Risk (least concern).

Common Name	Scientific Name	Australian Distribution
Crocodile shark	*Pseudocarcharias kamoharai*	WA, NT, Q, C
Shortfin mako	*Isurus oxyrinchus*	All states and C, L, NI, E & M.
Porbeagle	*Lamna nasus*	WA, N, V, T, SA, C
Blacktip topeshark	*Hypogaleus hyugaensis*	WA, SA, V, N, Q, C
Gummy shark	*Mustelus antarcticus*	WA, Q, N, V, T, SA, C
Grey reef shark	*Carcharhinus amblyrhynchos*	WA, NT, Q, L, C
Spinner shark	*Carcharhinus brevipinna*	WA, NT, Q, N, C
Silky shark	*Carcharhinus falciformis*	WA, NT, Q, N, C
Bull shark	*Carcharhinus leucas*	WA, NT, Q, N, C
Tiger shark	*Galeocerdo cuvier*	WA, NT, Q, N, L, C
Blue shark	*Prionace glauca*	All states and C, NI, E & M, L
Whitetip reef shark	*Triaenodon obesus*	WA, NT, Q, C
Scalloped hammerhead	*Sphyrna lewini*	WA, NT, Q, N, C
Great hammerhead	*Sphyrna mokarran*	WA, NT, Q, N, C
Smooth hammerhead	*Sphyrna zygaena*	WA, N, V, T, SA, C
Whitespot giant guitarfish	*Rhynchobatus djiddensis*	WA, NT, Q, N, C
Bluespotted ribbontail ray	*Taeniura lymma*	WA, NT, Q
Spotted eagle ray	*Aetobatus narinari*	WA, NT, Q, N, C
Manta ray	*Manta birostris*	WA, N, V, T, SA, C

Common	Scientific	IUCN	Australian

Name	Name	Status	Distribution
Sixgill shark	*Hexanchus griseus*	DD	WA, Q, N, V, T
Sevengill shark	*Notorynchus cepedianus*	DD	WA, N, V, T, SA
Megamouth shark	*Megachasma pelagios*	DD	WA, C
Basking shark	*Cetorhinus maximus*	DD	WA, N,V, T, SA, C
Spotted wobbegong shark**	*Orectolobus maculatus*	DD	WA, Q, N, V, SA
Banded wobbegong shark	*Orectolobus ornatus*	DD	WA, Q, N, V, SA
Whale shark	*Rhincodon typus*	DD	WA, NT, Q, N,V, SA, C
Common blacktip shark	*Carcharhinus limbatus*	DD	WA, NT, Q, N, C
Gulper shark**	*Centrophorus granulosus*	DD	WA, Q, N,
Black shark	*Dalatias licha*	DD	WA, Q, N, V, T, SA, C
Wide sawfish	*Pristis pectinata*	DD	Unconfirmed
Warty handfish*	*Sympterichthys verrucosus*	DD	N, V, T, SA
Eastern potbelly seahorse**	*Hippocampus abdominalis*	DD	N
Western spiny seahorse*	*Hippocampus angustus*	DD	WA
Winged seahorse	*Hippocampus alatus*	DD	WA, NT
Northern spiny seahorse*	*Hippocampus multispinus*	DD	WA, NT
Gorgonian seahorse	*Hippocampus bargibanti*	DD	Q
Shorthead seahorse*	*Hippocampus breviceps*	DD	V, T, SA
West Australian seahorse*	*Hippocampus elongatus*	DD	WA
Eastern spiny seahorse*	*Hippocampus hendriki*	DD	Q
Bullneck seahorse*	*Hippocampus minotaur*	DD	V
Flatface seahorse*	*Hippocampus planifrons*	DD	WA
Highcrown seahorse*	*Hippocampus procerus*	DD	Q
Queensland seahorse**	*Hippocampus queenslandicus*	DD	Q
Common seahorse	*Hippocampus taeniopterus*	DD	NT, Q
Sad seahorse*	*Hippocampus tristis*	DD	Q, N, L
Knobby seahorse*	*Hippocampus tuberculatus*	DD	WA
White’s seahorse*	*Hippocampus whitei*	DD	N
Zebra seahorse	*Hippocampus zebra*	DD	Q
Prickly pipefish	*Hypselognathus horridus*	DD	SA
Western crested pipefish	*Mitotichthys meraculus*	DD	WA
Mollison’s pipefish*	*Mitotichthys mollisoni*	DD	T,V
Halfbanded pipefish*	*Mitotichthys semistriatus*	DD	T,V
Duncker’s pipehorse*	*Solegnathus dunckeri*	DD	Q, N, L
Pallid pipehorse	*Solegnathus hardwickii*	DD	WA, NT, Q, N
Günther’s pipehorse	*Solegnathus lettiensis*	DD	WA
Robust pipehorse*	*Solegnathus robustus*	DD	SA
Spiny pipehorse**	*Solegnathus spinosissimus*	DD	Q, N, V, T
Alligator pipefish	*Syngnathoides biaculeatus*	DD	WA, NT, Q, N
Striated wirrah*	*Acanthistius paxtoni*	DD	N, possibly WA
Bar cod**	*Epinephelus ergastularius*	DD	Q, N
Kimberley dottyback*	*Assiculoides desmonotus*	DD	WA
Multicolour dottyback*	*Ogilbyina novaehollandiae*	DD	Q, N
Pilbara eelblenny*	*Congrogadus winterbottomi*	DD	WA
Eastern king wrasse	*Coris sandeyeri*	DD	N, V, L, NI, E & M
Humpheaded parrotfish	*Bolbometopon muricatum*	DD	WA, Q
Patagonian toothfish	*Dissostichus eleginoides*	DD	C, MQI, HI, MI
Earspot snakeblenny*	*Ophiclinops hutchinsi*	DD	SA
Eelblenny*	*Peronedys anguillaris*	DD	SA
Tasmanian robust triplefin**	*Grahamina gymnota*	DD	T
Hoese’s silhouette goby*	*Silhouettea hoesei*	DD	WA, NT
Gemfish (western stock)*	*Rexea solandri*	DD	WA, SA, C
Swordfish	*Xiphias gladius*	DD	WA, Q, N, C

4.2 Species Conservation Synopses Arranged in Phylogenetic Order

4.2.1 CLASS CHONDRICHTHYES: SHARKS, RAYS AND CHIMAERAS

The chondrichthyans, which include the sharks, rays and chimaeras (spookfishes, ghost sharks and elephantfishes), are a diverse group of cartilaginous fishes that have evolved over the past 400 million years or so (Camhi *et al.*, 1998; Last and Stevens, 1994). Approximately 1000 species of chondrichthyans, consisting of over 500 skates and rays, about 400 sharks and about 40 chimaeras, are known from marine, estuarine and freshwater systems of the world (Last and Stevens, 1994). The vast majority of chondrichthyans occur in marine habitats, with about 5% of species known to occur in freshwater environments (Compagno, 1990). Most chondrichthyans (about 55% of the species) occur on the continental shelves from the intertidal zone to depths of 200m. About 35% of the species are restricted to the continental slope (200m to 2000m), about 2% are strictly oceanic (epipelagic and mesopelagic) species, and the remaining 8% occur in mixed habitats, mostly shelf-slope, but also shelf-oceanic and a few in all three habitats. The diversity of chondrichthyan shelf species is greatest in the tropics and least at high latitudes (Compagno, 1990). Of the roughly 1000 chondrichthyan species worldwide, about 300 occur in Australian waters and over half of these 300 species are endemic (or restricted) to Australia (Last and Stevens, 1994).

Chondrichthyans are the targets of directed commercial and recreational fisheries worldwide and are increasingly taken as an incidental catch of fisheries targeting other species (Bonfil, 1994; Camhi *et al.*, 1998), such as tunas. Between 1947 and 1986 more than 20 million tonnes (t) of chondrichthyans were taken by targeted fisheries worldwide (Last and Stevens, 1994). Recorded world commercial catches of chondrichthyans totalled 704,000t in 1991, making up less than 1% of the total world fisheries catch (Bonfil, 1994).

In evolutionary terms, the success of chondrichthyans as a group is directly attributable to their well-adapted life history strategies (Compagno, 1990; Vas, 1995). In ecological terms, most chondrichthyans are considered ‘k-selected’ species. Such species typically have a large body size (thus few natural predators), a slow rate of growth, a late age of first maturity, and give birth to a small number of large, well-developed young (each with a high chance of survival in the absence of fishing) (Vas, 1995). Although restricted in their ecological roles by morphology, reproduction and other factors, the cartilaginous fishes are highly diverse and show numerous life-history styles in exploiting available niches permitted by chondrichthyan limitations. Chondrichthyans are entirely carnivorous, with no known specialist herbivores, and as a group are mostly high in the food web; they feed on most marine animals, from plankton and minute benthic invertebrates to whales (Compagno, 1990). The ecological and evolutionary characteristics of chondrichthyans make them extremely vulnerable to the effects of over-exploitation, and there are few fisheries that fish chondrichthyans on a sustainable basis, without continually increasing effort (Vas, 1995). Hence, the recovery of overfished populations may take decades (Vas, 1995). Compared with other marine fishes, sharks have relatively low productivity, but there is a wide variation among species in their differing abilities to withstand, or to recover from, exploitation (Smith *et al.*, 1998). In comparing life histories across a number of vertebrate taxa, it is clear that many chondrichthyans are among the latest maturing and slowest reproducing of vertebrates. The reproductive potential and strategies of chondrichthyans are more closely related to those of the cetaceans, sea turtles, large land mammals and larger birds than to teleost fishes (Camhi *et al.*, 1998). This demonstrates that a very different management approach is required to prevent over-exploitation and sustain their fisheries over a long period of time (Camhi *et al.*, 1998).

Shark fisheries have expanded in size and number around the world since the mid 1980s, primarily in response to the rapidly increasing demand for shark fins, flesh, cartilage and other products. The need to improve shark fishery management and monitoring, expand biological research and take management action is of primary importance (Camhi *et al.*, 1998). Australian shark fisheries are among the most well documented and managed elasmobranch fisheries in the world (Bonfil, 1994), with several shark fishery management plans in place (Walker, 1998), though the extent of management controls varies from fishery to fishery. Although directed fisheries have been the primary cause of stock collapses in many species of elasmobranchs, the greatest threat to long-lived sharks and rays appears to be mortality in mixed-species fisheries (Musick *et al.*, 2000b). It is thus critical that fisheries managers are sensitive to the vulnerability of less productive species of sharks and rays taken as bycatch in mixed-species fisheries (Musick *et al.*, 2000b). It is especially important to address the issue of elasmobranchs taken as bycatch before their population numbers are reduced to critically low levels.

Those elasmobranch species which have the highest capacity to rebound from over-exploitation tend to be smaller, inshore coastal species that mature early and are comparatively short-lived as an adaptation to higher rates of predation (Smith *et al*., 1998). The gummy shark *Mustelus antarcticus* in southern Australia, which reaches maturity at 4-5 years of age (for females) and a maximum age of 16, has sustained a commercial shark fishery for over 25 years with careful conservation and management (Camhi *et al*., 1998).

Some small and/or unusual elasmobranchs are being increasingly targeted for the public and private aquarium trade, which places added risks on endemic species with restricted distributions. The educational value of elasmobranchs in public aquaria, however, can be crucial to changing the negative public perception of sharks, thereby building political will to conserve them (Camhi *et al*., 1998).

Sharks are frequently taken as bycatch of dropline, longline, handline, haul net, bait net and gillnet fishing in northern Australian waters (Stevens, 1999). Similarly, in southern Australian waters, sharks and rays are often retained as bycatch of longlining and/or trawling operations along the south-eastern (McLoughlin *et al*., 1998; Graham *et al*., 2001) and south-western (Simpfendorfer, 1999a) coastlines. The Commonwealth fisheries that regularly retain and record the landed shark component of their catch are the Southern Shark Fishery, the South East Fishery and the Great Australian Bight Trawl Fishery. Elasmobranchs are also caught, but less regularly landed and not always regularly recorded, in a number of other fisheries in Australian waters. These fisheries include the Northern Prawn Fishery, the Torres Strait Fisheries, the Tuna and Billfish Fisheries, the Western Australian Deepwater Trawl Fishery, the North West Slope Trawl Fishery and the South Tasman Rise Trawl Fishery (SAG, 2000). Additionally, there are a number of minor and developing Commonwealth fisheries in which the non-targeted elasmobranch catch is currently small. Such elasmobranch catches have the potential to increase with the expansion of fisheries that include the Northern Finfish Trawl Fishery, Coral Sea Fishery, Southern Squid Jig Fishery and East Coast Deepwater Trawl Fishery (SAG, 2000). The Sub-Antarctic Fisheries (Macquarie Island Fishery and Heard Island and MacDonald Islands Fishery) also currently report on elasmobranch catches (mainly Pacific sleeper shark and skates) (AFMA, 2000e).

The quantities of recorded shark catches in Australian fisheries have declined by around 30% from 11,000t to 7,800t during the three year period 1996/97 - 1998/99, with declines in the quantities of shark landed evident in most of the fisheries in the various States and Territories. The exceptions are the WA shark fisheries and the West Australian, NT and Victoria non-target fisheries, where the quantity of the shark catch has remained fairly stable over this period (SAG, 2000).

The decline in the catches of sharks and rays on the South East Fishery trawl grounds (mainly from Sydney, NSW southwards to Gabo Island, Victoria) between the years 1976-77 (exploratory trawling) and 1996-97 (commercial trawling) was approximately 80%. The 1996-97 average catch rate of 65kg/hr was only approximately 20% of the 323kg/hr average recorded in 1976-77 (Graham *et al*., 2001). This is a classical demonstration of the susceptibility of elasmobranchs to intensive trawling activities.

The IUCN Species Survival Commission's (SSC) Shark Specialist Group (SSG) has set an ambitious target by aiming to assign a conservation status to all sharks, rays and chimaeras (approx. 1000 species) by the year 2003 (http://www.redlist.org/programme.html). When achieved, this global assessment of all shark, ray and chimaera species will provide a more accurate indicator of the health of these species' populations and the threats to their marine, estuarine and freshwater habitats. In the 2000 IUCN Red List of Threatened Species, 95 elasmobranchs (or roughly 10% of the known living elasmobranch species) were listed (http://www.redlist.org/). Of these 95 elasmobranch species *

- 6 species were listed as Critically Endangered
- 17 species were listed as Endangered
- 20 species were listed as Vulnerable
- 5 species were listed as Lower Risk (conservation dependent)
- 33 species were listed as Lower Risk (near threatened)
- 14 species were listed as Data Deficient

Some of the above species are listed in the 2000 IUCN Red List in multiple categories based on their subpopulations. In these cases the most threatened status (i.e. the status of the most threatened subpopulation) has been used in the above figures. Australian species for which detailed synopses are included list all of the conservation categories of their individual subpopulations.

Of the 95 elasmobranchs listed on the 2000 IUCN Red List of Threatened Species, about 48 species (or roughly 50%) occur in Australian waters, and 25 species (or roughly 25%) have detailed species synopses included here. Last and Stevens (1994) estimated that about 300 sharks, rays and chimaeras were known to occur in the Australian region. If adequate resources are made available to collect, document, research, manage and protect Australian chondrichthyan species from over-exploitation, Australia will be in a good position to help educate other nations about the conservation of their own "charismatic megafaunas".

References:
Bonfil, 1994; Camhi *et al*., 1998; Compagno, 1990; Graham *et al*., 2001; Last and Stevens, 1994; McLoughlin *et al*., 1998; Musick *et al*., 2000b; Simpfendorfer, 1999a; Smith *et al*., 1998; Stevens, 1999; Vas, 1995; Walker, 1998.

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

SPECIES SYNOPSES: Introductory Notes

Species synopses are not included for the following elasmobranch species. The conservation status indicated for all of these species (i.e. Lower Risk least concern) is preliminary given the fact that no literature searches and/or data on catches have been analysed for these species in this report. This conservation status listing of Lower Risk (least concern) is for Australian waters only.

Common Name	**Scientific Name**
Crocodile shark	*Pseudocarcharias kamoharai*
Shortfin mako	*Isurus oxyrinchus*
Porbeagle	*Lamna nasus*
Blacktip topeshark	*Hypogaleus hyagaensis*
Gummy shark	*Mustelus antarcticus*
Grey reef shark	*Carcharhinus amblyrhynchos*
Spinner shark	*Carcharhinus brevipinna*
Silky shark	*Carcharhinus falciformis*
Bull shark	*Carcharhinus leucas*
Tiger shark	*Galeocerdo cuvier*
Blue shark	*Prionace glauca*
Whitetip reef shark	*Triaenodon obesus*
Scalloped hammerhead	*Sphyrna lewini*
Great hammerhead	*Sphyrna mokarran*
Smooth hammerhead	*Sphyrna zygaena*
Whitespot giant guitarfish	*Rhynchobatus djiddensis*
Bluespotted ribbontail ray	*Taeniura lymma*
Spotted eagle ray	*Aetobatus narinari*
Manta ray	*Manta birostris*

FAMILY BRACHAELURIDAE: BLIND SHARKS

Colclough's Shark

Family Name:	Brachaeluridae
Scientific Name:	*Brachaelurus colcloughi* Ogilby, 1908
Conservation Status:	Vulnerable

Australian Synonyms:
Heteroscyllium colcloughi (Ogilby, 1908)

Alternative Common Name:
Bluegrey carpet shark

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Vulnerable (C2b)

No ASFB Listing

Distribution:
Brachaelurus colcloughi generally occurs on the continental shelf off southern Queensland between Gladstone and Coolangatta and also on the Great Barrier Reef (Last and Stevens, 1994). It has also apparently been recorded from off the Cape York Peninsula, though there are no known existing specimens to back up these identifications. Parker (1999) occasionally recorded adult *B. colcloughi* from Julian Rocks (off Byron Bay, northern NSW), which is nearing the southern range for this species. There are very few records from outside the Moreton Bay area (J. Johnson, pers. comm.).

Museum Records - 19 specimens (Standard Length embryos to 85cm), collected from depths of up to 217m, ranging in geographical distribution from off the Proserpine area (20^{o}41'S), Great Barrier Reef, Qld (only GBR record) and then around Moreton Bay (approx. 27^{o}S), Qld, southwards to off Brunswick Heads (28^{o}33'S), NSW. Specimens were collected between 1913 and 1999.

Habitat:
This species has mainly been found in relatively shallow, inshore waters (Compagno *et al*., in prep.), but has been recorded to depths of 217m (J. Johnson, pers. comm.). Parker (1999) recorded *B. colcloughi* from a depth range of 10-22m at Julian Rocks (off Byron Bay, northern NSW), noting its occurrence as occasional.

Biology and Behaviour:
Brachaelurus colcloughi is an ovoviviparous species, with 6 to 8 pups per litter. Term fetuses are 17.4 – 18.4cm in length and size at birth is probably around 17-18cm. Pregnant females have been recorded at 65.8 - 75.5cm and males are adolescent at about 48.2-51.6cm in length. The age at maturity, average reproductive age, and longevity are all unknown (Compagno *et al*., in prep.). The diet of this species is also unknown, but the closely related *Brachaelurus waddi* feeds on reef invertebrates and small fishes (Last and Stevens, 1994).

Size:
Brachaelurus colcloughi attains a total length of at least 85cm (Johnson, pers. comm).

Evidence for Decline:
Brachaelurus colcloughi is an uncommon species. Trawling, recreational fishing and general habitat degradation on the inner coastal reefs threaten its main population in Moreton Bay (J. Johnson pers.

comm.). This species is caught as a bycatch in other fisheries and exploited at low levels for the marine aquarium trade.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park, Qld
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW

Suggested Conservation Status:
Vulnerable on an Australia-wide basis
Brachaelurus colcloughi is not known to occur anywhere except off the eastern coast of Australia. About 20 specimens of this small, attractive, but poorly known shark have been recorded, mostly from inshore waters of Moreton Bay. This shark seems to be uncommon as far as is known despite considerable collecting coverage of its available habitat. From the little that is known, it has a relatively limited geographic and bathymetric range off Queensland and mainly occurs in waters that are heavily utilised by humans and which are subjected to intensive fisheries (Compagno *et al*., in prep.).

Threatening Processes:
Commercial trawling and recreational fishing (where it is taken as a bycatch), and general habitat degradation threaten the survival of this species in Australian waters.

Critical Habitats:
Inner coastal reef habitats of southern Queensland are critical to this species. Further degradation of these habitats threatens to reduce the area of occupancy of this species within its range.

Recovery Objectives/Management Actions Required:
Significant data gaps exist for this species. Information is lacking on trends in numbers or details of its distributional range, but it is not found in quantity at any locality surveyed despite reasonable survey coverage. The behavioural ecology of this species also needs to be investigated. Studies should include under-water census and tagging (Compagno *et al*., in prep.). Habitat protection is required in areas of Moreton Bay where remaining populations are known to exist.

References:
Compagno, *et al*., in prep.; J. Johnson, pers. comm 1999-2000; Last and Stevens, 1994; Parker, 1999.

FAMILY ORECTOLOBIDAE: WOBBEGONG SHARKS

Reported commercial catches of wobbegong sharks retained in the NSW fisheries 1985/86 to 1998/99 (NSW Fisheries Catch Figures)

Totals combined for all fishing methods and for *Orectolobus maculatus* and *O. ornatus*[1]

FISCAL YEAR	TOTAL CATCH (kg)
1985/1986	2531
1986/1987	1296
1987/1988	3436
1988/1989	830
1989/1990	4258
1990/1991	112,977
1991/1992	111,435
1992/1993	120,726
1993/1994	97,470
1994/1995	91,942
1995/1996	87,286
1996/1997	64,192
1997/1998	80,939
1998/1999	58,436
1999/2000[2]	38,634

Reported commercial catches of wobbegong sharks retained in the Commonwealth fisheries 1994-1998 (AFMA logbook data, unpublished)

Totals combined for all fishing methods[3] and for all wobbegong species[4]

CALENDAR YEAR	TOTAL CATCH (kg)
1994	2758
1995	3042
1996	3963
1997	5113
1998	2539
1999	2298
2000	1812[5]

[1] Total catches are mixtures of whole (i.e. uncleaned) weights and those of cleaned fish. For catches from 1997/98 onwards, whole weights ranged between 36% and 51% of the totals, with the remainder being predominantly headed and gutted specimens (M. Tanner, pers. comm. 9/2000).
[2] Some catch forms have not been yet returned for the 1999/00 fiscal year (M. Tanner, pers. comm. 9/2000).
[3] Combined fishing methods include those methods used in the Great Australian Bight Trawl Fishery, the Southern Shark Fishery, the South East Non-Trawl Fishery and the Western Deepwater Trawl Fishery, in order of decreasing magnitude of catches. Catches for 1994 to 1996 are whole weights. Over 98% of 1997 catches are whole weights, over 93% of 1998 catches are whole weights, 75% of 1999 catches are whole weights and 66% of 2000 catches are whole weights. Others have fins and trunks retained, i.e. gutted fish, or are headed and gutted or have had trunks removed, in order of decreasing magnitude.
[4] There are probably three to four wobbegong species included in these data, including *Orectolobus maculatus* and *Orectolobus ornatus*, and possibly *Orectolobus* sp. and *Sutorectus tentaculatus*.
[5] Catches for the year 2000 are incomplete and only cover the period to the end of June.

Reported catches of wobbegong sharks from WA waters
1994-95 to 1997-98

Fiscal Year	Live weight (kg)	Landed weight (kg)	Landed / live weight %
1994-1995	69,223	39,858	57.6
1995-1996	52,694	33,028	62.7
1996-1997	58,771	36,734	62.5
1997-1998	54,864	34,629	63.1

REFERENCES:
AFMA LOGBOOK DATA, UNPUBLISHED; M. TANNER (NSW FISHERIES RESEARCH INSTITUTE – CATCH RECORDS), PERS. COMMS. 1999-2000.

Spotted Wobbegong

Family Name:	Orectolobidae
Scientific Name:	*Orectolobus maculatus* (Bonnaterre, 1788)
Conservation Status:	Data Deficient

Taxonomic Problems:
Often confused with *Orectolobus ornatus* (De Vis, 1883), especially live specimens viewed underwater.

Alternative Common Name:
Wobbegong

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Orectolobus maculatus occurs in inshore waters off the southern coast of Australia from Fremantle (Western Australia) to Moreton Island (southern Queensland). Records from Japan and the South China Sea need to be confirmed. Tasmanian records are probably invalid (Last and Stevens, 1994).

Museum Records – 38 specimens (Standard Length 22-134cm), collected from a depth range of 20-176m, and ranging in geographical distribution from east of Swains Reef (21°S), Qld southwards to Hobsons Bay (37°52'S), Victoria, westwards to St. Vincents Gulf (35°10'S, 137°55'E), SA and north-westwards to Shark Bay (26°54'S), WA. Specimens were collected between circa 1882 and 1995.

Habitat:
This species is most common on algal-covered rocky reefs, but has also been trawled to 110m depth (Last and Stevens, 1994). It occurs mainly on rocky reefs, and occasionally over seagrass meadows and bare sand (Coleman, 1980), but also on coral reefs and under piers (Compagno, 1984). Juveniles occur in estuaries and are occasionally found over seagrass beds (Lieske and Myers, 1994).

Biology and Behaviour:
Reproduction is ovoviviparous and females have large litters, of usually 20 or more (Last and Stevens, 1994) and up to 37 young (Grant, 1978). *Orectolobus maculatus* is primarily a nocturnal feeder, preying on some of the larger bottom-dwelling animals such as crabs, rock lobsters, octopuses and reef fishes (Last and Stevens, 1994).

Size:
Born at a length of around 20cm, and can attain at least 300cm. Males may mature at about 60cm (Last and Stevens, 1994).

Evidence for Decline:
Commercial and recreational fishing may be contributing to a decline of this species, but this has not yet been unequivocally demonstrated. The flesh is highly regarded as food, but in the past has generally been of only limited commercial value. The attractive skin makes excellent decorative leather (Last and Stevens, 1994). Wobbegongs are commonly caught in trawls, beach seines, gill nets, lobster pots and traps, and by hook-and-line. Skin divers with spears take some fish. These sharks are sometimes regarded as pests by lobster fishers, because they are adept at wedging themselves into lobster pots, to eat the catch and bait (Compagno, 1984). A survey conducted by The Ecology Lab (1991-2) in the Seal Rocks area of northern NSW shows evidence of site-attachment for wobbegongs, observing what seemed to be the same individuals in exactly the same positions over consecutive dives. This suggests that wobbegongs may be territorial and thus particularly susceptible to fishing pressure, although further work is necessary in this area.

Australian Marine Protected Areas in Which the Species Occurs:
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW

Solitary Islands Marine Park, northern NSW
Fly Point - Halifax Park Aquatic Reserve, Port Stephens, NSW
Jervis Bay Marine Park, southern NSW
Possibly also occurs in the following areas:
Shark Bay Marine Park, WA (unconfirmed)
Hamelin Pool Marine Nature Reserve, WA (unconfirmed)

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Currently there are insufficient catch statistics to validate any declines, but this species needs to be closely monitored. It is recommended that it be assigned the above status, adopting the IUCN categories.

Threatening Processes:
Commercial fishing by a variety of methods is potentially threatening this species in southern Australian waters. This species is taken in the Great Australian Bight Trawl Fishery (GABTF), the South East Trawl Fishery (SENTF), the Southern Shark Fishery (SSF) (AFMA logbook data, unpublished) and the Western Australian (Temperate) Shark Fishery (Simpfendorfer, 1999a). Most of the above fisheries take this species as bycatch, but like many bycatch species it is nonetheless often utilised. Dropline fishers in NSW target this species (M. Tanner, pers. comm.) and recreational fishers probably also have a minor impact.

Critical Habitats:
Estuaries and seagrass beds may be important nursery areas for this species.

Recovery Objectives/Management Actions Required:
There is a paucity of information on size/age structures, sex ratios, breeding habits, possible migrations and population genetics of wobbegongs. Further work in these areas is crucial to provide accurate data upon which to base management decisions. Catch statistics from commercial fishers in NSW waters do not currently separate *Orectolobus maculatus* and *Orectolobus ornatus*, and this taxonomic impediment needs to be overcome in order to make any accurate judgements about the abundances of the two species. Recreational fishers may also have had an impact on this species in the past. Recently, an in-possession limit of two wobbegong sharks per person was introduced for recreational fishers in NSW (http://www.fisheries.nsw.gov.au/). This new regulation may help to alleviate any adverse affects caused by recreational fishing practices.

References:
AFMA logbook data, unpublished; Anon., 1992; Coleman, 1980; Compagno, 1984; Grant, 1978; Last and Stevens, 1994; Lieske and Myers, 1994; M. Tanner (NSW Fisheries), pers. comms. 1999-2000.

Websites:
http://www.fisheries.nsw.gov.au/ (NSW Fisheries homepage)

Banded Wobbegong

Family Name:	Orectolobidae
Scientific Name:	*Orectolobus ornatus* (De Vis, 1883)
Conservation Status:	Data Deficient

Australian Synonyms:
Orectolobus devisi Ogilby, 1916
Orectolobus ornatus halei Whitley, 1940

Taxonomic Problems:
Often confused with *Orectolobus maculatus,* especially live specimens viewed underwater.

Alternative Common Names:
Ornate wobbegong; carpet shark; gulf wobbegong

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Orectolobus ornatus is known from Indonesia, Papua New Guinea (PNG) and Australia; records for Japan are doubtful. It has been recorded locally from tropical eastern Australia southwards to Flinders Island in Bass Strait (Last and Stevens, 1994) and north-westwards to Shark Bay, Western Australia (Hutchins, 1990).

Museum Records - 75 specimens (Standard Length embryos to 1.77m), collected from a depth range of 0-117m, and ranging in geographical distribution from Port Douglas (16^{o}32'S), Qld southwards to Port Phillip Bay (38^{o}14'S, 144^{o}39'E), Victoria and north-westwards to Shark Bay (25^{o}21'S), WA. There is also one record from Port Moresby, PNG. Specimens were collected between circa 1888 and 1997.

Habitat:
Orectolobus ornatus is a common inshore bottom-dwelling shark of continental waters, that is found on algal-covered rocky reef areas and coral reefs (Compagno, 1984). It occurs inshore on the continental shelf to at least 100m depth (Last and Stevens, 1994) and is also known from around offshore islands. It appears to prefer clear-water reefs (Kuiter, 1993).

Biology and Behaviour:
The biology of this species is poorly known, but others in the family are ovoviviparous and have litters of 20 or more young. The small size at maturity of some male specimens is unusual (Last and Stevens, 1994). The young are approximately 20cm in length at birth. *Orectolobus ornatus* occurs as solitary individuals or in aggregations, and is often found in clearer water than the closely related *Orectolobus maculatus* (Lieske and Myers, 1994). *Orectolobus ornatus* is primarily a nocturnal feeder, preying on bottom invertebrates and fishes (Last and Stevens, 1994).

Size:
Attains about 300cm (Kuiter, 1993). Born at 20cm and normally matures at about 175cm, but a Queensland male was found to be mature at 63cm (Last and Stevens, 1994). One specimen 2.35m in length weighed 73kg (Hutchins and Swainston, 1986).

Evidence for Decline:
Commercial and recreational fishing may be contributing to a decline of this species, but this has not yet been unequivocally demonstrated. It has tough, attractively patterned skin that makes good leather. Small quantities are taken as a bycatch in the Western Australian shark fishery and by dropline off NSW. A survey conducted by The Ecology Lab (1991-2) in the Seal Rocks area of northern NSW shows evidence of site-attachment for wobbegongs. This suggests that wobbegongs may be territorial and thus particularly

susceptible to fishing pressure. They do not appear to migrate to different areas for breeding purposes, although further work is necessary in this area.

Australian Marine Protected Areas in Which the Species Occurs:
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW
Solitary Islands Marine Park, north of Coffs Harbour, NSW
Possibly also occurs in the following areas:
Shark Bay Marine Park, WA (unconfirmed)
Hamelin Pool Marine Nature Reserve, WA (unconfirmed)

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More information is necessary to determine the status of this species, and to validate any perceived declines. It is recommended that it be assigned the above status, adopting the IUCN categories.

Threatening Processes:
Commercial fishing by a variety of methods is potentially threatening this species in southern Australia waters. This species is taken in a number of Commonwealth fisheries including the GABTF, the SETF, the SENTF and the SSF (AFMA logbook data, unpublished). It is also taken in a number of State managed fisheries such as the NSW dropline fishery (M. Tanner, pers. comm.) and the Western Australian (Temperate) Shark Fishery (Simpfendorfer, 1999a). Most of the above methods take this species as a bycatch, but like many bycatch species it is nonetheless often utilised. Recreational fishers may have a minor impact on this species.

Critical Habitats:
Algal-covered rocky and coral reefs may be of importance to this species.

Recovery Objectives/Management Actions Required:
There is a paucity of information on size/age structures, sex ratios, breeding habits, possible migrations and population genetics of wobbegongs. Further work in these areas is crucial to provide accurate data upon which to base management decisions. Catch statistics from commercial fishers in NSW waters do not currently separate *Orectolobus ornatus* and *Orectolobus maculatus*, and this taxonomic impediment needs to be overcome in order to make any accurate judgements about the abundances of the two species. Recreational fishers may have had an impact on this species in the past. Recently, an in-possession limit of two wobbegong sharks per person was introduced for recreational fishers in NSW (http://www.fisheries.nsw.gov.au/). This new regulation may help to alleviate any adverse affects caused by recreational fishing practices.

References:
AFMA logbook data, unpublished; Anon., 1992; Coleman, 1980; Compagno, 1984; Hutchins and Swainston, 1986; Hutchins, 1990; Kuiter, 1993; Last and Stevens, 1994; Lieske and Myers, 1994; M. Tanner, pers. comms. 1999-2000.

Websites:
http://www.fisheries.nsw.gov.au/ (NSW Fisheries homepage)

Whale Shark

Family Name:	Rhincodontidae
Scientific Name:	*Rhincodon typus* Smith, 1828
Conservation Status:	Data Deficient

Current Conservation Status:
In Australian waters:
Listed under the *Bonn Convention for Migratory Species* and as such is a Matter of National Environmental Significance under the *Environment Protection and Biodiversity Conservation Act 1999*

Protected species in Western Australian waters under the *Wildlife Conservation Act 1950* and the *Fish Resources Management Act 1994*

Protected Species in Tasmanian waters under the *Fisheries Regulation 1996*

ASFB Threatened Fishes Committee
1993-1999: Indeterminate or Not Evaluated

On a Global Basis:
Protected species in Republic of the Maldives, the Philippines, and on the USA Atlantic and Gulf coasts

1996 IUCN Red List of Threatened Animals
Data Deficient

2000 IUCN Red List of Threatened Species
Vulnerable (A1bd + 2d)

A USA proposal that the whale shark be listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), submitted for consideration at the 11th Conference of the Parties to CITES in Nairobi, 10-20 April 2000, was not adopted.

The Australian Government has proposed listing the whale shark on Appendix III of CITES indicating Australia's concern for the status of this species. Such a listing would require any trade in body parts from this species anywhere in the world to be advised to CITES (SAG, 2000).

Distribution:
The whale shark is distributed worldwide in tropical to warm temperate seas, occurring in oceanic and coastal waters. In Australia it is known from New South Wales, Queensland, Northern Territory, Western Australia and occasionally Victoria and South Australia. (Compagno, 1984; Last and Stevens, 1994).

Museum Records - 3 specimens (Total Length to about 5m), ranging in geographical distribution from Great Detached Reef (11^{o}40’S), Qld (sight record) southwards to off Sydney (34^{o}00’S), NSW, collected between 1964 and 1965 (beach wash-ups) and 1993 (sight record). There are also CSIRO sightings (size range 4-10m, average size 7m) from Ningaloo Reef, WA in the months of March to June, and off Cairns in the Coral Sea, Qld in the months of October to December (average size about 9m) (J. Stevens, pers. comm.).

Habitat:
Rhincodon typus is an oceanic and coastal, tropical to warm-temperate pelagic shark, often seen far offshore, but coming close inshore and sometimes entering lagoons of coral atolls. It is generally encountered close to or at the surface, as single individuals or occasionally in schools or aggregations of up to hundreds of sharks (Compagno, 1984).

Biology and Behaviour:
Whale sharks are generally found in areas where the surface temperature is 21-25° C, preferably with cold water of 17° C or less upwelling into it, and salinity of 34 to 34.5 ppt. This species is highly migratory, with its movements probably being timed in relation to blooms of planktonic organisms and changes in the temperature of water masses. A commercial fishing vessel off the east coast of Taiwan harpooned a pregnant whale shark (measuring about 10.6m total length and weighing 16t) in July 1995. About 300 embryos were found in the uteri, far exceeding the largest number of embryos reported for any shark (Joung *et al*., 1996). This recent discovery indicates that the whale shark is a livebearer, with an ovoviviparous mode of development. Information about size at sexual maturity and longevity is sparse. The evidence suggests that sexual maturity in both sexes may not occur until the sharks are at least 9m in length. According to Taylor (1996), detailed and informal surveys carried out in both 1991 and 1992 demonstrated that whale sharks congregate off Ningaloo Reef from March to May, when the corals of that reef undergo mass spawning. The numbers of whale sharks rise to reach a peak about two weeks after this coral spawning. The whale shark is a suction filter feeder, and feeds on a wide variety of planktonic and nektonic organisms. These sharks consume masses of small crustaceans, and also fishes such as sardines, anchovies, mackerels and small tunas, as well as squid. The whale shark feeds at or close to the surface, and often assumes a vertical position in schools of baitfish, opening its mouth so that the baitfish can be sucked in.

Size:
The whale shark is the world's largest fish, growing to total length of at least 12m (Joung *et al*., 1996). There are few confirmed records of whale sharks of lengths between 93cm and 3m (Colman, 1997), but one was photographed in PNG (J. Stevens, pers. comm.). Animals over 3m in length are encountered worldwide. Most specimens reported in the literature are between 4 and 10m (Colman, 1997).

Evidence for Decline:
In Taiwan, the whale shark is caught commercially by harpoon; occasionally small individuals are also caught on long-lines or by set nets in coastal waters, except in the shallow seas in the north and north-west of the country. Like most commercially hunted sharks, the whale shark population around Taiwan seems to be decreasing. In the 1970s and early 1980s, it was not unusual for fishermen to catch 30 to 100 whale sharks in one season in the Peng Hu area, a group of over 60 islands off the south-west coast of Taiwan. By the late 1980s, some seasons produced less than 10 whale sharks. According to records from An-Ping Harbour (a major landing site for whale sharks about 80 miles south-east of the Peng-Hu Islands), more than 70 whale sharks were caught in 1992, but only 2 in 1993 and 14 in 1994. In 1996, whale shark meat sold for 400 New Taiwanese Dollars per kilogram, which is the highest price for the flesh of any commercial shark species. Considering that the quantity of meat obtained from even a small whale shark is tremendous, the high price makes it worthwhile for commercial fishermen to continue targeting this species (Joung *et al*., 1996). In the past, harpoon fisheries have been reported from India, Pakistan, Indonesia and Iraq. A seasonal (April to May) fishery existed in the Philippines, where 90 sharks were taken during the 1996 season (Colman, 1997). This species is now protected in Philippines waters. The whale shark may also be taken in China, and has been captured and utilised in Senegal; it is eaten either fresh or dried and salted, and the oil is used to treat boat hulls in Pakistan (Compagno, 1984). Other uses of whale shark products are for the manufacture of shoe polish and as a treatment for some skin diseases. The processing of whale shark fins and fin rays has been reported in India, at least partly to supply the growing external demand for whale shark fins and meat (Hanfee, 1998).

Australian Marine Protected Areas in Which the Species Occurs:
Ningaloo Marine Park, WA
Great Barrier Reef Marine Park, Qld
Possibly occurs in the following areas:
Solitary Islands Marine Park, northern NSW
Lord Howe Island Marine Park, Tasman Sea

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
Current information on *Rhincodon typus* is inadequate to enable an estimate of abundance to be made for this widespread species (Norman, in prep.). However, this species is captured in significant numbers by directed (and bycatch) fisheries in South East Asia, which, if allowed to continue, could lead to significant declines in its numbers. There is some evidence that they may move very long distances (e.g. across the Pacific), so heavy fishing in Asia (and other areas) may directly impact global populations (C.

Simpfendorfer, pers. comm.). It is recommended that, until more accurate population studies are undertaken, the whale shark should be assigned the above status, adopting the IUCN categories. Increased protection and bans on fishing would help to alleviate the pressures on whale shark populations.

Threatening Processes:
Targeted fishing of this species in South East Asian waters is a potential threat to its survival.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
The large size, free-swimming epipelagic nature, and sporadic appearance of whale sharks create numerous technical and methodological problems, making the study of these animals intrinsically difficult (Colman, 1997). Population studies require large sample sizes and this is a major problem when working with rarely encountered species such as the whale shark, especially if individuals cannot be captured or restrained (Colman, 1997). Ongoing research on this species on a worldwide basis is necessary to accurately assess population structures, including longevity and age/size at maturity, sex ratios, population genetics, and migrations.

References:
AFMA, 2000g; Camhi *et al*., 1998; Colman, 1997; Compagno, 1984; Hanfee, 1998; Joung *et al*., 1996; Last and Stevens, 1994; Norman, in prep.; C. Simpfendorfer, pers. comm. 8/1999; Shark Advisory Group (SAG), 2000; J. Stevens, pers. comm. 3/2000; Taylor, 1996.

FAMILY TRIAKIDAE: HOUND SHARKS

Hound sharks are small to medium sized sharks (maximum length of 1.7m in Australian waters and 2.4m worldwide) with spindle-shaped bodies, ventrally placed mouths, oval shaped eyes with nictitating membranes, spiracles, five pairs of gill slits, two spineless dorsal fins and an anal fin (Last and Stevens, 1994; Nelson, 1994). They differ from other similar looking sharks (i.e. the whaler sharks Carcharhinidae and the weasel sharks Hemigaleidae) in that they have a spiral intestinal valve and lack precaudal pits (Last and Stevens, 1994).

The family Triakidae contains 34 species and nine genera, of which six genera and nine species are known to occur in Australian waters. Most Australian species have restricted distributions, but at least three of the nine locally occurring species have distributions extending outside of Australia (Last and Stevens, 1994). Some species in this family have formed the basis for important commercial fisheries, both in Australia (e.g. school shark and whiskery shark) and overseas (e.g. school shark). Hound sharks are caught by various methods such as with linefishing gear, gillnets, set bottom nets or trawls (Compagno, 1984). They are primarily utilised for their meat, but have also been used for their liver oil, fishmeal and as a base for shark-fin soup (Compagno, 1984).

Hound sharks are generally found in demersal habitats on continental and insular shelves and upper slopes (Last and Stevens, 1994). Many species occur in sandy, muddy or rocky inshore habitats, including enclosed bays, though none can tolerate freshwater for extended periods (Compagno, 1984). Some species (e.g. school shark) undertake extended migrations, probably associated with feeding and/or breeding. Hound sharks feed on small teleost fishes and invertebrates such as crustaceans and cephalopods (Last and Stevens; Compagno, 1984). None of the species are particularly dangerous to humans. Reproduction is ovoviviparous or viviparous with a yolk-sac placenta (Last and Stevens, 1994), and litter sizes vary from 1-52 young (Compagno, 1984).

Eleven triakid species are listed on the 2000 IUCN Red List of Threatened Species, four of which occur in Australian waters. The whiskery shark *Furgaleus macki* and the gummy shark *Mustelus antarcticus* are listed as Lower Risk (conservation dependent), and the pencil shark (or blacktip topeshark) *Hypogaleus hyugaensis* is listed as Lower Risk (near threatened). The school shark is listed as Vulnerable worldwide, but the Australasian subpopulation is classified as Lower Risk (conservation dependent) (http://www.redlist.org/). Two species, the whiskery shark and the school shark, are included here and discussed in some detail.

References:
Compagno, 1984; Last and Stevens, 1994; Nelson, 1994.

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

Whiskery shark

Family Name:	Triakidae
Scientific Name:	*Furgaleus macki* (Whitley, 1943)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Fur macki Whitley, 1943
Fur ventralis Whitley, 1943
Furgaleus ventralis Whitley, 1951

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Lower Risk (conservation dependent)

No ASFB Listing

Distribution:
Furgaleus macki is restricted to the continental shelf and upper slope waters of southern Australia. Its range extends south and east from North West Cape in Western Australia to eastern Victoria and northern Tasmania (Simpfendorfer, 1999a; Simpfendorfer, in prep. a). It is rare off Victoria and Tasmania (Last and Stevens, 1994).

Museum Records - 147 specimens (Standard Length 48.7-125cm), collected from depths to 62m, ranging in geographical distribution from Wynyard (40°59'S, 145°43'E), north-western Tasmania north-westwards to Rottnest Island (32°S), WA, collected between 1943 and 1998.

Habitat:
Furgaleus macki lives on or near the bottom to a depth of 220m (Last and Stevens, 1994).

Biology and Behaviour:
The reproductive mode of *Furgaleus macki* is ovoviviparity. Litter sizes range from 4 to 28, with an average of 19 (Simpfendorfer, in prep. a). Both sexes mature at about 120cm (Last and Stevens, 1994). Fifty per cent of males are mature at 107cm Fork Length (FL), and 50% of females are mature at 112cm FL (Simpfendorfer, in prep. a). In the south-west of Western Australia, mating probably occurs in late spring, with ovulation in February, March and early April. Females may store spermatozoa in the oviducal glands during summer prior to ovulation. The gestation period is approximately 7 months, with the young born at 22 to 27cm in early spring. Every two years individual females give birth (Simpfendorfer, in prep. a). A tagging study in the waters off WA found that this species is capable of moving distances of up to 350km in relatively short periods of time. However, most recaptures were within 50km of release (Simpfendorfer, in prep. a). Age and growth estimates using vertebrae and tagging show that males mature at 4.5 years and females mature at 6.5 years (Simpfendorfer, in prep. a). The oldest reliably aged animals have been a 10.5 year old male and a 11.5 year old female, although older individuals are likely to occur (Simpfendorfer, in prep. a), probably to a maximum of 20 years (Simpfendorfer, 1999a). *Furgaleus macki* is primarily a benthic cephalopod (particularly octopus) feeder, although teleost fish and crustaceans are also taken (Last and Stevens, 1994).

Size:
Furgaleus macki is born at about 25cm in length and attains 160cm (Last and Stevens, 1994).

Evidence for Decline:
Furgaleus macki is exploited throughout much of its range by gillnet and longline fishing. Catches in south-eastern Australia are currently small (Simpfendorfer, in prep. a) in comparison to WA, totalling about 40t

and 20t for the years 1998 and 1999, respectively. All catches in south-eastern Australia are taken from the SENT and the SSF (AFMA, 2000g). There are no historical data for this area and it is unknown if their abundance has always been low, or whether commercial fishing since the 1930s has affected the population (Simpfendorfer, in prep. a). Since the mid 1970s *Furgaleus macki* has been a major target species for demersal gillnet fishers in south-western Australia. Annual catches are currently around 250t (live weight), but during the 1980s reached as high as 600t. The Fisheries Department of WA, using age-structured population models, regularly undertakes assessment of the status of the *Furgaleus macki* stock in Western Australian waters. The best estimates of total and mature biomass in 1997/98 were 38.8% and 23.0% of virgin stock, respectively (Simpfendorfer *et al*., 2000). The 95% confidence intervals for total biomass were 22.7 to 47.2%, and for mature biomass were 13.4 to 36.4% (Simpfendorfer *et al*., 2000). Other commercial fishing methods, and recreational fishing, catch very few of this species and do not present a significant threat to the stock (Simpfendorfer, in prep. a).

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Commercial fishing in south-western Australia has reduced the biomass of *Furgaleus macki* significantly. However, a management plan to ensure the survival of the species and the long-term economic viability of the fishery has been implemented. Given the high level of research and management in this fishery it is likely that there is no extinction risk for this species in the foreseeable future (Simpfendorfer, in prep. a).

Threatening Processes:
Targeted commercial fishing in south-western Australia (and to a lesser extent south-eastern Australia) is currently the main threat to the survival of this species.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
The target biomass level for the stock is 40% of the virgin biomass (Simpfendorfer, in prep. a). To achieve this biomass target a management plan including effort reductions to 50% of the 1996 level of fishing effort were implemented in mid-1997 (Simpfendorfer, in prep. a). At this level of effort the risk assessment indicates a greater than 70% chance of achieving the biomass target by the year 2010 (Simpfendorfer, in prep. a). Risk analysis indicates that there is a need to substantially reduce commercial catches if the target set by the management committee is to be met (Simpfendorfer *et al*., 2000).

References:
AFMA, 2000g; Last and Stevens, 1994; Simpfendorfer, 1999a; Simpfendorfer, in prep. a; Simpfendorfer *et al*., 2000.

School Shark

Family Name:	Triakidae
Scientific Name:	*Galeorhinus galeus* (Linnaeus, 1758)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Galeus australis Macleay, 1881
Galeorhinus australis Ogilby, 1898
Carcharhinus cyrano Whitley, 1930
Notogaleus australis Whitley, 1931

Alternative Common Names:
Snapper shark (Australia and New Zealand); tope (British Isles); vitamin shark (Uruguay and Argentina); soupfin shark (California to British Columbia, also South Africa).

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Animals
Vulnerable (A1bd) globally; Lower Risk (conservation dependent) in Australasia

No ASFB Listing

Distribution:
Widespread in temperate waters of the eastern North Atlantic, western South Atlantic, eastern North and South Pacific, and off South Africa, New Zealand and southern Australia. In Australia, this species occurs from Moreton Bay (southern Queensland) to Perth (southern Western Australia), including Lord Howe Island and Tasmania (Last and Stevens, 1994), but is most abundant from eastern Victoria and Tasmania to the western side of the Great Australian Bight (Stevens and West, 1997).

Museum Records - 50 specimens (Standard Length 21.5-83cm), collected from a depth range of 29-49m, ranging in geographical distribution from off Port Stephens (32^{o} S), NSW, southwards to central Bass Strait (39^{o}56'S, 144^{o}48'S), Victoria and north-westwards to Rottnest Island (32^{o}S, 115^{o}30'E), WA. Specimens were collected between 1885 and 1973.

Habitat:
This species occurs demersally and in midwater over the continental shelf and upper slope from inshore to at least 600m and probably deeper. In Australia, it is predominantly taken in depths of less than 200m (Yearsley *et al*., 1999).

Biology and Behaviour:
Galeorhinus galeus often occurs in small schools composed predominantly of one sex and size group (Last and Stevens, 1994). It makes long migrations associated with feeding and reproduction (Last and Stevens, 1994; J. Stevens, pers. comm.). One individual tagged in New Zealand travelled nearly 5000km before being recaptured in Australian waters (Hurst *et al*., 1999a and b). Recent research in New Zealand suggests that school shark fisheries in that country should be treated as one stock with a relatively high emigration rate to Australia (Hurst *et al*., 1999a). Male Australian school sharks mature at over eight years of age and mate soon after (Compagno, 1984), whereas females do not mature until at least eight to ten years of age (Last and Stevens, 1994). School sharks reproduce by ovoviviparity and Australian school sharks produce litters of 15-43 pups in December and January (off southern Australia) after a gestation period of about twelve months (Last and Stevens, 1994). This species reproduces at one to three year intervals (Stevens, in prep.). In Australian waters, schools of this species are narrowly size and sex related, with those of yearling juveniles ranging into more estuarine situations than older juveniles and adults (except for pupping females). Off south-eastern Australia, the average size of school sharks in catches increases from east to west (from

eastern Bass Strait to South Australia), and also off southern Tasmania, indicating a gradation of higher numbers of adults westward and southward, and also the impact of differences in gill-net mesh size. In south-eastern Australia, pregnant females move into shallow, partly enclosed bays and estuaries in late spring and early summer and after dropping their young depart to offshore feeding grounds. Most young of the year depart the pupping grounds in late summer and move offshore. Most sharks probably return to the bays and estuaries of their birth the following spring, though some juveniles may switch to adjacent bays and estuaries and others may remain in an estuary for up to two years before departing. From late summer to winter schools of adult sharks move either to deeper waters at the edge of the continental shelf in the Bass Strait region, or to warmer waters off South Australia and New South Wales. At the edge of the shelf copulation occurs. Adult sharks then travel southwards and shorewards in spring to converge along the coastlines, where they feed in schools. About half of all adult females in these schools may be pregnant during the breeding season, and these visit the pupping grounds to renew the cycle (Compagno, 1984). Large aggregations of neonatal and young juveniles of this species are known to currently occur in the south-eastern region of Westernport Bay. The Geelong Arm of Port Phillip Bay provided important nurseries in the past, but numbers there have since been seriously reduced, possibly because of habitat change (Walker, 2000). From feeding studies carried out in southern Australia, school sharks eat mainly teleost fishes and cephalopods (Last and Stevens, 1994). Young sharks take more invertebrate prey than adults, and in some areas crabs and squid are also important prey items (Compagno, 1984).

Size:
The school shark is born at a length of 30cm and attains a maximum length of about 175cm in south-eastern Australian waters. Males and females mature at about 120cm and 130cm, respectively (Last and Stevens, 1994). This species grows to a weight of 33kg and is commonly marketed at 100-130cm and 6-12kg (Yearsley *et al*., 1999).

Evidence for Decline:
The school shark, which has been exploited since the mid-1920s, is an important component of the southern Australian shark fishery (SSF) (Last and Stevens, 1994), with annual catches occasionally exceeding 2000t (Yearsley *et al*., 1999). Between 1970 and 1998, catches of this species have varied from a maximum of 2595t in 1970 to a low of 579t in 1998 (Walker *et al*., 1999). Catches from Commonwealth fisheries in 1999 totalled 224t (AFMA, 2000g), while catches from state waters in South Australia (1999), Tasmania (1998-99) and Victoria (1998-99) totalled 25.4t (PIRSA, 2000), 31.4t (TDPIWE), and 0.02t (Walker, 2000), respectively. Catches have been declining since 1994. Of A$15.6 million paid to fishers for the total catch from the SSF fishery during 1994, school shark contributed A$5.6 million (Punt and Walker, 1998). It is marketed fresh as headed and gutted carcasses and sold by fish-and-chip shops as flake (Yearsley *et al*., 1999). Capture methods in the SSF include bottom-set gillnets and longlines. This species is taken as bycatch in demersal trawl and Danish seine nets (Yearsley *et al*., 1999). Recreational gillnetters in Tasmania have also taken this species in considerable numbers in the past (Williams and Schaap, 1992). Large fisheries for this species existed off California and South Africa in the 1930s and 1940s, both of which went through similar cycles of growth and collapse (Compagno, 1984). In New Zealand, school sharks have been exploited since the early 1940s, catches peaked at over 4700t live weight in 1983-84; landings for the fiscal years 1995-98 stabilised at around 3000t, slightly below the TAC of 3100t (Annala *et al*., 1999). Stock assessments of school sharks have been undertaken regularly. The most recent assessment (Punt *et al*., 2000) suggested that the pup production rate was between 12 and 18% of the pre-exploited population. As school shark nursery areas are often located in inshore bays and estuaries, they are vulnerable to the effects of habitat destruction (e.g. loss of seagrass), recreational fishing pressure and pollution from the increased human populations often associated with these areas (Stevens, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
There are a number of prescribed shark nursery waters in Tasmania where the taking of school shark is prohibited (TDPIWE, 2000). The school shark is protected in most of its known nursery grounds (A. Punt, pers. comm.).

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Environment Australia received a nomination in 1997 to list the school shark as a vulnerable species. A decision was made in February 1998 that the school shark should not be listed, but that the species should be regularly monitored and AFMA should provide an annual report on stock status (McLoughlin *et al*., 1998). Based on assessments made in relation to current Australian stocks, it is recommended that the status

of *Galeorhinus galeus* be regarded as Lower Risk (conservation dependent), adopting the IUCN categories. The school shark was previously managed through input controls (gear restrictions, etc.), but it is now managed by a quota system. The allowable maximum mesh size was reduced to 6.5 inches in 1997 (A. Punt, pers. comm) and the minimum mesh size is 6 inches (K. Dunn, pers. comm.; AFMA, 2000d). The minimum legal size for school shark in Commonwealth and State waters (commercial and recreational fishing) is 40cm partial length (fifth gill slit to base of caudal fin) (Walker, 1999), except for Tasmanian waters, where the minimum partial length is 45cm and the minimum whole length is 75cm (TDPIWE). Further catch reductions are being phased in for the southern Australian shark fishery, and along with ongoing stock assessment and continual review of management arrangements, the conservation of the school shark in Australian waters should be ensured.

Threatening Processes:
Commercial fishing pressure exerted on this species over many decades potentially threatens the survival of its breeding populations. Based on the historical catches in some Tasmanian estuaries, recreational fishing is also a minor threat to the species. Habitat degradation of inshore nursery areas is a potential threat to juveniles and breeding females in southeastern Australian waters.

Critical Habitats:
Inshore bays and estuaries in southern Australia which may act as nursery areas for this species are prone to fishing pressures and habitat degradation from the often high human populations associated with these areas.

Recovery Objectives/Management Actions Required:
A catch monitoring system has been recently implemented for the SSF and the South East Trawl Fishery (Punt, pers. comm 12/1999). Reliable catch data are important to the assessment (and management) of the resource. A discard monitoring system is needed to directly track the losses of school sharks in other fisheries. Such a program would allow management information needed to implement discard mortality controls, should discards increase to levels detrimental to the stock (Deriso, 1996). Given that the school shark has a low reproductive potential and that the distribution of juveniles is restricted to limited sheltered habitats, the protection of these juveniles from fishing pressure is a sound precaution (Williams and Schaap, 1992). The management of school sharks in Commonwealth waters adjacent to Tasmania, Victoria and South Australia is now the responsibility of the Commonwealth (i.e. AFMA) after the signing of an Offshore Constitutional Settlement (OCS) Agreement on 1 January 2001. The stock can now be managed in its entirety by the above states (L. Arney, pers. comm.). Management of school sharks under Commonwealth jurisdiction also commenced under an Individual Transferable Quota system on 1 January 2001 (AFMA, 2000d).

References:
AFMA, 2000d; AFMA, 2000g; Annala *et al*., 1999; L. Arney (AFMA), pers. comm. 1/2001; Camhi *et al*., 1998; Compagno, 1984; Deriso, 1996; K. Dunn (AFMA), pers. comm. 1/2000; Hurst *et al*., 1999a; Last and Stevens, 1994; McLoughlin *et al*., 1998; PIRSA, 2000; Punt and Walker, 1998; Punt *et. al*., 2000; A. Punt, pers. comms. 1999-2000; Stevens (in prep.); J. Stevens, pers. comm. 3/2000; Stevens and West, 1997; TDPIWE, 2000; Walker, 1999; Walker *et al*., 1999; Walker, 2000; Williams and Schaap, 1992; Yearsley *et al*., 1999.

FAMILY CARCHARHINIDAE: WHALER SHARKS

Of the approximately 50 species of carcharhinids known worldwide, about 31 are found in Australian waters. Most species are pelagic in tropical and warm-temperate areas; a few are oceanic, while at least two can penetrate far into fresh water (Last and Stevens, 1994). Many of the species are very similar, and accurate identification can be difficult. Identifying features are often subtle, and the most important of these are tooth shape and number, position of the dorsal fins, colour and the presence or absence of an interdorsal ridge (Last and Stevens, 1994).

Whalers are typically viviparous, with a yolk-sac placenta (the ovoviviparous tiger shark is an exception). The family contains three (bull, tiger and oceanic whitetip) of the four shark species (the other is the white shark) most dangerous to humans (Last and Stevens, 1994).

Carcharhinid sharks make up a significant component of the total shark catch in Australia and many species are commercially important in terms of adding value to Australian fisheries production. In WA waters, average landed weights of whaler sharks by commercial fishers have ranged between 84t and 191t per year over the period 1994-95 to 1997-98 (http://www.dpi.qld.gov.au/fishweb). These figures do not include dusky shark (*Carcharhinus obscurus*) catches, of which over 425t were landed in WA in 1998/99 alone. In the NT, catches of 'blacktip sharks' (which include at least three species - *Carcharhinus limbatus, C. sorrah* and *C. tilstoni*) have ranged between 39 and 67t per year for the years 1994 to 1998 (NT DPI&F website). Shark (i.e. Carcharhinidae) catches in Queensland are made up of several species taken by gillnet and hook and line along the entire Queensland coastline (http://www.dpi.qld.gov.au/fishweb).

Additionally, shark control programs in Queensland and NSW waters catch and kill hundreds of carcharhinid sharks per year (when numbers are combined). Paterson (1990) noted that Queensland *Carcharhinus* catches from the shark control program had declined in number from its onset in 1962. However, another carcharhinid, the tiger shark *Galeocerdo cuvier*, had increased in numbers in the same period (Paterson, 1990). The above statistics may demonstrate that there is still much to be learnt about the distribution, abundance, behaviour, ecology and biology of shark species, and particularly of the family Carcharhinidae.

Twenty carcharhinid species are listed on the 2000 IUCN Red List of Threatened Species, fourteen of which occur in Australian waters (http://www.redlist.org/). Five of these species are included and discussed in some detail here; the common blacktip shark *Carcharhinus limbatus*, the dusky shark *Carcharhinus obscurus*, the sandbar shark *Carcharhinus plumbeus,* and the two river sharks *Glyphis* spp.

References:

Last and Stevens, 1994; Paterson, 1990

Websites:
http://www.dpi.qld.gov.au/fishweb (Queensland Fisheries Service Website homepage)
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

Common Blacktip Shark

Family Name:	Carcharhinidae
Scientific Name:	*Carcharhinus limbatus* (Valenciennes, 1839)
Conservation Status:	Data Deficient

Australian Synonyms:
Galeolamna pleurotaenia tilstoni Whitley, 1950

Taxonomic Problems:
This species is very similar to, and has only recently been separated from, the Australian blacktip shark *Carcharhinus tilstoni* (Last and Stevens, 1994). It can only be reliably separated from the latter by the analysis of enzymes and vertebral counts (Last and Stevens, 1994; Stevens, 1984).

Alternative Common Name:
Blacktip whaler

Current Conservation Status:
<u>No 1996 IUCN Listing</u>

<u>2000 IUCN Red List of Threatened Species</u>
Lower Risk (near threatened) globally; Vulnerable (A1bcd + 2cd) in NW Atlantic

<u>No ASFB Listing</u>

Distribution:
Carcharhinus limbatus has a cosmopolitan distribution in tropical and warm temperate seas. In Australia, it occurs in tropical waters southwards to Sydney (NSW) on the east coast; its southern limit on the west coast is uncertain (Last and Stevens, 1994).

<u>Museum Records</u> - 16 specimens (Standard Length 12-158.5cm), collected from depths of 0-94m, ranging in geographical distribution from the North West Shelf (19°S), WA northwards to the Arafura Sea (11°02'S, 133°06'E), NT and eastwards to Lizard Island (14°40'S), Qld, collected between 1941 and 1994.

Habitat:
Carcharhinus limbatus is pelagic over continental and insular shelves, being commonly found close inshore, but occasionally caught far offshore (Last and Stevens, 1994).

Biology and Behaviour:
Carcharhinus limbatus is born at a length of between 40-70cm. Size at maturity shows considerable geographic variation, with males maturing between 135-180cm and females between 120-190cm (Last and Stevens, 1994). This species is an active, fast-swimming shark that occasionally leaps out of the water, apparently while feeding on small fish. It has been reported to occur in large aggregations, although it is not very common in Australian waters (Last and Stevens, 1994). Age at sexual maturity is variable, but averages 6-7 years for females and 4-5 years for males. Reproduction is viviparous and the average reproductive age for females is 8 years. The gestation period is 11-12 months, and females give birth to 4-11 young (average 4-6) every two years. Maximum longevity is unknown (Burgess and Branstetter, in prep.), but is likely to be at least 10-15 years.

Size:
Carcharhinus limbatus attains a maximum length of 250cm (Last and Stevens, 1994).

Evidence for Decline:
Commercial fishers in NT waters target blacktip sharks. Three *Carcharhinus* species (*C. limbatus, C. sorrah* and *C. tilstoni*) make up the catches, which have ranged between 392t and 678t (retained whole weight) per

year over the period from 1995 to 1998 (NTDPI&F website). However, we were unable to obtain statistics on the breakdown of each species from NTDPI&F.

Reported whole weights of blacktip sharks[6] retained by commercial fishers in the NT 1995-1998

Calendar year	Catch (kg)
1995	616,721
1996	678,643
1997	436,089
1998	392,524

This species, along with *Carcharhinus plumbeus*, is one of the primary target species of directed shark fisheries in the US Gulf of Mexico and Eastern Seaboard of the USA (Grace and Henwood, 1997). This species is frequently captured in recreational and commercial fisheries worldwide, its meat being well regarded and its fins highly marketable. It frequents inshore waters as adults and has inshore nursery areas (Burgess and Branstetter, in prep.). It makes up a minor component in the catch of the northern Australian gillnet fishery. Elsewhere it is used for its meat, hide and liver oil (Last and Stevens, 1994). It is understood that this species is taken in Indonesian waters, but the degree of exploitation in this area is unknown.

Australian Marine Protected Areas in Which the Species Occurs:
As this species is pelagic and wide ranging, it is not likely to be afforded much protection by MPAs in Australian waters.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
There is insufficient evidence of any declines in Australian waters to warrant a threatened status for this species, and at this stage it is recommended to assign it the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Commercial fishing, mainly in northern Australia, is a potential threat to populations of this species in Australian waters.

Critical Habitats:
None identified.

Recovery Objectives / Management Actions Required:
Further analysis of NTDPI&F data is necessary to attempt to calculate the catches of individual species of blacktip sharks. Such species-specific data is necessary to assess any impacts of the NT shark fishery on each individual species. It would be desirable to attempt to calculate the combined catches of *Carcharhinus limbatus* from all fisheries in Australian waters and overseas waters alike. To do this, the taxonomic impediment of the identification of many *Carcharhinus* species needs to be overcome, perhaps by producing suitable identification guides for use by fishers in distinguishing between the numerous species.

References:
Burgess and Branstetter, in prep.; Last and Stevens, 1994; Grace and Henwood, 1997; Paxton *et al.*, 1989; Stevens, 1984; S. Wilmore, pers. comm. 9/2000.

Websites:
http://www.nt.gov.au/dpif/ (Northern Territory Department of Primary Industries and Fisheries homepage)

[6] Source – NTDPI&F website. Catches include three species: *Carcharhinus limbatus, C. sorrah* and *C. tilstoni* (S. Wilmore, pers. comm. 9/2000)

Dusky Shark

Family Name:	Carcharhinidae
Scientific Name:	*Carcharhinus obscurus* (Lesueur, 1818)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Galeolamna macrurus Ramsay and Ogilby, 1887
Galeolamna (Galeolamnoides) eblis Whitley, 1944

Alternative Common Names:
Black whaler; bronze whaler. The true bronze whaler shark is scientifically known as *Carcharhinus brachyurus* (Günther 1870).

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Lower Risk (near threatened) globally; Vulnerable (A1abd) in NW Atlantic and Gulf of Mexico

No ASFB Listing

Distribution:
Carcharhinus obscurus has a cosmopolitan, but patchy, distribution in tropical and warm temperate seas. It occurs throughout Australian waters, but it is rare off southern Tasmania (Last and Stevens, 1994), with only one record from that area (J. Stevens, pers. comm.).

Museum Records - 25 specimens (Standard Length 85-123cm), collected from depths of 0-50m, ranging in geographical distribution from the Swain Reefs (21°30'S), Qld southwards to the Crookhaven River (34°56'S), NSW on the east coast of Australia. On the west coast of Australia, specimens have been collected from the Abrolhos Islands (28° 54' S) southwards to Albany (35°08'S), WA. Specimens were collected between circa 1887 and 1999.

Habitat:
Carcharhinus obscurus occurs over continental and insular shelves from the surf zone to adjacent oceanic waters, and is found from the surface down to depths of about 400m (Last and Stevens, 1994). As it apparently avoids areas of low salinity, it does not enter estuaries (Compagno, 1984; Kailola, 1993).

Biology and Behaviour:
Carcharhinus obscurus is born at lengths of between 70-100cm (mostly at about 95cm in Australia) and both sexes mature at about 280cm total length. Tagging studies have shown that this species makes distinct seasonal migrations over parts of its range. In Australian waters, it is known that adolescents and adults appear to move inshore into shallower water (less than 80m depth) off Western Australia during summer and autumn (Last and Stevens, 1994). Dusky sharks may breed in North West Shelf waters during winter and migrate southwards, giving birth to their young off the south-west off WA during autumn and winter (McAuley, pers. comm). Despite a small number of tagged juvenile dusky sharks being recaptured in South Australia, the young probably remain in the southern waters of WA for a number of years before migrating northwards (McAuley, pers. comm). Recent research suggests that in Western Australia female dusky sharks reach maturity at approximately 250cm fork length (about 24 years of age) and males at approximately 240cm fork length (22 years) (Simpfendorfer *et al.*, 1999). The dusky shark is viviparous - litter sizes vary from 3-14 - and the newborn young may occupy distinct nursery areas isolated from the rest of the population, such as inshore areas off Western Australia (Last and Stevens, 1994). Recent research suggests that the gestation period may be as long as 22-24 months and that there may be a one-year resting period between birth and mating, making the reproductive cycle at least three years long (Camhi *et al.*, in prep.). The oldest dusky shark reported from vertebral ageing studies is 37 years, although they are thought to live

to a maximum of 40-50 years (Camhi *et al.*, in prep.). From studies carried out in the South West Indian Ocean, Natanson and Kohler (1996) suggested that growth slows considerably after maturity and some sharks may live for up to 70 years. The annual rate of population increase is 2.8-5.6%, based on a two year reproductive cycle and the absence of fishing mortality (Camhi *et al.*, in prep.). Lower rates of annual population increase would be expected if a three year reproductive cycle is more accurate. The diet consists of teleost and elasmobranch fishes, as well as crustaceans and cephalopods. Dusky sharks feed throughout the water column, but are more frequently found near the bottom than at the surface (Last and Stevens, 1994). In Western Australia dusky sharks primarily eat teleosts; however, crustaceans and cephalopods also appear to be common prey (McAuley, pers. comm).

Size:
Carcharhinus obscurus attains a size of 365cm (Last and Stevens, 1994) and a maximum weight of over 320kg (Kailola *et al*., 1993), though specimens over 180kg are uncommon (Camhi *et al*., in prep.).

Evidence for Decline:
The biological characteristics of *Carcharhinus obscurus* (i.e. slow growing, late maturing, relatively few young) make it susceptible to over-exploitation, and catch rates for this species in the Western Australian shark fisheries declined during the late 1970s and early 1980s (R. McAuley, pers. comm.). The decline of this species in US waters can be partly attributed to its fins fetching high prices due to their large size and high fin needle content (Camhi *et al*., in prep.). *Carcharhinus obscurus* is the primary component in the catch of the Western Australian shark fisheries. In the 1998/99 fishing season, 425t of dusky sharks were landed (27% of all sharks caught by this fishery), with an approximate value of A$2 million (R. McAuley, pers. comm.). The fishery catches primarily juveniles and the sustainability of the stock is dependent on a very low mortality (less than 4%) of adult sharks (Simpfendorfer, 1999b). There is considerable concern over the largely unreported bycatch of adult *Carcharhinus obscurus* by other fisheries in Western Australia (R. McAuley, pers. comm.). Recreational game-fishers in NSW catch this species, but due to confusion with other whaler sharks accurate numbers caught are unavailable (Pepperell, 1992). However, it is likely that this species only comprised a minor proportion (up to about 5%) of the recreational game-fish catches from the 1960s to the 1980s (see Stevens, 1984; Pepperell, 1992; Kailola *et al*., 1993). In Australia, the meat is sold fresh or frozen for human consumption (Last and Stevens, 1994), with the valuable fins being consumed domestically and exported (C. Rose, pers. comm.); elsewhere it is used for its meat, hide, fins and liver-oil (Last and Stevens, 1994). This species is mainly caught by gillnets and set lines as a component of the temperate Australian shark fisheries, and as a bycatch of demersal trawls (Yearsley *et al*., 1999). It is occasionally taken as bycatch in directed tuna and swordfish longline fisheries around Australia (J. Stevens, pers. comm.; C. Rose, pers. comm.; AFMA, 2001a) and mostly finned with the remainder of the shark being discarded (C. Rose, pers. comm. 2001a). Shark control programs in Queensland, NSW and South Africa also catch this species, although accurate catch statistics are often not available due to difficulties in distinguishing this species from other species of whaler sharks. Between May 1996 and Feb 2000, 44 dusky sharks (measuring 1.6 to 3.5m TL; comprising 28 females, 15 males and one of undetermined sex) were taken in the Queensland Shark Control Program between Cairns and the Gold Coast. Of the 44 sharks taken above, 26 and 18 were captured by drumlines and mesh nets, respectively (QDPI Shark Control Program). An unquantified number of *Carcharhinus obscurus* are also taken in northern Western Australian waters as a component of the Northern Australian Shark Fishery (Stevens, 1999).

Australian Marine Protected Areas in Which the Species Occurs:
Carcharhinus obscurus occurs in most west coast and at least some north coast MPAs in Western Australia (McAuley, pers. comm). As this species probably only passes through these areas rather than residing permanently there, they would not offer much protection. However, the area between Steep Point (approx. 26^{o} S) and the North West Cape (approx. 21^{o} 47' S) in Western Australia is closed to demersal gillnet and longline fishing, primarily to protect adult *Carcharhinus obscurus* (R. McAuley, pers. comm.).

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis
Carcharhinus obscurus is taken in significant quantities by directed commercial fisheries in Western Australian waters. It is also taken as a bycatch of other fisheries, in shark control programs and by recreational fishers, all of which contribute to the pressures placed on this species. It is recommended to assign it the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Commercial fishing, whereby this species is targeted, but also taken as bycatch, is the main threat to the species in Australian waters. Finning of this species throughout its range is a growing concern. Shark fin processors in Western Australia pay fishers $20-$30 per kg (wet weight) for the fins of this species for export to Hong Kong, and also for sale to domestic consumers (C. Rose, pers. comm.). To a lesser extent, shark control methods and recreational game fishing are also potential threats to populations in Australian waters.

Critical Habitats:
None identified at this stage. Specific areas may be important nursery and breeding grounds, but the relationship between these grounds and the habitat they provide is unclear.

Recovery Objectives / Management Actions Required:
Continual monitoring of the abundances and size structures of dusky sharks caught in the Western Australian shark fisheries is essential to provide further information on which to base precautionary management actions. Examination of the numbers of dusky sharks caught in shark control programs in Queensland and NSW may provide additional information on this species. The extent to which this species occurs in recreational game-fish catches in Australian waters would also provide more information on its abundance. Protecting the reproductive stocks of this species is a major priority in ensuring the sustainable management of the species. Fisheries Western Australia (2000) is considering introducing a maximum size limit of 2m for this species to ensure that the breeding biomass is protected.

References:
AFMA, 2001a; Camhi *et al.*, in prep.; Compagno, 1984; Fisheries Western Australia (FWA), 2000; Kailola *et al.*, 1993; B. Lane (QDPI Shark Control Program), pers. comm. 2000; Last and Stevens, 1994; R. McAuley, pers. comm. 3-4/2000; Natanson and Kohler, 1996; Pepperell, 1992; C. Rose, pers. comm. 2000; Simpfendorfer, 1999b; Simpfendorfer *et al.*, 1999; J. Stevens, pers. comm. 3/2000; Stevens, 1984; Stevens, 1999; Yearsley *et al.*, 1999.

Sandbar Shark

Family Name:	Carcharhinidae
Scientific Name:	*Carcharhinus plumbeus* (Nardo, 1827)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Carcharias stevensi Ogilby, 1911
Galeolamna dorsalis Whitley, 1944

Alternative Common Name:
Thickskin shark

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Lower Risk (near threatened) globally; Lower Risk (conservation dependent) in NW Atlantic

No ASFB Listing

Distribution:
Carcharhinus plumbeus has a cosmopolitan, but patchy, distribution in tropical and warm temperate seas. Locally, it occurs off northern Australia, but its range extends southwards to Coffs Harbour, NSW and Esperance, WA (Last and Stevens, 1994).

Museum Records - 8 specimens (SL 74cm, other specimens jaws only), collected from depths of 73-156m, ranging in geographical distribution from north of Brisbane (27°S), Qld (only east coast record) and on the west coast from Maret Island (14°24'S), southwards to off Dirk Harthog Island (26°S), WA. Specimens were collected between 1940 and 1995.

Habitat:
Carcharhinus plumbeus inhabits continental and insular shelves and adjacent deep water from the intertidal zone to a depth of 280m. It is normally found near the bottom (Last and Stevens, 1994). Parker (1999) reported adults at Julian Rocks Aquatic Reserve (off Byron Bay) and at Windarra Bank (9 nm east of Mooball, N of Cape Byron) in a depth of 40m, recording their occurrence as uncommon.

Biology and Behaviour:
Carcharhinus plumbeus is viviparous and gestation has been estimated to vary between 9 and 12 months in the western North Atlantic, South Africa, the East China Sea and Taiwan (Musick, in prep.), but the duration of the gestation period in Australian waters is unknown. In the western North Atlantic, this species makes extensive migrations of up to 2700km, but in Australian waters little is known of its movements (Last and Stevens, 1994). It is normally slow growing (western Atlantic specimens take 13 to 16 years to reach maturity and live for over 30 years) (Sminkey and Musick, 1995; Last and Stevens, 1994; Musick, in prep.). Another study in the western Atlantic by Casey and Natanson estimated that maturity was not reached until an age of 29 years (Musick, in prep.). Regardless, sandbar sharks grow slowly and mature late (longevity is likely to be at least 35 years) (Musick, in prep.). In WA, this species appears to be most common on the north and west coasts and uncommon east of Albany (R. McAuley, pers. comm.). Pregnant females have been caught in the vicinity of the North West Shelf and new-born young are caught in the south-west of the state, suggesting that this species undertakes some migration during its lifetime (R. McAuley, pers. comm.). Litter size is variable - ranging from 1-14 and averaging 5-9 outside of Australia (range of 2-10, with an average of 6.7 in a small sample size from WA) - and may be dependent in part on the size of the mother and the size at which maturity is reached in any geographical area (Musick, in prep.; R. McAuley, pers. comm.). Females apparently give birth every two years, which equates to an average annual fecundity of 4-6, assuming litter sizes of 8-13 young (Musick, in prep.). The annual rate of population increase has been

estimated as 2.5 to 11.9% or a maximum of 5.2% if maturity is reached at 29 years (Musick, in prep.). This species feeds mainly on fishes, as well as cephalopods and crustaceans (Last and Stevens, 1994).

Size:
Carcharhinus plumbeus is born at lengths of 55-65cm (up to 75cm in some localities) and attains 240cm. Its size at maturity is regionally variable; in Australia, both sexes mature at about 155cm, elsewhere males mature between 130 and 180cm and females mature between 145 and 185cm (Last and Stevens, 1994).

Evidence for Decline:
The catch of *Carcharhinus plumbeus* in the Western Australian shark fishery has risen dramatically over the last five years (R. McAuley, pers. comm.). In the 1998/99 fishing season, 250t of sandbar sharks were landed (16% of all sharks landed by the fishery), a 30% increase on the 1997/98 catch, with an approximate value of A$553,000 (R. McAuley, pers. comm.). Over 11.3t of this species was reported as being retained as bycatch of the tuna longline fishery in Australian waters in 1998, and over 8.5t were retained from the same fishery in 1999 (AFMA logbook data, unpublished). In northern WA waters, 17t of this species were caught in the KGBF and the WAFJA in 1996 (Stevens, 1999). No stock assessment is currently available for this species in WA, although due to its biological characteristics (slow growth, low reproductive rate, etc.) it is susceptible to over-exploitation, and the level of unreported bycatch is also a cause for concern (McAuley pers. comm). Shark control programs in Queensland, NSW and South Africa also catch this species, although accurate catch statistics are often not available due to difficulties in distinguishing this species from other species of whaler sharks. Between September 1996 and February 2000, 25 sandbar sharks (measuring 1.1-2.9m TL, comprising 19 females and 6 males) were taken in the Queensland Shark Control Program between Cairns and the Gold Coast, of which 22 were captured by drumlines and 3 by mesh nets (QDPI Shark Control Program). An unquantified number of *Carcharhinus plumbeus* are also taken in northern Western Australian waters as a component of the Northern Australian Shark Fishery (Stevens, 1999). This species, along with *Carcharhinus limbatus,* is one of the primary target species of directed shark fisheries in the US Gulf of Mexico and Eastern Seaboard of the USA (Grace and Henwood, 1997).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park, Qld
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW and probably others around Australia
Carcharhinus plumbeus occurs in most west coast and at least some north coast MPAs of Western Australia (McAuley, pers. comm). As this species probably only passes through these areas rather than being permanently resident there, these reserves would not offer much protection. However, the area between Steep Point (approx. 26^{o} S) and the North West Cape (approx 21^{o} 47’ S) in Western Australia is closed to demersal gillnet and longline fishing to primarily protect adult *Carcharhinus obscurus,* which would also provide some protection to adult *Carcharhinus plumbeus* (R. McAuley, pers. comm.).

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
This species is susceptible to increasing exploitation from the directed commercial shark fishery in Western Australia as well as occurring as a bycatch in the tuna longline fishery. The slow growth and low reproductive potential of this species warrant its inclusion in the Lower Risk (near threatened) category, adopting the IUCN categories.

Threatening Processes:
Directed commercial shark fishing in Western Australian waters is the main threat to this species. Finning of this species throughout its range is also a growing concern. Shark fin processors in Western Australia pay fishers $20-$30 per kg (wet weight) for the fins of this species for export to Hong Kong, and also for sale to domestic consumers (C. Rose, pers. comm.). To a lesser extent, tuna longline fishing, shark control programs in Queensland and NSW waters, and possibly recreational game fishing, are all potential threats to the populations of this species in Australian waters, and these threats will need to be continually monitored.

Critical Habitats:
None identified.

Recovery Objectives / Management Actions Required:
A Fisheries Research and Development Corporation (FRDC) funded project on this species by Western Australian Fisheries commenced in July 2000 and is continuing for a duration of three years (R. McAuley,

pers. comm.). This study aims to provide further information on the biology and ecology of this species in WA waters, and this information will be used as a basis for any future management decisions (R. McAuley, pers. comm.). The spatial and temporal distributions and population age and size structures of sandbar shark catches in the Australian tuna longline fishery need to be investigated. It is essential to protect the breeding populations of this species, and any threats to the survival of these breeding populations need to be assessed and mitigated. Additionally, the extent to which this species occurs in recreational game-fish catches in Australian waters would provide more information on its abundance. Fisheries Western Australia (2000) is considering introducing a maximum size limit of 2m for this species to ensure that the breeding biomass is protected.

References:
AFMA logbook data, unpublished; Fisheries Western Australia (FWA), 2000; Grace and Henwood, 1997; B. Lane (QDPI Shark Control Program), pers. comm. 2000; Last and Stevens, 1994; R. McAuley, pers. comms. March to August 2000; Musick, in prep.; Parker, 1999; C. Rose, pers. comm. 4/2000; Stevens, 1999.

RIVER SHARKS: *Glyphis* spp

River sharks, which belong to the family Carcharhinidae, probably reach about 3m in length, although most specimens known are juvenile or newborn (partly because of the difficulty of preserving large adults). The smallest from the Kinabatangan River (northern Borneo) was just 60cm long and had an open umbilical scar, indicating an age of only one or two months. River sharks have characteristic small eyes and a relatively large second dorsal fin. Some species may enter seawater (Fowler, 1997).

It is uncertain how many species of *Glyphis* exist, but there are at least four or five. The Ganges River shark *Glyphis gangeticus* is listed as Critically Endangered in the 1996 IUCN Red List of Threatened Species. It was known from only three museum specimens collected over 100 years ago, until a freshly caught adult female (280cm long) and two fresh jaws were seen in 1996 (Fowler, 1997).

The speartooth shark *Glyphis glyphis* was originally known from eight specimens. One small stuffed fish is in a Berlin museum, two small preserved specimens have been destroyed by poor curation, and the remaining specimens are dried jaws. Its original geographic origin is unknown (Fowler, 1997).

There may be three undescribed species. The Bizant river shark *Glyphis* species ‘A’ is known from only two specimens, from Queensland, Australia. The Borneo River shark *Glyphis* species ‘B’ is recognised from just one preserved specimen found in a museum in Vienna, taken from an unknown river in Borneo over 100 years ago. The New Guinea river shark, *Glyphis* species ‘C’, may possibly be identical to *Glyphis glyphis* (Fowler, 1997).

Obviously, more specimens from different locations are required to solve current taxonomic problems within this genus. Based on these species' extreme rarity and restricted habitat, possibly being restricted to freshwater, and their consequent vulnerability to capture, the IUCN's Shark Specialist Group considered all *Glyphis* spp. to be Critically Endangered, adopting the IUCN criteria. Due to the relatively unpolluted nature of the rivers, and lower fishing pressure, northern Australia may be one of the few areas with viable *Glyphis* populations remaining. Plans are being considered to mount a research project, including tracking work, to learn something of their distribution, movements and biology (Nomination to the *Endangered Species Protection Act 1992*, by Last and Stevens 1997).

Glyphis sp ‘A’ (as described by Last and Stevens, 1994) was previously known from two localities in Northern Australia (Bizant River, north Queensland, and the Adelaide River, Northern Territory). It is now thought that these populations represent two different species (P. Last, pers. comm.). The Bizant River species retains the name *Glyphis* sp. A and the Adelaide River species is called *Glyphis* sp. C (P. Last pers. comm.). There are large differences in vertebral counts between the specimen from the Adelaide River (total vertebrae 148; precaudal 83) and the Bizant River (total 217; precaudal 93) (Last and Stevens, 1994). The recent collection of seven specimens suggests that both *Glyphis* sp. A and *Glyphis* sp. C occur in Kakadu National Park, NT (P. Last, pers. comm.).

Glyphis sp ‘A’ (as described by Last and Stevens, 1994) was previously known from Borneo as well, but this population is also now recognised as a different species, taking the total number of *Glyphis* spp. to possibly four or five (P. Last, pers. comm.).

References:
Fowler, 1997; P. Last, pers. comms. 6/1999-9/2000; Last and Stevens, 1994.

Bizant River Shark

Family Name:	Carcharhinidae
Scientific Name:	*Glyphis* sp. A
Conservation Status:	Critically Endangered

Taxonomic Problems:
Glyphis sp. A can be confused with the bull shark *Carcharhinus leucas* by non-specialists as the latter is known to occur in the same habitat and possibly occupies the known range of the former species at some stages of its lifecycle. (P Last, pers. comm.). Five specimens of *Glyphis* collected recently from the Alligator Rivers System in the Northern Territory appear to be this species. Further taxonomic work by CSIRO shark specialists may resolve this matter in the near future (Larson, 2000; P. Last, pers. comm.).

Other Common Names:
Speartooth shark

Current Conservation Status:
No IUCN (1996, 2000) Listing

Australian Commonwealth *EPBC Act 1999*
Schedule 1: Vulnerable (since February 1999)

ASFB Threatened Fishes Committee
1998-1999: Requiring investigation of its status

Distribution:
This species is based on two specimens collected in 2m of water, 17km upstream in the Bizant River in northern Queensland in March 1982 (Fowler, 1997). Additional specimens collected from the Kakadu National Park (NT) may be conspecific with this species (P. Last, pers. comm.)

Museum Records - 2 specimens collected from a depth of 2m in the Bizant River (approx. 14^{o}S, 144^{o}E), Qld, in 1982.

Habitat:
The Bizant River shark is so far only known from relatively shallow, upper freshwater (and possibly brackish) reaches of the Bizant River and its associated floodplain in Queensland.

Biology and Behaviour:
Virtually nothing is known about the biology of this species, due to the lack of specimens in research collections. The small eyes and slender teeth of *Glyphis* sharks suggest that they are primarily fish-eaters adapted to life in turbid river waters. Some may also enter seawater (Fowler, 1997).

Size:
The two Bizant River specimens were 70-75cm long (one was an immature male). The maximum size of this species is unknown, but it may grow to a length of 2 to 3m (Last and Stevens, 1994).

Evidence for Decline:
There is no documentary evidence of a decline, but this species does appear to be naturally very rare and has largely eluded the efforts of collectors in the past.

Australian Estuarine or Freshwater Protected Areas in Which the Species Occurs:
This species probably occurs in Kakadu National Park, NT.

Suggested Conservation Status:
Endangered on an Australia-wide basis.
Although little is known about this river shark, it is thought to have very specific habitat preferences and low fecundity, which make it extremely vulnerable to any forms of exploitation, such as gillnetting, and also habitat degradation.

Threatening Processes:
None identified. However, it is likely that recreational fishing and gillnetting (e.g for barramundi *Lates calcarifer* in this area) are potential threats to the survival of this species.

Critical Habitats:
Freshwater (and possibly brackish) reaches of the Bizant River in northern Queensland and its associated floodplain lagoons may provide critical habitats for this species. Fresh to brackish waters of Kakadu National Park may also be important habitat. However, accurate identifications of the recently collected specimens in Kakadu National Park are necessary to validate the occurrence of this species in the NT (P. Last, pers. comm.).

Recovery Objectives / Management Actions Required:
Despite the examination of numerous tropical carcharhinid shark specimens in Australian museums, and the examination of around 200 photographs of carcharhinid sharks collected from fresh and brackish waters of tropical Australia, no additional *Glyphis* specimens have been discovered (P. Last, pers. comm.). Further research in the form of surveys of northern Australian freshwater catchments is urgently required to establish the population status of this species and to accurately determine its range. The first step in the Recovery Plan for this species is to form a National Recovery Team to coordinate research into its distribution, ecology and biology. This species may be afforded some protection if it occurs in Kakadu National Park, but the protection of any ‘new’ areas where the species may be found appears to be essential to its conservation.

References:
Fowler, 1997; P. Last, pers. comm. 6/1999-9/2000; Last and Stevens, 1994.

Northern River Shark

Family Name:	Carcharhinidae
Scientific Name:	*Glyphis* sp. C
Conservation Status:	Endangered

Taxonomic Problems:
Glyphis sp. C can be confused with the bull shark *Carcharhinus leucas* by non-specialists as the latter is known to occur in the same habitat and possibly occupies the known range of the former species at some stages of its lifecycle. *Glyphis* sp. C can be distinguished from the bull shark by its taller second dorsal fin (about two thirds the height of the first dorsal), the triangular shape of the first dorsal fin, and the small eye located on the grey-shaded part of the head as opposed to the white counter-shaded part (Larson, 2000). Additionally, when alive the northern river shark is steely grey in colour in comparison to the yellowish grey of the bull shark (Larson, 2000).

Alternative Common Names:
Northern speartooth shark

Current Conservation Status:
<u>No IUCN (1996, 2000) Listing</u>

<u>ASFB Threatened Fishes Committee</u>
1998-1999: Requiring investigation of its status

Distribution:
Glyphis sp. C. is so far known only from the Adelaide and Alligator Rivers systems in the Northern Territory of Australia. It is possibly the same species which occurs in the Fly River of PNG, where it is possibly more common (P. Last, pers. comm.).

<u>Museum Records</u> – Currently, no databased specimens in Australian collections are known. However, at least two whole specimens of *Glyphis* collected from the Alligator Rivers system of the NT in June 1999 appear to be this species (P. Last, pers. comm.) and await registration into collections. Previously, specimens were collected from the Adelaide River, NT in May 1989 (probably housed at the University of Tokyo in Japan) and South Alligator River, NT in 1996 (jaws only preserved as the specimen was eaten by a fisherman).

Habitat:
Glyphis sp. C is probably restricted to the relatively shallow, upper freshwater to brackish (0-26 ppt) reaches of the Adelaide and Alligator Rivers systems of the Northern Territory (Larson, 2000; Taniuchi and Shimizu, 1991). Despite considerable fishing and collecting activity in the Northern Territory, no specimens have ever been found in coastal marine habitats (Larson, 2000).

Biology and Behaviour:
Little is known about the biology of this species, mainly due to the lack of specimens in research collections. There is some evidence that these sharks survive longer out of water than other brackish water carcharhinid sharks such as *Carcharhinus amboinensis* and *C. leucas* (Larson, 2000). Tanaka (1991) estimated that the 131cm female taken in the Alligator River in 1989 was four years old, based on the vertebral centra. A 145cm male weighed 17.5kg, and judging from the elongated claspers was probably mature (Fowler, 1997). The small eyes and slender teeth of *Glyphis* sharks suggest that they are primarily fish-eaters adapted to life in turbid river waters. Some may also enter seawater (Fowler, 1997).

Size:
The maximum size of the specimens collected to date is 145cm (Fowler, 1997). Considering that only a few specimens have been collected, the true maximum size of this species remains unknown, though it may grow to a length of between 2-3m (Last and Stevens, 1994).

Evidence for Decline:
There is no evidence for any decline of this species. However, net-fishing within its distributional range potentially threatens its survival.

Australian Protected Areas in Which the Species Occurs:
Kakadu National Park (NT)

Suggested Conservation Status:
Endangered on an Australia-wide basis
Although relatively little is known about this river shark, it is thought to have very specific habitat preferences and low fecundity, which make it extremely vulnerable to any forms of exploitation, such as gillnetting and longlining, and also habitat degradation.

Threatening Processes:
Any forms of fishing which use nets or lines in the habitat of this species have the potential to threaten its survival. Specimens caught by such fishing activities would generally be discarded or utilised as bycatch (Larson, 2000).

Critical Habitats:
Freshwater and brackish reaches of the abovementioned Northern Territory river systems are critical habitats for this species.

Recovery Objectives / Management Actions Required:
Despite the examination of numerous tropical carcharhinid shark specimens in Australian museums, and the examination of around 200 photographs of carcharhinid sharks collected from fresh and brackish waters of tropical Australia, no additional *Glyphis* specimens have been discovered (P. Last, pers. comm.). Further research in the form of surveys of northern Australian freshwater catchments is urgently required to establish the population status of this species. If populations are found during future surveys, conservation efforts should be directed towards the cessation of net fishing in any sites where the species occurs. The first step in the recovery of this species is to list it under the *Environment Protection and Biodiversity Conservation Act, 1999* so that any remaining extant populations can be protected from fishing activities in the Northern Territory. A National Recovery Team will need to be formed to coordinate research into its distribution, ecology and biology. Tagging studies of remaining populations will be essential to document the home range and possible migrations of this species.

References:
Larson, 2000; H. Larson, pers. comm. 1999-2000; P. Last, pers. comm. 6/1999; Last and Stevens, 1994; Fowler, 1997; Tanaka, 1991; Taniuchi and Shimizu, 1991.

Grey Nurse Shark

Family Name:	Odontaspididae
Scientific Name:	*Carcharias taurus* Rafinesque, 1810
Conservation Status:	Endangered

Australian Synonyms:
Carcharias arenarius Ogilby, 1911

Other scientific names recently in use:
Odontaspis taurus (Rafinesque, 1810)
Eugomphodus taurus (Rafinesque, 1810)

Alternative Common Names:
Sand tiger shark (USA); spotted ragged-tooth shark (South Africa)

Current Conservation Status:
In Australian waters:
Listed as an Endangered Species in NSW waters under the *Fisheries Management Act 1994* (since 1999)

Listed as a Vulnerable Species in Victorian waters under the *Fisheries Act 1995*

Protected Species in NSW waters under the *Fisheries Management Act, 1994* (since November 1984)

Protected Species in Tasmanian waters under *Fisheries Regulations, 1996* (since 1998)

Protected Species in Queensland waters under *Fisheries Act, 1994 (Fisheries Regulation, 1995)* (since 1997)

Protected Species in Western Australian waters under the *Wildlife Conservation Act, 1950* (since December 1999)

Protected Species in Commonwealth waters under the *Environment Protection and Biodiversity Conservation Act, 1999*: Schedule 1, Status Vulnerable (since 1997)

Australian Society for Fish Biology (ASFB) Threatened Fishes Committee
1989: Requiring Investigation of its Status
1990 to 1995: Vulnerable
1996 to 1999: Vulnerable (not re-evaluated)

On a Global basis:
ANZECC Listed Fauna
Vulnerable

1996 IUCN Red List of Threatened Animals
Endangered (A1ab + 2d)

2000 IUCN Red List of Threatened Species
Vulnerable (A1ab + 2d)

Distribution:
Carcharias taurus is found primarily in warm-temperate (from sub-tropical to cool-temperate) inshore waters around the main continental landmasses, except in the eastern Pacific Ocean off North and South America (Pollard *et al*., 1996; Otway and Parker, 1999). In Australia, *C. taurus* has been recorded regularly from Mooloolaba in southern Queensland southwards to around the Victorian border in eastern Australia,

and from south-western Australia northwards to Shark Bay in Western Australia (Hutchins and Swainston, 1986). The species appears to be more frequently sighted by divers in NSW and to a much lesser extent in south-western Western Australia (Pollard *et al*., 1996). Records and sightings have also been confirmed from the North West Shelf (WA) and Arafura Sea (NT) (J. Stevens, pers. comm.). Occasionally, the grey nurse shark has been recorded northwards to Cairns on the north-east coast of Queensland (B. Lane, pers. comm.).

Museum Records - 17 specimens (Standard Length 1.2–2.1m; no capture depths recorded), ranging in geographical distribution from Southport (27^{o}58'S), Qld southwards to Hobsons Bay (37^{o}52'S, 144^{o}56'E), Victoria on the east coast of Australia; and from Jurien Bay (30^{o}18'S) southwards to Albany (35^{o}S), WA. Specimens were collected between 1879 and 1995. Additionally, 54 specimens are housed at the WAMRL in WA. They were captured at depths of 6-116m (average 38.5m) and ranged in geographical distribution from the Geraldton area (approx. 28^{o}S) southwards to the Augusta area (34^{o}S), WA, collected between May 1994 and April 1999. Sizes ranged from approximately 1.1m to 2.9m in total length.

Habitat:
Carcharias taurus generally occurs in warm-temperate and sub-tropical waters, ranging from rocky inshore reefs (also occasionally being found in the surf zone and in shallow bays) to southerly coral reefs and down to around 200m depth on the continental shelf. It is often found near or on the bottom, but can also occur in midwater or at the surface (Compagno, 1984). In NSW, *C. taurus* is most frequently sighted in or near sandy-bottomed gutters or in rocky caves, often around inshore rocky reefs and islands at depths between 15 and 25m (Pollard *et al*., 1996; Otway and Parker, 1999).

Biology and Behaviour:
Carcharias taurus generally occurs as solitary individuals or in small schools. Larger aggregations of individuals may occur for courtship and mating. It is strongly migratory in most parts of its range (Compagno, 1984). Relatively little is known about the migratory movements of Australian *C. taurus,* but migrations on the east coast of Australia have been suggested to be northwards in autumn and winter and southwards in summer (Pollard *et al*., 1996; Otway and Parker, 1999). Reproduction features oophagy and uterine cannibalism, and there are normally two young to a litter - one per uterus (Gilmore *et al*., 1983; Compagno, 1984). Eggs leaving the ovaries are fertilised while in transit in the oviducts and then enclosed in groups of 16-23 in egg cases (Gilmore *et al*., 1983; Compagno, 1984). The embryos grow and develop by feeding firstly on any unfertilised eggs, then become cannibalistic until only one embryo remains in each uterus prior to birth (Gilmore *et al*., 1983). The gestation period is usually from 9 to 12 months (Gilmore *et al*., 1983; Otway and Parker, 1999), and from recapture data for tagged *C. taurus* in South African waters (Cliff, unpublished) it appears that females only reproduce every second year. *Carcharias taurus* is a voracious feeder on a wide variety of teleost fishes as well as smaller sharks, rays, squids, crabs and lobsters. Groups of these sharks have been observed to feed cooperatively, surrounding and bunching schooling prey fish before feeding on them (Compagno, 1984).

Size:
The maximum total length from the literature is about 318cm for females (which mature at around 220cm total length, at about 6 years of age) and 257cm for males (which mature at around 190-195cm total length at around 4-5 years of age), and the size at birth is around 95 to 105cm (Compagno, 1984; Branstetter and Musick, 1994). However, Hutchins and Swainston (1986) noted that it attained 3.6m and 141kg. Krogh (1994) reported an adult of 4.2m in length recorded as being caught in the NSW protective beach-meshing program, with the next largest specimen caught being 3.4m. As there was no scientific involvement in the meshing program in 1972 when this maximum length of 4.2m was recorded, this specimen cannot be confirmed as a grey nurse shark (D. Reid, pers. comm.). The growth increment for ages 0-1year is 25-30cm, declining by approximately 5cm every two years to a minimum of 5-10 cm/year (Branstetter and Musick, 1994). This species grows to a maximum weight of at least 190kg (Pepperell, 1992) and can survive for at least 16 years in captivity (Govender *et al*., 1991).

Evidence for Decline:
The numbers of *C. taurus* in NSW inshore waters declined dramatically throughout the 1960s and 1970s due to the combined effects of spearfishing, commercial and recreational fishing (including gamefishing), and beach protective shark meshing (Pollard *et al.*, 1996). Commercial fishers took the species as an incidental bycatch in a setline fishery for wobbegong sharks (*Orectolobus* spp.) in the Seal Rocks area of central-northern NSW during the early 1990s (Pollard *et al.*, 1996). This fishery has since been closed in

this area. Grey nurse sharks are still occasionally taken on shallow setlines in the NSW Trap and Line Fishery (Fletcher and McVea, 2000). In a visual diver survey of grey nurse sharks along the entire NSW coastline reported by Otway and Parker (2000), between 5 and 7% of these sharks observed had wobbegong setline hooks embedded in their jaws, and this percentage is evidently still increasing over time. Given that *C. taurus* only produces a maximum litter of two pups every two years, the species is highly vulnerable to human-induced mortality (Pollard *et al.*, 1996). The conservation status of WA populations is less well known, and although rarely seen by divers off the WA coastline (B. Hutchins, pers. comm.), this species is still caught as a bycatch of other shark fisheries in WA. In WA waters, a total of about 17t (live weight) of this species was reported to be taken in the period from 1 July 1994 to 30 June 1998 in the Southern Demersal Gillnet and Demersal Longline Fishery and the West Coast Demersal Gillnet and Demersal Longline Fishery. The mesh size of these gillnets is 6.5 to 7 inches, which would make them selective to catching smaller sharks (R. McAuley, pers. comm.). Adapting Branstetter and Musick's (1994) length-weight relationship for this species, it could be inferred that anywhere from 400 (using roughly a 40kg average weight) to 800 sharks (using roughly a 20kg average weight) may have been captured over this four year period. Additionally, at least 15.5t of *Carcharias taurus* were taken in WA waters between 1994 and 1998 by holders of Open West Coast Licences, which includes those professional fishing boats fishing outside of all managed fisheries (R. McAuley, pers. comm.). To add to the above catches, grey nurse sharks were also recorded as a bycatch of the Kimberley Gillnet and Barramundi Fishery (KGBF) and by the Western Australian Fishery Joint Authority (WAFJA, northern WA) in 1996 (Stevens, 1999). The quantities of grey nurse sharks taken from these northern WA fisheries have not been included in the state catch figures, as there has been misreporting of catches taken in these fisheries (R. McAuley, pers. comm.). It appears that grey nurse sharks may be more abundant in Western Australia than originally thought, but at these catch rates population declines are inevitable considering the species' life-history characteristics. Six grey nurse sharks (one released alive), ranging in size from 1.6 to 3.0m, were caught in the Queensland Shark Control Program between January 1993 and August 2000 (B. Lane, pers. comm. 2000). Five of the six were caught using drumlines (3 females, 2 males), while the other was netted (male) (B. Lane, pers. comm. 2000). They ranged in distribution from Cairns southwards to the Gold Coast (B. Lane, pers. comm. 2000). The grey nurse shark is also a popular aquarium species that is displayed by a few large public aquaria, which has some educational value for conservation. However, numbers taken from the wild for the aquarium industry should be minimised, as it is not in the best interest of this threatened species to take any further specimens for display at this stage. Attempts should be made to breed grey nurse sharks in captivity for aquarium uses, in order to reduce the impact of removing further sharks from the wild.

Australian Marine Protected Areas in Which the Species Occurs:
Possibly occurs in the southern section of the Great Barrier Reef Marine Park, Qld
Known to occur in the following MPAs
Moreton Bay Marine Park, southern Qld
Cook Island Aquatic Reserve, off Tweed Heads, northern NSW
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW
Solitary Islands Marine Park, north of Coffs Harbour, northern NSW
Off Long Reef Aquatic Reserve, Sydney, NSW
Jervis Bay Marine Park, off Huskisson, southern NSW
Previously recorded from:
Off Bushrangers Bay Aquatic Reserve at Bass Point, Shell Harbour, southern NSW

Suggested Conservation Status:
Endangered on an Australia-wide basis
Due to the declines observed over the last few decades and the fact that no visible recovery of NSW populations has occurred since this species' protection in 1984, it is recommended that an Endangered conservation status be implemented Australia-wide until a long-term recovery plan is completed. Until further research on the species' population biology, including sex ratios and stock structure, is completed, every measure must be taken to protect and conserve this species and its known habitat. Both eastern and western Australian populations need to be conserved to ensure conservation of the genetic variation of the species as a whole. As the Lamniform group of sharks in general is thought to be of Lower Cretaceous origin (i.e. around 100 million years old), the main surviving continental stocks of "*C. taurus*" may in fact represent several separate Gondwanaland relicts, with little or no interchange having since occurred between the various stocks of this ancient 'species' (Pollard, 1991).

Threatening Processes:
The main current threatening processes in Australian waters would appear to be commercial and recreational fishing (including shark control programs in NSW and Qld), in which this species is taken as a bycatch. In Argentine waters this species is taken by recreational and commercial fishers (Chiaramonte, 1998). Shark finning and excessive ecotourism activities (i.e. 'shark diving') also have the potential to adversely impact upon populations of the grey nurse shark (Environment Australia, 2000a).

Critical Habitats:
Critical aggregating habitats for this species, especially during its breeding migrations, are currently being investigated with a view to their conservation as marine protected areas (N. Otway, pers. comm.).

Recovery Objectives/Management Actions Required:
The overall recovery objective is to promote the increase of grey nurse shark numbers in Australian waters to a level that will see the species removed from the schedules of the *EPBC Act 1999* (Environment Australia, 2000a). WA populations need to be accurately assessed to determine population numbers and their distributional range. Any new legislative requirements designed to protect the grey nurse in WA waters will need to accept that occasional specimens will be accidentally killed as a bycatch of commercial fisheries in that State. Fishers should be instructed to retain any accidentally killed specimens and deposit them with the nearest relevant research institute without fear of being prosecuted. This would help in the scientific understanding of the biology of the grey nurse shark in WA waters. The use of trained observers over several years is required to determine the extent and timing of movements of male and female sharks. Tagging and tracking sharks would provide an insight into their movements along both the south-eastern and south-western Australian coastlines. Management of grey nurse shark habitats will require better temporal information on shark abundances, and would need to consider the effects of such activities as commercial and recreational fishing, recreational scuba diving and protective beach meshing on this shark's biology and behaviour. A protocol for diving with grey nurse sharks is currently being drafted by NSW Fisheries (P. Parker, pers. comm.) Given the low fecundity of the grey nurse shark, recovery is likely to be a slow process and may take many decades. A Grey Nurse Shark Recovery Team, consisting of scientists, conservation managers and fisheries managers, was formed and first met in October 1999 to discuss recovery actions for this species. Environment Australia, with the help of the Grey Nurse Shark Recovery Team, has since prepared a Draft Recovery Plan (Environment Australia, 2000a) which identifies the following specific objectives:

- Reduce the impact of commercial fishing on grey nurse sharks
- Reduce the impact of recreational fishing on grey nurse sharks
- Reduce the impact of shark control activities on grey nurse sharks
- Identify and establish refugia at key locations to protect grey nurse sharks from threatening activities such as commercial and recreational fishing
- Reduce the impact of shark finning on grey nurse sharks
- Develop research programs towards the conservation of grey nurse sharks
- Develop population models to assess and monitor recovery of grey nurse shark populations
- Manage the impact of dive ecotourism activities on grey nurse sharks
- Reduce the impact of aquarium display on grey nurse sharks
- Promote community education about the plight of the grey nurse shark
- Reassess the conservation status of the grey nurse shark

To fulfil the specific objectives of this plan, the following actions are designed to identify and reduce threats to grey nurse sharks, to determine levels of mortality and to reduce that mortality. The assessment of these actions against the criteria for success is essential to measure the recovery of grey nurse sharks. These actions and recovery criteria (Environment Australia, 2000a) are:

- Assess commercial and recreational fisheries data to determine current level of grey nurse shark bycatch
- Modify fisheries logbooks to record grey nurse shark catch and biological data (e.g. size, sex, etc.)
- Ensure existing fishery observer programs record interactions with grey nurse sharks
- Quantify and reduce levels of grey nurse shark take in shark control activities
- Establish community based programs to identify and monitor key sites for grey nurse sharks
- Develop appropriate mechanisms to protect key sites

- Establish tag and release programs for grey nurse sharks
- Prevent unregulated shark finning of grey nurse sharks
- Assess the population size and status of grey nurse sharks
- Collect biological and genetic information on grey nurse sharks
- Minimise the impacts of dive ecotourism activities and aquarium display on grey nurse sharks
- Develop a community education strategy for grey nurse sharks
- Reassessment of the conservation status of the grey nurse shark

References:
Branstetter and Musick, 1994; Camhi *et al*., 1998; Chiaramonte, 1998; Cliff, G. (unpublished); Compagno, 1984; Environment Australia, 2000a; Fletcher and McVea, 2000; Gilmore *et al*., 1983; Govender *et al*., 1991; B. Hutchins, pers. comm. 10/1999; Hutchins and Swainston, 1986; Krogh, 1994; B. Lane, pers. comm. 8/2000; Last and Stevens, 1994; R. McAuley, pers. comms. 1999-2000; N. Otway, pers. comm. 10/1999; Otway and Parker, 1999; Otway and Parker, 2000; P. Parker, pers. comm. 10/2000; Pepperell, 1992; Perry, 1999; Pollard, 1991; Pollard *et al*., 1996; D. Reid, pers. comm. 10/1999; Shark Advisory Group, 2000; C. Simpfendorfer, pers. comm. 8/1999; Stevens, 1999; J. Stevens, pers. comm. 3/2000.
Websites: http://www.fsc.nsw.gov.au (NSW Fisheries Scientific Committee)

Herbsts Nurse Shark

Family Name:	Odontaspididae
Scientific Name:	*Odontaspis ferox* (Risso, 1910)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Odontaspis herbsti Whitley, 1950

Other scientific names recently in use:
Carcharias ferox (Risso, 1910)

Taxonomic Problems:
Odontaspis ferox is a rarely encountered species that is morphologically very similar to *Carcharias taurus,* though the latter is generally found in much shallower waters.

Alternative Common Names:
Smalltooth sand tiger shark; ragged-tooth shark; bumpytail ragged-tooth shark

Current Conservation Status:
Protected Species in NSW Waters (since 1984)

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Previous records show a very irregular distribution throughout most of the world's oceans: it has been recorded in the north-eastern Atlantic Ocean, the Indian Ocean (including the Cocos (Keeling) Atolls), and the western Pacific, central Pacific and north-eastern Pacific Oceans. The first record for the western North Atlantic was in 1989 (Bonfil, 1995). It is also known from the Mediterranean (Last and Stevens, 1994). In Australasia, it has been recorded off NSW, north-western Australia, New Zealand (Last and Stevens, 1994) and the Kermadec Islands (Francis, 1993). It is probably more widespread in Australian waters than voucher specimens would indicate (P. Last, pers. comm.).

Museum Records - 7 specimens (Standard Length 1.1-1.5m, some specimens not measured), collected from depths of 130-366m, ranging in geographical distribution from off Brush Island (35^{o}33'S), NSW southwards to south-east of Gabo Island (37^{o}36'S), Victoria, collected between 1947 and 1997. The NSW Fisheries Research Vessel Kapala recorded 30 additional specimens (Total Length 1.3-2.9m, some specimens not measured) between 1975 and 1997, ranging in geographical distribution from off northern NSW (approx. 29^{o}S) to off southern NSW (approx. 36^{o}S) (K. Graham, pers. comm.).

Habitat:
Odontaspis ferox lives on or closely associated with the bottom in deep waters along continental and insular shelves and upper slopes (Last and Stevens, 1994) to depths of about 850m (K. Graham, pers. comm). It is very occasionally found in shallower water (Last and Stevens, 1994). Hutchins filmed underwater video of an individual in 20m of water at the Cocos (Keeling) Atolls (B. Hutchins, pers. comm.). There are at least 3 records from pelagic zones in open waters of the Indian Ocean (Bonfil, 1995).

Biology and Behaviour:
Little is known of the biology of this shark. Its reproduction is presumably similar to that of the grey nurse shark. Size at birth is over 105cm and males mature at about 275cm (Compagno, 1984). In Australian waters, this species is born at over 100cm and attains at least 360cm, but the size at maturity here is unknown (Last and Stevens, 1994). A 2.7m female specimen caught off the Sydney area was judged to be immature, as there was no sign of ovarian development (K. Graham, pers. comm.). The large oily liver probably has a hydrostatic function (Last and Stevens, 1994), and may help the shark to maintain neutral buoyancy while swimming. Stomachs examined have contained small bony fish, cephalopods, crustaceans

(Last and Stevens, 1994) and small squalid dogfish. A very large *O. ferox* trawled on the Norfolk Ridge north of New Zealand in 1997 was found to contain a 200cm seal shark in its stomach (Stewart, 1997). The above information suggests that this species is an opportunistic carnivore.

Size:
Large, up to 3.7m in total length (Bonfil, 1995) and over 300kg in weight (Stewart, 1997). In April 2000, a 33kg female specimen was trawled off Eden, NSW (N. Otway, pers. comm.)

Evidence for Decline:
There is little information on this species in Australia outside of NSW waters. From the available information, *Odontaspis ferox* was never abundant off NSW, but there is strong evidence that numbers have declined between 1972 and 1997. Of the 35 caught by the NSW Fisheries Research Vessel 'Kapala', 33 were caught between 1975 and 1981 (from 500 slope trawl tows), but only 2 were taken from about 250 trawl tows made between 1982 and 1997 (K. Graham, pers. comm). The NSW upper slope trawl grounds were again surveyed in 1996-97 and results compared to an initial survey made in 1976-77 (Graham *et al*., 1997). Twelve captures (14 sharks) were made during 246 tows in 1976-77, but only a single juvenile was caught during 165 tows in 1996-97.

Australian Marine Protected Areas in Which the Species Occurs:
In Australian waters this species is unlikely to be found in any MPA's (most of which are located inshore), as it seemingly prefers the deeper (greater than 100m) waters off the mainland coastline.

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
This species may be naturally rare and is only seldom caught, but numbers appear to have declined due to commercial fishing operations off NSW in the last few decades. At this stage it is recommended to assign the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Commercial fishing, whereby this species is taken incidentally, on the outer continental shelf and continental slope is a potential threat to its survival in Australian waters.

Critical Habitat:
None identified in Australian waters.

Recovery Objectives/Management Actions Required:
In Australia, more study is needed to accurately determine the distributional range, abundance and biology (including possible migrations, sex ratios, fecundity, etc.) of this species. Any dead specimens landed by commercial fishing (especially trawling) operations should be retained and delivered to the nearest relevant research organisation, so that more biological information can be obtained.

References:
Bass *et al.*, 1975; Bonfil, 1995; Compagno, 1984; Francis, 1993; Graham *et al*., 1997; K. Graham, pers. comm. 2/2000; B. Hutchins, pers. comm. 1/2000; Last and Stevens, 1994; P. Last, pers. comm. 3/2000; N. Otway, pers. comm. 4/2000; Stewart, 1997.

Megamouth Shark

Family Name:	Megachasmidae
Scientific Name:	*Megachasma pelagios* Taylor, Compagno and Struhsaker, 1983
Conservation Status:	Data Deficient

Current Conservation Status:
In Australian waters:
Protected Species in Tasmanian waters under the *Fisheries Regulations 1996* since 1998

No ASFB Listing

On a Global Basis:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Data Deficient

Distribution:
Only 14 specimens have been reported to date, from Japan, the Hawaiian Islands, south-western Australia, southern Brazil, Sulawesi (Indonesia), the Philippines, California and Senegal (West Africa). It is likely that this species has a wide-ranging distribution considering that it has now been recorded from the central, eastern and western Pacific Ocean, the Atlantic Ocean and the eastern Indian Ocean.

Museum Records: 1 specimen (Standard Length 5.15m) stranded on beach at Mandurah (32^{o}31’S), WA in 1988.

Habitat:
Megachasma pelagios inhabits deepwater oceanic waters of tropical regions.

Biology and Behaviour:
Megachasma pelagios is a weak swimming, vertically migrating, harmless shark that feeds on plankton (Berra and Hutchins, 1991). A male shark (4.94m total length) was captured in California in October 1990 and released alive with a tracking device attached (Anon., 1991; Hutchins, 1992). The tracking showed that, during the day, the shark was travelling about 150m below the surface. At night, however, it ascended into shallow water (within about 10m of the surface) (Hutchins, 1992). The shark's depth changes were most likely determined by its main food source, euphausiid shrimps, which migrate up and down in the water column according to light levels (Hutchins, 1992). *Megachasma pelagios* is a specialised filter feeder. The diet of the first shark captured consisted of euphausiid shrimps, *Thysanopoda pectinata*, with a median length of 31mm (Taylor, *et al.,* 1983). The second specimen examined contained fragments of euphausiids, copepods and possibly sea jellys (Lavenberg, 1985).

Size:
This species reaches a total length of at least 5.15m and a weight of at least 790kg.

Evidence for Decline:
No evidence of any population decline exists for *M. pelagios*. Only 14 specimens have been caught or photographed (some released alive) since its discovery in 1976. This species appears to be very rare throughout its range, but it may be increasingly likely to be taken as a bycatch in deepwater fisheries.

Australian Marine Protected Areas in Which the Species Occurs:
Megachasma pelagios is unlikely to occur in any Australian MPAs, given its deepwater habitat. Only one beach-washed specimen has been recorded in Australia, near Mandurah in WA.

Suggested Conservation Status:
Data-Deficient on an Australia-wide basis.
Considering that only about a dozen specimens have been captured, photographed or observed worldwide, no accurate estimate of its conservation status is likely to be made in the near future.

Threatening Processes:
None identified.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
None identified.

References:
Anon., 1991; Berra and Hutchins, 1991; Hutchins, 1992; Lavenberg, 1985; Compagno, 1984; Taylor *et al.*, 1983

Basking Shark

Family Name:	Cetorhinidae
Scientific Name:	*Cetorhinus maximus* (Gunnerus, 1765)
Conservation Status:	Data Deficient

Other scientific names recently in use:
Halysdrus maximus (Gunnerus, 1765)
Halysdrus maccoyi (Barrett, 1933)
Cetorhinus rostratus (Macri, 1819)
Cetorhinus normani Siccardi, 1960

Current Conservation Status:
In Australian waters:
<u>Protected Species in Tasmanian waters under the *Fisheries Regulations 1996* since 1998</u>

<u>No ASFB Listing</u>

On a Global basis:
<u>Protected species in Isle of Man, Irish Sea</u>

<u>No 1996 IUCN Listing</u>

<u>2000 IUCN Red List of Threatened Species</u>
Vulnerable (A1ad + 2d) globally; Endangered (A1ad) in North Pacific and North-eastern Atlantic

A United Kingdom nomination that it be listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), submitted for consideration at the 11th Conference of the Parties to CITES in Nairobi, 10-20 April 2000, was not adopted.

Distribution:
The basking shark has a coastal distribution in temperate regions of the world (Compagno, 1984). It occurs in the Western Pacific (Japan, the Koreas, China), Australia (NSW, Victoria, Tasmania, SA and WA), New Zealand, the Eastern Pacific (Gulf of Alaska to Gulf of California, Ecuador, Peru and Chile, and possibly the Galapagos Islands) (Compagno, 1984). It also occurs in the Eastern and Western Atlantic and the Western Indian Ocean (Compagno, 1984).

<u>Museum Records</u> - 9 specimens (Total Length to about 7.5m), collected from depths of 454-832m, ranging in geographical distribution from off the Port Stephens area, NSW, southwards to Williamstown (37^{o}53'S, 144^{o}E), Victoria, and westwards to Fowlers Bay (31^{o}58'S, 132^{o}25'E), SA. Specimens were collected between 1888 and 1991.

Habitat:
Cetorhinus maximus is a coastal, pelagic shark found in boreal to warm-temperate waters of the continental and insular shelves. It is usually found close to land, but also occurs well offshore. It can sometimes be found just off the surf-zone and is known to enter coastal bays (Compagno, 1984).

Biology and Behaviour:
Cetorhinus maximus is generally seen at or near the surface, singly, in pairs or in schools of up to a hundred or more individuals. Surface basking may be correlated with surface concentrations of plankton and also with courtship and mating. Basking sharks are highly migratory. Pregnant *C. maximus* are almost entirely unknown, suggesting that such females are spatially and bathymetrically separated from those members of the population that are regularly seen basking at the surface. Juveniles below 3m long are also rarely seen, and the smallest record of a free-living individual was about 1.65m in length, reported from the British Isles. Adult, non-pregnant female basking sharks have immense numbers of small eggs in their ovaries.

Presumably this shark is oophagous like other lamnoids, with embryos feeding on the small unfertilised eggs (Compagno, 1984). Female basking sharks may not reach maturity until 18-20 years of age and may live to perhaps 50 years. The only known litter consisted of just five very large young (Camhi *et al.*, 1998). *Cetorhinus maximus* feeds exclusively on small planktonic organisms trapped by its gillrakers, apparently with the help of mucous secreted in its pharynx. Food items include small copepods, barnacles, decapod larvae and fish eggs (Compagno, 1984).

Size:
This species reaches a total length of at least 9.8m. Males mature at about 4 or 5m and reach about 9m, females are mature at about 8.1 to 9.8m. Size at birth is unknown; the smallest known free-living individual was 1.65m in length (Compagno, 1984). They are estimated to reach 5m in total length at an age of 3-4 years, and 10m at age 8-15 years (Sims *et al.*, 1997). The only known pregnant female recorded had a litter size of five (Camhi *et al.*, 1998).

Evidence for Decline:
Cetorhinus maximus appears to be extremely vulnerable to overfishing, due to its slow growth rate, lengthy maturation time, long gestation period, probable low fecundity, and the probable small size of existing populations (Compagno, 1984). The interannual variability of its occurrence and market forces may be contributing threats to the species (J. Stevens, pers. comm.). It has been targeted by small-scale harpoon fisheries from small boats off the Norwegian coast, Ireland and Scotland, Iceland, California, Peru and Ecuador, often being only sporadically fished due to periodic depletion of local basking shark stocks (Compagno, 1984). It has also been heavily fished off China and Japan by harpoon (Compagno, 1984). This species has also been taken in nets, including bottom set gillnets and even bottom and pelagic trawls (Compagno, 1984). About 1200 basking sharks were caught for liver oil in Shima Province, Japan, during the 12 years to 1976, chiefly by spear, but catches subsequently decreased considerably (Izawa and Shibata, 1993). Present day fisheries are uncommon, but basking sharks continue to be taken as a bycatch in other fisheries and some basking sharks are also occasionally killed or injured in collisions with boats (Fowler, in prep.). Since there is now an important international trade in shark fins and there are still markets for shark oil, the basking shark is a potential target for fishermen unable to make a living from their traditional fisheries, if increased protection is not introduced throughout their range (Fowler, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly the Great Australian Bight Marine Park, SA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
The basking shark has rarely been encountered in Australian waters and more data are necessary to accurately determine the status of this species in this area.

Threatening Processes:
None identified in Australian waters.

Critical Habitats:
None identified in Australian waters.

Recovery Objectives/Management Actions Required:
As the basking shark has rarely been found in Australian waters to date, no recovery objectives are identified.

References:
Camhi *et al.*, 1998; Fowler, in prep.; Compagno, 1984; Izawa and Shibata, 1993; Sims *et al.*, 1997; J. Stevens, pers. comm. 3/2000.

FAMILY LAMNIDAE: MACKEREL SHARKS

Mackerel sharks are large, active, powerful sharks, attaining maximum lengths of 3-6m (Last and Stevens, 1994). They have a stout, spindle-shaped body with a conical snout, two spineless dorsal fins (the second much reduced), small anal fins, a crescent-shaped caudal fin, precaudal pits, and a laterally expanded caudal peduncle with well-developed caudal keels (Last and Stevens, 1994). They have a ventrally placed mouth with moderate to large-sized teeth, large eyes that lack nictitating membranes, and five long gill slits (Last and Stevens, 1994).

Mackerel sharks are distributed worldwide in tropical and temperate seas and inhabit both coastal and oceanic habitats (Last and Stevens, 1994). They have broad geographic distributions in most seas, and have been found to depths of over 1200m (Compagno, 1984). A heat exchanging circulatory system allows these sharks to maintain a body temperature above that of the surrounding water, increasing their levels of activity (Compagno, 1984; Last and Stevens, 1994). Reproduction is ovoviviparous, without a yolk-sac placenta. They feed on a wide variety of teleost fishes, other elasmobranchs, marine birds and reptiles, marine mammals, squids and crustaceans (Compagno, 1984).

Five species in three genera are known to occur worldwide, three of which are known from Australian waters. This family contains the white shark, the species usually considered the most dangerous to humans (Last and Stevens, 1994). Mackerel sharks have been a target for shark fisheries outside of Australia, and have been utilised for their meat, oil, fins, hides, fishmeal, jaws and teeth. They are taken mainly by pelagic longlining, gillnets and hook and line fishing methods (Compagno, 1984).

Four of the five known lamnid species are listed on the 2000 IUCN Red List of Threatened Species, three of which occur in Australian waters (http://www.redlist.org/). The white shark *Carcharodon carcharias* is listed as Vulnerable and the shortfin mako *Isurus oxyrinchus* is listed as Lower Risk (near threatened). The porbeagle *Lamna nasus* is listed as Lower Risk (near threatened) worldwide, but the North-eastern and North-western Atlantic subpopulations are regarded as being Vulnerable and Lower Risk (conservation dependent), respectively (http://www.redlist.org/). A detailed species conservation synopsis is included here for only one species, the white shark *Carcharodon carcharias.*

References:
Compagno, 1984; Last and Stevens, 1994

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

White Shark

Family Name:	Lamnidae
Scientific Name:	*Carcharodon carcharias* (Linnaeus, 1758)
Conservation Status:	Vulnerable

Australian Synonyms:
Carcharodon albimors Whitley, 1939

Alternative Common Names:
Great white shark; white pointer

Current Conservation Status:
In Australian waters:
Protected Species in all Australian range states

Protected Species in Commonwealth waters under the Australian Commonwealth *EPBC Act 1999*
Schedule 1: Vulnerable (listed October 1997)

NSW *Fisheries Management Act 1994*
Vulnerable (listed 1998)

Tasmanian Threatened Species Protection Act
Schedule 4: Vulnerable (listed 1999)

ASFB Threatened Fishes Committee
1988 to 1989: Requiring Investigation of its Status
1990 to 1999: Uncertain Status or Not Evaluated

A joint Australian and USA nomination that this species be listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was submitted for consideration at the 11th Conference of the Parties to CITES in Nairobi, 10-20 April 2000. However, this nomination was not adopted.

The Australian Government has proposed listing the white shark on Appendix III of CITES indicating Australia's concern for the status of this species. Such a listing would require any trade in the body parts of this species anywhere in the world to be notified to CITES (SAG, 2000).

On a Global basis:
ANZECC Listed Fauna
Vulnerable

Protected Species in the following areas:
Floridian, Californian, South African, Namibian and Maltese waters and waters of the Republic of the Maldives

1996 IUCN Red List of Threatened Animals:
Vulnerable (A1bcd +2cd)

2000 IUCN Red List of Threatened Species
Vulnerable (A1cd + 2cd)

An assessment of Vulnerable was reached by the IUCN Species Survival Commission's Shark Specialist Group on the basis of this species' biological characteristics (e.g. late maturing, very low fecundity) and declining catches in many areas. This assessment takes into consideration observed trends in abundance of the species, where available, combined with its rarity, vulnerability to target and bycatch fisheries, and very low reproductive potential. However, it is qualified with the very genuine concern and suspicion that a global status of Endangered may prove to be more accurate for this shark as further data are collated. Some individual populations are considered to be Lower Risk (conservation dependent) in some overseas areas where the species receives effective protection. However, any relaxation of current protective measures (as demanded by some South African sport-anglers) would be potentially disastrous (Fergusson *et al*., in prep.).

Distribution:
Carcharodon carcharias is a wide-ranging species found in all seas, including cold temperate waters in both hemispheres. It is most frequently observed and captured in inshore cool to warm temperate continental waters of the Western North Atlantic, Mediterranean Sea, off southern Africa, southern Australia, New Zealand, and the Eastern North Pacific. It also occasionally occurs elsewhere, including other temperate regions and the inshore tropics, in the open ocean, and on the continental slopes (Compagno *et al*., 1997). In Australia white sharks have been recorded from all states except the Northern Territory. The northernmost Queensland record of a white shark is for a specimen taken at Mackay, though most Queensland records of white sharks are from further southwards off the Gold and Sunshine Coast regions of southern Queensland (Paterson, 1990).

Museum Records - 28 specimens (Standard Length 1.53m - approx. 4m), collected from depths of 0-50m, ranging in geographical distribution from off Nilson Park, Bargara (24^{o}49’S), Qld, through NSW and Victoria southwards to Port Arthur (43^{o}17’S) in Tasmania, and westwards to Rottnest Island (32^{o}S, 115^{o}30’S), WA. Specimens were collected between circa 1888 and 1995.

Habitat:
Carcharodon carcharias is primarily an inhabitant of continental and insular shelf waters. It often occurs close inshore near the surf-line, and may penetrate shallow bays in continental coastal waters; it also occurs around continental islands. This species can be found from the surface down to the bottom in epicontinental waters, but occasionally ranges down the continental slope, where it has been caught on a bottom set longline at 1280m (Compagno, 1984). It is normally found in inshore waters in the vicinity of islands, and often near seal colonies. Nursery areas are located in inshore coastal waters (Smith and Pollard, 1997).

Biology and Behaviour:
Carcharodon carcharias often occurs singly or in pairs, but can be found around food sources in feeding aggregations of 10 or more; schooling apparently does not occur (Compagno, 1984). The reproductive mode of the white shark is thought to involve oophagy, where embryos *in utero* eat large numbers of unfertilised eggs that are ovulated during gestation (Compagno *et al*., 1997; Francis, 1996a). The gestation period is unknown, but is probably at least 12 months, and mature females may not breed every year. Female white sharks produce up to 10 pups per litter (Francis, 1996a). Pups are fully developed and independent at birth, being 1.2 to 1.5m in length and weighing up to 32kg (Compagno *et al*., 1997). Little is known about pupping areas although neonatal white sharks and juveniles have most commonly been reported from inshore waters (B. Bruce, pers. comm.). Maturity is estimated to occur at 350 to 410cm (9 - 10 years) for males and 400 to 500cm (12 - 14 years) for females (Compagno *et al*., 1997). Longevity is thought to be around 30 years (14 - 15 years validated) (Smith and Pollard, 1997). The white shark has a heat-exchanging circulatory system allowing it to maintain body temperatures up to 14^{o} C above that of the surrounding seawater (Goldman *et al*., 1996).

Long-term movement patterns of white sharks are poorly known. There are several reports of individuals being sighted at the same locality over several years (Bruce, 1992, Strong *et al*., 1996, Klimley and Anderson, 1996). Tagged white sharks have been recaptured up to 1400km from the point of tagging (Cliff *et al*., 1996) and they may move in and out of areas at the limits of their range on a seasonal basis in some areas (e.g. in the Mediterranean - see Fergusson, 1996). Research suggests that white shark populations may segregate according to size and gender, and for reproduction. Strong *et al.* (1992) found that, in South Australia, the ratio of females to males was 6:1 at Dangerous Reef and other inshore islands, whereas around the offshore islands of the North and South Neptunes, it was 1: 20. Up to September 1999, 209 white sharks had been tagged in Australia through game-fish tag and release, tagged free swimming (by researchers and ecotourism operators) and the tag and release of bycatch from commercial fishing operations. Of these, 9 tagged white sharks have been recaptured. This represents a recapture rate of about 5%. The time at liberty ranged from 0 to 1813 days (B. Bruce, pers. comm.).

The prey of the white shark includes a wide array of teleost and elasmobranchs fishes. Sea turtles are also occasionally taken. Marine mammals are an important food source for large white sharks. Those mammals killed and eaten include harbour porpoises, dolphins, and a number of pinnipeds such as harbour seals, northern elephant seals, Steller's and Californian sea lions, South African fur seals, and several other (e.g various Australian and New Zealand) species (Le Boeuf *et al*., 1982; Compagno, 1984). Invertebrate prey include squids, crabs, abalone and other gastropods (Compagno, 1984).

Size:
Maximum total length is at least 640cm and possibly to over 700cm. Individuals captured are more commonly between 140 and 600cm. Adult males may reach about 550cm (Compagno, 1984).

Evidence for Decline:
Five-hundred and seventeen *C. carcharias* have been captured through protective beach meshing operations in NSW between 1950 and April 2000, averaging 10 per year over the whole period and 5 per year over the last 20 years (D. Reid, pers. comm.). Most were captured from the Newcastle region, with a few from the Sydney region and less from the Wollongong area (Anon., 1996c). Eight immature *Carcharodon carcharias* (total lengths ranging from 1.79m to 2.5m) were captured in protective beach-meshing operations in the Newcastle (6 including 1 released) and central coast (2 including 1 released) regions between 1 September 1999 and 1 April 2000 (D. Reid, pers. comm). The size distribution of white sharks caught in NSW protective beach-meshing operations has shown a shift to smaller sized sharks (<2.25m) in the catches over time (Anon., 1996c). Only 31% of white sharks taken were in this size category (<2.25m) during the period 1950-1970, compared to 50% in 1970-1990 and over 90% in the 1990s (Anon., 1996c).

Since 1962, a total of 670 white sharks have been caught in the Queensland Shark Control Program. During the first 20 years of beach meshing in Queensland an average of about 20 white sharks were caught per year, but this has dropped to an average of about 10 per year over the last 10 years (Environment Australia, 2000b). In Queensland waters, however, there has been no significant change in the average size of white sharks caught in the shark control program since its inception (Anon., 1996c; G. McPherson, pers. comm.). Twenty-one white sharks, ranging in size from 2.1 - 4.8m, were caught in the Queensland Shark Control Program in the region from the Gold Coast northwards to Rockhampton between January 1993 and August 2000 (B. Lane, pers. comm.). The majority (14) of these were caught with drumlines, while the remainder (7) were caught with nets. More females (12) were caught than males (8) (B. Lane, pers. comm.).

The Game Fishing Association of Australia recorded a total of 183 white sharks caught in NSW between 1960 and 1995 (mainly from the Sydney region). In recent times the number of white sharks captured in NSW has averaged about 1.8 per year, due mainly to the behaviour of gamefishers fishing further offshore (Anon., 1996c; Pepperell, 1992). Commercial fishing activities in southern Australian waters may be the greatest current cause of mortality of this species (up to 300 sharks per year) (Anon., 1996c).

Despite its natural rarity, *Carcharodon carcharias* is an important marine macro-predator. Although it enjoys protected status in parts of its range, the white shark is still threatened by mortality from commercial fisheries bycatch, sports angling (in waters outside of Australia), and directed fisheries for its jaws, teeth and fins (Camhi *et al*., 1998).

Trade in white shark products such as jaws, teeth and fins are of serious concern, but the impact of these activities is difficult to quantify, partly because of the illegal 'black market' nature of such trades for highly lucrative white shark products (Compagno *et al*., 1997). Shark finning and trade in shark products are global conservation problems which need to be addressed to halt the suspected declines of the white shark and numerous other elasmobranch species. The above statistics suggest that *C. carcharias* has been declining at an unsustainable level due to a variety of fishing activities, and this needs to be reversed for the species to regain a secure status.

Australian Marine Protected Areas in Which the Species Occurs:
As the white shark is wide-ranging, MPAs may not provide much protection for this species. However, white sharks have been recorded from the following MPAs:
Great Barrier Reef Marine Park, Qld
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW
Solitary Islands Marine Park, north of Coffs Harbour, northern NSW
Lord Howe Island Marine Park, Tasman Sea

Suggested Conservation Status:
Vulnerable on an Australia-wide basis.
Until further studies can reliably document increases in Australian populations of *C. carcharias*, it is recommended to assign it the conservation status of Vulnerable, adopting the IUCN categories. There are no accurate estimates for population sizes of this species in Australian waters.

Threatening Processes:
The main threat to white sharks in Australian waters is commercial fishing, during which the white shark is taken as a bycatch. White sharks are taken as bycatch in the SSF, snapper fisheries operating in Victoria and SA, and in WA shark fisheries (Environment Australia, 2000b). White sharks have also been killed in southern bluefin tuna farming operations in Australia (Environment Australia, 2000b; SAG, 2000). An added threat to white sharks are the shark control programs in NSW and Queensland waters, which continue to take small numbers through beach meshing and drumline techniques. Recreational gamefishers may also occasionally catch this species. The degradation of inshore waters used as nursery areas could also have an effect on breeding and/or juvenile survival, but further research is necessary to test this assumption.

Critical Habitats:
As indicated above, undegraded inshore nursery and feeding (e.g. seal colonies) habitats may be important to the survival of this species.

Recovery Objectives/Management Actions Required:
The main objective of white shark recovery planning is: 'To recover white shark numbers in Australian waters to a level that will see the species removed from the vulnerable category in the ESP Act (based on the 1994 IUCN criteria)' (Environment Australia, 2000b). A Great White Shark Recovery Team consisting of scientists, conservation managers, fisheries managers and other stakeholders, has been formed and first met in October 1999 to discuss recovery actions for this species. Environment Australia, with the help of this Great White Shark Recovery Team, has written a Draft Recovery Plan (Environment Australia, 2000b) which identifies the following specific objectives:
- Reduce the impact of commercial fishing on white sharks
- Investigate and evaluate the impact of recreational fishing on white sharks
- Monitor and reduce the impact of shark control activities on white sharks
- Reduce the impact of trade in white shark products
- Manage the impact of ecotourism on white sharks
- Develop research programs toward the conservation of white sharks
- Identify and establish refugia to protect and conserve white sharks
- Promote community education

To fulfil the specific objectives, actions are designed to identify and reduce the threats to white sharks, to determine levels of mortality, and to reduce that mortality (Environment Australia, 2000b). The assessment of the actions against the criteria for success is essential for the successful recovery of white sharks identified in this plan. These actions and criteria are summarised as:
- Assess available commercial and recreational fisheries data to determine current level of white shark bycatch
- Modify commercial fisheries logbooks to record white shark catch and biological data
- Ensure existing fishery observer programs record interactions with white sharks
- Quantify and reduce levels of white shark take in shark control activities
- Establish tag and release programs in shark control and research programs
- Regulate shark finning
- Model the population status of white sharks
- Collect biological and genetic information on white sharks
- Minimise ecotourism impacts on white sharks
- Develop a community education strategy for white sharks

A review of the five-year recovery plan will be carried out annually for its duration by the recovery team and reports of these reviews will be forwarded to the Endangered Species Advisory Committee (Environment Australia, 2000b). The recovery team will also undertake an evaluation of the success of the recovery plan after five years.

References:

Anon., 1996c; Bruce, 1992; B. Bruce, pers. comm. 1999-2000; Camhi *et al*., 1998; Cliff *et al*., 1996; Compagno, 1984; Compagno *et al*., 1997; Environment Australia, 2000b; Fergusson, 1996; Fergusson *et al*., in prep.; Francis, 1996a; Klimley and Anderson, 1996; B. Lane (QDPI Shark Control Program), pers. comm. 8/2000; Le Boeuf *et al.*, 1982; S. Lemm (QPWS), pers. comm. 3/2000; G. McPherson, pers. comm. 2/2000; Paterson, 1990; Pepperell, 1992; D. Reid, pers. comm. 1999-2000; Smith and Pollard, 1997; J. Stevens and B. Bruce, pers. comm. 12/1999; Shark Advisory Group (SAG), 2000; Strong *et al*., 1992; Strong *et al*., 1996.

Websites: http://www.fsc.nsw.gov.au (NSW Fisheries Scientific Committee)

FAMILY HEXANCHIDAE: SIXGILL and SEVENGILL SHARKS

Members of this small family; also known as cowsharks, can be easily distinguished by the presence of six or seven pairs of gill slits, none of which is continuous across the throat (Last and Stevens, 1994).

This family of medium to large (attaining 1.4 to 4.8m) sharks has a worldwide distribution in cold temperate and tropical seas (Compagno, 1984; Last and Stevens, 1994). They are usually found near the bottom in deepwater, although one species, *Notorynchus cepedianus*, inhabits relatively shallow bays and estuaries (Last and Stevens, 1994). All four species in this family occur in the Australian region (Last and Stevens, 1994).

The behaviour of these sharks is poorly known (Compagno, 1984). Though they have not been implicated in unprovoked attacks on swimmers and divers, two species grow large enough (over 3m) to be potentially dangerous to humans (Compagno, 1984). They are ovoviviparous, lacking a yolk-sac placenta (Compagno, 1984; Last and Stevens, 1994). Their diet includes large mammalian prey, elasmobranchs (Last and Stevens, 1994), bony fishes and crustaceans (Compagno, 1984).

Compagno (1984) reported that cow sharks were relatively unimportant, but regular components of shark fisheries and a bycatch of other fisheries in temperate and tropical waters. They are taken by line gear, bottom and pelagic trawls and gill nets (Compagno, 1984). They are regarded as excellent for human food and are utilised fresh and dried-salted; they are also processed for fishmeal, oil and leather, and some species are subject to sports fisheries in shallow waters (Compagno, 1984).

Two species of this family, *Hexanchus griseus* and *Notorynchus cepedianus,* have conservation synopses included in the following pages.

References:
Compagno, 1984; Last and Stevens, 1994

Bluntnose Sixgill Shark

Family Name:	Hexanchidae
Scientific Name:	*Hexanchus griseus* (Bonnaterre, 1788)
Conservation Status:	Data Deficient

Australian Synonyms:
Hexanchus griseus australis De Buen, 1960

Alternative Common Name:
Sixgill shark

Current Conservation Status:
In Australian waters:
No ASFB Listing

On a Global basis:
1996 IUCN Red List of Threatened Animals
Vulnerable (A1d; A2d)

2000 IUCN Red List of Threatened Species
Lower Risk (near threatened)

Distribution:
Hexanchus griseus is widely, but discontinuously, distributed in tropical and temperate waters of the Atlantic (including the Mediterranean), Indian and Pacific Oceans. In Australian waters it has been recorded from seamounts off Queensland and a few specimens have been collected off New South Wales, Victoria, Tasmania and northern Western Australia (Last and Stevens, 1994).

Museum Records - 8 specimens (Standard Length 45.5-425cm), collected from a depth range of 144-549m, ranging in geographical distribution from off Mooloolaba (26°04'S), Qld southwards to off Port Fairy (38°23'S, 142°14'E), Victoria, collected between 1963 and 1990.

Habitat:
Hexanchus griseus is known from continental and insular shelves and upper slope waters from the surface to about 2000m. Juveniles may occur close inshore while adults are normally taken on or near the bottom in deeper waters (Last and Stevens, 1994).

Biology and Behaviour:
Ovoviviparous, with large litters of 22 to 108 young being reported (Last and Stevens, 1994). Longevity, pupping interval and mating behaviour are unknown, as are nursery and pupping grounds (Cook and Compagno, in prep.). This species is relatively sluggish and a poor fighter when captured on hook and line (Last and Stevens, 1994). *Hexanchus griseus* preys on a wide variety of teleost and elasmobranch fishes, cephalopods, crustaceans, sea cucumbers, carrion and sometimes seals (Last and Stevens, 1994; Cook and Compagno, in prep.).

Size:
Hexanchus griseus pups are born at 65-70cm in length and adults attain 480cm. Males mature at about 315cm and females at around 420cm (Last and Stevens, 1994). Young are occasionally found in shallow waters close to the shore, but as they grow they move into deeper waters. It is unknown whether these sharks segregate by sex (Cook and Compagno, in prep.).

Evidence for Decline:
Hexanchus griseus is utilised in some areas outside of Australia for its meat and liver oil (Last and Stevens, 1994). Worldwide, this species has often been taken as a bycatch of other fisheries. In the USA, it has been

targeted and exploited by sport fisheries, but attempts to develop directed commercial fisheries for the species have rapidly collapsed in Californian waters. Development of a fishery for this species in British Colombia has proceeded despite strong concerns voiced by fisheries biologists about the success and sustainability of such fisheries historically (Cook and Compagno, in prep.).

Australian Marine Protected Areas (MPAs) in Which the Species Occurs:
Possibly occurs in Ningaloo Marine Park, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
There is no evidence of any decline in Australian waters, but this species may be susceptible to capture as a bycatch of other fisheries. However, more data are necessary to accurately determine its conservation status in Australian waters.

Threatening Processes:
There are no specific threats to this species recognised in Australian waters. However, unsustainable fisheries have been a threat to the species overseas.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
None identified at this stage.

References:
Cook and Compagno, in prep.; Last and Stevens, 1994.

Broadnose Sevengill Shark

Family Name:	Hexanchidae
Scientific Name:	*Notorynchus cepedianus* (Peron, 1807)
Conservation Status:	Data Deficient

Australian Synonyms:
Notorynchus macdonaldi Whitley, 1931

Alternative Common Names:
Ground shark; sevengill shark; spottie; Tasmanian tiger shark; broad-snout; cowshark

Current Conservation Status:
In Australian waters:
No ASFB Listing

On a Global basis:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Data Deficient globally; Lower Risk (near threatened) in the Eastern Pacific

Distribution:
Notorynchus cepedianus is a wide-ranging species that occurs in temperate waters of the South Atlantic, Pacific and Indian Oceans. In Australasia, it is recorded from New Zealand and in Australia from off Sydney (New South Wales) to Esperance (Western Australia), including Tasmania (Last and Stevens, 1994).

Museum Records - 30 specimens (Standard Length 25.5-237.5cm), collected from a depth range of 20-201m, ranging in geographical distribution from Broken Bay (33°34'S), NSW southwards to southern Tasmania (42°56'S), and westwards to Investigator Strait (35°20'S, 137°50'E), SA. Specimens were collected between 1889 and 1998.

Habitat:
Notorynchus cepedianus inhabits inshore bays and estuaries, and is found to depths of at least 200m on the continental shelves. It occurs on or near the bottom, but it may come to the surface in inshore areas (Last and Stevens, 1994).

Biology and Behaviour:
Little is known of the biology of this species in Australian waters (Last and Stevens, 1994). From studies in Californian and South African waters, however, this species is known to be ovoviviparous, with large litters of up to 82 young (Ebert, 1986). The average reproductive age is unknown, but is estimated to be 20-25 years for females, while maximum longevity is estimated to be about 50 years (adults reaching lengths 300cm) (Compagno, in prep.). Females give birth every two years after consecutive, year-long ovarian and gestation cycles (Ebert, 1996). Compagno (1984) noted that this species had attacked divers in aquarium display tanks. It feeds on bony fishes, other sharks, seals and carrion (Last and Stevens, 1994). In a predation study of Tasmanian school shark pupping grounds, Stevens and West (1997) noted that *Notorynchus cepedianus* preyed upon school and gummy sharks (family Triakidae), *Squalus* dogfishes (family Squalidae) and stingarees (family Urolophidae).

Size:
This species is born at lengths of 40-45cm and attains 300cm. Males mature at about 150cm (4-5 years) and females at about 220cm (11-21 years) (Last and Stevens, 1994).

Evidence for Decline:
There is no evidence of any decline of this species in Australian waters. Between the years 1994 and 1998 inclusive, over 58t of this species were reported as retained bycatch from Commonwealth fisheries in Australia, predominantly from the South East Non-Trawl Fishery (SENTF) and the Southern Shark Fishery (SSF) (AFMA logbook data, unpublished), but also from the South East Trawl Fishery (SETF) (AFMA, 2000g). According to AFMA logbook data, catches from Commonwealth fisheries have increased each year from 1994 to 1998, with nearly 30t being retained in 1998 alone (AFMA logbook data, unpublished) and approx. 25t in 1999 (AFMA, 2000g). A total of 50 sevengill sharks were caught in the NSW beach meshing program between October 1972 and December 1990; most were caught between August and November and a high proportion were male (Krogh, 1994). The seasonal abundance of sevengill sharks in inshore waters off NSW during winter and spring and the apparent lack of mature females suggest that their occurrence in these waters is related to feeding rather than breeding (Krogh, 1994). A further 46 sharks have been caught in NSW beach-meshing operations in the last 10 years, averaging about 5 per year (D. Reid, unpublished data). The flesh is of good quality and this species is also taken for its hide and liver oil (Last and Stevens, 1994). Intensive commercial and sports fisheries in San Francisco Bay targeting it for its fine meat caused a marked local decline in numbers during the early 1980s. Pollution may be a possible threat to inshore bays, which are nurseries for this species (Compagno, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
None identified, but some southern Australian MPAs may provide habitat for this species.
Possibly occurs in Ningaloo Marine Park, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
Little is known about the biology and possible migrational movements of this species in Australian waters, and until better biological information is available, it is recommended to assign it the status of Data Deficient, adopting the IUCN categories. This species may have low recovery capabilities if overfished, as in overseas waters it is known to be slow growing and late maturing (Smith *et al*., 1998). In Australian waters it is known to occur in coastal areas where it may be susceptible to a variety of fishing methods.

Threatening Processes:
Commercial fishing in southern Australia waters (where the SENTF and the SSF take this species) is potentially the greatest threat to this species. Habitat degradation of inshore areas could also adversely affect the nursery grounds of this species.

Critical Habitats:
Inshore bays and estuaries in southern Australia may be critical to this species as they probably act as nursery areas.

Recovery Objectives/Management Actions Required:
Analysis of basic biological characteristics, such as sex and size structure of sharks taken as a bycatch of the SENTF and the SSF, will help improve our knowledge of the biology of Australian populations. Additionally, biological studies on the movements and/or migrations of this species would enhance our understanding of both the spatial and temporal variability of its populations.

References:
AFMA logbook data, unpublished; AFMA, 2000g; Compagno, 1984; Compagno, in prep.; Ebert, 1986; Ebert, 1996; Krogh, 1994; Last and Stevens, 1994; D. Reid, unpublished data; Smith *et al*., 1998; Stevens and West, 1997.

FAMILY SQUALIDAE – DOGFISHES

Dogfishes are highly varied in morphology and include some of the smallest and largest of sharks (0.2m to 6m in length at maturity) (Last and Stevens, 1994). Dogfishes have the widest depth ranges and geographical distributions of all sharks - they have been caught from near shore to depths exceeding 6km and are represented in all oceans (Last and Stevens, 1994). Worldwide, many dogfish species are of commercial value as food, and others are exploited for high-quality squalene oil, which is stored in the liver (Last and Stevens, 1994). The family Squalidae is the largest elasmobranch family in the Australian region, with 14 genera and at least 40 species (Last and Stevens, 1994). All members of this family are ovoviviparous and reported litter sizes vary between 1 and 36 (or more) young (Last and Stevens, 1994). Five dogfish species are examined in this report - three *Centrophorus* species, *Dalatias licha* and *Squalus acanthias*.

Centrophorus species are of high conservation concern, mainly due to their occurrence for many years in the catches of commercial continental slope fishers off southeastern Australia, and their observed declines over this period. Landings of *Centrophorus* species in the NSW Deepwater Line Fishery totalled 7t in 1997-98 (Fletcher and McVea, 2000). Continental slope habitats are critical to *Centrophorus* and there have been marked declines in the abundances of some of these species, probably due their exploitation in south-eastern Australia. The specific nature of the habitats which are used by *Centrophorus* species are not well understood, and need to be further investigated in order to protect them from overexploitation.

Shark experts at CSIRO in Hobart are currently revising the taxonomy of the *Centrophorus* dogfishes, and additional species await formal description (P. Last, pers. comm.). The discovery of previously unknown taxa will, in some cases, result in the contraction of some species' distributional ranges. Once the taxonomy of these species is more clearly understood it may be necessary to redress their conservation status in light of any changes to their distributional ranges and abundances.

Squalene, which is extracted from shark liver oil, is used in cosmetics, pharmaceuticals, health foods and as a high grade machine oil. Squalene is extracted from several species of sharks, particularly deep-sea dogfishes in depths of 600-1000m, which has prompted the targeting of some of these sharks in Australian waters (SAG, 2000). Off Western Victoria, trawling in over 1000m has begun to capture species of dogfish not previously landed commercially (Walker 1998). Dogfishes will be increasingly targeted worldwide when fisheries move into deeper waters as inshore fishing grounds are depleted. The need for accurate species data in terms of species identifications and catch rates is crucial to the conservation of dogfishes, both in Australia and overseas.

AFMA and CSIRO have recently produced a field identification guide to these sharks (*Common sawsharks and dogfish sharks of southern Australia*). This was developed to improve the quality of shark data collection, and was distributed amongst Southern Shark, South-East Non-Trawl (AFMA, 2000g), South East Trawl and Great Australian Bight Trawl Fishery operators. This field guide encourages fishers to record the different species caught as accurately as possible (T. Skousen, pers. comm.).

Between 270-300t of dogfishes were reputedly identified only to family level in Commonwealth fisheries in the years 1998-1999 (AFMA, 2000g). This highlights the need for the abovementioned field guides in attempting to increase the generic and specific levels of logbook reporting.

References:

AFMA, 2000g; Fletcher and McVea, 2000; P. Last, pers. comm. 7/2000; Shark Advisory Group (SAG), 2000; T. Skousen (AFMA), pers. comm. 9/2000.

Gulper shark

Family Name:	Squalidae
Scientific Name:	*Centrophorus granulosus* (Bloch and Schneider, 1801)
Conservation Status:	Data Deficient

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Vulnerable (A1abd + 2d)

No ASFB Listing

Distribution:
Centrophorus granulosus occurs in the western North Atlantic, eastern Atlantic, and Indian Oceans, and in the western Pacific Ocean from Japan, PNG and tropical Australia (Queensland and northern Western Australia) (Last and Stevens, 1994).

Museum Records - 5 specimens (Standard Length 35-153cm), collected from a depth range of 400-868m, ranging in geographical distribution from north-east Qld (the only east coast record) to the Exmouth Plateau (approx. 20°S, 113°E), WA. There are also specimens collected from France and the western Mediterranean. Specimens were collected between 1885 and 1991.

Habitat:
Centrophorus granulosus inhabits demersal regions on continental shelves and slopes in depths of 100-1200m (Last and Stevens, 1994).

Behaviour and Biology:
Little is known of the biology of this species, other than that it is ovoviviparous and feeds mainly on bony fishes (Last and Stevens, 1994).

Size:
Centrophorus granulosus is born at lengths of about 35cm and attains an adult length of at least 160cm (Last and Stevens, 1994).

Evidence for Decline:
There is no evidence of any decline of this species in Australian waters. In the eastern Atlantic, it is utilised for human consumption and processed for fishmeal and liver oils (Last and Stevens, 1994). In Japan it is sought for its liver oil to supply the squalene health food market (Cook, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
Due to its deep-water habitat this species is unlikely to occur in any MPA's in Australia.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
More information is necessary to accurately determine the status of this species in Australian waters. However, based on the observed declines of the closely related *Centrophorus harrissoni*, the status of this species needs to be closely monitored.

Threatening Processes:
None identified

Critical Habitats:
None identified

Recovery Objectives/Management Actions Required:
Biological studies are required to determine the life-history characteristics of this species.

References:
Cook, in prep.; Last and Stevens, 1994.

Harrissons Dogfish

Family Name:	Squalidae
Scientific Name:	*Centrophorus harrissoni* McCulloch, 1915
Conservation Status:	Endangered

Alternative Common Names:
Harrissons deepsea dogfish; dumb shark; dumb gulper shark

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Centrophorus harrissoni is endemic to east coast Australian waters and is mainly restricted to waters off the New South Wales coastline, though it has been recorded as far southwards as Flinders Island in Tasmania (P. Last, pers. comm.). Trawling on the continental slope off south-eastern Queensland has not yielded any specimens of this species (P. Last, pers. comm.).

Museum Records – approximately 40 specimens (Standard Length 21.7-90cm), collected from depths of 346-823m, ranging in geographical distribution from off Crowdy Head (31°48'S), NSW southwards to off St Helens (approx. 41°20'S), Tasmania, collected between 1914 and 1986. Some of the above identifications may need to be confirmed due to the recent work conducted by CSIRO shark specialists on this and related species.

Habitat:
This species occurs in demersal habitats on the continental slope in depths of 220-790m (Last and Stevens, 1994). As the continental slope is relatively steep, the total area available to this species is relatively limited (P. Last, pers. comm.).

Behaviour and Biology:
Centrophorus harrissoni is presumably ovoviviparous, but little is known about its biology (Last and Stevens, 1994). Females produce one, or more commonly two pups (Graham *et al.*, 2001). Based on preliminary ageing studies of closely related species that suggest the longevity of *Centrophorus uyato* to be in excess of 46 years (Fenton 2001), *C. harrissoni* is also likely to have a high longevity and late age at first maturity. Details of the diet of *C. harrissoni* are unknown, but other members of this genus feed on bony fishes, cephalopods, crustaceans and other elasmobranchs (Last and Stevens, 1994). Myctophid fishes have been reported from the stomach contents of this species (K. Graham, pers. comm.). As myctophids are generally mesopelagic fishes that undertake vertical migrations at night, this may suggest that *Centrophorus harrissoni* is also found, to some extent, in midwater (K. Graham, pers. comm.). Recently collected specimens of this species were caught in the early morning hours, which may suggest a feeding-related movement in response to the movements of some of its prey (K. Graham, pers. comm.). This aspect of the species biology needs to be further investigated.

Size:
Centrophorus harrissoni is born at about 32cm and attains about 100cm in length. Males mature at about 85cm (Last and Stevens, 1994).

Evidence for Decline:
Centrophorus harrissoni is taken as a bycatch by demersal trawlers, but has been of little commercial interest, probably due to its rarity (Last and Stevens, 1994). The 1996-1997 survey of upper slope trawling grounds between Sydney (NSW) and Gabo Island (Victoria) carried out by the Fisheries Research Vessel "Kapala" yielded only 15kg (a total of eight sharks) of *Centrophorus harrissoni* in 165 tows (Graham *et al.*, 1997; K. Graham, pers. comm.). This species has declined considerably since the surveys carried out by the same vessel in 1976-1977, which yielded over 5000kg (equivalent to over 1000 sharks based on an adult weight of 4-5kg, which underestimates the juvenile component) in 173 tows (Graham et al., 1997; K. Graham, pers. comm.). The 1976-77 figures above do not include data where *C. harrissoni* was not

differentiated from *C. uyato*. In the years 1976-1977, *C. harrissoni* occurred in nearly half of the tows (84 of 173), in comparison with only 3% of tows (5 of 165) in the years 1996-1997 (Graham *et al*., 1997; K. Graham, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
Due to the deep-water habitat of this species, it is unlikely to occur in any MPAs in Australia.

Suggested Conservation Status:
Endangered on an Australia-wide basis
Adopting the IUCN criteria, *Centrophorus harrissoni* would qualify as Critically Endangered, based on the observed declines most probably due to trawling operations in the Sydney to Gabo Island area. However, at this stage the conservation status of Endangered is suggested for this species until further information is gathered.

Threatening Processes:
Commercial trawling and droplining are continuing threats to this species within most of its distributional range.

Critical Habitats:
Demersal habitats of the upper continental slope off NSW are critical habitat to this species. However, no qualitative or quantitative surveys of the habitat used by this species have been carried out to demonstrate any habitat preferences within the depth range mentioned above.

Recovery Objectives/Management Actions Required:
The recent recognition of additional *Centrophorus* species by CSIRO shark specialists has resulted in a contraction of the previously known range of this species (P. Last, pers. comm). Further study is necessary to accurately determine the distributional and depth range of the species, along with its biological characteristics. No demersal fishing gear can selectively fish for this species (K. Graham, pers. comm.). Similarly, no demersal fishing gear can exclude this species from the catches if it is present in the area of trawling and/or droplining in large enough numbers (K. Graham, pers. comm.). Therefore, the designation of adequately sized no-take reserves within the known range of the species is essential to ensure its survival. The first step in any Recovery Plan for this species would be to attain listing of the species on the *Environment Protection and Biodiversity Conservation Act, 1999*. It will then be necessary to form a National Recovery Team to coordinate and conduct research into its distribution, ecology and biology.

References:
Graham *et al*., 1997; K. Graham, pers. comm. 8/2000 - 6/2001; P. Last, pers. comm. 7/2000 - 9/2000; Last and Stevens, 1994.

Southern Dogfish

Family Name:	Squalidae
Scientific Name:	*Centrophorus uyato* (Rafinesque, 1810)
Conservation Status:	Vulnerable

Alternative Common Name:
Little gulper shark

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Centrophorus uyato occurs in the western North Atlantic (Gulf of Mexico), eastern Atlantic (Portugal to Namibia, including the Mediterranean Sea), Indian Ocean (southern Mozambique and possibly India), and the western Pacific (Taiwan). In Australia, it occurs in temperate waters from Albany to Geraldton (Western Australia) and from Fowlers Bay (South Australia) to Port Stephens (New South Wales), including Tasmania (Last and Stevens, 1994).

Museum Records - 45 specimens (Standard Length 31.6-96cm), collected from a depth range of 293-750m, ranging in geographical distribution from off Sydney (33^{o}44'S), NSW southwards to east of Maria Island (42^{o}39'S), Tasmania and resuming again in WA from south of Cape Leeuwin (35^{o}02'S) northwards to Sahul Banks (11^{o}33'S) in the Timor Sea, WA. Specimens were collected between 1971 and 1996.

Habitat:
Centrophorus uyato occurs demersally on continental shelves and slopes in depths of 50 to 1400m. In Australian waters it is mainly known from depths between 400 to 650m (Last and Stevens, 1994).

Behaviour and Biology:
The size at maturity of this species is unknown, although males are mature by 80cm length (Last and Stevens, 1994). Females produce only a single pup at any one time (Graham *et al*., 2001). A Fisheries Research and Development Corporation (FRDC) funded project (Fenton 2001) demonstrated that many dogfishes have high longevity. This work, although preliminary in its findings, examined a sample size of eight *Centrophorus uyato* (ranging from 58.6 - 80.9cm in total length) for longevity estimates (Fenton 2001). The age of these eight specimens was estimated to be in the range of 24.63 to 45.57 years (with an error range of 2.51 to 4.25 years for the 8 specimens). If the above age estimates are correct, it is feasible that longevity of *C. uyato* exceeds 50 years and age at first maturity is at least 25 years (but possibly up to 40 or more years). The diet of *C. uyato* consists mainly of bony fish and cephalopods (Last and Stevens, 1994).

Size:
Centrophorus uyato is born at about 35cm and attains a length of around 100cm (Last and Stevens, 1994). The exact size at maturity is unknown, but males are mature by 80cm length (Last and Stevens, 1994).

Evidence for Decline:
Centrophorus uyato is dried and salted for human consumption in the eastern Atlantic, but in Australia it is of little commercial interest (Last and Stevens, 1994). The 1996-1997 survey of upper slope trawling grounds between Sydney (NSW) and Gabo Island (Victoria), carried out by the NSW Fisheries Research Vessel "Kapala" yielded only 52kg of *Centrophorus uyato* in 165 tows. This species has declined considerably since surveys carried out by this same vessel in 1976-1977, yielded over 18.6t of this species in 246 tows. In the years 1976-1977, *C. uyato* occurred in more than 42% of the tows, in comparison with only 8% of tows in the years 1996-1997 (Graham *et al*., 1997).

Australian Marine Protected Areas in Which the Species Occurs:
Great Australian Bight Marine Park, SA (unconfirmed)

Suggested Conservation Status:
Vulnerable on an Australia-wide basis.
There is some taxonomic evidence to suggest that the southern (i.e. Australian) stock is different from the stock in Atlantic waters, which would greatly reduce the range for the southern form of this species (P. Last, pers. comm.). Further taxonomic research by CSIRO shark specialists will help to elucidate and overcome these taxonomic impediments.

Threatening Processes:
Commercial trawling and droplining are threats to this species in Australian waters.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
The recent recognition of additional *Centrophorus* species by CSIRO shark specialists may result in range contractions of Australian species (P. Last, pers. comm). Further study is necessary to accurately determine the distributional and depth ranges of this species, along with its biological characteristics. The designation of specific non-trawl areas within the known range of the species may be necessary to ensure its survival. The first step in any Recovery Plan for this species would be to form a National Recovery Team to coordinate research into its distribution, ecology and biology.

References:
Fenton, 2001; Graham *et al*., 1997; Graham *et al*., 2001; P. Last, pers. comm. 1999-2000; Last and Stevens, 1994.

Black shark

Family Name:	Squalidae
Scientific Name:	*Dalatias licha* (Bonnaterre, 1788)
Conservation Status:	Data Deficient

Australian Synonyms:
Scymnorhinus phillippsi Whitley, 1934

Alternative Common Names:
Kitefin shark; seal shark

Current Conservation Status:
<u>1996 IUCN Red List of Threatened Animals</u>
Vulnerable (A1d + 2d)

<u>2000 IUCN Red List of Threatened Species</u>
Data Deficient globally; Lower Risk (near threatened) in North-eastern Atlantic

<u>No ASFB Listing</u>

Distribution:
Dalatias licha is a relatively common, but unevenly distributed, deeper-water dogfish (Compagno and Cook, in prep.) which occurs in the eastern and western Atlantic, western Indian Ocean and in the western and central Pacific from Hawaii, Japan and Australia to New Zealand (Last and Stevens, 1994). In Australian waters it is known from the Swain Reefs (Queensland) to Port Hedland (Western Australia), including Tasmania and adjacent seamounts (Last and Stevens, 1994).

<u>Museum Records</u> - 62 specimens (Standard Length 20.2-137cm), collected from depths of 20-1000m, ranging in geographical distribution from off Swain Reefs (22^{o}34'S), Qld southwards to Cascade Plateau (43^{o}51' S), Tasmania and north-westwards to Scott Reef (approx. 19^{o}S), WA. There is also a specimen from Italy. Specimens were collected between 1909 and 1992.

Habitat:
Dalatias licha is mainly demersal (sometimes pelagic) on the outer continental and insular shelves and slopes from 40-1800m, but mainly occurs between 450-800m in Australian waters (Last and Stevens, 1994).

Behaviour and Biology:
Dalatias licha occurs as solitary individuals or in small schools. It is ovoviviparous, with litters of 10-16 young (Last and Stevens, 1994). The diet consists mainly of bony fishes, but also includes elasmobranchs, cephalopods and crustaceans (Last and Stevens, 1994), and also annelid worms (Compagno and Cook, in prep.).

Size:
Dalatias licha is born at a length of about 30cm (Last and Stevens, 1994). Females attain a length of 160cm, and males grow to 120cm (Compagno and Cook, in prep.). Males are mature at about 100cm and females at about 120cm (Last and Stevens, 1994). Little is known about growth, age at maturity, or longevity in the wild (Compagno and Cook, in prep.).

Evidence for Decline:
There is no evidence of any decline in Australian waters. This species is of little commercial value in Australia, though it has occasionally been used for its liver oil (J. Stevens, pers. comm.). Over 227t of this species were reported to be taken in Commonwealth fisheries between the years 1994 and 1998, primarily as retained bycatch of the SEF (221t), but also as a bycatch of the tuna longline (4t) and GAB fisheries (2t) (AFMA logbook data, unpublished). Most of this catch (182t) was reported to be taken in 1998 (AFMA

logbook data, unpublished). In the 1999 calendar year, approx. 155t (including discards) of this species were taken, 150t of which were from the SETF (AFMA, 2000g). In the year 2000, only 14.5t of this species were taken up to the end of June (AFMA logbook data, unpublished). These lower catches may be explained by the recent distribution to commercial fishers of identification guides to dogfishes. Earlier catch statistics for black sharks (i.e. 1994 to 1999) may have included other dogfishes such as *Centroscymnus* species in their totals (T. Skousen, pers. comm.). *Dalatias licha* is one of the main discard species in the SENTF demersal line sector (AFMA, 2000d). However, the survival rates of these discards are unknown. *Dalatias licha* is an important bycatch species of New Zealand shark fisheries and is marketed for its flesh (Francis and Shallard, 1999). Between 1986-87 and 1996-97 an average of about 250t of *Dalatias licha* per year have been taken in shark fisheries in New Zealand (Francis and Shallard, 1999). This species has long been exploited commercially outside of Australia, being taken primarily in deep-water directed fisheries, and it is used for its squalene liver oil, leather and meat, as well as for fishmeal. Records of yields from the Portuguese kitefin shark fishery suggest that targeted fisheries are capable of reducing populations quite rapidly (Last and Stevens, 1994; Compagno and Cook, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly occurs in the following areas:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Great Australian Bight Marine Park, SA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
This species is not targeted in Australian waters, but it is taken in considerable quantities as a bycatch in the South East Fishery. More data are necessary to accurately determine its conservation status in these waters.

Threatening Processes:
Commercial fishing, whereby this species is taken as a bycatch, is a potential threat to this species in Australian waters.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
Further biological research in Australian waters is recommended to help ascertain the impacts of the current levels of bycatch on this species. The survival rate of discarded black sharks needs to be investigated to accurately quantify the impact of the relevant fisheries on this species.

References:
AFMA, 2000d; AFMA, 2000g; AFMA logbook data, unpublished; Compagno and Cook, in prep.; Francis and Shallard, 1999; Last and Stevens, 1994; T. Skousen (AFMA), pers. comm. 9/2000.

White-spotted dogfish

Family Name:	Squalidae
Scientific Name:	*Squalus acanthias* Linnaeus, 1758
Conservation Status:	Lower Risk (least concern)

Alternative Common Names:
Piked dogfish; spiny dogfish; spotted spiny spurdog; white-spotted spurdog; spurdog; Victorian spotted dogfish.

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Lower Risk (near threatened)

No ASFB Listing

Distribution:
Squalus acanthias has an antitropical distribution. It is widely distributed in the North Atlantic and North Pacific Oceans, and around the southern tips of South America, Africa, Australia and New Zealand. In Australian waters this species is common around Tasmania and Victoria (also recorded from the Great Australian Bight), inshore in bays and estuaries (Last and Stevens, 1994). It also occurs in southern Western Australia and South Australia, and possibly southern New South Wales (Gomon *et al*., 1994).

Museum Records - 46 specimens (Standard Length 11.5cm (embryos) - 68.5cm), collected from depths of 2-330m, ranging in geographical distribution from Port Phillip Bay (37°52'S), Victoria southwards to off Woodbridge (43°10'S), Tasmania. Outside of Australia there are specimens from England, Norway, Spain, Sweden and the United States of America in Australian fish collections. Specimens were collected between 1872 and 1996.

Habitat:
Squalus acanthias penetrates well into brackish waters and is occasionally found in intertidal waters of southern Tasmania (Last and Stevens, 1994). In Australia, this species is demersal and occurs in estuaries, bays and on the continental shelf down to 180m (May and Maxwell, 1986).

Behaviour and Biology:
Squalus acanthias is an ovoviviparous shark (Gomon *et al*., 1994) that breeds inshore in large bays and estuaries, and may produce litters of up to 20 young (Last and Stevens, 1994), though litter sizes of 4 to 6 are more common (Gomon *et al*., 1994). The reported gestation period of 18-24 months is among the longest of all chondrichthyans. The species is also very long-lived, first maturing at 10-25 years and estimated to live for 70 years in some areas (Last and Stevens, 1994). This species forms immense feeding aggregations or packs in rich foraging grounds where it may be present in its thousands (Compagno, 1984). It often occurs in schools segregated by size and sex, including schools of small juveniles of both sexes in equal numbers, of mature males, of larger immature females and of large mature females. Generally, males occur in shallower water than females, with the exception of large pregnant females (Compagno, 1984). An important factor in migrational movements of *S. acanthias* seems to be water temperature. These sharks favour a temperature range of 7-8° C and a maximum of 12-15° C, and apparently make latitudinal and depth migrations to stay within their optimum range (Compagno, 1984). They make annual seasonal migrations of hundreds of miles and may travel longer distances (Ayling and Cox, 1982). Mating of dogfish may occur in the winter and birth may occur primarily during the cold months of the year, with considerable variation, some young being produced in spring and summer (Compagno, 1984). In a study of south-eastern Tasmanian shark nursery areas, Williams and Schaap (1992) captured 275 *S. acanthias* (257 males [93%] and 18 females [7%]), from May 1990 to February 1991. All were captured at a depth range of 1-15 m. The large number of males captured in these samples suggest significant sex segregation in Australian stocks. In

the same study, the average CPUE for *S. acanthias* captured in depths of 5-15m at night was double that of those captured during the daytime for the period June to November, suggesting nocturnal behaviour by this species. The annual rate of population increase for *Squalus acanthias* is near the lowest for any known vertebrate, averaging 2-3% per year (Camhi *et al*., 1998). Growth is also slow - about 4cm per year up to sexual maturity (Last and Stevens, 1994). *Squalus acanthias* feeds on a wide variety of prey items including schooling fishes, squid, crabs, crayfish and occasionally jellyfish (Ayling and Cox, 1982). They mainly eat small fishes and crustaceans, but they will also eat molluscs, including small scallops (Last and Stevens, 1994). Their invertebrate prey also includes shrimps, euphausiid shrimps, amphipods, polychaete worms, sea snails, sea cucumbers and comb jellys (Compagno, 1984).

Size:
The size of this species varies considerably on a regional basis. It is reported to reach 160cm in length in the eastern North Pacific, but it is generally much smaller in other regions. In Australia, *S. acanthias* attains a length of at least 100cm. Males mature at about 59cm and young are born at a length of about 22cm (Last and Stevens, 1994). This species attains a weight of about 5kg, and is commonly marketed at lengths of 50-85cm and weights of 0.6 – 1.8kg (Yearsley *et al*., 1999).

Evidence for Decline:
In Australia, *S. acanthias* is of little value as a food fish because the flesh is considered to be rather coarse (Last and Stevens, 1994). In Commonwealth fisheries, less than 0.5t were taken in 1998, but approx. 5t were taken in 1999, mainly by the GABTF and the SENT and SSF (AFMA, 2000g). Outside of Australia, this species is commercially targeted, with the annual European catch reaching up to 34, 000t. It is also used for its oil and in the manufacture of leather, pet foods, fishmeal and fertiliser (Last and Stevens, 1994). At a time of peak abundance in 1904 to 1905, an estimated 27 million dogfish were taken off the Massachusetts (USA) coast each year. Western North-Atlantic dogfish stocks are currently being depleted like the heavily exploited European stocks (Compagno, 1984). New Zealand catches of this species peaked at over 8000t in the fiscal year 1995-96, and have stabilised to around 6500t from 1996 to 1998 (Annala *et al*., 1999). In Australia it forms a small bycatch component of local inshore gillnet and Danish seine fisheries and the flesh is marketed in small quantities as fresh headed and gutted carcasses (Yearsley *et al*., 1999).

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis
As there is no current commercial fishery targeting *Squalus acanthias* in Australian waters, the main threat to this species appears to be as a bycatch of other fisheries. Between the years 1994 and 1998, over 15t of this species were taken as bycatch, primarily in the Great Australian Bight fishery (14t) and the SENTF and Shark fisheries (1t). Williams and Schaap (1992) collected data suggesting that a large number of *S. acanthias* frequent shallow waters (0-15m depth) at times, which may render the species vulnerable to other fishing pressures such as gillnetting and recreational line fishing. However, as its habitat range extends down to 180m, it is not regarded as being seriously threatened by inshore fishing activities. It is recommended to classify this species as Lower Risk (least concern), adopting the IUCN categories.

Threatening Processes:
This species is captured primarily in bottom trawls and with line gear (handlines and longlines set near the bottom), but it is also commonly taken in gillnets and is readily captured by sportfishing gear (Compagno, 1984). Commercial and recreational fishing activities in southern Australia, where this species is taken as bycatch, are potential threats to populations in Australian waters.

Critical Habitats:
Shallow, inshore bays in southern Australia may be important nursery areas for this species, but more research is required to validate this.

Recovery Objectives/Management Actions Required:
The designation of adequately sized and suitably located MPAs may protect populations of this species at particular times of the year (e.g. when pupping). Further research on the ecology, biology and distribution of inshore populations would provide more information in this regard.

References:

Annala *et al*., 1999; Ayling and Cox, 1982; Compagno, 1984; Gomon *et al*., 1994; Last and Stevens, 1994; May and Maxwell, 1986; Semeniuk and Hurlbut, 1998; Vas, 1995; Williams and Schaap, 1992; Yearsley *et al*., 1999.

FAMILY PRISTIOPHORIDAE: SAWSHARKS

Sawsharks are small and very slender sharks with rostral teeth (Compagno, 1984) that grow to about 1.5m in length (T. Walker, pers. comm.). Mature animals breed each year (T. Walker, pers. comm.) by ovoviviparity (Last and Stevens, 1994) and have between 3 and 22 young, depending on the species (T. Walker, pers. comm.). They are considered to be harmless, although the rostral teeth, which consist of enlarged embryological denticles interspersed with smaller teeth that form after birth, are sharp enough to warrant careful handling (Last and Stevens, 1994). Unlike sawfishes (family Pristidae), which also have a blade-like snout with rostral teeth, sawsharks have gills that are situated on the side of the head rather than on the undersurface, and a pair of barbels on the ventral surface of the snout (Last and Stevens, 1994).

Several sawsharks are abundant where they occur, and are found in large schools or feeding aggregations (Compagno, 1984). Their habits are poorly known, but at least one species shows segregation by depth within populations, with adults inhabiting deeper water than the young (Compagno, 1984).

There are two genera (*Pristiophorus* and *Pliotrema*) and at least seven species of sawsharks currently known (Last and Stevens, 1994). All but one of these (a Caribbean species *Pristiophorus schroederi*) occur in the Indo-Pacific region (Last and Stevens, 1994). Four members of the genus *Pristiophorus* are found only on the continental shelf and upper slopes of temperate and tropical Australia (Last and Stevens, 1994).

In Australia, sawsharks have previously been caught and marketed as a non-targeted bycatch, but recently commercial fishers have begun targeting them (T. Walker, pers. comm.). At least two species (*Pristiophorus cirratus* and *P. nudipinnis*) (T. Walker, pers. comm.), and possibly a third undescribed species, are retained by fishers in Australian waters. Fishers operating in the following Commonwealth fisheries retain sawsharks:

- the Southern Shark Fishery
- the South-East Non-Trawl Fishery
- the South-East Trawl Fishery
- the Great Australian Bight Trawl Fishery (AFMA logbook data, unpublished).

Over 1800t of sawsharks comprising at least two, but probably three species were reported as being retained by commercial fishers in Australian Commonwealth fisheries in the years 1994 to 1999 inclusive (AFMA logbook data, unpublished). Annual catches from the above Commonwealth fisheries over the above time period ranged from 190 to 409t per year (AFMA logbook data, unpublished).

AFMA and CSIRO have recently produced a field identification guide to these sharks (*Common sawsharks and dogfish sharks of southern Australia*). This was developed to improve the quality of shark data collection, and was distributed amongst Southern Shark, South-East Non-Trawl (AFMA, 2000g), South East Trawl and Great Australian Bight Trawl Fishery operators. This field guide encourages fishers to record the different species in their catches as accurately as possible (T. Skousen, pers. comm.).

Only the common sawshark (*P. cirratus*) has a species synopsis included in this section. Recent research on sawsharks in southern Australia shows that the southern sawshark (*P. nudipinnis*) is much rarer than the common sawshark (*P. cirratus*) and any future analyses of the conservation of this family will need to consider this species (R. Hudson, pers. comm.).

References:
AFMA, 2000g; Compagno, 1984; AFMA logbook data, unpublished; R. Hudson., pers.comm.Sept.2001, Last and Stevens, 1994; T. Skousen (AFMA), pers. comm. 9/2000; T. Walker, pers. comm. 8/2000

Common Sawshark

Family Name:	Pristiophoridae
Scientific Name:	*Pristiophorus cirratus* (Latham, 1794)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Squalus anisodon Lacépède, 1802
Squalus tentaculus Shaw, 1804

Alternative Common Name:
Longnose sawshark

Current Conservation Status:
<u>No 1996 IUCN Listing</u>

<u>2000 IUCN Red List of Threatened Species</u>
Lower Risk (near threatened)

<u>No ASFB Listing</u>

Distribution:
Pristiophorus cirratus is a widely distributed temperate and subtropical Australian endemic species with a poorly defined distribution. It possibly occurs along the southern coast from Eden (New South Wales) to Jurien Bay (Western Australia), including Tasmania. It is the largest Australian member of this family (Last and Stevens, 1994).

<u>Museum Records</u> - 121 specimens (Standard Length 24.2-106.7cm), collected from depths of 20 to 1200m, ranging in geographical distribution from east of Cape Byron (28°40'S), NSW southwards to Frederick Henry Bay (42°51'S), Tasmania and north-westwards to off Green Head (30°S), WA. Specimens were collected between 1885 and 1996.

Habitat:
Pristiophorus cirratus occurs demersally on the continental shelf and slope (Last and Stevens, 1994) in depths of 20m to at least 450m. On rare occasions, this species has been found to depths of 1200m. In Bass Strait it is most commonly caught in the 40 to 70m depth range (R.Hudson, pers. comm. Sept. 2001).

Behaviour and Biology:
Males mature at about 97cm (Last and Stevens, 1994) and females are 99cm at first pregnancy (T. Walker, pers. comm.). In any one year only half of the mature female population is breeding as there is a two-year reproductive cycle and the gestation period is approximately 18 months (R. Hudson, pers. comm.). The reproductive mode is aplacental viviparity, whereby the embryos continues to grow after the yolk sac is absorbed which suggests that nutrition must be received from the mother after this period (R.Hudson, pers. comm.). Mature animals breed each year (T. Walker, pers. comm.) and the reproductive mode is ovoviviparity (Last and Stevens, 1994; Simpfendorfer, in prep. b). Young are born at about 38cm (Last and Stevens, 1994) and females have been observed to have 3 to 22 embryos (T. Walker, pers. comm.). Tagging studies suggest a maximum life span of about 15 years, and this species is among the more productive shark species (T. Walker, pers. comm.). Sawsharks use their sensory barbels to locate food in the sand and then uproot their prey with vigorous movements of the snout (Last and Stevens, 1994). The diet consists of small fish and crustaceans (Simpfendorfer, in prep. b) and, to a lesser extent, octopus (T. Walker, pers. comm.).

Size:
Male *Pristiophorus cirratus* grow to 121cm and females grow to 149cm (T. Walker, pers. comm.).

Evidence for Decline:

In the past, small quantities of this species have reached fish markets from the bycatch of trawlers and gillnetters (Last and Stevens, 1994). In the waters of south-western Australia, nearly all are discarded and, due to their rostral teeth, removal from the nets involves damage to the animal which results in most individuals being discarded dead (Simpfendorfer, in prep. b.). During 1980 to 1999, fishers in the SSF reported taking 176-359t of sawsharks (carcass weight) annually (both *P. cirratus* and *Pristiophorus nudipinnis*), with generally stable catch rates (T. Walker, pers. comm.) In the SSF, *P. cirratus* makes up about 90% of the sawshark catch, with the remainder being that of *P. nudipinnis*. The vast majority of the sawshark catch is the SSF is taken in Bass Strait (R. Hudson, pers. comm.).Concerns have been expressed that after quotas for other species such as school and gummy sharks have been filled, fishers may target sawsharks, substantially increasing the impact of fishing on them (Simpfendorfer, in prep. b). Catches of sawsharks are also made in both the South-East Fishery and the Great Australian Bight (GAB) Trawl Fishery. The reported catch of sawsharks (*P. cirratus* and *P. nudipinnis*) over the last 5 years in the SEF has been between 25 and 43t per year, and in the GABTF it has been between 17 and 29t per year (Simpfendorfer, in prep. b). Most of the catch in the SSF is taken by 6-inch monofilament gillnets in Bass Strait, with small amounts being taken by hooks (T. Walker, pers. comm.). At least 43t of *Pristiophorus cirratus* were retained from Commonwealth fisheries in 1999, making up at least 16% of the total catches of sawsharks for that year (AFMA logbook data, unpublished). However, the retained catches of this species are likely to be much higher than these figures. Small catches are also taken in both the demersal trawl and non-trawl sectors of the SEF (T. Walker, pers. comm.). The flesh is of good quality and the saw is sometimes used for ornamental purposes (Last and Stevens, 1994).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly the Great Australian Bight Marine Park, SA

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis
No assessment of the impact of commercial fishing has been made for this species. Although it is caught only as a bycatch, the fisheries involved are extensive and have the potential to impact on the populations, as most specimens are discarded dead. With changes to the management of the SSF it is possible that this species may be targeted more (C. Simpfendorfer, pers. comm.). It is recommended to assign the above category, adopting the IUCN categories.

Threatening Processes:
Commercial fishing is a potential threat to this species in Australian waters.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
All of the demersal gillnet and trawl fisheries that take sawsharks have management plans in place (Simpfendorfer, in prep. b). However, none have regulations that specifically apply to sawsharks because of their low proportion in the catch (Simpfendorfer, in prep. b). No assessments have been undertaken to determine how these fisheries have impacted upon the common sawshark (Simpfendorfer, in prep. b). This is an area where future research could be directed to make the best possible use of the available catch information. From 1999 there has been some separation of sawshark species in the catch logbooks of Commonwealth fisheries. Accurate catch statistics which separate individual species are essential information in determining which of the sawshark species comprise the majority of the catches for each fishery. Further research is being undertaken to fully determine the conservation status of this species, but at present there appears to be no risk of extinction (T. Walker, pers. comm.). In the SSF the introduction of a Total Allowable Catch for combined sawshark landings is planned (R. Hudson, pers. comm).

References:
AFMA logbook data, unpublished; R. Hudson, pers.comm.Sept.2001, Last and Stevens, 1994; C. Simpfendorfer, pers. comm. 8/1999; Simpfendorfer, in prep. b; T. Walker, pers. comm. 8/2000.

SAWFISHES - FAMILY PRISTIDAE

The sawfishes are an unusual group of highly modified large rays that probably evolved from ancient sharks. There are between five and seven species of sawfishes in the family Pristidae (the taxonomy requires revision); four to five of which occur in Australia. Sawfishes are inshore specialists with low species diversity (Compagno, 1990). All possess a long, blade-like snout studded with lateral rostral teeth. All live in relatively shallow coastal, estuarine and/or freshwater habitats in warm-temperate to tropical regions (Camhi *et al*., 1998).

The restricted habitat range of sawfishes and their great vulnerability to net fisheries have resulted in very serious population declines for most, if not all, species over the past 50 years (Camhi *et al*., 1998). The fins of all sawfish species are very highly priced in the shark fin trade (Rose and McLoughlin, in press; Stobutski *et al*., 2000) and some species also have valuable flesh (Camhi *et al*., 1998). The saw is used in traditional Chinese medicine and appears in domestic and international trade as a curio. In addition, aquarists collect sawfishes from the wild for display (there is no known record of successful captive breeding) and there is also limited sports fishing (for trophies) (Camhi *et al*., 1998). Since sawfishes occur in areas where human activities are particularly intensive (e.g. some South-East Asia countries), habitat loss and degradation are also significant threats to these species' survival (Camhi *et al*., 1998). Barramundi gillnet fishers in northern Australia have probably also impacted on the sawfishes by killing off many of the larger, mature individuals (P. Last, pers. comm.).

In Thailand, a combination of fisheries and habitat changes have effectively eliminated low-density riverine elasmobranchs, like the sawfishes, from the Chao Phraya River and adjoining freshwater habitats, where they have not been reported for some 40 years (Compagno and Cook, 1995). Sawfishes, in general, tend to be of low to moderate abundance in freshwater habitats. In recent years, zealous collection efforts for specimens for museums and public aquaria at various sites around the world have added an additional threat factor to those already confronting the Pristidae (Cook *et al*., 1995).

Members of the family Pristidae have been recorded as being taken in commercial catch and effort logbooks, with 5.5t caught in the Gulf of Carpentaria between 1981-1995 and 1.8t in north-eastern Queensland between 1985-1986 (Gribble, 1999). Between 0.8-3.1t of sawfishes were taken yearly between the fiscal years 1994/95 and 1998/99 from the targeted shark fishery in the Northern Territory (NTDPIF, 2000). In terms of incidentally caught sawfishes, reported catches in this area were significantly lower in the fiscal years 1997-98 (139kg) and 1998-99 (230kg) than in the preceding years (1994-95: 4944kg, 1995-6: 985kg and 1996-97: 1604kg) (NTDPIF, 2000). Three hundred and sixteen sawfishes, fifty of which were released alive, were caught by beach-protective shark meshing nets in the Queensland Shark Control Program (QSCP) between January 1983 and February 2000 (B. Lane, pers. comm.). These catches are a potential source of genetic, biological, ecological, and distributional information. The allocation of additional resources to the QSCP for the study of sawfishes taken during shark control activities in Queensland needs to be seriously considered.

In northern WA waters there are thought to be at least four species regularly caught, although at this stage it is impossible to quantify or even estimate the sawfish catch in this State (R. McAuley, pers. comm.). Northern WA may be the last international stronghold for some members of the Pristidae, as the remote location and small human population may result in less exploitation of these species in this area (R. McAuley, pers. comm.). A proposal to study the sawfishes in this region has been formulated, but the proposal is reliant on the approval of funding to be decided in the near future.

In a study of the bycatch of northern Australian prawn fisheries, Stobutski *et al.*, (2000) reported the sawfishes as being the least likely to be sustainable, due to their bottom-dwelling habitat which increases their susceptibility to capture. Research on these high priority threatened species is vital to ensure their long-term sustainability. This research should focus on the biology, distributions, movement patterns and stock structures of the different sawfish species (Stobutski *et al*., 2000). An FRDC-funded study entitled *Monitoring the catch of turtles in the NPF* is also keeping records of sawfish captures (Stobutski *et al*., 2000), which may help to increase the baseline data on these species.

The species-specific monitoring of all sawfishes taken by any fishing methods in Australian waters is essential for the accurate assessment of their current distributions, biological, behavioural and ecological characteristics, and threats to their habitats and / or their survival.

References:

Camhi *et al*., 1998; Compagno and Cook, 1995; Cook *et al*., 1995; NTDPIF, 2000; B. Lane (QDPI Shark Control Program), pers. comm. 2/2000; P. Last, pers. comm. 7/2000; R. McAuley, pers. comm. 3/2000; Stobutski *et al*., 2000.

Narrow Sawfish

Family Name:	Pristidae
Scientific Name:	*Anoxypristis cuspidata* (Latham, 1794)
Conservation Status:	Vulnerable

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Endangered (A1acde + 2cd)

IUCN Species Survival Commission Shark Specialist Group Red List Assessments: (in prep.)
Endangered (A1acde + 2cde)

ASFB Threatened Fishes Committee
1994 to 1999: Uncertain Status

This species was nominated and considered for listing as Vulnerable under the *Commonwealth Endangered Species Protection Act 1992*, but the decision not to list it was made on the basis that it could not be demonstrated to be likely to become endangered within 25 years. There was insufficient information available on which to decide whether or not the species is currently vulnerable (http://www.ea.gov.au/biodiversity/threatened/action/index.html).

Distribution:
Anoxypristis cuspidata occurs in the Indo-Pacific region from the Red Sea to Japan and southwards to northern Australia. This species occurs in low abundances in the Gulf of Carpentaria from inshore areas to 40m depth (Last and Stevens, 1994), and it has a relatively wide distribution in northern Australian waters.

Museum Records: 12 specimens (Standard Length 37.5-250cm), collected from a depth range of 10-128m, ranging in geographical distribution from the Townsville area (19°S), Qld northwards to the Gulf of Carpentaria (approx. 12°S), Qld and westwards to the Dampier Archipelago region (approx. 20°S, 116°E), Western Australia. There are also records from Australian fish collection records from India. Specimens were collected between 1877 and 1997.

Habitat:
Anoxypristis cuspidata is mainly a marine species (Gloerfelt-Tarp and Kailola, 1984) inhabiting inshore areas to depths of at least 40m (Last and Stevens, 1994), and occasionally occurring in waters of depths exceeding 120m. It has, however, also been collected in brackish waters (salinity of 20-25ppt) of the Oriomo River estuary in PNG (Taniuchi and Shimizu, 1991).

Behaviour and Biology:
Little is known of the biology of this species. Sawfishes usually feed on slow-moving shoaling fish such as mullet, which are stunned by sideswipes of the snout. Molluscs and small crustaceans are also swept out of the sand and mud by the saw (Allen, 1982; Cliff and Wilson, 1994).

Size:
In Australia, *Anoxypristis cuspidata* attains a length of about 350cm. Elsewhere, it is reported, rather doubtfully, to attain 600cm (Last and Stevens, 1994).

Evidence for Decline:
Anoxypristis cuspidata is caught for its flesh in parts of Asia. The liver is also rich in oil (Last and Stevens, 1994). An average of 0.0131 *Anoxypristis cuspidata* (standard deviation of 0.0060) per hour trawled per km of headrope length (n/h/km) were taken as bycatch in the Northern Prawn Fishery in the Gulf of Carpentaria in 1997-98 (Stobutzki *et al*., 2000). Fifteen *Anoxypristis cuspidata*, nine of which were released alive, were

caught in the nets of the Queensland Shark Control Program in the Cairns region between February 1996 and February 2000 (B. Lane, pers. comm.). This species is capable of being caught by many fishing methods, and like all sawfishes, seems particularly susceptible to any forms of fishing which employ demersal nets. Due to its K-selected lifestyle, and the virtual disappearance of this species from commercial catches in regions where it was once considered to be fairly common, the global population of this species is considered to be certainly less than 50% of its level some 30 to 50 years ago. Some of its populations are likely to be less than 80% of their levels in the 1950s and the species could be regarded as Critically Endangered in these regions.

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Vulnerable on an Australia-wide basis
Owing to the fishing pressures placed on this species throughout much of its range, and its occurrence as bycatch in fisheries in northern Australian waters, it is recommended to assign the status of Vulnerable on an Australia-wide basis, adopting the IUCN categories.

Threatening Processes:
Incidental catches (or bycatch) by commercial trawling, commercial gillnetting and possibly fish trapping operations in the Gulf of Carpentaria region have the potential to further reduce the numbers of this species. Anecdotal evidence suggests that the shark fin trade is impacting on this and other pristid species.

Critical Habitats:
Inshore, soft-bottom habitats of tropical northern Australian waters are critical habitats for this species.

Recovery Objectives/Management Actions Required:
The first step towards the recovery of this species to list it as a threatened species under the *Environment Protection and Biodiversity Conservation Act, 1999*. The formation of a national recovery team is necessary to implement and coordinate a recovery plan for this and other Australian sawfish species. The implementation of monitoring requirements for all commercial fisheries in northern Australia (e.g. Northern Prawn Fishery, Torres Strait Prawn Fishery) where this species is caught is an essential measure in managing its remaining populations.

References:
Allen, 1982; Cliff and Wilson, 1994; Gloerfelt-Tarp and Kailola, 1984; B. Lane, pers. comm. 1/2000; Last and Stevens, 1994; J. Stevens, pers. comm. 1999; Stobutzki *et al*., 2000; Taniuchi and Shimizu, 1991.
Websites:
http://www.ea.gov.au/biodiversity/threatened/action/index.html

Dwarf Sawfish

Family Name:	Pristidae
Scientific Name:	*Pristis clavata* Garman, 1906
Conservation Status:	Endangered

Alternative Common Name:
Queensland sawfish

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Endangered (A1acd + 2cd)

ASFB Threatened Fishes Committee
1994 to 1999: Uncertain Status

This species was nominated and considered for listing as Vulnerable under the *Commonwealth Endangered Species Protection Act 1992*, but the decision not to list it was made on the basis that it could not be demonstrated as being likely to become endangered within 25 years. There was insufficient information available on which to decide whether or not the species is currently vulnerable (http://www.ea.gov.au/biodiversity/threatened/action/index.html).

Distribution:
Pristis clavata occurs in tropical Australia from Cairns (Queensland) to the Kimberley coast (Western Australia). It is possibly more widely distributed in the Indo-Pacific region. Little is known of the distribution of this species outside Australia (Last and Stevens, 1994).

Museum Records: 13 specimens (Standard Length 70-140.2cm), collected from a depth range of 2-3m ranging in geographical distribution from north Qld (approx. 17^{o}S) westwards to near Kununurra (approx. 15^{o}S, 128^{o}E), WA, collected between 1912 and 1991.

Habitat:
Pristis clavata occurs in coastal and estuarine habitats in tropical Australia. It occurs over mudflats in the Gulf of Carpentaria. It occurs some distance up rivers, almost into freshwater (Last and Stevens, 1994).

Behaviour and Biology:
Very little is known of the biology of this species. Sawfishes generally feed on slow-moving shoaling fish such as mullet, which are stunned by side swipes of the snout. Molluscs and small crustaceans are also swept out of the sand and mud by the saw (Allen, 1982; Cliff and Wilson, 1994).

Size:
Pristis clavata grows to at least 140cm in length (Last and Stevens, 1994).

Evidence for Decline:
Populations of *Pristis clavata* have been significantly reduced as a result of bycatch in commercial gillnet and trawl fisheries throughout its limited confirmed range in northern and north-western Australia. Its known distribution may expand with further collections in adjacent waters, but these areas are also fished intensively. Local fisheries incidentally capture all species of sawfishes present, so populations may be similarly depleted. The flesh is likely to be good eating (Last and Stevens, 1994).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Endangered on an Australia-wide basis
Like all sawfishes, *Pristis clavata* is likely to have undergone considerable declines in the last few decades, and further fishing pressures will continue to endanger its survival. The high prices of sawfish fins (currently up to A$250 per kg dried weight) in Asian markets are cause for grave concern and add to the threats to all species in this family (C. Rose, pers. comm.).

Threatening Processes:
Any commercial or recreational net fishing in coastal and estuarine habitats within the range of this species will continue to threaten its survival.

Critical Habitats:
Healthy estuarine and inshore coastal regions of northern Australia appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
The first step towards the recovery of this species would be to list it as a threatened species under the *Environment Protection and Biodiversity Conservation Act, 1999*. The formation of a national recovery team is necessary to implement and coordinate a recovery plan for this and other Australian sawfish species. Mature males of *Pristis clavata* are not well represented in museum collections and are required for research purposes (Last and Stevens, 1994). Further studies are urgently needed on the biology, ecology, abundance and distributional range of this species.

References:
Allen, 1982; Cliff and Wilson, 1994; Last and Stevens, 1994; C. Rose, pers. comm. 4/2000.

Websites:
http://www.ea.gov.au/biodiversity/threatened/action/index.html (Wildlife Australia Endangered Species Program homepage)

Freshwater sawfish

Family Name:	Pristidae
Scientific Name:	*Pristis microdon* (Latham, 1794)
Conservation Status:	Critically Endangered

Australian Synonyms:
Pristiopsis leichhardti Whitley, 1945

Taxonomic Problems:
Verifiable records of *Pristis microdon* from the sea are considered misidentifications of the coastal dwarf sawfish *Pristis clavata* (P. Last, pers. comm.).

Alternative Common Names:
Leichhardt's sawfish; smalltooth sawfish

Current Conservation Status:
In Australian waters:
Australian Commonwealth *EPBC Act 1999*
Schedule 1: Vulnerable (since February 1999)

ASFB Threatened Fishes Committee
1994-1999 Potentially Threatened

On a Global basis:
1996 IUCN Red List of Threatened Animals
Endangered (A1bcd + 2cd)

2000 IUCN Red List of Threatened Species
Endangered (A1bcde + 2bcde) globally; Critically Endangered (A1abc + 2cd) in South East Asia

Protected Species in Irian Jaya

Distribution:
Pristis microdon is known from several drainages of northern Australia in fresh or weakly saline water including the Fitzroy, Durack and Ord Rivers (Western Australia), the Adelaide, Victoria and Daly Rivers (Northern Territory), and the Gilbert, Mitchell, Norman and Leichhardt Rivers (Queensland) (Last and Stevens, 1994). There are no confirmed records of this species occurring in the sea off Australia (Last and Stevens, 1994). Its distribution outside of Australia is uncertain; so far it has been confirmed from several major river basins in Indonesia and New Guinea, but it possibly also occurs westwards to India (Last and Stevens, 1994; Taniuchi and Shimizu, 1991). In New Guinean waters this species has been recorded from the Digul, Middle Fly, Middle and Lower Sepik, and Ramu Rivers (Allen, 1991) and also from at least one river in New Britain (A. Jenkins, pers. comm.). It is also known from Lake Sentani in Irian Jaya (Allen, 1991). A similar, if not conspecific form occurs more widely throughout parts of the tropical and subtropical Atlantic, eastern Pacific and south-western Indian Oceans (Last and Stevens, 1994).

Museum Records: 16 specimens (Standard Length 76.5-137cm), collected from a depth range of 0-4m, ranging in geographical distribution from the Bynoe River (17^{o}56'S), Qld north-westwards to the Darwin area (approx. 12^{o}S, 131^{o}E), NT. There are also specimens in Australian fish collections from PNG. Specimens were collected between 1921 and 1991. Additionally, Tanaka and party collected five specimens from the Gilbert River, north Qld (97.1-104.7cm TL) and four specimens from the Daly River, NT (99.2-108.4cm) in August 1989 (Tanaka, 1991; Taniuchi and Shimizu, 1991).

Habitat:
In Australia, *Pristis microdon* appears to be confined to freshwater drainages and the upper reaches of estuaries in northern Australian waters (in some cases more than 100km from the sea) (Last and Stevens, 1994). Small specimens, mostly less than 150cm, have been caught in remote ponds where they have been isolated for several years between floods (Last and Stevens, 1994). This species prefers mud bottoms of riverine embayments and upper estuaries, but it also enters large rivers and goes well upstream (Allen, 1997). They are generally not found near riparian vegetation, but are usually found in the river channels (Wilson, 1999). In the Oriomo River estuary of PNG, a mature male was collected in waters with salinities ranging from 20 to 25ppt (Taniuchi and Shimizu, 1991).

Behaviour and Biology:
Pristis microdon is usually found in depths of greater than 1m, but will move into shallow waters when travelling upstream or when hunting its prey (Wilson, 1999). It prefers slightly alkaline waters between 22 and 28^{o} C (Wilson, 1999). This species can breed in freshwater, is viviparous, and the young are born at about 50cm in length approximately five months after copulation, with litter sizes likely to range between 1 and 12 (Wilson, 1999). In the Mitchell River on western Cape York Peninsula (Queensland), spawning generally occurs at the beginning of the wet season in November or December (Allen, 1991). An individual at the Territory Wildlife Park (NT) grew from 60cm to 260cm in 3 years, suggesting that growth can be very rapid in captivity (Wilson, 1999). However, Tanaka (1991) estimated the annual growth rate of *Pristis microdon* to be 18cm in the first year and 10cm in the tenth year, from specimens captured in northern Australia and PNG. Results from this study suggested that an immature male of 2.47m length collected at Lake Murray in PNG was 16 years of age (Tanaka, 1991). A 3.61m specimen collected from the Oriomo River mouth in PNG in 1989 had large, hardened claspers, demonstrating that males reach sexual maturity by this size (Tanaka, 1991). The lifespan of this species is unknown, but Tanaka (1991) estimated the 3.61m male specimen referred to above to be 44 years of age. The remaining 35 specimens of *Pristis microdon* (Total Lengths 971-2473mm) collected from northern Australia and PNG in 1989-90 during this study were regarded as immature (Tanaka, 1991). On the basis of electrophoretic analysis, Watabe (1991) concluded that there was little genetic variability between populations of *Pristis microdon* in Australia and PNG. Sawfishes feed on slow-moving shoaling fish such as mullet, stunned by sideswipes of the snout. Molluscs and small crustaceans are swept out of the sand and mud by the saw (Allen, 1982; Cliff and Wilson, 1994). In aquarium situations, this species feeds on fresh fish and prawns (Wilson, 1999).

Size:
In Australia *Pristis microdon* attains at least 280cm (Last, pers. comm), but outside of Australia it is reputed to reach a length of 7m (Last and Stevens, 1994).

Evidence for Decline:
This species is characterised by extreme and continued vulnerability to fisheries (evidenced by serious declines in virtually all known populations). Additionally, habitat loss and degradation also threaten it over much of its range from eastern India, through much of South East Asia, to Northern Australia. There is insufficient information to determine changes in population abundances and range within Australia; however, all populations of pristids overseas are threatened and their distributional ranges are shrinking. This species is highly vulnerable to gillnet fishing. Populations may be threatened in streams where illegal net fishing is a common practice. *Pristis microdon* has been eliminated from parts of South East Asia (P. Last, pers. comm.). In a study of the Embley estuary on the eastern side of the Gulf of Carpentaria (Qld) by Blaber *et al*., (1989), *Pristis microdon* (as *Pristis pristis*) made up about 10% of the gill net catch biomass (by g m^{-1} h^{-1} net) in the middle estuary region. This demonstrates its susceptibility to net fishing techniques. At current rates of decline, this species may face extirpation in the wild in the next few decades in many parts of its range. Northern Australia may represent the only geographical region where viable populations of this species remain.

Australian Estuarine or Freshwater Protected Areas in Which the Species Occurs:
Kakadu National Park, NT

Suggested Conservation Status:
Critically Endangered on an Australia-wide basis
Due to the destruction and pollution of its restricted riverine habitats, and its extreme vulnerability to incidental and targeted capture with even the most primitive fishing gear and methods, it is recommended to assign the status of Critically Endangered for Australian populations, adopting the IUCN categories. The

high prices of sawfish fins (currently up to A$250 per kg dried) in Asian markets are cause for grave concern and add to the threats to all species in this family (C. Rose, pers. comm.).

Threatening Processes:
Commercial and recreational fishing practices, whereby this species is mainly taken as a bycatch, threaten this species. Additionally, habitat degradation of riverine areas within its range also threatens the survival of this species through water pollution and loss of habitat.

Critical Habitats:
Freshwater and estuarine habitats of northern Australia appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
The relationships between the Australian freshwater sawfish and two other similar species that enter freshwater, *Pristis pristis* and *Pristis perotteti* need to be established (Last and Stevens, 1994). Further research in the form of surveys of northern Australian freshwater catchments is urgently required to establish the population status of this species. The formation of a national recovery team is necessary to implement and coordinate a recovery plan for this and other Australian sawfish species.

References:
Allen, 1982; Allen, 1991; Blaber *et al*., 1989; Allen, 1997; Cliff and Wilson, 1994; A. Jenkins, pers. comm. 8/2000; P. Last, pers. comm. 6/1999 – 7/2000; Last and Stevens, 1994; C. Rose, pers. comm. 4/2000; Tanaka, 1991; Taniuchi and Shimizu, 1991; Watabe, 1991; Wilson, 1999.

Wide sawfish

Family Name:	Pristidae
Scientific Name:	*Pristis pectinata* Latham, 1794
Conservation Status:	Data Deficient

Alternative Common Name:
Smalltooth sawfish

Current Conservation Status:
1996 IUCN Red List of Threatened Animals
Endangered (A1bcd + 2cd)

2000 IUCN Red List of Threatened Species
Endangered (A1bcd + 2cd) globally; Critically Endangered (A1abc + 2cd) in North and Southwest Atlantic

USA *Endangered Species Act*
Endangered - US population proposed listing April 2001

ASFB Threatened Fishes Committee
1994-1999: Uncertain Status

Distribution:
Pristis pectinata is considered to be circumtropical, but its occurrence in the Indo-West Pacific is questionable. Australian records also require validation; so far these are based on photographs of adult specimens trawled in the Gulf of Carpentaria, Queensland (Last and Stevens, 1994).

Museum Records: There are no confirmed records or specimens of this species in any museums in Australia.

Habitat:
Pristis pectinata is a marine sawfish that rarely enters rivers (Gloerfelt-Tarp and Kailola, 1984). In the western Atlantic, this species seems adapted to water temperatures of 16 to 30^{o} C (Whitehead *et al.*, 1984).

Behaviour and Biology:
In southern Africa, *Pristis pectinata* enters estuaries to give birth to litters of 15-20 young. To avoid damage to the parent, the saws of its young are soft and sheathed before birth (Last and Stevens, 1994). Sawfishes generally feed on slow-moving shoaling fish such as mullet, which are stunned by sideswipes of the snout. Molluscs and small crustaceans are also swept out of the sand and mud by the saw (Allen, 1982; Cliff and Wilson, 1994).

Size:
Pristis pectinata is the largest of the sawfishes, reported to reach 760cm, but more commonly less than 550cm in length. Young are born at 60cm (Last and Stevens, 1994).

Evidence for Decline:
This species has been wholly or nearly extirpated from large areas of its former range in the North Atlantic (Mediterranean, US Atlantic and Gulf of Mexico) and off the south-west Atlantic coast. Its status elsewhere in the Atlantic is uncertain, but it is likely to be similarly reduced. Declines in the south-eastern United States have been attributed to intensive commercial and recreational fishing (Anon., 1996b). Because of its size, adults are rarely held in museums. In the past, adults have been stuffed or only the high-priced saws kept. An absence of whole specimens has made comparisons of forms between areas difficult. The flesh is of good quality and it is used as a food fish in parts of the Indo-Pacific. Also, the liver contains high concentrations of oil suitable for medicine, soap making and leather tanning (Last and Stevens, 1994).

Australian Marine Protected Areas in Which the Species Occurs:

None identified.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Specimens are necessary to confirm the existence of this species in Australian waters. If its presence is confirmed in Australian waters, it may warrant a threatened conservation status. However, until valid specimens are identified from Australian waters, its conservation status must remain as Data Deficient.

Threatening Processes:
None identified.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
The formation of a national recovery team is necessary to implement and coordinate a recovery plan for all Australian sawfish species.

References:
Allen, 1982; Anon., 1996b; Cliff and Wilson, 1994; Gloerfelt-Tarp and Kailola, 1984; Last and Stevens, 1994; Whitehead *et al*., 1984.

Green sawfish

Family Name:	Pristidae
Scientific Name:	*Pristis zijsron* Bleeker, 1851
Conservation Status:	Endangered

Synonyms:
Pristis zysron is an older spelling for this species.

Alternative Common Names:
Dingagubba (Aboriginal); narrowsnout sawfish; sawfish

Current Conservation Status:
Listed as an Endangered Species in NSW waters under the *Fisheries Management Act 1994* (since 1999)

No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Endangered (A1bcd + 2cd) globally

ASFB Threatened Fishes Committee
1994-1999: Uncertain Status (or Requiring Investigation of its status)

This species was nominated and considered for listing as Vulnerable under the Commonwealth's *Endangered Species Protection Act 1992*, but the decision not to list it was made on the basis that it could not be demonstrated to be likely to become endangered within 25 years. There was insufficient available information on which to decide whether or not the species is currently vulnerable (http://www.ea.gov.au/biodiversity/threatened/action/index.html).

Distribution:
Pristis zijsron is widely distributed in the northern Indian Ocean (westwards to South Africa), and off Indonesia and Australia. Locally, it is more commonly encountered in the tropics and was occasionally caught south to Sydney, New South Wales and Broome, Western Australia. There is also a single record off Glenelg, South Australia (Last and Stevens, 1994). This species had in the past occasionally also been taken southwards to Jervis Bay in NSW (Stead, 1963).

Museum Records: 59 specimens (Total Length approx. 1.1-5.4m), collected from a depth range of about 5-38m, ranging in geographical distribution from the Parramatta River (33°55'S), NSW northwards to Thursday Island (10°35'S), Qld and south-westwards to the Port Headland region (approx 20°S, 118°E), WA. There is also a specimen from off Glenelg, SA and there are specimens from India. Specimens were collected between 1885 and 1990.

Habitat:
Pristis zijsron inhabits muddy bottom habitats and enters estuaries (Allen, 1997). Stead (1963) reported that this species was frequently found in shallow water.

Behaviour and Biology:
Grant (1978) suggested that adult males of this species use their saws during mating battles, evident from the scars and gashes on the saws of collected specimens, possibly through warding off blows from one another. The young are born alive; their tiny saws have a gelatinous edging to them at birth to protect the mother from injury. Sawfishes generally feed on slow-moving shoaling fish such as mullet, which are stunned by sideswipes of the snout. Molluscs and small crustaceans are also swept out of the sand and mud by the saw (Allen, 1982; Cliff and Wilson, 1994).

Size:
Pristis zijsron attains a size of at least 500cm in length in Australia, although it is reported to reach 730cm. Males are mature by 430cm (Last and Stevens, 1994).

Evidence for Decline:
In the past, net fishermen working the muddy estuaries of the entire length of the Queensland coastline detested *Pristis zijsron*. Despite its large size, slabs of the white meat were acceptable in the fried fish trade (Grant, 1978). Intensive exploitation in directed and bycatch fisheries throughout its Australian, South East Asian and Indian Ocean range has resulted in severe population depletions in many, if not most areas. Records have been extremely infrequent or absent from parts of its range during the past 30-40 years (Compagno *et al.*, in prep.). An average of 0.0020 *Pristis zijsron* (standard deviation of 0.0020) per hour trawled per km of headrope length (n/h/km) were taken as bycatch in the Northern Prawn Fishery in the Gulf of Carpentaria in 1997-98 (Stobutzki *et al.*, 2000). In the Moreton Bay area there have been no reports of this species since the 1960s (Johnson, 1999). It has also been extremely rare anywhere on the east coast of Australia in the last 25 to 30 years (P. Last, pers. comm.), partly evident by the lack of specimens in museum and research institute collections over that time.

Australian Marine Protected Areas in Which the Species Occurs:
Coburg Marine Park, NT (sight record only, not confirmed)
Great Barrier Reef Marine Park, Qld (unconfirmed)

Suggested Conservation Status:
Endangered on an Australia-wide basis.
Pristis zijsron once occurred at least as far southwards as the Parramatta River in Sydney. Ogilby (1888) examined at least seven specimens collected from Lake Macquarie southwards to Sydney, the largest being approx. 4.8m in length. The last most southerly confirmed record of this species in NSW (i.e. a museum specimen) was from the Clarence River, taken in 1972. It is now seems that it is uncommon anywhere in Australian waters, and the last museum voucher specimens were taken off Western Australia in 1982, the Northern Territory in 1989 and in the Gulf of Carpentaria, Queensland in 1990. The high prices of sawfish fins (currently up to A$250 per kg dried) in Asian markets are cause for grave concern and add to the threats to all species in this family (C. Rose, pers. comm.).

Threatening Processes:
Commercial prawn and fish trawling and gillnetting, where it may be taken as a bycatch, threaten the survival of this species in Australian waters.

Critical Habitats:
Inshore soft bottom and possibly estuarine habitats in tropical Australia may be critical to this species.

Recovery Objectives/Management Actions Required:
The first step towards the recovery of this species would be to list it as a threatened species under the *Environment Protection and Biodiversity Conservation Act, 1999*. Subsequently, the formation of a national recovery team is necessary to implement and coordinate a recovery plan for this and other Australian sawfish species. The monitoring of the bycatch of this species from the Northern Prawn Fishery and any other fisheries in which it is caught is essential in accumulating information on its distributional range and abundance, biology and ecology.

References:
Allen, 1982; Cliff and Wilson, 1994; Compagno *et al.*, in prep. (IUCN SSG Status Report for Chondrichthyan Fishes); Grant, 1978; Johnson, 1999; H. Larson, pers. comm. 12/1999; P. Last, pers. comm. 1999-2000; Last and Stevens, 1994; Ogilby, 1888; C. Rose, pers. comm. 4/2000; Stead, 1963; Stobutzki *et al.*, 2000.

Websites:
http://www.ea.gov.au/biodiversity/threatened/action/index.html (Wildlife Australia Endangered Species Program homepage)
http://www.fsc.nsw.gov.au (NSW Fisheries Scientific Committee)

FAMILY RAJIDAE: SKATES

This widely distributed and diverse family is found worldwide in all oceans except for insular areas of the western Pacific (Last and Stevens, 1994). Skates are primarily marine on the continental slopes to more than 2000m (Last and Stevens, 1994), with the highest diversity occurring in deep water and at higher latitudes (Compagno, 1990). In some temperate areas they occur closer inshore and one Australian species (*Raja* sp. L) is known only from estuarine environments (Last and Stevens, 1994). This family contains at least seven genera and almost 200 species (Last and Stevens, 1994). The Australian fauna consists of 38 species from at least five genera, most of which are endemic (Last and Stevens, 1994).

In the Heard Island and MacDonald (HIMI) Island Patagonian toothfish fishery, skates made up about 20% of the total bycatch weight in all areas combined from 1996-97 to 1998-99 (Williams *et al*., 1999). The investigation and possible use of alternative fishing methods for the Patagonian toothfish fishery (e.g. midwater trawling, pot and trap fishing) may be necessary to ensure that the ecological impacts of fishing operations on skates (and other bycatch species) are kept to acceptable levels (AFMA, 2000e). Additionally, the introduction of tagging programs for skates (AFMA, 2000e) may elucidate our understanding of the movements of these species. Agreed initiatives have been put in place in the HIMI Fishery to release live skates (AFMA, 2000g).

One of the largest skates in the North Atlantic, the barndoor skate *Raja laevis,* has been taken as bycatch of major fisheries for decades and has been nearly extirpated from much of its range (Casey and Myers, 1998). The conservation of skates and other elasmobranchs requires species-specific monitoring and specific attention needs to be directed to the larger species that are more readily caught by fishing operations (Dulvy *et al*., 2000). Additionally, species that have restricted distributions and/or very specific habitat preferences (e.g. *Raja* sp. L, see following species synopsis) are particularly vulnerable to fishing pressures and habitat degradation.

It is unclear how many species of skates regularly occur in the catches of fisheries around Australia. In the USA, there are seven species of *Raja* occurring along the North Atlantic coast of the United States that are captured regularly in fisheries. These skates are known to undertake large-scale migrations, moving seasonally in response to changes in water temperature (NMFS, 2000). Skates can be caught commercially with trawl, gillnet, longline, handline, and dredge fishing gear. However, the principal commercial fishing method in the Atlantic used to catch skates and rays is otter trawling (NMFS, 2000). Recreationally, skates can be caught with rod and reel. Skate landings in the Atlantic peaked in 1969 at 9,500t, but declined quickly during the 1970s to 500t in 1981. Landings of skates have since increased substantially, partially in response to increased demand for them for lobster bait, and more significantly, to the increased export market for skate 'wings' taken from winter and thorny skates, the two species currently known to be used for human consumption. Bait landings appear to be primarily of little skate, based on areas fished and known species distribution patterns. Landings in the Atlantic increased to 12,900t in 1993 and then declined somewhat to 7,200t in 1995; however, the 1996 total was 14,200t, the highest on record (NMFS, 2000). Recent increases in aggregate skate biomass have been due to an increase in smaller sized skates (<100 cm maximum length; i.e., little, clearnose, rosette, and smooth skates), but primarily little skate (NMFS, 2000).

The above statistics show that large fluctuations can occur in the catches of skates, probably dependent upon a number of factors such as fishing effort. In Australian waters, it is firstly important to quantify the catches of individual species of skates by conducting further research into their taxonomy, distributions and habitats. This could be done by examining the bycatch of skates from commercial fishing operations or by conducting fishery-independent scientific surveys. Depending on the difficulty in identifying individual species, it may be possible to adjust logbooks to account for individual species catches in some fisheries in conjunction with educating fishers of the characteristics of each species. Much research is clearly necessary in Australia to adequately understand this family of fishes.

References:
AFMA, 2000g; Anon., 1999e; Casey and Myers, 1998; Dulvy *et al*., 2000; Last and Stevens, 1994; NMFS, 2000, Williams *et al*., 1999.

Maugean Skate

Family Name:	Rajidae
Scientific Name:	*Raja* sp. L
Conservation Status:	Endangered

Taxonomic Problems:
This species is presently assigned to the genus *Raja,* but it may be assigned to a separate genus based on its phylogenetic relationships with other skates. Some taxonomists place it in the genus *Dipturus* (P. Last, pers. comm.).

Alternative Common Name:
Port Davey skate

Current Conservation Status:
<u>No 1996 IUCN Listing</u>

<u>2000 IUCN Red List of Threatened Species</u>
Endangered (B1+ 2c) globally

<u>No ASFB Listing</u>

Distribution:
Raja sp. L is confined to the upper reaches of two large estuary systems in western Tasmania, Bathurst and Macquarie Harbours (Gledhill and Last, in prep.; P. Last, pers. comm.). Despite multiple surveys over many years, no specimens have been found in any other Tasmanian estuaries or the adjacent coastal areas (P. Last, pers. comm.). Its closest relative, the rough skate *Raja nasuta*, occurs inshore off New Zealand (Last and Stevens, 1994).

<u>Museum Records:</u> 7 specimens (Standard Length: 57.6-70.9cm), collected from a depth range of 6-7m, in Bathurst and Macquarie Harbours, Tasmania, collected between 1989 and 1995.

Habitat:
The specimens collected to date have been from brackish, estuarine waters in 5 to 7m depth (Last and Stevens, 1994). Specimens have been caught in a narrow range of brackish salinities to almost fresh water (Gledhill and Last, in prep.). This habitat covers only a small fraction (about 10%) of the area of the two estuaries in which it occurs (P. Last, pers. comm.).

Behaviour and Biology:
There is little specific information known about the biology of this species. This skate has been observed during diver surveys within its narrow distributional range, as they do not completely bury themselves in the sand (P. Last, pers. comm.).

Size:
Raja sp. L attains a size of at least 77cm total length (Gledhill and Last, in prep.).

Evidence of Decline:
There is no evidence of any declines for this species.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Endangered on an Australia-wide basis.
This species has an extremely restricted habitat and range, being only known from specific habitats within the upper reaches of two estuaries in western Tasmania (Gledhill and Last, in prep.; P. Last, pers. comm.).

Threatening Processes:
The Macquarie Harbour population is in an estuary that is heavily polluted by prolonged mining operations (P. Last, pers. comm). Both populations occur in areas that are facing increasing pressure from ecotourism activities (Gledhill and Last, in prep.). This species is probably also caught by recreational gillnetting (Gledhill and Last, in prep.).

Critical Habitats:
Shallow, upper estuarine areas of medium to low salinity appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
The isolation of Bathurst Harbour in the World Heritage area of south-western Tasmania affords some habitat protection for this species (Gledhill and Last, in prep.). The first step towards the recovery of this species would be to list it as a threatened species on the *Environment Protection and Biodiversity Conservation Act, 1999*. Subsequently, it will be necessary to form a national recovery team to accumulate as much information as possible about its distribution, ecology and biology in order to coordinate and implement an appropriate recovery plan.

References:
Gledhill and Last, in prep.; P. Last, pers. comms. 9/1999 – 9/2000; Last and Stevens, 1994.

FAMILY DASYATIDIDAE: STINGRAYS

Stingrays are among some of the larger cartilaginous fishes, with some species exceeding 2m in disc width and weighing upwards of 350kg (Last and Stevens, 1994). They are highly adapted fishes that mainly occur demersally in both marine and freshwater habitats, though some species occur in the open ocean (Last and Stevens, 1994). The family is represented by more than 60 living species from five or more genera (Last and Stevens, 1994), with the most diversity occurring in inshore tropical waters (Compagno, 1990). The family is represented by a single genus in southern Australian waters (Gomon *et al.*, 1994), while all five genera are known from tropical Australia (Last and Stevens, 1994). Due to their large average size, they are poorly represented in museum collections and more research is required to resolve nomenclatural problems (Last and Stevens, 1994). Species in this family are viviparous with litters of 2-6 that may take up to 12 months to gestate (Last and Stevens, 1994).

In Australian Commonwealth fisheries alone, over 20t of stingrays were retained as bycatch for each of the years 1994 to 1998 (AFMA, logbook data, unpublished). One of the challenges in monitoring the bycatch of stingray species is to overcome the problems encountered in the correct species identification of stingrays in the catch. Without these data, analyses of individual species catches is impossible and is likely to result in any species declines going unnoticed.

In a study of northern Australian prawn fisheries, Stobutski *et al.* (2000) reported that some stingrays were, along with the sawfishes, the bycatch species least likely to be sustainable due to their bottom-dwelling habitat, which increases their susceptibility to capture. Research on these species is vital to ensure their long-term sustainability. This research should focus on the biology, distributions, movement patterns and stock structures of stingrays (Stobutski *et al*., 2000), especially in tropical northern Australian waters where their species diversity is highest.

References:
AFMA logbook data, unpublished; Last and Stevens, 1994; Stobutski *et al*., 1993

Estuary Stingray

Family Name:	Dasyatididae
Scientific Name:	*Dasyatis fluviorum* Ogilby, 1908
Conservation Status:	Lower Risk (near threatened)

Alternative Common Names:
Brown stingray; estuary stingaree (this latter common name is misleading as the stingarees belong to the family Urolophidae).

Current Conservation Status:
<u>No IUCN (1996, 2000) or ASFB Listings</u>

Taxonomic Problems:
In the past, *Dasyatis fluviorum* has sometimes been confused with other stingray species of the family Dasyatididae, namely *Dasyatis thetidis* and *Himantura* spp.

Distribution:
Dasyatis fluviorum has an inshore tropical to subtropical Australian distribution from Forster, New South Wales northwards to at least the central Queensland coast. Its occurrence along the north Queensland coastline requires verification. The range of this species seems to have contracted in the last 100 years, as there are records of it from Port Jackson, NSW in the late 1880's, but it has not been recorded there since.

<u>Museum Records</u> - 23 specimens (Standard Length 43-110.5cm), collected from a depth range of 0-28m, ranging in geographical distribution from the Proserpine area (approx. 20^{o}30'S), Qld southwards to Port Jackson (33^{o}51'S), NSW, collected between circa 1885 and 1997.

Habitat:
Dasyatis fluviorum inhabits mangrove-fringed rivers and estuaries (Last and Stevens, 1994) to depths of at least 28m.

Behaviour and Biology:
Little is known of the biology of this species. It has a reputation of being a major predator of shellfish, including farmed oysters (Last and Stevens, 1994).

Size:
Dasyatis fluviorum is reported to reach a disc width of 120cm. Young are born at a disc width of about 11cm (35 cm total length) (Last and Stevens, 1994).

Evidence for Decline:
There is anecdotal evidence of a significant range contraction for this species, but there remains some doubt as to the cause of this. However, it is possibly due to the effects of inshore fishing activities (both commercial and recreational) over many decades. This species was once common in southern Queensland, but it is declining, probably due to the reclamation of shallow muddy tidal bays and mangroves for urban/canal estate/marina development, and the activities of recreational fishers who often destroy incidental catches of this species (J. Johnson, pers. comm.). However, *Dasyatis fluviorum* still occurs in the southern parts of Moreton Bay in Queensland (J. Johnson, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
Accurate distributional data and biological information for this species are necessary to reliably assess its conservation status. It is recommended to assign the conservation status of Lower Risk (near threatened),

adopting the IUCN categories. It is, however, emphasised that there is greater concern for this species than all other Lower Risk (near threatened) species listed in this report, due to a combination of the endemic nature of its occurrence and its low fecundity.

Threatening Processes:
Habitat degradation (including urban runoff, which can cause toxic algal blooms), land reclamation and commercial and recreational fishing probably all combine to some degree to threaten the populations of this species within its natural range.

Critical Habitats:
Relatively shallow mangrove and estuarine areas are important habitats for this species.

Recovery Objectives/Management Actions Required:
Habitat protection is required to protect the shallow, inshore and estuarine areas in which this species is often found. Further research in the form of taxonomic, biological and ecological studies may help to provide a clearer picture of the distributional range, biological characteristics and habitat preferences of this species. The welfare of the species needs to be closely monitored to ensure that its conservation status is not raised into the Vulnerable category in the near future (P. Last, pers. comm).

References:
J. Johnson, pers. comms. 8/1999 – 8/2000; P. Last, pers. comm. 9/2000; Last and Stevens, 1994.

Freshwater whipray

Family Name:	Dasyatididae
Scientific Name:	*Himantura chaophraya* Monkolprasit and Roberts, 1990
Conservation Status:	Vulnerable

Taxonomic Problems:
In some of the literature *Himantura chaophraya* has been misidentified as the estuary stingray *Dasyatis fluviorum* Ogilby, 1908 (Last and Stevens, 1994), and it may have been listed under the old name of *Himantura polylepis* Bleeker, 1852 in Indonesia (Compagno and Cook, 1995).

Alternative Common Name:
Giant freshwater stingray

Current Conservation Status:
1996 IUCN Red List of Threatened Animals
Endangered (A1b,c,d,e + 2c,d,e)

2000 IUCN Red List of Threatened Species
Vulnerable (A1bcde + 2ce) globally; Critically Endangered (A1bcde + 2ce) in Thailand

This species was nominated and considered for listing as Vulnerable under the Commonwealth's *Endangered Species Protection Act 1992*, but the decision not to list it was made on the basis that it could not be demonstrated that it was likely to become endangered within 25 years. This was because there was insufficient information available on which to decide whether or not the species is currently vulnerable in Australian waters (http://www.ea.gov.au/biodiversity/threatened/action/index.html).

Distribution:
In Australia, *Himantura chaophraya* has been positively identified from the Gilbert River (Queensland), the Daly and South and East Alligator Rivers (NT) and the Ord and Pentecost Rivers (WA) (Last and Stevens, 1994). It possibly occurs in most large rivers of tropical Australia. It is also known from the Fly River basin (New Guinea), the Mahakam basin (Borneo), and several rivers of Thailand (Last and Stevens, 1994), including the Chao Phraya, Nan, Mekong, Bongpakong, Tachin and Tapi Rivers (Compagno and Cook, 1995).

Museum Records: 2 databased specimens (Standard Length unknown), collected from 0.3m depth (only 1 specimen had depth data), from the Pentecost River, WA and the Gilbert River, Qld, collected between 1989 and 1990.

Habitat:
Himantura chaophraya is the only Australian stingray to live entirely in fresh and brackish estuarine waters (Last and Stevens, 1994). This species has not been recorded from marine waters anywhere in its known range (Compagno and Cook, 1995).

Behaviour and Biology:
Himantura chaophraya belongs to a species group of large rays, widely distributed in the tropical Indo-Pacific region, and found mainly in fresh water (Monkolprasit and Roberts, 1990). Males generally mature by around 110cm disc width and the young are born at about 30cm disc width (Last and Stevens, 1994). A male captured in the Daly River of the Northern Territory (40cm disc-width and 90cm total length when caught) remained in captivity at the Territory Wildlife Park Aquarium until it died (Wilson, 2000). At death, this male measured 160cm disc-width (3.1m total length) and was reported to be immature (Wilson, 2000). Maximum lifespan in the wild is unknown (Compagno and Cook, 1995), but the abovementioned male lived in captivity for approximately nine years (Wilson, 2000). No information on the diet of this species could be found in the available literature. Closely related (i.e other *Himantura* spp.) species feed on crustaceans and probably other invertebrates.

Size:
Himantura chaophraya is one of the largest living dasyatids in the world (Compagno and Cook, 1995). The adult size is unknown locally, with the largest validated specimen slightly exceeding 100cm in disc width (about 270cm total length) (Last and Stevens, 1994). However, a male at the Territory Wildlife Park Aquarium attained 1.6m disc width (3.1m total length) and a weight of 120kg (Wilson, 2000). Outside of Australia, this species reaches a disc width of almost 200cm and about 600kg in weight (Last and Stevens, 1994).

Evidence for Decline:
Himantura chaophraya has been taken by fishermen on the rivers of Central Thailand, in fisheries for bony fishes, notably giant gouramy *Osphronemus goramy* and giant river catfishes (*Pangasius* spp.). In 1992, Thai fishermen reported twenty-five individuals of *H. chaophraya* in their catches, but in 1993 reported landings had dropped to only three individuals (Compagno and Cook, 1995). In the South (and possibly East) Alligator Rivers, which run through Kakadu National Park, concern has arisen for *Himantura chaophraya* in relation to possible adverse effects of silt carrying heavy metals and radio-isotopes from uranium exploitation sites around Coronation Hill and mines in the park (Compagno and Cook, 1995). It remains to be seen whether this is a serious potential threat to this species. In Thailand, many habitat-degrading factors have a negative impact on riverine environments, effecting the chances of survival of *Himantura chaophraya* and other species. These include:
- over-harvesting of forest canopy, leading to drought upstream and flooding downstream during monsoon conditions, which further leads to excess siltation;
- dam building to control flooding, which leads to silt build-up and retention of agrochemicals behind impoundments; and
- development of lands adjoining river habitats, which facilitates degradation and destruction of stingray habitats with deposition of broad-spectrum wastes.

Dams effectively isolate portions of the reproductive populations of all riverine stingrays, preventing them from intermixing and mating, thus dramatically reducing the gene pool for any given species (Compagno and Cook, 1995).

Australian Protected Areas in Which the Species Occurs:
Kakadu National Park, NT

Suggested Conservation Status:
Vulnerable on an Australia-wide basis.
Himantura chaophraya should be assigned the conservation status of Vulnerable in Australian waters. It has been and will continue to be affected by the complex and synergistic effects of the restrictions of its obligate freshwater habitat, fishing pressures and habitat alteration / destruction. The possibility of biological extinction in the wild is considered to be high (Compagno and Cook, 1995).

Threatening Processes:
Commercial and recreational fishing and habitat degradation all have the potential to adversely affect this species in the wild.

Critical Habitats:
Shallow, freshwater and brackish water environments are crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research is urgently needed to ascertain the status and possible threats to this species within Australia and throughout its known range (including Borneo, New Guinea and Indonesia). The first step towards the recovery of this species is the formation of a national recovery team to accumulate information on its distribution, abundance, ecology and biology.

References:
Compagno and Cook, 1995; Last and Stevens, 1994; Monkolprasit and Roberts, 1990; Wilson, 2000.

Websites:
http://www.ea.gov.au/biodiversity/threatened/action/index.html (Wildlife Australia Endangered Species Program homepage)

Porcupine Ray

Family Name:	Dasyatididae
Scientific Name:	*Urogymnus asperrimus* (Bloch and Schneider, 1801)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Raja africana Bloch and Schneider, 1801
Urogymnus asperrimus solanderi Whitley, 1939

Taxonomic Problems:
There is some doubt as to the specific placement of this species. Some taxonomists use the name *Urogymnus africanus.*

Alternative Common Names:
Solanders ray; roughskin stingaree; thorny ray

Current Conservation Status:
No 1996 IUCN Listing

2000 IUCN Red List of Threatened Species
Vulnerable (A1bd, B1 + 2b)

No ASFB Listing

Distribution:
Urogymnus asperrimus is widespread in the western Pacific and Indian Oceans from Natal (South Africa) to Fiji (though apparently not found in the Japanese Archipelago). It also occurs in the tropical eastern Atlantic, off central Africa (Last and Stevens, 1994). There have been few Australian specimens recorded.

Museum Records: 9 specimens (Standard Length to 1.2m, no collection depths recorded), ranging in geographical distribution from Broome (17°58'S), WA north-eastwards to Darnley Island (09°35'S), Qld and southwards to Heron Island (23°27'S), Qld, collected between circa 1888 and 1998.

Habitat:
Urogymnus asperrimus occurs in benthic habitats of inshore waters (Paxton *et al*., 1989), and has been found in association with seagrasses (Last and Stevens, 1994). It appears to have very specific habitat preferences and is uncommon throughout its Australian range (P. Last, pers. comm.).

Behaviour and Biology:
Little is known of the biology of this highly distinctive ray and its occurrence locally is based on very few verified accounts. If caught, adults should be handled carefully because their thorns are particularly sharp (Last and Stevens, 1994). No information on the diet of this species could be found in the available literature.

Size:
Urogymnus asperrimus attains a disc width of at least 100cm (Last and Stevens, 1994).

Evidence for Decline:
This species is presumably taken as a bycatch in unregulated fisheries in both open access and nearshore waters and appears to have become extremely rare (compared to certain other batoids) amongst the batoid catches from the Gulf of Thailand over the last three decades. Similar trends are likely to be occurring, or will occur, in other areas where tropical batoids are taken in multi-species fisheries (Compagno, in prep.).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef World Heritage Area, Qld

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis
This species is apparently uncommon throughout its Australian range, and is vulnerable to inshore habitat degradation and bycatch of commercial and recreational fishers.

Threatening Processes:
Habitat degradation of inshore waters may threaten the survival of this species. Commercial and recreational fishing practices also have the potential to adversely affect this species.

Critical Habitats:
Shallow, inshore habitats of tropical regions of Australia appear to provide crucial habitat for this species.

Recovery Objectives/Management Actions Required:
Further research on the biology, distributional range, and abundance and ecology of this species would provide valuable information on its susceptibility to human-induced pressures.

References:
Compagno, in prep.; P. Last, pers. comm. 1999; Last and Stevens, 1994; Paxton *et al*., 1989.

CLASS OSTEICHTHYES: BONY FISHES

The class Osteichthyes, of which by far the largest group is the Teleostei (herein referred to as teleosts) of the subclass Actinopterygii (or ray-finned fishes) contains the vast majority of the dominant living fishes of the world (Helfmann *et al*., 1998). There are an estimated 24,000 species of bony fishes worldwide, making up approximately 96% of all the known living species of fishes and constituting the world's major fisheries (Helfman *et al*., 1998). The estimated 24,000 species belong to around 45 different orders, 435 families and 4079 genera (Nelson, 1994), although estimates vary (Grande, 1998).

Evidence suggests that the earliest known teleosts appeared about 200 million years ago in the Late Triassic and Early Jurassic periods of the Mesozoic Era (Grande, 1998). Teleosts appear to have undergone a major diversification in the Cretaceous period of this era (140 to 65 million years ago), which seems to have continued up to today where they now dominate the world's fish fauna (Grande, 1998).

Teleosts inhabit the widest range of habitat types and show the greatest variation in body plans and foraging and reproductive habits of any fishes. They occur in every imaginable freshwater and marine habitat, from ocean trenches to high mountain lakes and streams, from polar oceans at -2^{o} C to alkaline hot springs at 41^{o} C, from torrential rivers and wave-tossed coastlines to stagnant pools (Helfmann et al., 1998). In contrast to the 5% (c. 50 of 1000 species) of chondrichthyans (sharks, rays and chimaeras) occurring in freshwater environments at some stage of their lifecycles (Compagno, 1990; Nelson, 1994), about 40% (or roughly 9,500 species) of teleosts occur in freshwater habitats during some part of their lives (Nelson, 1994). Using this figure of 40% of teleosts being freshwater species, an estimated 14,000 species (or roughly 60%) of teleosts are marine or estuarine inhabitants. Of roughly 14,000 marine/estuarine teleosts worldwide, approximately 4000 species (about 28%) are known to occur in marine and estuarine habitats within the waters of Australian marine jurisdiction. Australia is therefore in a strong position to conserve a significant proportion of the world's marine and estuarine fishes.

In the 2000 IUCN Red List of Threatened Species, 1160 species of fishes belonging to the class Osteichthyes are listed (http://www.redlist.org/), making up approximately 5% of all known living species. Considering that the general biology and ecology of a large proportion of bony fishes is still not well understood, there are likely to be far more species threatened with extinction than these figures suggest.

References:
Compagno, 1990; Grande, 1998; Helfmann *et al*., 1998; Nelson, 1994

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Animals homepage)

FAMILY BATRACHOIDIDAE: FROGFISHES

Frogfishes (or toadfishes, as they are known in some parts of the world) are bottom-dwelling fishes which generally inhabit shallow to moderately deep coastal waters, though some species prefer brackish water habitats (Hutchins, 1998). The family is widely distributed in all tropical and subtropical seas (Paxton *et al*., 1989). Worldwide, the family is represented by 69 species in 22 genera, ranging in maximum size from 7cm to 57cm in length (Hutchins, 1998). Eight species representing two genera (*Batrachomoeus* and *Halophryne*) have been described from Australian waters, and all but one of these is endemic to Australia (Paxton *et al*., 1989). There are probably an additional three undescribed species which are also endemic to Australian waters (B. Hutchins, pers. comm.). The habitats of Australian species include coral reefs, sand or mud flats, estuaries, and deeper offshore trawling grounds to depths of at least 180m (Paxton *et al*., 1989). Frogfishes rely on camouflage to hunt their prey, swallowing it whole in one swift movement (Hutchins, 1998). Most species of frogfishes produce a relatively small number of large eggs (usually between 20 and 100) (Hutchins, 1998). The male demonstrates parental care by guarding the eggs from predators, and continuing to protect the young fish until they are big enough to fend for themselves (Hutchins, 1998).

As frogfishes have large mouths (Hutchins, 1998) and bite readily on cut baits (J. Johnson, pers. comm.), they may be prone to the effects of being taken as bycatch of recreational and /or commercial hook-and-line fishing methods, especially in areas where fishing intensity is high (e.g. near centres with high population). Coupled with their low reproductive potential, hook-and-line-fishing pressures may be a significant threat to members of this family.

Worldwide, there are five frogfish species listed as vulnerable by the IUCN, none of which occur in Australia (Hutchins, 1998; http://www.redlist.org/). Some coral reef species have restricted distributions (Almada-Villela, 1998), perhaps because of their limited dispersal potential and/or their specialised habitat requirements.

Further work on the biology of the eight species occurring in Australian waters may elucidate their life-history characteristics and aid in the understanding of their conservation needs.

References:
Almada-Villela, 1998; Hutchins, 1998; B. Hutchins, pers. comm. 8/2000; J. Johnson, pers. comms. 1999-2000; Paxton *et al*., 1989;

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

Sculptured frogfish

Family Name:	Batrachoididae
Scientific Name:	*Halophryne queenslandiae* (De Vis, 1882)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Porichthys queenslandiae De Vis, 1882

Taxonomic Problems:
It is difficult to distinguish this species from the closely related, and in part sympatric, *Halophyrne diemensis* (Hutchins, 1976).

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Halophryne queenslandiae is a rare endemic species with a very sparse distribution between South Solitary Island in New South Wales and Dunk Island in Queensland. Outside of these two localities all records are between Moreton Bay and Caloundra in Queensland (J. Johnson, pers. comm.). It has been collected from islands close to the coast, and also from the Brisbane River estuary (Hutchins, 1976).

Museum Records: 9 specimens (Standard Length 120-215mm), ranging in geographical distribution from Dunk Island (17^{o}57’S) southwards to the Brisbane River (27^{o}28’S), Qld, collected between circa 1908 and 1991.

Habitat:
Although this species is recorded from estuaries, it seems to be more common offshore at islands, in clear waters among rocks and sand in depths of 20m or more (Kuiter, 1993). They are usually cryptic on rocky reefs, often among algae (J. Johnson, pers. comm.).

Behaviour and Biology:
Members of this family feed on crustaceans (crabs and prawns), molluscs (bivalves, gastropods, chitons and octopuses), echinoderms (sand dollars) and fishes (Hutchins, 1976; Hutchins, 1998). Food is generally ingested whole (Hutchins, 1976; Hutchins, 1998). The stomach is capable of great expansion and can occupy the whole abdominal cavity (Hutchins, 1976; Hutchins, 1998). More work is required to accurately determine the biological characteristics of this species.

Size:
Halophryne queenslandiae attains a length of about 30cm (Kuiter, 1993).

Evidence for Decline:
Like most batrachoidids, *Halophryne queenslandiae* bites readily on cut baits and is probably quickly removed from areas with high line fishing pressure (J. Johnson, pers. comm.). Frogfishes are often mistaken for members of the venomous scorpionfish Scorpaenidae, in particular the extremely dangerous stonefishes (Hutchins, 1998). Many anglers tend to destroy anything remotely resembling a “stonefish”, and frogfishes are no exception (J. Johnson, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly Great Barrier Reef Marine Park and World Heritage Area, Qld
Possibly Solitary Islands Marine Park, northern NSW

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
More information is necessary to accurately determine the status of this species. However, due to the apparent pressures exerted on this species by recreational line fishing, and its restricted and sparse distribution, it is recommended to assign it the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Recreational (and possibly commercial) fishing, where this species is taken as bycatch, are the main threatening process for this species.

Critical Habitats:
Rocky reef localities associated with offshore islands may be critical to this species.

Recovery Objectives/Management Actions Required:
Educating recreational fishers about the identification and the harmless nature of this species may help in protecting it from the effects of overfishing. Concurrently, the designation of suitably located no-take fishing areas may be necessary to protect this species. Further surveys are required to determine the accurate distribution and abundance of this species. This could be carried out by underwater visual surveys (which would be complicated by their camouflage), or by line fishing with barbless hooks, which would do minimal damage to the fish.

References:
Hutchins, 1976; Hutchins, 1998; J. Johnson, pers. comms. 1999-2000; Kuiter, 1993.

FAMILY BRACHIONICHTHYIDAE: HANDFISHES

The family Brachionichthyidae is the most speciose of the few marine fish families that are endemic to Australia. Five of the currently eight recognised species have among the narrowest ranges of any of the 4000+ marine fishes of the Australian region and are potentially at risk due to their small population sizes (Bruce *et al*., 1998). The handfishes are small, peculiar looking fishes, which occur in benthic habitats of inshore and shelf waters to around 200m or more in depth. Handfishes reach a maximum length of about 150mm (Paxton *et al*., 1989). Although occasionally observed by divers, or collected in dredging or trawling operations, most species have very restricted distributions and their abundances are normally low (Last *et al*., 1983). Consequently, little is known of their biology. Between 8 and 10 species occur in Australia, 4 of which occur on mainland Australia; the remainder are endemic to Tasmanian waters (P. Last, pers. comm.). The taxonomy of this family is currently being researched, but is unlikely to be resolved in the near future (P. Last, pers. comm.). Species synopses were only completed for those species with sufficient available information. These are *Brachionichthys hirsutus* (spotted handfish), *Brachionichthys politus* (red handfish), *Brachionichthys* sp. (Australian handfish), *Sympterichthys* sp. (Ziebells handfish) and *Sympterichthys verrucosus* (warty handfish). Museum records should be treated as preliminary identifications until the relevant experts have examined specimens from the major Australian fish collections with holdings of these species.

One species (*Brachionichthys hirsutus*) is listed on the 2000 IUCN Red List of Threatened Species as Critically Endangered (http://www.redlist.org/).

References:
B. Bruce, pers. comms. 1999-2000; Bruce *et al*., 1998 Kuiter, 1993; Last *et al*., 1983; P. Last, pers. comms. 1999-2000; Paxton *et al*., 1989

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species hompage)

Spotted Handfish

Family Name:	Brachionichthyidae
Scientific Name:	*Brachionichthys hirsutus* (Lacépède, 1804)
Conservation Status:	Critically Endangered

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Critically Endangered (A1cde)

ASFB Threatened Fishes Committee
1994-1999: Endangered (Critically Endangered adopting IUCN Categories from 1996)

Australian Commonwealth *EPBC Act 1999*
Schedule 1: Endangered (since 1996)

ANZECC Listed Fauna
Critically Endangered

Listing under Tasmanian State Threatened Species Protection Act ratified December 1999

Distribution:
Brachionichthys hirsutus is endemic to south-eastern Tasmania in areas of the lower Derwent River estuary, Frederick Henry Bay, D' Entrecasteaux Channel and the northern regions of Storm Bay (Bruce *et al*., 1998).

Museum Records - 56 specimens (Standard Length 56-92mm), collected from a depth range of 1-60m, ranging in geographical distribution from Eddystone Point (approx. 41^{o}S), to the Bruny Island area (approx. 43^{o}30'S), in Tasmania. Specimens were collected between 1884 and 1996.

Habitat:
Brachionichthys hirsutus is a benthic species, occurring in coarse to fine sand habitats in depths of 5-40m (most commonly 5-10m). It is often found in shallow, shell-filled depressions or near rocks of low relief projecting from the substrate (Bruce *et al*., 1998).

Biology and Behaviour:
Brachionichthys hirsutus is a small benthic species with modified pectoral and pelvic fins upon which it rests or moves slowly across the bottom. The modified first dorsal spine (illicium) is used to probe egg masses and is sometimes extended to rest on the substrate (Bruce *et al*., 1998). Spawning occurs in September to October. Egg masses (80-250 eggs) are attached to vertical structures on the substrate (primarily stalked ascidians, but also sponges or seagrasses). Eggs are large (approximately 3-4mm in diameter), housed in individual flask-shaped envelopes and are interconnected in a single mass by a series of fine tubules of unknown function. Tendrils attached to each egg assist in holding the egg mass together and attaching it to the spawning substrate. The female guards and tends the egg mass. *Brachionichthys hirsutus* lacks a pelagic larval period with eggs hatching after 7 to 8 weeks as fully formed juveniles (6-7mm standard length) (Bruce *et al*., 1998, 1999). Growth rates of females suggest that maturity is reached after 2-3 years at a size of 75-80mm, while the smallest male to fertilise eggs in a captive breeding program for this species was 87mm TL (Bruce *et al*., 1999). Longevity is yet to be determined (Bruce *et al*., 1999). The diet includes small crustaceans, polychaete worms (Bruce *et al*., 1998) and small shells (Kuiter, 1996).

Size:
Brachionichthys hirsutus grows to a maximum size of about 120mm Standard Length (Bruce *et al*., 1998).

Evidence for Decline:
Brachionichthys hirsutus was once common throughout the lower Derwent estuary and adjoining bays prior to the mid-1980s and has since suffered a serious decline in distribution and abundance (Bruce *et al*., 1999).

The cause of the decline in *B. hirsutus* is yet to be determined. Suggested reasons include predation by the recently introduced Northern Pacific seastar *Asterias amurensis*, habitat modification through increased siltation of the estuary (thereby reducing preferred habitat) and heavy metal contamination of sediments and urban effluent input (Bruce *et al*., 1998, 1999). Loss of spawning substrate may be a significant factor in the species decline (Bruce *et al*., 1998, 1999).

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Critically Endangered on an Australia-wide basis
Brachionichthys hirsutus is endemic to Tasmania, and here the population(s) are in decline. There has been no evidence of any recovery (B. Bruce, pers. comm.). It is therefore recommended to assign the status of Critically Endangered, adopting the IUCN categories.

Threatening Processes:
Habitat degradation of the few estuaries in which this species is found has the potential to jeopardise the populations of this species.

Critical Habitats:
Undegraded shallow, benthic, sandy habitats with suitable spawning substrates (e.g. primarily stalked ascidians *Sycozoa* sp., but also sponges, and seagrasses) are critical to the survival of this species.

Recovery Objectives/Management Actions Required:
A National Recovery Team has been formed and a National Recovery Plan (Bruce and Green, 1998) for *B. hirsutus* was implemented in 1999. The collection of data on basic biology, population dynamics and habitat requirements as well as effective monitoring of existing colonies and the identification of threatening processes are high priorities. Captive breeding and release trials have been successful and offer a strategy to supplement wild colonies should they continue to decline. Trials with artificial spawning substrate in the wild have also been highly successful and offer a short-term amelioration strategy in areas where spawning substrate is limiting. Ultimately the conservation of *B. hirsutus* is undoubtedly linked to the overall management of the Derwent River estuary system and may include ameliorating habitat changes caused by rural, urban and industrial practices or the control of introduced marine species.

References:
B. Bruce, pers. comms. 1999-2000; Bruce *et al*., 1998; Bruce *et al*., 1999; Bruce and Green, 1998; Kuiter, 1996; Last *et al*., 1983

Red handfish

Family Name:	Brachionichthyidae
Scientific Name:	*Brachionichthys politus* (Richardson, 1849)
Conservation Status:	Vulnerable

Taxonomic Problems:
There is some debate as to whether this species should be assigned to the genus *Brachionichthys* or *Sympterichthys.*

Current Conservation Status:
No IUCN (1996, 2000) Listing

ASFB Threatened Fishes Committee
1994-1999: Indeterminate Status

Distribution:
Brachionichthys politus is confined to Tasmanian waters. It was first collected from the Port Arthur region and is also known from near the Actaeon Islands (Last *et al*., 1983).

Museum Records - 6 specimens (Standard Length 51-68mm), collected from a depth range of 5-20m, ranging in geographical distribution from the Forestier Peninsula (42°51'S), Tasmania southwards to the Actaeon Island Group (approx. 43°32'S), Tasmania. Specimens were collected between 1980 and 1985.

Habitat:
Brachionichthys politus inhabits mixed sand and rocky reef in depths of 2-20 (B. Bruce pers. comm., Kuiter, 1996).

Biology and Behaviour:
Spawning occurs in September to October. Egg masses have been observed attached to algae (primarily *Caulerpa*) in shallow (3-5m) reef areas. Eggs are large (approximately 3-4mm in diameter), orange in colour, housed in individual flask-shaped envelopes and are interconnected in a single mass by a series of fine tubules and tendrils similar to that of *B. hirsutus*. The female remains with the egg mass until hatching. *B. politus* lacks a pelagic larval period with eggs hatching after 7 to 8 weeks as fully formed juveniles (6-7mm standard length) (B. Bruce, pers. comm.). *Brachionichthys politus* feeds on worms and crustaceans (Kuiter, 1996).

Size:
Brachionichthys politus attains a length of 80mm (Last *et al*., 1983).

Evidence for Decline:
There has been no observed decline for this species. However, it has a very restricted, fragmented distribution and is uncommon within this small range. It occurs at less than ten localities (B. Bruce, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Vulnerable on an Australia-wide basis.
The natural rarity of this species in combination with its small, restricted distribution warrants a Vulnerable conservation status, adopting the IUCN categories.

Threatening Processes:
Habitat degradation appears to be the main threat to this species survival.

Critical Habitats:
Undegraded shallow, rocky and sandy reefs with suitable spawning substrates (e.g *Caulerpa* algae) are critical to this species.

Recovery Objectives/Management Actions Required:
The listing of this species on the Commonwealth's *EPBC Act 1999* is essential to protect this species in the wild. The design and implementation of adequately sized and suitably located MPAs would help in protecting the habitat in which this species occurs. The formation of a National Recovery Team to accumulate information on its distribution, abundance, ecology and biology will be necessary to accurately assess any threats to this species.

References:
B. Bruce, pers. comms 1999-2000; Kuiter, 1996; Last *et al*., 1983

Australian handfish

Family Name:	Brachionichthyidae
Scientific Name:	*Brachionichthys* sp.
Conservation Status:	Lower Risk (least concern)

Taxonomic Problems:
This species resembles the spotted handfish *Brachionichthys hirsutus* that is confined to Tasmanian waters (Gomon *et al*., 1994).

Alternative Common Name:
Common handfish

Current Conservation Status:
<u>No IUCN (1996, 2000) or ASFB Listings</u>

Distribution:
Brachionichthys sp. is the most widespread species in the family, ranging from southern Queensland to South Australia and Tasmania (Kuiter, 1993).

<u>Museum Records</u> - 14 specimens (Standard Length 23-56mm), collected from a depth range of 24-277m, ranging in geographical distribution from off Bermagui (approx. 36^{o}20'S), NSW southwards to the Maria Island region (approx. 42^{o}40'S) of Tasmania, collected between 1978 and 1996.

Habitat:
Brachionichthys sp. is rarely seen in shallow water, preferring waters of 40-100m in depth (Kuiter, 1993), though it has been recorded to depths of 200m (May and Maxwell, 1986). It lives on soft muddy or shelly substrates (Last *et al*., 1983).

Biology and Behaviour:
The biology of this species is unknown. The diet for this species is also unknown, but probably consists of small invertebrates.

Size:
Brachionichthys sp. attains a length of 80mm (Kuiter, 1993).

Evidence for Decline:
There is no evidence of any declines for this species. It may be afforded better protection than other handfishes in that it has a more widespread distribution and has been recorded in deeper waters.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
The widespread distribution and mainly offshore habitat may help to ensure the survival of this species.

Threatening Processes:
Commercial fishing (i.e trawling and dredging, where it is occasionally taken as bycatch) is the only identified threat to this species.

Critical Habitats:
Muddy or shelly soft bottom substrates appear to be important to this species.

Recovery Objectives/Management Actions Required:
Further research is needed on the biology and ecology of this species.

References:
Gomon *et al*., 1994; Kuiter, 1993; Last *et al*., 1983; May and Maxwell, 1986.

Warty Handfish

Family Name:	Brachionichthyidae
Scientific Name:	*Sympterichthys verrucosus* McCulloch and Waite, 1918
Conservation Status:	Data Deficient

Australian Synonyms:
Also known as *Brachionichthys verrucosus* (McCulloch and Waite, 1918)

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Sympterichthys verrucosus is confined to continental shelf waters of South Australia eastwards to at least the New South Wales-Victoria border. Specimens are rare in fish collections (Gomon *et al*., 1994).

Museum Records - 11 specimens (Standard Length 47-75mm), collected from a depth range of 82-225m, ranging in geographical distribution from off Wattamolla (34°10'S), NSW southwards to Tasmania. Specimens were collected between 1898 and 1996.

Habitat:
Sympterichthys verrucosus has been collected from depths of 15-110m (Gomon *et al*., 1994).

Biology and Behaviour:
Unknown. The diet for this species is also unknown, but probably consists of small invertebrates.

Size:
Sympterichthys verrucosus attains a length of at least 8cm (Gomon *et al*., 1994).

Evidence for Decline:
There is no evidence of any decline for this species. However, fishermen occasionally catch it when dredging for scallops (Gomon *et al*., 1994).

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Bottom trawling may be posing a threat to this species, but more information is required.

Threatening Processes:
Commercial fishing (i.e. trawling) activities potentially threatens this species.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
Further research on the biology and ecology of this species is required to fill data gaps. The examination of the bycatch of scallop dredgers in the Bass Strait Scallop Fishery is necessary to determine the presence or absence of this species in its catches. The development of strategies towards a Bycatch Action Plan for the Bass Strait (Central Zone) Scallop Fishery is in its final stages (AFMA, 2000a).

References:
AFMA, 2000a; Gomon *et al*., 1994.

Ziebells Handfish

Family Name:	Brachionichthyidae
Scientific Name:	*Sympterichthys* sp.
Conservation Status:	Vulnerable

Other scientific names in recent use:
Brachionichthys sp. 1 (from Last *et al*., 1983)

Taxonomic Problems:
A similar form from near Eaglehawk Neck (Tas.), which is almost uniformly purple, may be another undescribed species (Last *et al*., 1983).

Alternative Common Names:
Actaeon handfish; yellow-finned handfish

Current Conservation Status:
ANZECC Listed Fauna
Vulnerable

No IUCN (1996, 2000) Listing

ASFB Threatened Fishes Committee
1994-1999: Vulnerable

Distribution:
Sympterichthys sp. is confined to Tasmanian waters, and has been found from Bicheno to the Actaeon Islands along the east coast of Tasmania and at Cox's Bight in southern Tasmania (P. Last, pers. comm.).

Museum Records – 11 specimens (Standard Length 88-112mm), collected from a depth range of 10-16m, ranging in geographical distribution from Waterfall Bay (43°04'S), southwards to the Actaeon Islands (43°32'S) in southern Tasmania, collected between 1980 and 1986.

Habitat:
Abalone divers in depths of 15-20m first collected *Sympterichthys* sp. over sandy bottoms beneath forests of the towering kelp *Macrocystis* (Last *et al*., 1983).

Biology and Behaviour:
Individuals can survive in aquaria for long periods on a diet of live shrimps. The flesh appears to be poisonous (Last *et al*., 1983). Egg masses of the Eaglehawk Neck form have been observed around sponges in depths of 20m (B. Bruce, pers. comm.). The diet for this species is unknown, but probably consists of small invertebrates.

Size:
Sympterichthys sp. is the largest of the handfishes, and attains a length of 150mm (Last *et al*., 1983).

Evidence for Decline:
There is no evidence of any decline. However, this species has a very restricted distribution and is only known from a few localities.

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Vulnerable on an Australia-wide basis
Based on the very small distribution of this species, as a precautionary approach it is recommended to assign the status of Vulnerable, adopting the IUCN categories.

Threatening Processes:
Habitat degradation has the potential to be detrimental to this species.

Critical Habitats:
Shallow, soft-bottom habitats associated with sponges and algae appear to be critical to this species.

Recovery Objectives/Management Actions Required:
Adequately sized and suitably located MPAs need to be implemented to protect the few recorded populations of this species. The first step towards recovery of this species is the formation of a National Recovery Team to accumulate information on its distribution, abundance, ecology and biology. The taxonomic relationships between this species and other species of handfishes need to be resolved to determine the accurate distribution of the populations of this species. Further surveys are critical to accurately assess the threats to populations of this species.

References:
B. Bruce, pers. comm. 2000; Last *et al*., 1983. P. Last, pers. comm. 7/2000.

Orange Roughy

Family Name:	Trachichthyidae
Scientific Name:	*Hoplostethus atlanticus* Collett, 1889
Conservation Status:	Lower Risk (conservation dependent)

Alternative Common Names:
Deepsea perch; sea perch

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Orange roughy are widely distributed within the temperate latitudes of the world (Tilzey, 2000a). In Australia, they occur from central NSW, southwards around Tasmania and across the Great Australian Bight to south-west of Western Australia (Tilzey, 2000a). They also occur on seamounts and ocean ridges off southern Australia and the South Tasman and Lord Howe Rises (Tilzey, 2000a).

Museum Records - 83 specimens (Standard Length 15-408mm), collected from depths of 438-1273m, ranging in geographical distribution from off New South Wales (29°59'S) southwards to the South Tasman Rise (47°32'S, 148°16'E) and north-westwards to off south-western Australia (approx. 34° S, 114°50'E). There is also 1 specimen from New Zealand. Specimens were collected between 1972 and 1992.

Habitat:
Hoplostethus atlanticus forms demersal schools on the mid-slope and seamounts in depths of 500 to 1400m (more typically 750-1050m) (Yearsley *et al*., 1999), but they are most common between the depths of 800 and 1000m (Tilzey, 2000a).

Biology and Behaviour:
Hoplostethus atlanticus lives for well over 100 years and matures between 27 and 32 years of age (Caton *et al*., 2000). Natural mortality is very low and is estimated to be 4 - 6% per annum (Tilzey, 2000a). They form spawning aggregations between mid-July and late August (Tilzey, 2000a). Fecundity is relatively low, rarely exceeding 90,000 eggs per female (Tilzey, 2000a). They are synchronous spawners, shedding eggs and sperm into the water at the same time, but not all of the adult population spawns each year (Kailola *et al*., 1993). Two estimates of natural mortality rate (0.064 and 0.048) were derived from different assumptions about the age of recruitment to the fishery, but presently there is no information to favour one over the other (Tilzey, 2000a). Despite considerable research the stock structure in the South East Fishery (SEF) remains uncertain (Tilzey, 2000a). Recent research suggests that there is a migratory stock common to both the eastern and southern management zones of the SEF, as well as more localised 'resident' fish (Tilzey, 2000a). The stock structure of orange roughy in the GABTF is also uncertain (Tilzey, 2000b). Genetic studies in the GABTF suggest a single Australian stock, whereas biological studies (parasite loadings, morphometrics and size structure) and chemical studies (otolith microchemistry) suggest there are several stocks including one off Western Australia (Tilzey, 2000b). The occurrence of spawning aggregations of orange roughy within the GAB supports the hypothesis of a separate GAB stock (Tilzey, 2000b). Adult orange roughy feed opportunistically on bentho-pelagic and meso-pelagic fishes and squid, and juveniles feed mainly on crustaceans (Kailola *et al*., 1993).

Size:
Hoplostethus atlanticus attains a size of at least 60cm and 3.5kg (commonly 35-45cm and 0.8-1.5kg) (Yearsley *et al*., 1999).

Evidence for Decline:
The aggregating behaviour of spawning individuals and the extremely slow growth rate of orange roughy make them very vulnerable to overfishing (Tilzey, 2000a). In the South East Fishery, orange roughy catches

totalled over 50,000t in 1990, but only 5579t in 1997 (Tilzey and Chesson, 1998) and 4174t in 1998 (Tilzey, 2000a). Orange roughy catches have been declining since 1990, but this species still remains the most important in the South East Fishery, with a value of about A$12.7 million in 1998 (Tilzey, 2000a). In the Great Australian Bight Trawl Fishery the orange roughy catch has decreased from a 1989 peak of 4139t to 323t in 1997 (Tilzey, 1998). Since 1997 catches have increased to 820t in 1999 (AFMA, 2000b). However, catches of orange roughy in the GABTF have not exceeded 1000t since 1990 (Tilzey, 2000b). Spawning aggregations have been targeted off Tasmania since the late 1980s. Numbers declined soon after exploitation commenced and the fishery is now strictly managed to protect the populations in each of the exploited areas (Yearsley *et al*., 1999).

Australian Marine Protected Areas in Which the Species Occurs:
Tasmanian Seamounts Marine Reserve
Great Australian Bight Marine Protected Area - orange roughy may occur in the benthic strip at depths greater than 500m out to the 200nm boundary (the benthic strip is 20nm wide) (K. Truelove, pers. comm.).

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis
Adopting the IUCN criteria, some stock of orange roughy would qualify for Critically Endangered. However, this is a gross exaggeration of the extinction risk of this species given the meta-population structure and the current management controls in place. Therefore, it is recommended to assign the status of Lower Risk (conservation dependent) to this species. Ongoing fisheries management will be a key factor in maintaining healthy stock(s) of this species.

Threatening Processes:
Targeted commercial trawling, which directly reduces numbers by removing fish and potentially reduces numbers by degrading structure of bottom habitats, is the only identified threat to this species.

Critical Habitats:
Specific seamounts are important aggregating habitats for this species, but the relationship between the habitat structure, the size of the seamounts and the size of the aggregation is unclear.

Recovery Objectives/Management Actions Required:
Quota restrictions and sustainable management are essential practices in the preservation of this resource. It is AFMA policy to maintain the spawning biomass of each orange roughy stock above 30% of the spawning biomass that existed at the onset of significant commercial fishing (1988) (Bax, 1999; Tilzey, 2000a). Where there is a greater than 50% probability that a stock is below 30% of the 1988 spawning biomass, then the TAC for the stock will be set in future such that the biomass reaches 30% of the initial biomass by 2004 (Bax, 1999).

References:
AFMA, 2000b; Bax, 1999; Caton *et al*., 2000; Kailola *et al*., 1993; Tilzey, 1998; Tilzey, 2000a; Tilzey, 2000b; Tilzey and Chesson, 1998; K. Truelove, pers. comm. 9/1999; Yearsley *et al*., 1999.

FAMILY PEGASIDAE: SEAMOTHS

The family Pegasidae is an Indo-Pacific fish family, with only 2 genera (*Pegasus* and *Eurypegasus*) and 5 species; both genera and three species are found in Australian waters (Kuiter, 1996). Only one species *Pegasus lancifer* is endemic to Australian waters. Pegasids began appearing in directories of ingredients used in traditional Chinese medicine in the 1980s, and are now traded by several South East Asian countries, including southern China and Hong Kong, although the scale and impact of the trade remains unclear (Lourie *et al*., 1999; Vincent, 1997). Behavioural studies have shown that these benthic fishes exhibit high social structuring, with close pair bonding and a monogamous mating system. The behaviour and ecology of sea moths would probably make them vulnerable to over-exploitation (Vincent, 1997; Project Seahorse Website, 8/1999). The two other species that occur in Australian waters, *Pegasus volitans* and *Eurypegasus draconis*, have a wide geographical distribution and are not included in these synopses.

All five species are listed as Vulnerable and /or Data Deficient (depending on different geographical regions) on the 2000 IUCN Red List of Threatened Species (http://www.redlist.org/).

References:
Kuiter, 1996; Lourie *et al*., 1999; Vincent, 1997

Websites:
IUCN (World Conservation Union) Website
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

Project Seahorse Website:
http://www.seahorse.mcgill.ca/relat.htm (Seahorse relatives)

Sculptured seamoth

Family Name:	Pegasidae
Scientific Name:	*Pegasus lancifer* Kaup, 1861
Conservation Status:	Lower Risk (least concern)

Australian Synonyms:
Acanthopegasus lancifer McCulloch, 1915

Alternative Common Name:
Dragonfish

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

No ASFB Listing

Distribution:
Pegasus lancifer is a temperate, inshore endemic species (Paxton *et al*., 1989) which is known from the southern coast of Australia between Rottnest Island, Western Australia and Lakes Entrance, Victoria including Tasmania (Palsson and Pietsch, 1989; Edgar, 1997).

Museum Records - 146 specimens (Standard Length 18-119mm), collected from depths of 0-56m, ranging in geographical distribution from off Lakes Entrance (37°53'S, 148°E), Victoria, southwards to Hobart (43°07'S), Tasmania and north-westwards to Rottnest Island (32°S, 115°30), WA, collected between 1909 and 1996.

Habitat:
Adult *Pegasus lancifer* are mainly bottom-dwelling fish that are most often found on sand or mud amongst or near seagrass (Gomon *et al*., 1994) or near low rubble reef (Kuiter, 1996). They occur at a variety of depths from intertidal shallows to about 55m (Gomon *et al*., 1994).

Behaviour and Biology:
Pegasus lancifer camouflages itself by rapidly changing colours to match its surroundings and occasionally burrow into the substrate to escape predators. In spring, they enter sandy bays to breed, sometimes congregating in small numbers. Juveniles are pelagic before taking on the adults' bottom mode of existence (Kuiter, 1985; Gomon *et al*., 1994). They are mostly buried during the day, and active at dusk. Males have ornamental patches on the edges of their pectoral fins for displaying to females (Kuiter, 1996). Spawning involves the pair swimming upwards together, to several metres from the substrate. They quickly dart back after the release of eggs and sperm, which floats to the surface. These activities are mainly towards dusk on high tides (Kuiter, 1993). Seasonal migrations are suggested by the fact that they are trawled with prawns only during certain times of the year (Kuiter, 1985; Vincent, 1997). They often crawl over the seabed on their paired fins in search of small crustaceans, worms and molluscs on which they feed (Kuiter 1985; Gomon *et al*., 1994).

Size:
Pegasus lancifer reaches a maximum length of 12cm (Kuiter, 1996).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species in Australia. Like many fish species, there have been no quantitative surveys.

Australian Marine Protected Areas in Which the Species Occurs:
Possibly occurs in the following areas:

Great Australian Bight Marine Park, SA

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
Some members of this family have been exploited in other countries, but in Australia the conservation status of this species remains relatively secure, considering its wide distribution across the southern part of Australia.

Threatening Processes:
The traditional Chinese medicine trade has the potential to impact on this species in the future, but there is no known trade for this species at the present time (Vincent, 1997).

Critical Habitats:
Unpolluted, soft-bottom sandy and muddy habitats associated with seagrass are important to the survival of this species.

Recovery Objectives/Management Actions Required:
The presence of this species in the Chinese medicine trade needs to be confirmed and, if present, monitored.

References:
Edgar 1997; Gomon *et al.*, 1994; Kuiter, 1985; Kuiter, 1993; Kuiter, 1996; Palsson and Pietsch, 1989; Paxton *et al.*, 1989; Vincent, 1997;

Websites:
http://www.seahorse.mcgill.ca

FAMILY SYNGNATHIDAE: SEAHORSES, SEADRAGONS, PIPEFISHES AND PIPEHORSES

Dawson (1985) recognised approximately 210 syngnathid species, representing 52 genera, as occurring worldwide. Around half of these species (over 100), representing 38 genera, were listed from Australian waters at that time, with 14 of the 38 genera (or 37%) regarded as endemic (Dawson, 1985). In terms of species numbers, about 50 (or roughly 25%) of the world's species were known to be endemic to Australia at that time (Dawson, 1985). In recent years many additional syngnathid species have been described and /or recognised. Somewhere in the order of 330 species in 54 genera are now thought to occur worldwide, around 120 (or 36%) of which are thought to occur in Australian waters (Kuiter, 2000).

Pipefishes and seahorses have limited reproductive potential, with the numbers of eggs in a single batch typically in the 100's. The number of young in each brood will generally be lower in the smaller-sized species (Vincent 1996; Kuiter 2000).

In 1996 the IUCN listed 37 species of syngnathids as being of some conservation concern. Of these, one was listed as Endangered and 36 were listed as Vulnerable (Baillie and Groombridge, 1996; Orr and Pietsch, 1998), partly because of the pressures placed on many species by the Traditional Medicine Trade (Vincent, 1996; Almada-Villela, 1998) and the predicted future declines that would result. The rapidly growing trade in seahorses, pipehorses and their allies in this Traditional Chinese Medicine (TCM) trade and its derivatives (e.g. the Japanese and Korean traditional medicine trades) has prompted much concern for the conservation of these syngnathids. A study motivated by this concern led to the publication of a report entitled *The International Trade in Seahorses* (Vincent, 1996). Of the roughly 120 syngnathid species that occur in Australia (Kuiter, 2000), 38 are proposed for listing in the present report. This places particular emphasis on Australia's role in conserving and protecting syngnathid species from overexploitation, as has occurred in parts of South East Asia.

In Australian waters, there is so far little or no evidence of any serious declines in populations of syngnathids, but there is a potential risk of the traditional medicine trades concentrating on Australia once stocks are fully depleted in tropical South East Asian regions. Additionally, the threat of an increasing aquarium trade for Australian species cannot be discounted. Species-specific data on the trade in syngnathid species is required to effectively manage and implement controls on these species in Australia and overseas. The monitoring of the bycatch of syngnathid species taken in Australian fisheries is also essential in assessing which species are most at risk from fishing activities. Syngnathid species taken from deepwater trawling operations (e.g. *Solegnathus* spp.) are unlikely to survive if returned to the water. However, syngnathid species taken by shallow water trawling or dredging activities may survive if returned to the water, especially if the trawl duration is relatively short (A. Mednis, pers. comm.). Investigations into the survival rates of trawled or dredged syngnathid species would provide baseline information on the susceptibility of individual species to fishing activities. Adequately sized and suitably located no-take zones and Marine Protected Areas are likely to be the most reliable method of ensuring the survival of populations of individual species in Australian waters.

The South-East Trawl Fishery (SETF) Draft Bycatch Action Plan (AFMA, 2000c) recognises that actions are necessary to "quantify the extent of interactions with syngnathids in the SETF". This action is necessary to achieve the following aim: "reduce, to the greatest extent feasible, the catch and impact on marine mammals and protected species". The quantities of syngnathids taken in the SETF will be assessed by the AFMA, and the success of aiming to reduce the catch and impact on these species will then be evaluated (AFMA, 2000c).

The continued protection of species such as the weedy and leafy seadragons will help conserve these unique endemic species and the protection of other syngnathids will need to be considered on a species by species basis.

References:
AFMA, 2000c; Almada-Villela, 1998; Baillie & Groombridge, 1996; Dawson, 1985; Kuiter, 2000; A. Mednis, pers. comm. 9/2000; Orr and Pietsch, 1998; Vincent, 1996

Legislation Pertaining to the Family Syngnathidae

The Commonwealth's *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (the Act) was amended in 1997 so that all syngnathids (seahorses, pipefishes, pipehorses and seadragons) and solenostomids (ghost pipefishes) became subject to export controls since 1 January 1998. Prior to this amendment species listed under Schedule 4 of the Act were not subject to export controls and most Australian native marine finfish were listed here (AFMA, 1999a). However, the family Syngnathidae and the family Solenostomidae have been removed from Schedule 4 of the Act.

There is international interest and demand for syngnathid species, particularly in the traditional Asian medicine and marine aquarium fish markets. As a precautionary measure, these species are now subject to export controls so as to regulate and monitor the export trade. Environment Australia requires an export permit/authority where it is proposed to export these species (including live animals and products derived from these species). Export permits will only be granted where these species have been obtained from either an approved breeding (aquaculture) operation (operated in a manner that satisfies Regulation 8 of the Act) or taken from the wild under an approved harvesting regime under section 10A of the Act.

A variety of syngnathid species is currently being exported from several states under a number of arrangements (AFMA, 1999a). The Minister for the Environment has declared as controlled specimens a number of syngnathid species harvested from Victoria, Tasmania and South Australia (AFMA, 1999a). Further, as an interim arrangement, authorities to export syngnathids derived as bycatch from Queensland trawl fisheries and the syngnathid aquarium fishery have been granted to exporters. The exceptional circumstance in this case is that the Queensland Fisheries Service (QFS) is developing a syngnathid management arrangement document for approval under this WP (REI) Act 1982 (AFMA, 1999a).

Although they are not a target species, syngnathids are also taken and have been exported from the Commonwealth managed South East Trawl Fishery (SETF) as an unavoidable part of the bycatch from trawling operations. As the Commonwealth Government Authority responsible for the SETF, the Australian Fisheries Management Authority (AFMA) is required to submit for approval by the Minister for the Environment and Heritage a management regime for the taking and any future export of syngnathids in the SETF (AFMA, 1999a).

The Minister for Environment and Heritage has approved the export of wild harvested and captive-bred syngnathids derived throughout Australia including Tasmania, South Australia, Victoria, Western Australia and Queensland. Some of these exports are derived as bycatch from trawl fisheries in Queensland and used for traditional medicine purposes, while other species are targeted specifically for use in the aquarium trade. A few companies based in Victoria, South Australia and Tasmania are currently breeding seahorses, primarily for the aquarium trade.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*. Additional pieces of state fisheries legislation which protects syngnathid species include the Victorian *Fisheries Act 1995* which lists all syngnathids as Protected Aquatic Biota, and the *Tasmania Living Marine Resources Management Act 1995,* which prohibits the take of all syngnathid species (presumably without a permit) in Tasmanian waters.

A syngnathid discussion paper was considered at the CITES COP 2000, presented by the USA and Australia. A resolution from a working group was formulated directing the CITES Secretariat and Animals Committee to undertake a number of actions relating specifically to the conservation, protection and sustainable use of syngnathids. Therefore, while syngnathids are not currently CITES listed, CITES has identified that attention should be given to this group of species (A. Mednis, pers. comm.).

References:
AFMA, 1999a; A. Mednis (Environment Australia), pers. comms. August - September 2000

Banded Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Dunckerocampus dactyliophorus* (Bleeker, 1853)
Conservation Status:	Lower Risk (least concern)

Taxonomy:
Kuiter (2000) recognised *Dunckerocampus* as a valid genus, rather than as a subgenus of *Doryrhamphus*. Most of the earlier Australian references were to *Doryrhamphus dactyliophorus.*

Alternative Common Name:
Ringed pipefish (Australia)

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Dunckerocampus dactyliophorus occurs in tropical and subtropical waters of the Indo-West Pacific. It is uncommon in Micronesia (Myers, 1989). It ranges from the Red Sea to the Austral Islands, north to southern Japan and south to the Great Barrier Reef and New Caledonia (Lieske and Myers, 1994). In Australia, this species has been recorded from Western Australia (Clerke Reef [17° 18' S] to Mermaid Reef [17° 06' S]), Northern Territory (Darwin [131° E]), Queensland (Tijou Reef [13° 10' S] to Escape Reef [15° 49' S]) (Paxton *et al*., 1989).

Museum Records - 111 specimens (Standard Length: Larvae - 160mm), collected from depths of 1-40m, ranging in geographical distribution from Herald Cays (17°S) northwards to Cape York (13°04'S), Qld, westwards to Rowley Shoals (17°10'S, 119°20'E) and south-westwards to Ashmore Reef (10°13'S). Specimens have also been collected outside of Australia from Indonesia, PNG, the Solomon Islands and Vanuatu. Specimens were collected between 1965 and 1999.

Habitat:
Dunckerocampus dactyliophorus inhabits protected coastal reefs, in large caves and among boulders with long-spined urchins (Kuiter, 1996). It has been recorded to occur at depths of up to 56m, and there are many records from tidepools and intermediate depths (Dawson, 1985). They hover in deep recesses beneath ledges (Lieske and Myers, 1994). In north-western Australia this species inhabits coral reef crevices on offshore reefs of the North-West Shelf (Allen and Swainston, 1988).

Behaviour and Biology:
Dunckerocampus dactyliophorus is often found together with cleaner shrimps, and probably participates in cleaning. The deep red eggs are attached to the trunk of the male without additional cover. Juveniles often occur in small aggregations, and adults are usually found in pairs (Kuiter, 1996). Males may be found brooding at about 90mm standard length (Dawson, 1985). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
This species grows to a maximum length of about 20cm (Kuiter, 1996).

Evidence for Decline:
There is no evidence of any declines for this species in Australian waters. In Indonesia and the Philippines, this species is locally collected and exported live to regions such as North America for the aquarium trade (Vincent, 1996). However, there is no known trade of this species in Australian waters.

Australian Marine Protected Areas in Which the Species Occurs:
Ashmore Reef National Nature Reserve, off northern WA
Cartier Island Marine Protected Area, off northern WA (unconfirmed)
Great Barrier Reef Marine Park and World Heritage Area, Qld
Rowley Shoals Marine Park, off north-western WA

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
This species has a relatively broad distribution and inhabits depths of up to 50m. It is unlikely to be trawled by any fisheries in Australian waters (R. Kuiter, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Protected coral reefs are an important habitat for this species.

Recovery Objectives/Management Actions Required:
None identified

References:
Allen and Swainston, 1988; Dawson, 1985; Kuiter, 1996; Kuiter, 2000; R. Kuiter, pers. comm. 9/1999; Lieske and Myers, 1994; Myers, 1989; Paxton *et al*., 1989; Vincent, 1996.

Ladder Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Festucalex scalaris* (Günther, 1870)
Conservation Status:	Lower Risk (least concern)

Synonyms:
Ichthyocampus scalaris Günther, 1870

Current Conservation Status:
No IUCN or ASFB Listings

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

Distribution:
Festucalex scalaris is a temperate, inshore endemic Australian pipefish known from Warroora and the Shark Bay area in Western Australia (Dawson, 1985). It is also known from the Monte Bello islands, west of the Dampier Archipelago (B. Hutchins, pers. comm.).

Museum Records - 39 specimens (Standard Length: larval stage to 191mm), collected from a depth range of 0-7m, ranging in geographical distribution from Monte Bello islands (20^{o}25’S) and Warroora (23^{o}29’S), WA southwards to Shark Bay (26^{o}S), WA, collected between 1939 and 1993.

Habitat:
Most specimens were taken from trawls, some in association with algae (Dawson 1985) such as <I>*Sargassum*</I> (Kuiter 2000). This species is resident on rocky reefs where there is an abundance of brown algae. As they are not strong swimmers they inhabit sheltered lagoons, inlets and bays (Coleman 1981). Museum specimens have been collected from sandy and silty habitats, coral reef, mangroves, and areas with seagrass and algae (such as *Sargassum*). It occurs from the intertidal region to about 20m depth (R. Kuiter, pers. comm.).

Behaviour and Biology:
Males may be brooding at 120mm standard length (Dawson 1985). Mating takes place in early summer and the females deposit their eggs in the sub-caudal brood pouch of the male who protects the eggs until the tiny pipefishes hatch (Coleman 1981). Aquarium observations suggest that another closely related species, *Festucalex cinctus*, has broods of up to 300-400 eggs and broods up to 3-4 times per year (R. Kuiter, pers. comm.). *F. scalaris* may have a similar reproductive rate to *F. cinctus*, but research will be necessary to test this theory. This species is carnivorous, feeding on crustaceans (Coleman, 1981).

Size:
Festucalex scalaris grows to a length of at least 190mm (Dawson 1985).

Evidence for Decline:
There is no evidence of any declines for this species.

Australian Protected Areas in Which Species Occurs:
Shark Bay Marine Park (WA)
Hamelin Pool Marine Nature Reserve (WA) (unconfirmed)

Suggested Conservation Status:

Lower Risk (least concern) on an Australia-wide basis
Festucalex scalaris is abundant in shallow seagrass beds of Shark Bay, but its distribution and abundance in areas to the north (Exmouth Gulf and Dampier Archipelago) and south of the Shark Bay area require further investigation. This species is not threatened by trawling activities in Shark Bay (Hutchins, pers comm.). It is recommended to assign the above conservation status, adopting the IUCN categories.

Threatening Processes:
None identified.

Critical Habitats:
Shallow algal habitats and seagrass beds appear to be critical to the survival of this species.

Recovery Objectives/Management Actions Required:
Little is known about the biology of this species. Future research needs to be directed into studies on its biology, distribution and ecology within its restricted Western Australian range.

References:
Coleman, 1981; Dawson, 1985; B. Hutchins, pers. comm. 11/1999; R. Kuiter, pers. comm. 11/1999 and 6/2000; Kuiter, 2000; Paxton *et al.*, 1989

Shortkeel Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Hippichthys parvicarinatus* (Dawson, 1978)
Conservation Status:	Lower Risk (least concern)

Other names:
The common name was first used by Kuiter, 2000, p182.

Current Conservation Status:
No IUCN or ASFB Listings

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248. of the *EPBC Act 1999*

Distribution:
Hippichthys parvicarinatus is a tropical pipefish known from Darwin Harbour, Kakadu National Park, the Roper and Towns Rivers, and Bathurst Island in the Northern Territory as well as Saibai Island in southern PNG.

Museum Records - 53 specimens (Standard Length 33-100mm), collected from depths of 0-5m, ranging in geographical distribution from Darwin Harbour, NT (approx. 12^{o}27'S, 130^{o}50'E), to the West Alligator River and Field Island (12^{o}06'S, 132^{o}23'E), Kakadu National Park, and eastwards to the Roper and Towns Rivers in the western Gulf of Carpentaria, NT. It is also known from Bathurst Island (approx. 11^{o}30'S, 130^{o}30'E), NT, and from Saibai Island in southern PNG. Specimens were collected between 1969 and 1998.

Habitat:
Hippichthys parvicarinatus is known from estuarine habitats in the abovementioned areas. The type specimens were collected in muddy pools. Other specimens have been collected from mudflats, mangroves and mangrove pneumatophores, gravel, sandy and rocky habitats and coral and shell rubble.

Behaviour and Biology:
Unknown. Like other members of the family Syngnathidae, this species probably feeds on small crustaceans.

Size:
Hippichthys parvicarinatus probably grows to a length of about 100 to 120mm (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. It probably occurs in other areas of the Northern Territory with similar habitats, but many of these habitats have not been well sampled.

Australian Protected Areas in Which Species Occurs:
Kakadu National Park (NT)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
This species is relatively common in estuarine areas throughout its range (H. Larson, pers. comm.) and there are no immediate threats to its survival. However, it has a restricted distribution and may be prone to the effects of habitat degradation, so it warrants monitoring of its abundance. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Muddy estuarine areas associated with mangroves and coral rubble appear to be important habitats for this species.

Recovery Objectives/Management Actions Required:
Further sampling of muddy estuarine habitats of the Northern Territory may extend the known range and abundance of this species.

References:
Dawson, 1985; Kuiter, 2000; H. Larson, pers. comm. 9/1999; Paxton *et al*., 1989.

SEAHORSES: *Hippocampus* species

Until recently, Australian seahorses were inadequately studied and poorly understood. Paxton *et al*., (1989) recognised only seven Australian species. Lourie *et al*., (1999) significantly increased our understanding and knowledge, recording 13 species from Australian waters while admitting further research was required. Rudie Kuiter has recently revised the Australian seahorses (herein referred to as “Kuiter, 2001”) and Sara Lourie is currently working on a PhD dissertation dealing with the morphology and systematics of seahorses (not examined for this work). In order to clearly identify each species of Australian seahorse during this time of changing taxonomy, we have attempted for each species to indicate equivalence between Kuiter (2001) and Lourie *et al*., (1999). However, Kuiter (2001) has become available only recently, and this comparison was not possible in some cases. Museum records for the following *Hippocampus* species are limited to those cited by Kuiter (2001) where overlapping ranges prevent the interpretation of the new species from museum records. For many of the seahorse species there are additional specimens for which the identifications have not been confirmed. Some of these unconfirmed records have been excluded for the sake of accuracy. Kuiter (2001) describes several new species of seahorses in Australian waters. We have not included species conservation synopses for some of these ‘new’ species (or previously unrecorded species from Australian waters) due to insufficient data. For example, Kuiter (2001) recognises a new species (*Hippocampus jugumus*) from a single specimen found at Lord Howe Island in 1925, a second new species (*Hippocampus montebelloensis*) from two specimens found at the Monte Bello Islands and Exmouth Gulf, a previously described species which possibly occurs off northern Western Australia (*Hippocampus kampylotrachelos*) and another species (*Hippocampus histrix*) not previously recorded from Australian waters. We have not included any of these abovementioned species in this report, due to a lack of basic information, and in any regard they would have been classified as Data Deficient. In most cases where we have included a new species, there has been a restriction of the former range of existing species, so a precautionary approach must be taken in assessing the conservation status of these species. We emphasise, however, that further research will be required to accurately assess the conservation status of most Australian seahorses (like other syngnathids and many Australian fish genera with high species diversity), and significant gaps still exist in our knowledge of this diverse group. Because of their distinctive appearance, shallow occurrence and relatively low reproductive potential, seahorses and their distinctive relatives seadragons may be useful indicator species for the health of the marine environment (Paxton 1995; Lourie *et al*., 1999).

References:
Kuiter, 2000; Kuiter, 2001; Lourie *et al*., 1999; Paxton 1995; Paxton *et al*., 1989

Eastern Potbelly Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus abdominalis* Lesson, 1927
Conservation Status:	Data Deficient

Previous or Alternative Common Names:
Big-bellied seahorse; Pot-bellied seahorse (Australia); kiore (NZ)

Taxonomic Problems:
In the past ichthyological literature, the name *Hippocampus abdominalis* has been used to encompass the Australian and New Zealand populations of this species. However, recent taxonomic work by Rudie Kuiter suggests that there are two morphologically distinct species in Australian waters, *Hippocampus abdominalis* and *Hippocampus bleekeri.* The name *Hippocampus abdominalis* is now adopted for the eastern potbelly seahorse that is known in Australian waters from Newcastle to Eden and possibly further southwards where it may overlap with *Hippocampus bleekeri.* To validate the identity of the NSW population requires further taxonomic research on the populations from New Zealand, the type locality. The name *Hippocampus bleekeri* now refers to the populations ranging from the northern Great Australian Bight in South Australia eastwards to Lakes Entrance, Victoria (R. Kuiter, pers. comm.; Kuiter, 2001).

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A2d)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus abdominalis is known from Newcastle, NSW southwards to at least Eden, NSW and possibly further south (Kuiter, 2001). In New Zealand waters it is widespread, occurring on both the north and south Islands. Specimens have been recorded from the Three Knights Islands to Stewart Island, the Snares and the Chatham Islands (Paulin and Roberts, 1992).

Museum Records - 7 specimens (Height 90-165mm), captured from depths of 10-19m, ranging in geographical distribution from Newcastle (32^{o}52'S) southwards to Port Hacking (34^{o}04'S), NSW. Specimens were collected between 1916 and 1991. There are additional specimens from NSW in various fish collections around Australia, but the identifications of these specimens have not yet been verified.

Habitat:
Adult *Hippocampus abdominalis* occur in harbours and protected coastal bays or in deep waters together with sponges (Kuiter, 1993; Kuiter, 2001). In New Zealand waters, specimens have been captured from depths of 0-40m (Paulin and Roberts, 1992).
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Behaviour and Biology:
The young of *Hippocampus abdominalis* grow to a few centimetres long before settling on the bottom (Kuiter, 1993; R. Kuiter, pers. comm.). As with other members of the seahorse and pipefish family, the males incubate the eggs in an abdominal pouch and eventually release young that look like miniature replicas of the adult (Edgar, 1997). In New Zealand waters spawning occurs from spring to summer and juveniles are released from the pouch after about thirty days. Juveniles up to 30mm in length are pelagic and have been collected in surface waters of the open ocean over the Chatham Rise off New Zealand. This species is more active at dusk and at night than during the day (Paulin and Roberts, 1992). The pouch is developed after

about 6 months, but the age of first breeding is closer to 12 months, and they reach their maximum size after about 2 years of age (R. Kuiter, pers. comm.). The brood size is probably several hundred individuals. *Hippocampus abdominalis* probably feeds mainly on small crustaceans.

Size:
Hippocampus abdominalis probably grows to a maximum height of 18cm in NSW waters (Kuiter, 2001). New Zealand populations, which are probably the same species may attain a height of up to and exceeding 30cm, probably due to the lower water temperatures (Kuiter, 1996).

Evidence for Decline:
There is no evidence of any declines in this species.

Australian Marine Protected Areas in Which Species Occurs:
Jervis Bay Marine Park, southern NSW
Probably most NSW Aquatic Reserves within its range

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
At the September 1999 workshop, distinction of two Australian species of potbelly *Hippocampus* was unknown, and most discussion focused on the Tasmanian population, considered here as *Hippocampus bleekeri*. Populations of *H. abdominalis* seem to be reasonably secure, but should be closely monitored, as it may be vulnerable to over-collecting by the aquarium trade. It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Overcollecting of wild specimens for the marine aquarium fish trade and the Traditional Medicine trades are the greatest potential threats to this species. Inshore habitat degradation in southern Australian waters may also decrease the available habitat for populations of this species.

Critical Habitats:
This species is often associated with soft-bottom, coastal and outer estuarine habitats where they attach themselves to kelp and sponges.

Recovery Objectives/Management Actions Required:
Further research is required to accurately determine the ecology, biology, distributional range and abundance of this species. Monitoring of possible threats associated with aquarium collecting, medicinal trade and habitat degradation is also recommended. The designation of adequately-sized and suitably-located MPAs are necessary to protect this species from the abovementioned threats.

References:
Edgar, 1997; R. Kuiter, pers. comms. 1999-2000; Kuiter, 1993; Kuiter, 1996; Kuiter, 2001; Last *et al*., 1983; Paulin and Roberts, 1992.

Winged Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus alatus* Kuiter, 2001
Conservation Status:	Data Deficient

Taxonomic Problems:
This species has been previously identified as *Hippocampus kuda, H. barbouri, H. hystrix and H. spinosissimus* (Kuiter, 2001). It is closely related to *Hippocampus moluccensis* (possibly restricted to Moluccan Seas) and *Hippocampus queenslandicus* (Kuiter, 2000 & 2001).

Current Conservation Status:
<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB or IUCN Listings</u> (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus alatus has been recorded from the Dampier Archipelago region in Western Australia north-eastwards to the Gulf of Carpentaria, eastern Cape York and south-eastern PNG (Kuiter, 2001).

<u>Museum Records</u> - 8 specimens (Height 69.5-136mm), collected from a depth range of 10-80m, ranging in geographical distribution from off the Monte Bello Islands (20°17'S, 116°01'S), WA north-eastwards to Cape York (11°37'S, 142°56'E), Qld. Specimens were collected between circa 1963 and 1991. Additional specimens are probably housed in various Australian fish collections, but identifications need to be confirmed.

Habitat:
Hippocampus alatus has been trawled or dredged in soft-bottom habitats in depths of 10-80m (Kuiter, 2001). It is usually found on remote outcrops of debris or corals that provide shelter and substrate. It is often found in deep current prone channels between reefs or islands, in depths over 20m (Kuiter, 2000). In PNG, specimens were found on deep open sand slopes with a few sponges and gorgonian corals in an area influenced by strong tidal currents (Kuiter, 2001).

Behaviour and Biology:
Unknown. Like most seahorses, this species probably feeds on small crustaceans.

Size:
Hippocampus alatus grows to a height of about 18cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence of any decline for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
This species is thought to have a broad, patchy distribution, and occurs from inshore (less than 10m) to offshore waters (at least 80m). It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Prawn trawling in northern Australian waters is a potential threat to this species.

Critical Habitats:
Soft-bottom substrates appear to be important to this species.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, ecology and biology of this species in Australian waters. The accumulation of bycatch information by northern Australian fisheries that take this species would benefit research efforts by providing baseline data on abundances, habitat and distribution.

References:
Kuiter, 2000; Kuiter, 2001.

Western Spiny Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus angustus* Günther, 1870
Conservation Status:	Data Deficient

Taxonomic Problems:
Hippocampus angustus is one of several similar tropical spiny seahorse species that can be difficult to distinguish (Kuiter, 2001). This species has often been misidentified as *Hippocampus histrix*. The real *H. histrix* is only rarely found in northern Australian waters (Kuiter, 2000). The name *H. angustus* has been used to encompass *H. elongatus* in the past, but they are now recognised as different species (Lourie *et al*., 1999; Kuiter, 2000).

Previous Common Name:
Narrow-bellied seahorse

Current Conservation Status:
<u>2000 IUCN Red List of Threatened Species</u>
Vulnerable (A2cd)

<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB Listing</u>

Distribution:
Hippocampus angustus is endemic to Western Australian waters and has been recorded from Shark Bay to the Dampier Archipelago (Kuiter, 2001).

<u>Museum Records</u> - 11 specimens (Height to 149mm), collected from a depth range of 1-31m, ranging in geographical distribution from Denham (25°56'S), Shark Bay northwards to north of the Monte Bello Islands (20°05'S), WA. Specimens were collected between 1961 and 1981. Additional specimens are housed in various Australian fish collections, but identifications need to be confirmed.

Habitat:
Hippocampus angustus has been trawled to depths of at least 31m (Kuiter, 2001).

Behaviour and Biology:
Hippocampus angustus is one of several spiny seahorse species that can be difficult to distinguish (Kuiter, 2001). Females are much spinier than males in those species (Kuiter, 2001). Like most seahorses *Hippocampus angustus* probably feeds on small crustaceans.

Size:
Hippocampus angustus grows to a height of about 16cm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Shark Bay Marine Park, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
This species has a relatively restricted and patchily known distribution, and occurs from inshore (about 1m) to offshore waters (at least 31m). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, ecology and biology of this species. Genetic studies on this species may be necessary to accurately define its distributional range.

References:
Kuiter, 2000; Kuiter, 2001; Lourie *et al*., 1999.

Gorgonian Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus bargibanti* Whitley, 1970
Conservation Status:	Data Deficient

Alternative Common Names:
Bargibant's seahorse; pygmy seahorse

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus bargibanti was described from Noumea, New Caledonia and it is now known from Bali and Sulawesi in Indonesia, Ogasawara Islands of southern Japan, PNG, Solomon Islands and the Great Barrier Reef in Queensland (Kuiter, 2001). The first specimen from Australia was taken from Triangle Reef in the northern section of the Great Barrier Reef, Queensland.

Museum Records - 5 specimens (Total Length 19.5-24.2mm), collected from a depth range of 20-30m all from Noumea (22^{o}16'S, 166^{o}26'E), New Caledonia, collected between 1969 and 1997.

Habitat:
Hippocampus bargibanti is a tropical seahorse species, which has been found only on gorgonians (sea fans) of the genus *Muricella* (Lourie *et al*., 1999) in depths of 10 to 60m (Kuiter, 2001). In the northern Great Barrier Reef specimens have been found in depths of 30-60m (Kuiter, 2001).

Behaviour and Biology:
The small size of *Hippocampus bargibanti* and its amazing resemblance to the gorgonians on which it lives makes it very difficult to detect underwater. The type specimens were discovered only when the seafans were brought into an aquarium. There are two known colour forms of this species; the first one is pale grey or purple with pink or red tubercules (found on the gorgonian *Muricella plectana*) and the other is yellow with orange tubercules (found on the gorgonian *Muricella paraplectana*). The tubercules and truncated snout of *Hippocampus bargibanti* match the colour and shape of the polyps of the host gorgonian, while its body matches the gorgonian stem (Lourie *et al*., 1999). Although seahorses are known for their unusual appearance, few, if any, have developed the extreme protective colouration and morphology of *Hippocampus bargibanti* (Gomon, 1997). Adult *Hippocampus bargibanti* are usually found in pairs or clusters of pairs (up to 28 pairs on a single gorgonian). This species is possibly monogamous in the wild with the breeding season starting in March and finishing in November (Lourie *et al*., 1999). Young are pelagic and may disperse over great distances. Post-pelagic young may settle on shallow water gorgonians (Kuiter, 2001). Lourie witnessed birth and counted 34 young from a single brood in Sulawesi (R. Kuiter, pers. comm.). This species feeds on the tissue of gorgonian corals (Kuiter, 2001).

Size:
Specimens found to date have all been less than 2.5cm in length (Randall *et al*., 1997).

Evidence for Decline:
There is no evidence of decline for this species. There is no known trade for this species in Australia.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Owing to the lack of detailed Australian distributional information available for *Hippocampus bargibanti*, it is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Gorgonian corals, particularly species of the genus *Muricella*, are critical to the survival of this seahorse species. The gorgonians provide both habitat and food for the seahorse. As these gorgonians are often found in areas of coral reef associated with high current flow, there is unlikely to be any threat of damage to this habitat by fishing disturbance such as trawling, as this habitat is usually considered unsuitable for trawling.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, ecology and biology of this species.

References:
Gomon, 1997; Kuiter, 2001; R. Kuiter, pers. comm. 5/2000; Lourie *et al.*, 1999; Randall *et al.*, 1997

False-eyed Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus biocellatus* Kuiter, 2001
Conservation Status:	Lower Risk (near threatened)

Taxonomic Problems:
This species is very similar to *H. planifrons* (Kuiter, 2001).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No IUCN or ASFB Listings (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus biocellatus appears to be restricted to the Shark Bay region of WA (Kuiter, 2001).

Museum Records - 6 specimens (Height 60-108mm) collected from a depth range of 1-12m, all from Shark Bay (approx. 24°45'S to 26°40'S), WA, collected between 1958 and 1985.

Habitat:
Hippocampus biocellatus occurs in shallow algal or weedy reef habitats from the intertidal zone to depths of about 20m (Kuiter, 2001).

Behaviour and Biology:
This species has two distinctive eye-like spots on its back that probably serve to distract predators. Seahorses usually lean forwards and often tuck their head below their trunk when threatened, and in the case of this species, the eye-like spots would be positioned horizontally on top (Kuiter, 2001). Amongst weed or algae this would look more like the eyes of a crab or a fish with a big head that may not be of interest to potential seahorse predators. Males of this species have a deep keel-like skin membrane on the ventral trunk ridge that may be used in courtship or display (Kuiter, 2001). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus biocellatus grows to a height of about 11cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence of any declines of this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Probably occurs at:
Shark Bay Marine Park, WA
Hamelin Pool Marine Nature Reserve, WA

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis
This species has a very limited known distribution. More information is necessary to accurately determine the conservation status of this species in Australian waters. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:

Habitat degradation of shallow inshore regions of Shark Bay is potentially a threat to this species.

Critical Habitats:
Shallow algal or weedy reef habitats to depths of 20m appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, biology and ecology of this species in Western Australian waters.

References:
Kuiter, 2000; Kuiter, 2001.

Southern Potbelly Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus bleekeri* Fowler, 1908
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Hippocampus graciliformis McCulloch, 1911

Taxonomic Problems:
In the past ichthyological literature, the name *Hippocampus abdominalis* has been used to encompass the Australian and New Zealand populations of this species. However, recent taxonomic work by Rudie Kuiter suggests that there are two species in Australian waters, but further work is required on New Zealand populations to assess the species in those waters and compare them to Australian populations. The name *Hippocampus abdominalis* is now adopted for the Eastern Potbelly Seahorse that is known in Australian waters from Newcastle to Eden and possibly further southwards. *Hippocampus bleekeri* is in need of further study to determine if populations in the area of South Australia, Victoria and Tasmania represent a single species (Kuiter, 2001).

Alternative Common Names:
Pot-bellied seahorse; big-bellied Seahorse (Australia); kiore (NZ)

Current Conservation Status:
2000 IUCN Red List of Threatened Animals
Vulnerable (A2d) (as *Hippocampus abdominalis*)

All syngnathids are listed as Protected Aquatic Biota under the Victorian *Fisheries Act 1995*

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus bleekeri is known from the Great Australian Bight in South Australia eastwards to Victoria and southwards to Tasmania (Kuiter, 2001).

Museum Records - 12 specimens (Height 46-250mm), captured from depths of 0-32m, ranging in geographical distribution from the northern Great Australian Bight (approx. 32^{o}24'S, 133^{o}30'E), SA eastwards to Lakes Entrance (37^{o}53'S, 148^{o}S), Vic. Specimens were collected between 1948 and 1996.

Habitat:
Hippocampus bleekeri are often found under jetties, attached to kelp holdfasts. The young are pelagic and have been found floating attached to bits of seagrass or algae (Kuiter, 1993; R. Kuiter, pers. comm.). In deeper water this species is often associated with sponges (Kuiter, 1996; R. Kuiter, pers. comm.). It is common near the entrances of large estuaries in southern Tasmania where it lives on muddy bottoms or near reef edges (Last *et al.*, 1983).

Behaviour and Biology:
The sedentary habits of this species make it relatively easy to culture (Neira *et al*., 1998). Newborn fry of *Hippocampus bleekeri* are about 21mm in length (Seahorse Australia website). The young grow to a few centimetres long before settling on the bottom (Kuiter, 1993; R. Kuiter, pers. comm.). As with other members of the genus *Hippocampus,* the males incubate the eggs in a pouch and eventually release young that look like miniature replicas of the adult (Edgar, 1997). Adult *Hippocampus bleekeri* breed all year round, but are probably more productive in the summer months (R. Kuiter, pers. comm.), with males giving birth up to three to four times in the wild during summer (Seahorse Australia website). In Port Phillip Bay, Vic., pregnant males have been photographed in June and pairs have also occasionally been seen (R. Kuiter, pers. comm.). This species does not pair with the same mate for life - females have been observed mating with several males and vice versa both in the wild and in captivity (Seahorse Australia website; N. Forteath, pers. comm.). Adult males nurture broods of up to and probably exceeding 400 individuals (R. Kuiter, pers. comm.), and one seahorse under aquaculture conditions produced a brood of 1116 young (Seahorse Australia website). The gestation period is about a month long, but varies with water temperature (R. Kuiter, pers. comm.). The pouch is developed after about six months, but the age of first breeding is closer to twelve months (R. Kuiter, pers. comm.). Aquarium-bred individuals are capable of breeding at four months of age (Seahorse Australia website; N. Forteath, pers. comm.) Maximum size is reached after about two years of age (R. Kuiter, pers. comm.; Seahorse Australia website). *Hippocampus bleekeri* feeds mainly on small crustaceans (Last *et al*., 1983).

Size:
Hippocampus bleekeri grows to a height of at least 22.5cm, but probably attains a height of about 30cm in Tasmanian waters (Kuiter, 1996; Kuiter, 2001).

Evidence for Decline:
No documented evidence for any declines of this species could be found from the literature. Live, captive-bred and reared specimens are sold locally in Australia and exported from Tasmania, Victoria and SA, to countries such as USA, Japan, Taiwan, South Africa, the Netherlands and the UK for aquarium purposes (N. Forteath, pers. comm.; P. Quong, pers. comm.; T. Warland, pers. comm.). Over 1600 specimens (87% live, 13% dried) were exported between June 1999 and June 2000, all of which were captive-bred and reared (EA export data, unpublished). Live individuals of this species sell for as low as A$7 and as high as A$50, depending upon supply and demand. All size ranges are sold, but adults are rarely sold as the expense of keeping them for long periods in aquaria makes them valuable as broodstock (P. Quong, pers. comm.). The sale of dried specimens of this species from Australia to the Asian Traditional Medicine trades has not yet occurred, but may occur in the future (Seahorse Australia website; N. Forteath, pers. comm.). This species is not seen in Traditional Chinese Medicine, although some from New Zealand are sold for Korean traditional medicine (Lourie *et al*., 1999). In 1998 the aquaculture company Seahorse Australia Pty. Ltd.™, based in northern Tasmania, removed 600 individuals of this species from Tasmanian waters for breeding purposes under permits issued by state and federal governments (Seahorse Australia website). Other operations in SA and Vic also have permits to remove wild individuals. Market development is currently being concentrated in north America, Europe and Asia, and also domestically (Seahorse Australia website).

Australian Marine Protected Areas in Which Species Occurs:
Blanche Harbour-Douglas Bank Aquatic Reserve, Spencer Gulf, SA
Probably also most Tasmanian Aquatic Reserves within its range

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Populations of this species seem to be reasonably secure, but should be closely monitored, as it may be vulnerable to over-collecting for the aquarium trade and traditional medicine trade. It is abundant only in certain habitats and may be susceptible to concentrated over-collecting (P. Last, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Overcollecting by the marine aquarium fish trade and the traditional medicine trade are the greatest potential threats to this species.

Critical Habitats:
This species is often associated with soft-bottom, coastal and outer estuarine habitats where they attach themselves to kelp and sponges.

Recovery Objectives/Management Actions Required:
Further research should focus on the taxonomy and population genetics of this species in southern Australian waters.

References:
EA export data, unpublished; Edgar, 1997; N. Forteath, pers. comm. 9/2000; R. Kuiter, pers. comms. 1999-2000; Kuiter, 1993; Kuiter, 1996; Kuiter, 2001; P. Last, pers. comm. 11/1999; Last *et al*., 1983; Lourie *et al*., 1999; Neira *et al*., 1998; P. Quong, pers. comm. 9/2000; T. Warland, pers. comm. 9/2000; Vincent, 1996.

Websites:
Seahorse Australia website: http://www.seahorseaquaculture.com.au/

Short Headed Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus breviceps* Peters, 1869
Conservation Status:	Data Deficient

Taxonomic Notes:
This species was previously recognised as occurring in Western Australian waters, but it is now thought that its distribution is limited to South Australia, Victoria and Tasmania, where suitable sheltered habitat exists (Kuiter, 2001).

Alternative Common Names:
Short-snouted seahorse (Australia); knobby seahorse (America)

Current Conservation Status:
2000 IUCN Red List of Threatened Animals
Data Deficient

All syngnathids are listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus breviceps is a temperate, southern Australian endemic seahorse which is most common in the Port Phillip Bay region of Victoria (Kuiter, 1993). It is also known from Spencer Gulf and St Vincents Gulf in South Australia, and Forsters Inlet southwards to Port Arthur in eastern Tasmania (Lourie *et al*., 1999). It has also been recorded from Bass Strait (Last *et al*., 1983). Its occurrence in WA waters is, at this stage, unclear.

Museum Records - 132 specimens (Standard Length 28-98mm), collected from a depth range of 0-20m, ranging in geographical distribution from Venus Bay (134°40'S), SA, eastwards to Port Welshpool (38°42'S, 146°28'E), Victoria and also from Forsters Inlet (42°34'S) southwards to the Port Arthur region (43°S) of Tasmania. Specimens were collected between circa 1889 and 1997.

Habitat:
Hippocampus breviceps occurs in sheltered coastal reefs in yellowish to brown *Sargassum*, often in small groups comprising several pairs (Kuiter, 1996). They are generally found attached to the fronds of brown algae (particularly *Cystophora* and *Sargassum*) in depths to 5m, and although rarely seen because of good camouflage, they can be common in localised areas (Edgar, 1997). In Port Phillip Bay they occur in small to large aggregations in seaweed patches attached to rocks over a sandy bottom, mostly in *Sargassum* (Kuiter, 1993). They inhabit the subtidal zone down to depths of 15m, but are sometimes seen on sponge reef in deeper water (Kuiter, 2000). It is occasionally found amongst seaweed floating at the surface (Gomon *et al*., 1994) and is often associated with rocky reef and jetty habitats (Coleman, 1980).

Behaviour and Biology:
The pouch of the male is large and inflates when courting females (Kuiter, 1996). This species breeds on a monthly cycle throughout summer, producing 50 to 100 young in a single or combined brood from several

females (Kuiter, 1993). The egg diameter is about 1.6mm (Lourie *et al*., 1999). Young are born after about a 25 day incubation period and swim to the surface after leaving the pouch. The pelagic larvae cling to surface weeds until they reach settling size at a height of about 25mm (Kuiter, 2000). It occurs in small groups that congregate in safe places at night, usually high in the weeds to keep away from the crabs on the substrate. Specimens found in *Sargassum* usually have long appendages on the head and back. Longevity in aquaria is at least 3 to 5 years (P. Quong, pers. comm.), but longevity in the wild is unknown. This species feeds close to the sand or rubble during the day and is carnivorous, targeting mysids (Kuiter, 2000).

Size:
Hippocampus breviceps is a small species that attains a height of about 10cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence of any declines for this species and there is no known Traditional Medicine Trade for this species (Vincent, 1996). However, a significant aquarium trade exists for this species in Australia (A. Mednis, pers. comm.). Captive-bred and reared specimens are exported from Victoria to countries such as America and Japan for aquarium purposes. Live individuals of this species sell for as low as $A7 and as high as $A50, depending upon supply and demand. All size ranges are sold, but adults are rarely sold as the expense of keeping them for long periods in aquaria makes them valuable as broodstock (P. Quong, pers. comm.). Between February 1998 and May 2000, 130 live individuals of this species (52% wild-collected from Vic and WA, 48% captive-bred and reared) were exported to Japan, USA, UK and Taiwan (EA trade data, unpublished).

Australian Marine Protected Areas in Which the Species Occurs:
This species probably occurs in the following areas:
Blanche Harbour-Douglas Bank Aquatic Reserve, Spencer Gulf, SA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species is brilliantly coloured and could potentially be threatened by collecting for the aquarium trade (Coleman, 1980). It has healthy populations in specific South Australian, Victorian and Tasmanian waters, and its conservation status seems relatively secure. However, further information is necessary on its distributional range and the possible threat of the marine aquarium fish trade. It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Overcollecting for the marine aquarium fish trade and inshore habitat degradation are potential threats to the survival of populations of this species.

Critical Habitats:
Shallow, sheltered coastal reefs associated with brown algae such as *Sargassum* appear to be critical to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research should concentrate on the abundance, biology, ecology and population genetics of this species to help in any future assessments of its conservation status. Continued monitoring of numbers removed from the wild for aquarium breeding stock is necessary to assess the impacts of this activity on its populations. The western-most distribution of this species also needs further investigation to determine its presence or absence from Western Australia waters.

References:
EA trade data, unpublished; Coleman, 1980; Edgar, 1997; Gomon *et al*., 1994; Kuiter, 1993; Kuiter, 1996; Kuiter, 2000; Kuiter, 2001; Last *et al*., 1983; Lourie *et al.*, 1999; A. Mednis, pers. comm. 9/2000; P. Quong, pers. comm. 9/2000; Vincent, 1996.

Low-crown Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus dahli* Ogilby 1908
Conservation Status:	Lower Risk (near threatened)

Taxonomic Problems:
Since Whitley synonymised *H. dahli* and the Western Australian *H. planifrons* in 1952, specimens with a low coronet were regarded as a single species that was broadly distributed in tropical Australian waters (Kuiter, 2001). However, Kuiter (2001) regards both as valid species, with *H. dahli* restricted to north-eastern Australia.

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Hippocampus dahli is known from west of the Darwin region in the Northern Territory south-eastwards to Moreton Bay in Queensland (Kuiter, 2001).

Museum Records - 17 specimens (Height 55.6-125mm), collected from a depth range of 3-21m, ranging in geographical distribution from Bynoe Harbour (130°33'E), NT south-eastwards to Moreton Bay (approx. 27°15'S), Qld. Specimens were collected between 1912 and 1999.

Habitat:
Most specimens of *Hippocampus dahli* in collections have been trawled in shallow coastal waters on rubble substrates to depths of 21m (Kuiter, 2001). It also occurs in channels of estuaries (Kuiter, 2000).

Behaviour and Biology:
Unknown. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus dahli grows to a height of at about 14cm (Kuiter, 2000).

Evidence for Decline:
There is no known trade for this species. This species has become rare in some areas such as Moreton Bay (Johnson, 1999; Kuiter, 2001), possibly due to habitat degradation and trawling within the bay.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Moreton Bay Marine Park, southern Qld

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis
More information is necessary to accurately determine the conservation status of this species in Australian waters. However, there have been declines reported from parts of its range (i.e. Moreton Bay) and as a precautionary measure it is recommended to assign the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Inshore habitat degradation and trawling are potential threats to this species, as it is so far known from only shallow (to 21m) depths.

Critical Habitats:
Shallow coastal waters associated with rubble substrates appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research on the biology, ecology, distribution and abundance of this species are necessary to provide an accurate picture of its conservation status.

References:
Johnson, 1999 (as *Hippocampus planifrons*); Kuiter, 2000; Kuiter, 2001; Whitley, 1952.

West Australian Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus elongatus* Castelnau, 1873
Conservation status:	Data Deficient

Australian Synonyms:
Hippocampus subelongatus Castelnau, 1873 (Kuiter, 2001)

Taxonomic Problems:
The name *Hippocampus angustus* has been used for the seahorses found off the south-west of Australia, and *Hippocampus histrix* for those from Shark Bay northwards. The original specimens of *H. angustus* were from Shark Bay and that name should refer to the northern species only, the southern ones being *H. elongatus* (Lourie *et al*., 1999; Kuiter, 2000).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Hippocampus elongatus is endemic to Western Australian waters, and has been found at Fremantle, Perth, the Swan River, the Houtman Abrolhos Islands (Lourie *et al*., 1999) and Cockburn Sound (Kuiter, 2001).

Museum Records - 5 specimens (height 94-145mm), collected from a depth range of 3-18m, all from Cockburn Sound (32^{o} 08' S to 32^{o} 11' S) in WA. Specimens were collected between 1971 and 1978. There are more specimens in various Australian fish collections registered under the name *Hippocampus angustus* that are probably this species.

Habitat:
Hippocampus elongatus occurs around the edges of rocky areas, on muddy bottoms, in areas of high sediment load, on jetty piles and moorings, and is also often associated with sponges or sea squirts or attached to man-made objects. It moves to deeper waters in winter and has been found at depths of 1 to 25m (Lourie *et al*., 1999). It is also known to inhabit protected coastal bays on rocky reefs with mixed short algae and rich invertebrate growth (Kuiter, 1996; R. Kuiter, pers. comm.). This species prefers sheltered reef and seagrass to a depth of 10m (Edgar, 1997; R. Kuiter, pers. comm.). It is abundant on broken bottom habitat and *Posidonia* seagrass in Cockburn Sound, Western Australia, but is not often seen elsewhere (Edgar, 1997).

Behaviour and Biology:
Hippocampus elongatus is highly variable in colour, matching its colour to that of sponges in its surroundings. Small numbers of pairs are often spread over a suitable section of reef (Kuiter, 1996; R. Kuiter, pers. comm.). The gestation period of *Hippocampus elongatus* is two to three weeks (but varies with water temperature), and the brood size is 250 to 600 (Lourie *et al*., 1999). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus elongatus grows to a maximum height of about 20cm (Lourie *et al*., 1999; Kuiter, 2001).

Evidence for Decline:
Lourie *et al*., (1999) reported that numbers recently declined substantially in the Swan River near Perth due to overcollecting for aquaria. It is unsure whether these declines were due to possible seasonal migrations

within this area (R. Kuiter, pers. comm.) or whether excessive aquarium collecting occurred. Over 125 individuals of this species collected from WA waters were exported live to Japan, Taiwan and the USA between January 1998 and October 1999 (EA trade data, unpublished).

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
More research is required to accurately determine the abundance and possible threats to the survival of this species, especially given the recent taxonomic changes to this family. There may be potential for habitat degradation and exploitation within its range, and this also needs to be investigated in greater detail. At this stage it is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Habitat degradation and overcollecting for the marine aquarium fish trade are potential threats to the survival of this species in WA waters. These potential threats need to be investigated. Continued monitoring of numbers of individuals taken from the wild is essential, and should be used in conjunction with surveys of known populations to assess the threat of overcollecting.

Critical Habitats:
Shallow coastal bays and rocky reefs associated with seagrass, algae, and sponge habitats appear to be crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
Numbers of this species collected for the marine aquarium fish trade need to be monitored in order to assess the impact of this activity on the species' populations. Further studies on the abundance, and possible movements of this species would also provide a clearer picture from which to accurately assess its conservation status.

References:
EA trade data, unpublished; Kuiter, 2001; Kuiter, pers. comms. 1999-2000; Lourie *et al*., 1999.

Bighead Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus grandiceps* Kuiter, 2001
Conservation Status:	Lower Risk (near threatened)

Taxonomic Problems:
Hippocampus grandiceps is most similar to *Hippocampus multispinus*, but has shorter spines and males lack long spines over the superior trunk ridge anteriorly to the dorsal fin which are long in *Hippocampus multispinus* (Kuiter, 2001).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No IUCN or ASFB Listings (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus grandiceps appears to be restricted to the Gulf of Carpentaria (Kuiter, 2001). The limited geographic range of this species may be a reflection of a unique habitat (Kuiter, 2001).

Museum Records - 10 specimens (Height 75-105mm), collected from a depth range of 10-18m, ranging in geographical distribution from Booby Island (10°36'S, 141°55'E), Qld southwards to the western side of Gulf of Carpentaria (17°24'S, 140°09'E).

Habitat:
Hippocampus grandiceps is only known from relatively shallow waters (to 18m) (Kuiter, 2001), probably associated with soft-bottom substrates.

Behaviour and Biology:
Unknown. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus grandiceps grows to a height of at least 105mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines of this species in Australian waters. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis
More information is necessary to accurately determine the conservation status of this species in Australian waters. However, considering that prawn trawlers in the Gulf of Carpentaria have captured specimens, they may be susceptible to prawn trawling operations in that area. It is recommended to assign the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Prawn trawling and inshore habitat degradation in the Gulf of Carpentaria potentially threaten this species.

Critical Habitats:
Soft-bottom inshore habitats of the Gulf of Carpentaria are crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the extent of occurrence of this species in the bycatch of the Northern Prawn Fishery. The abundance, distributional range, ecology and biology of this species need to be investigated to accurately assess the vulnerability of this species to the abovementioned threats.

References:
Kuiter, 2001.

Eastern Spiny Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus hendriki* Kuiter, 2001
Conservation Status:	Data Deficient

Taxonomic Problems:
This species has been confused with other species that have prominent spines, including *H. angustus*, *H. multispinus* and *H. grandiceps*. Males often looks superficially similar to *Hippocampus queenslandicus* which has different fin counts and a tail with less spine development, *H. hendriki* is readily distinguished from that species by its nose spine and the barring on its snout (Kuiter, 2001).

Current Conservation Status:
<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB or IUCN Listings</u> (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus hendriki appears to be restricted to the inner Great Barrier Reef area from Cape York southwards to the Capricorn region in Queensland (Kuiter, 2001).

<u>Museum Records</u> - 6 specimens (Height 47-104mm), collected from a depth range of 16-20m, ranging in Australian geographical distribution from off Lindeman Island (20^{o}27'S) north-westwards to west of Adolphus Passage (10^{o}38'S), Qld. Specimens were collected between 1935 and 1993.

Habitat:
This species has been recorded from open substrate adjacent to inner reefs. All specimens examined to date were trawled in depths of up to about 50m (Kuiter, 2000).

Behaviour and Biology:
Unknown. *Hippocampus hendriki* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus hendriki attains a size of at least 104mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
It is recommended to assign the conservation status of Data Deficient to this species, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
Further research is necessary to accurately define the distributional range and abundance of this species. The biology and ecology of this species also need to be studied, as well as its occurrence in prawn trawl bycatch.

References:
Kuiter, 2000; Kuiter, 2001.

Bullneck Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus minotaur* Gomon, 1997
Conservation Status:	Data Deficient

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

All syngnathids are listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus minotaur is endemic to southern Australia and is known from off Eden and Bass Strait (Lourie *et al*., 1999; Kuiter, 2001).

Museum Records - 4 specimens (Total Length 19.2-52.6mm), collected from depths of 64-110m off Eden (approx. 37^{o}S), NSW southwards to central Bass Strait (38^{o}56'S), Victoria, collected between circa 1927 and 1981.

Habitat:
Hippocampus minotaur has been trawled from depths of 64 to 110m on fine sandy or hard bottoms, possibly in association with gorgonian corals (Lourie *et al*., 1999). Noticeable bud-like processes are present on the dorsal surface of the tail of *H. minotaur*, reminiscent of those on the body of *H. bargibanti* that are used for camouflage. This may suggest that they inhabit southern soft corals, but collection information to date has given scant habitat information (Gomon, 1997).

Behaviour and Biology:
Unknown. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus minotaur grows to a length of less than 5cm (Lourie *et al*., 1999).

Evidence for Decline:
There is no evidence of any decline for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Hippocampus minotaur is very small and lives in deep (up to more than 100m) water, so it is probably not as threatened as other seahorse species. However, more data are necessary to accurately determine the conservation status of this species in Australian waters. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Deep (64-110m) offshore sandy or rocky reefs may be important for the survival of this species.

Recovery Objectives/Management Actions Required:
Further study is necessary to determine the distributional range, abundance, biology and ecology of this species in southern Australian waters. No genetic data have yet been obtained for this species (Lourie *et al*., 1999).

References:
Gomon, 1997; Kuiter, 2001; Lourie *et al*., 1999.

Northern Spiny Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus multispinus* Kuiter, 2001
Conservation Status:	Data Deficient

Taxonomic Problems:
This species has been misidentified as *Hippocampus hystrix and H. spinosissimus* (Kuiter, 2001).

Current Conservation Status:
<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB or IUCN Listings</u> (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus multispinus has been recorded from the Dampier Archipelago region in Western Australia north-eastwards to the Gulf of Carpentaria, Queensland and southern PNG (Kuiter, 2001).

<u>Museum Records</u> - 8 specimens (Height 50-140mm), collected from a depth range of 12-60m, ranging in geographical distribution from off the Dampier Archipelago (approx. 20°26'S, 116°20'E), WA north-eastwards to the Gulf of Carpentaria (13°03'S, 136°45'E), NT. Specimens were collected between 1983 and 1992. Additional specimens are probably housed in various Australian fish collections, but identifications need to be confirmed.

Habitat:
Hippocampus multispinus has been trawled from soft-bottom habitats in depths of 12-60m (Kuiter, 2001). A photograph taken in Milne Bay of this species showed it clinging to a soft coral in a strong current-prone habitat at a depth of 25m (Kuiter, 2001)

Behaviour and Biology:
Unknown. Like most seahorses, this species probably feeds on small crustaceans.

Size:
Hippocampus multispinus grows to a height of at least 140mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any decline for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
This species is thought to have a broad, but patchily known distribution, and occurs in depths from 12-60m. It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Prawn trawling in northern Australian waters is a potential threat to this species.

Critical Habitats:
None identified

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, ecology and biology of this species in Australian waters. The accumulation of bycatch information by northern Australian fisheries that take this species would benefit research efforts by providing baseline data on abundances, habitat and distribution.

References:
Kuiter, 2001.

Flatface Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus planifrons* Peters, 1877
Conservation Status:	Data Deficient

Taxonomic Problems:
This species is similar to *H. dahli*, but the coronet is not as low, the spines are more developed on the trunk and tail ridges and the nape spine is directed well forward and away from the coronet, rather than pointing upwards in *H. dahli*. The coloration is also different, in particular the presence of the lateral spots on the snout of this species, that are absent in *H. dahli* (Kuiter, 2001).

Current Conservation Status:
<u>2000 IUCN Red List of Threatened Species</u>
Vulnerable (A2cd)

<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB Listing</u>

Distribution:
Hippocampus planifrons is only known from Shark Bay and Broome in Western Australia (Kuiter, 2001).

<u>Museum Records</u> – 3 specimens (Height 40-70.2mm), collected from a depth range of 0.5m (only one specimen had depth data), ranging in geographical distribution from Broome (18^{o}01'S) southwards to the Shark Bay region (approx. 26^{o}15'S), in WA. Specimens were collected between 1929 and 1979.

Habitat:
Hippocampus planifrons lives in algae and rubble reefs in shallow bays to depths of 20m (Kuiter, 2000).

Behaviour and Biology:
Unknown. *Hippocampus planifrons* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus planifrons grows to a height of at least 7cm (Kuiter, 2001), but possibly to about 12cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence for any declines of this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Shark Bay Marine Park, WA
Possibly also occurs in Hamelin Pool Marine Nature Reserve, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More specimens are required to elaborate on the distributional range and abundance of this species.

Threatening Processes:
Inshore habitat degradation is a potential threat to this species, as it is known to occur in shallow depths.

Critical Habitats:
Shallow inshore regions may be important for the survival of this species. More habitat information is required.

Recovery Objectives/Management Actions Required:
Further studies on the distributional range, abundance, biology and ecology of this species will be necessary to accurately assess its conservation status in western Australian waters.

References:
Kuiter, 2000; Kuiter, 2001.

Highcrown Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus procerus* Kuiter, 2001
Conservation Status:	Data Deficient

Taxonomic Problems:
This species has been previously identified as *Hippocampus whitei* and appears to be closely related, but has a taller and spinier crown, higher fin ray counts, sharp spines on the ridges and grows to a larger maximum size (Kuiter, 2000). Kuiter (2000) provisionally called this species *Hippocampus* cf *whitei*.

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus procerus ranges from Moreton Bay northwards to at least Port Curtis in southern Queensland, but possibly further northwards (Kuiter, 2001).

Museum Records – 16 specimens (Height 55-110mm), collected from a depth range of 3-9m, ranging in geographical distribution from Port Curtis (23^{o}55'S) southwards to Moreton Bay (27^{o}25'S), Qld. An additional specimen identified as this species from the Gulf of Carpentaria (Qld) is dubious. Specimens were collected between 1886 and 1997 (Kuiter, 2001).

Habitat:
Hippocampus procerus occurs on algae reef and rubble substrates to depths of 20m (Kuiter, 2000).

Behaviour and Biology:
Unknown. *Hippocampus procerus* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus procerus attains a height of about 12cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Considering the recent discovery of this species, it is recommended to assign it the status of Data Deficient.

Threatening Processes:
None identified

Critical Habitats:
Shallow reefs associated with algae appear to be critical to the survival of this species.

Recovery Objectives/Management Actions Required:
Further research on the distribution, abundance, ecology and biology of this species is required to accurately determine its conservation status.

References:
Kuiter, 2000; Kuiter, 2001.

Queensland Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus queenslandicus* Horne 2001
Conservation status:	Data Deficient

Taxonomic Problems:
This species has been previously identified as *Hippocampus histrix*, *Hippocampus kuda* and *Hippocampus spinosissimus* based on the mixture of spiny or smooth appearances with different sizes or sexes (Kuiter, 2001). It is most similar to *Hippocampus alatus* that is stockier and has short blunt spines or tubercules, whereas *Hippocampus queenslandicus* usually has sharper, longer spines. In southern Queensland it is replaced by the closely related *Hippocampus tristis* that has more fin rays, grows to almost twice the height and differs considerably in colour (Kuiter 2001).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings (species not formerly recognised as being distinct from other *Hippocampus* spp)

Distribution:
Hippocampus queenslandicus occurs from the Southport area in southern Queensland northwards to the Cape York region (Kuiter, 2001).

Museum Records – 19 specimens (Height 70-116mm), collected from a depth range of 21-63m, ranging in geographical distribution from Princess Charlotte Bay (14°09'S) southwards to off Southport (27°S), Qld. Specimens were collected between 1960 and 1999.

Habitat:
Most specimens of *Hippocampus queenslandicus* have been trawled from the inner reef waters of the Queensland coastline in depths of 20-63m (Kuiter, 2001). Deep-water specimens are usually red or orange, colours that are probably similar to sponges living at that depth. This species is often found in deep, current-prone channels between reefs or islands (Kuiter, 2000).

Behaviour and Biology:
Unknown. *Hippocampus queenslandicus* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus queenslandicus attains a height of at least 12cm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species is widely distributed along the Queensland coastline and occurs in deeper waters (20-63m). However, little is known of its abundance, ecology and biology. It is recommended to assign the conservation status of Data Deficient to this species, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
None identified

Recovery Objectives/Management Actions Required:
Further research is necessary on the abundance, ecology and biology of this species.

References:
Horne, 2001; Kuiter, 2000; Kuiter, 2001.

Common Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus taeniopterus* Bleeker, 1852
Conservation Status:	Data Deficient

Taxonomic Problems:
This species is generally referred to in Australia as *Hippocampus kuda*, which is closely related, but is not known to occur in Australian waters (Kuiter, 2001).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Hippocampus taeniopterus occurs in the Moluccan Seas, Sulawesi and Bali and ranges south to PNG and northern Australia (Kuiter, 2000). It appears to be uncommon in Australian waters, but this may be either an artefact of the lack of collecting in this area, or expatriation from New Guinea waters where this species is known to be well established on the east coast (Kuiter, 2001). A specimen from Moreton Bay may represent an expatriate (Kuiter, 2001).

Museum Records – 6 specimens (Height to 115 mm, no specimens had capture depths recorded), ranging in Australian geographical distribution from Darwin (12^{o}27'S, 130^{o}48'E), NT eastwards to Cooktown (15^{o}28'S), Qld and southwards to Moreton Bay (approx. 27^{o}S), Qld. Specimens were collected between 1908 and 1995. A specimen was also collected from the southeast coast of PNG in 1907.

Habitat:
Hippocampus taeniopterus is mainly a coastal, shallow water species that occurs along the edges of seagrass beds or in mangroves to about 15m depth (Kuiter, 2001). Juveniles and adults are sometimes found in floating weeds offshore (Kuiter, 2001).

Behaviour and Biology:
Adults usually occur in pairs (Kuiter, 2000). *Hippocampus taeniopterus* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus taeniopterus attains a height of at least 22cm (Kuiter, 2000).

Evidence for Decline:
There is no evidence for any declines in Australian waters. There is no known trade for this species in Australia.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
It is unknown whether this species is a permanent resident in Australian waters or just a vagrant from New Guinean waters. It is recommended to assign the conservation of Data Deficient at this stage, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Shallow coastal waters associated with seagrass beds and mangroves appear to be important habitat for this species.

Recovery Objectives/Management Actions Required:
Further research on the distribution, abundance, biology and ecology of this species is necessary to accurately determine its conservation status in Australian waters.

References:
Kuiter, 2000; Kuiter, 2001.

Sad Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus tristis* Castelnau, 1872
Conservation Status:	Data Deficient

Taxonomic Problems:
This species has previously been misidentified as *Hippocampus whitei*, *Hippocampus kuda* and *Hippocampus kelloggi.*

Current Conservation Status:
<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB or IUCN Listings</u>

Distribution:
Hippocampus tristis is known to occur in a relatively narrow range from southern Queensland southwards to at least Iluka on the mid-north coast of NSW, and also Lord Howe Island (Kuiter, 2001).

<u>Museum Records</u> – 7 specimens (Height approx. 60-222mm), collected from a depth range of 18-60m, ranging in geographical distribution from the south Qld coastline (approx. 25^{o} S) southwards to off Iluka (29^{o} 21' S) and eastwards to Lord Howe Island (approx. 31^{o} 30' S). Specimens were collected between 1889 and 1995.

Habitat:
Hippocampus tristis has been captured in depths of 18-60m, mainly as bycatch of trawling operations in south-east Queensland and northern New South Wales (Kuiter, 2001).

Behaviour and Biology:
Unknown. *Hippocampus tristis* is a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus tristis attains a height of at least 222mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species in Australia.

Australian Marine Protected Areas in Which the Species Occurs:
Lord Howe Island Marine Park, Tasman Sea

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More data are needed to accurately determine the conservation status of this species. Its relatively restricted distribution and low numbers may place the species at risk.

Threatening Processes:
Commercial trawling operations in southern Queensland and northern NSW are potential threats to this species.

Critical Habitats:
This species seems to inhabit a reasonably wide depth range, but the specific habitat requirements of this species are unknown.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, ecology and biology of this species in eastern Australian waters.

References:
Kuiter, 2001.

Knobby Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus tuberculatus* Castelnau, 1875
Conservation Status:	Data Deficient

Taxonomic Problems:
This species was previously confused with *H. breviceps*, that occurs in cooler temperate zones, but *H. tuberculatus* has different characteristics and is smaller when fully grown (Kuiter, 2000).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Hippocampus tuberculatus is endemic to Western Australian waters and is known to occur from the Perth region northwards to Onslow in Western Australia (Kuiter, 2000).

Museum Records – 12 specimens (Height 44-74mm), collected from a depth range of 20m (only one depth recorded), ranging in Australian geographical distribution from the Onslow area (approx. 21^o 38' S) southwards to Rockingham (32^o 17' S), WA. Specimens were collected between 1973 and 1980.

Habitat:
Hippocampus tuberculatus is often found in floating *Sargassum* as juveniles and subadults, while adults usually settle on sponge reefs in depths of about 20m (Kuiter, 2000).

Behaviour and Biology:
Males have fully-developed pouches in the sub-adult stage (Kuiter, 2000.). *Hippocampus tuberculatus* is probably a carnivorous species that feeds on small crustaceans.

Size:
Hippocampus tuberculatus attains a height of at least 74mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence for any declines of this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Possibly occurs at Shark Bay Marine Park, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Due to the recent discovery of this species, it is recommended at this stage to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
As juveniles and subadults, floating *Sargassum* appears to be crucial to this species, but in the adult phase sponge reefs may play an important role in their survival.

Recovery Objectives/Management Actions Required:
Further research is required to accurately assess the range, abundance, ecology and biology of this species.

References:
Kuiter, 2000; Kuiter, 2001.

White's seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus whitei* Bleeker, 1855
Conservation Status:	Data Deficient

Other Common Names:
Sydney seahorse (Australia); New Holland seahorse (English)

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A2cde)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Hippocampus whitei appears to be restricted to NSW waters and is confirmed from the Sydney and Newcastle regions (Kuiter, 2001).

Museum Records - 8 specimens (Height to 96mm), collected from depths of 2-5m, ranging in geographical distribution from Sydney Harbour (33^o 48' S) southwards to Botany Bay (34^o 01' S), NSW. Specimens were collected between 1921 and 1998. There are probably many more specimens in various fish collections around Australia, which await identification.

Habitat:
Hippocampus whitei occurs in shallow, weedy inshore areas and *Zostera* seagrass beds. It also inhabits sponges and is often found under jetties on kelp holdfasts and also on man-made objects such as shark nets. It is found to a depth of 25m (Lourie *et al.*, 1999). This species is common in estuarine *Posidonia* beds and is particularly abundant in Sydney Harbour, but in southern waters only vagrants associated with drifting algae have been found (Edgar, 1997).

Behaviour and Biology:
Hippocampus whitei is a diurnal species, which is very site specific. It breeds from October to April and has a gestation period of around 21 to 22 days (which varies with water temperature). Eggs are about 1.8mm in diameter. The brood size is 100 to 250 individuals and the young are about 8.5mm long at birth. In the wild, this species is monogamous and pairs bond for life (Lourie *et al.*, 1999). They are nearly always found in pairs, but they may separate over several metres when feeding (Kuiter, 1996). Males often have home ranges of approximately 1m ^{2}, whereas their female partners may have home ranges around 100 times larger. Sex differences in areas of occupancy may serve to reduce competition for food between the partners (Lourie *et al.*, 1999). The complex reproductive behaviour of this species, which has been elucidated by Amanda Vincent and colleagues, is described by Lourie *et al.* (1999) in more detail. Greeting rituals appear to facilitate reproductive synchrony of male and female so that the female has ripe eggs ready as soon as the male gives birth, with the pair commonly re-mating later that same day. These rituals also apparently serve to reinforce pair bonds. Partners remain faithful despite injury and reproductive incapacity. If one of the pair is removed or dies, the remaining partner will often take many weeks to find a replacement (Lourie *et al.*, 1999). *Hippocampus whitei* apparently mature during the first reproductive season after birth, at age six to twelve months (Lourie *et al.*, 1999). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus whitei grows to a maximum height of at least 96mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines of this species. There is no known trade for this species, but it possibly occurs in the aquarium fish trade.

Australian Marine Protected Areas in Which the Species Occurs:
Probably occurs in many NSW MPAs.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species seems to be relatively secure in its natural habitat, but continual monitoring of its populations is recommended to ensure its survival in the wild. It is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Small numbers of this species are taken as bycatch in the South East Trawl Fishery (AFMA, 1999a).

Critical Habitats:
Shallow (less than 25m), inshore areas associated with seagrass and algae appear to be crucial to this species.

Recovery Objectives/Management Actions Required:
The monitoring of numbers of this species taken in the South East Trawl Fishery may be able to provide some data on its density in specific areas. No-take MPAs are important for the conservation of this species. Further research on the distribution and abundance of this species is necessary, given the contraction of its range by Kuiter's (2001) taxonomic decisions.

References:
AFMA, 1999a; Edgar, 1997; Kuiter, 1996; Kuiter, 2001; Lourie *et al.*, 1999

Zebra Seahorse

Family Name:	Syngnathidae
Scientific Name:	*Hippocampus zebra* Whitley, 1964
Conservation Status:	Data Deficient

Taxonomic Problems:
The low-crowned *Hippocampus dahli* that is sympatric with this species can have similar body patterns, but with finer lines and a plain snout (Kuiter, 2001).

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Hippocampus zebra is endemic to Australia and is known from Cape York (Cape Grenville), Lindeman Island, the Swain Reefs in Queensland (Lourie *et al*., 1999) and a photograph taken in Milne Bay, southern PNG (Kuiter, 2001).

Museum Records - 2 specimens (Height 58-80mm), collected from depths of 20-69m, ranging in geographical distribution from east of Cape Grenville (11^{o} 55’ S, 143^{o} 55’ E), Qld southwards to the Swain Reefs (22^{o} S), Qld, collected between 1962 and 1993.

Habitat:
Hippocampus zebra is found on soft bottom habitats of coral reefs to depths of around 70m (Kuiter, 2001). It is probable that its specific habitat has not been adequately sampled.

Behaviour and Biology:
The contrasting stripes of *H. zebra* are known to break up the body outline and thus afford protection from predators (Paxton, 1995). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Hippocampus zebra grows to a maximum height of at least 80mm (Kuiter, 2001).

Evidence for Decline:
There is no evidence of any declines of this species. There is no known trade for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
There is a paucity of specimens of this species in collections, and further work is necessary to accurately assess the populations of this species. It is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
None identified.

Critical Habitats:

Soft bottom habitats associated with coral reefs appear to be important to this species.

Recovery Objectives/Management Actions Required:
Further research is necessary to determine the distributional range, abundance, ecology and biology of this species. No genetic data have yet been obtained for this species (Lourie *et al*., 1999).

References:
Kuiter, 2001; Lourie *et al*., 1999; Paxton, 1995

Prickly Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Hypselognathus horridus* Dawson and Glover, 1982
Conservation Status:	Data Deficient

Alternative Common Name:
Shaggy pipefish

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Hypselognathus horridus is a temperate, endemic Australian pipefish currently only known from the continental shelf in the Great Australian Bight, South Australia (134^o 37' E to 133^o 30' E).

Museum Records - 8 records (sizes unknown) collected from a depth range of 54-55m, ranging in geographic distribution from off Anxious Bay (33^o 13' S, 134^o 33' E) SA westwards to off Ceduna (32^o 08' S, 133^o 42' E) SA, collected between 1981 and 1982.

Habitat:
Hypselognathus horridus is presently known from scientific trawl collections in depths of 40.2 to 54.9m (Dawson, 1985).

Behaviour and Biology:
The brood pouch of males is developed at about 154mm Standard Length, suggesting that males are probably brooding at this size (Dawson, 1985). The diet is unknown, but like other members of the family Syngnathidae, this species probably feeds on small crustaceans.

Size:
Hypselognathus horridus probably approaches 290 to 300mm Standard Length (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Protected Areas in Which Species Occurs:
Possibly Great Australian Bight National Marine Park (SA)

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More information is necessary to confirm the status for this species, but it has a restricted distribution and may be prone to the effects of commercial fishing operations such as trawling. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Any commercial fishing (e.g. trawling) methods that catch this species are potentially threatening its survival within its limited documented distribution.

Critical Habitats:
None identified. However, it could be assumed that benthic habitats within the abovementioned parts of the Great Australian Bight in depths of 40-55m (and possibly a wider depth range) are important to the survival of this species.

Recovery Objectives/Management Actions Required:
The distributional range, abundance, biology and ecology of this species all need further investigation. Monitoring of the bycatch of trawlers in the Great Australian Bight Trawl Fishery needs to be investigated for the presence or absence of this species.

References:
Dawson, 1985; Gomon *et al*., 1994; Paxton *et al*., 1989.

Prophets Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Lissocampus fatiloquus* (Whitley, 1943)
Conservation Status:	Lower Risk (least concern)

Australian Synonyms:
Campichthys fatiloquus Whitley, 1943

Current Conservation Status:
All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Lissocampus fatiloquus is a temperate, Western Australian endemic pipefish known from continental shelf waters from Shark Bay (25^o 55' S) to Fremantle (32^o 18' S) (Paxton *et al*., 1989). It has also been recorded from offshore islands, such as Rottnest Island and the Houtman Abrolhos.

Museum Records - 35 specimens (Standard Length 22 - 90mm), collected from a depth range of 0 - 21m, ranging in geographical distribution from the Shark Bay region (c. 26^oS), WA southwards to the Fremantle area (c. 32^o S), WA between 1939 and 1994.

Habitat:
There is little information on preferred habitat or depth for this species, but one specimen was collected among floating *Sargassum* and others specimens are from trawl and dredge samples (Dawson, 1985).

Behaviour and Biology:
Brooding males are unknown, but the brood pouch of males was developed in some specimens 74mm in Standard Length (Dawson, 1985). Like other members of the family Syngnathidae, this species probably feeds on small crustaceans.

Size:
Lissocampus fatiloquus probably fails to exceed 100mm Standard Length (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Protected Areas in Which Species Occurs:
Possibly occurs in the following areas:
Shark Bay Marine Park (WA)
Hamelin Pool Marine Nature Reserve (WA)
Abrolhos Islands Fish Habitat Protection Area (WA)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
The small size of this species may protect it somewhat from trawling operations within its range, as it may be able to escape through the mesh. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:

None identified

Critical Habitats:
None identified

Recovery Objectives/Management Actions Required:
Further study on the biology and ecology of this species would help in accurately assessing any risks to its survival.

References:
Dawson, 1985; Paxton *et al*., 1989

Western Crested Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Mitotichthys meraculus* (Whitley, 1948)
Conservation Status:	Data Deficient

Australian Synonyms:
Histiogamphelus meraculus Whitley, 1948

Taxonomic Notes:
This species was originally placed in the genus *Histiogamphelus* and Dawson changed it provisionally to *Mitotichthys* on the basis of a missing snout ridge. Since this feature mainly develops in males, it possibly should revert back to the original genus (R. Kuiter, pers. comm.).

Current Conservation Status:
<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB or IUCN Listings</u>

Distribution:
Mitotichthys meraculus is a temperate, inshore Western Australian endemic pipefish known from Perth (31° 56' S) to Augusta (34° 21' S) (Paxton *et al.*, 1989).

<u>Museum Records</u> - 3 specimens (sizes unknown), ranging in geographical distribution from Perth (31° 56' S) to Augusta (34° 21' S), WA, collected between 1932 and 1991.

Habitat:
Mitotichthys meraculus inhabits weedy areas in protected waters (B. Hutchins, pers. comm.).

Behaviour and Biology:
Unknown. Like other members of the family Syngnathidae, this species probably feeds on small crustaceans.

Size:
Mitotichthys meraculus probably reaches about 230 to 240mm Standard Length (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Protected Areas in Which Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
The habitats in which this species lives have been scarcely collected, so data on this species is limited (B. Hutchins, pers. comm.). More information is therefore necessary to accurately assess the conservation status of this species. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
As this species has a relatively restricted inshore distribution, the effects of habitat degradation potentially threaten its survival.

Critical Habitats:
Shallow, inshore habitats associated with seagrass and/or algae appear to be crucial to this species.

Recovery Objectives/Management Actions Required:
Further study on the biology and ecology of the species is necessary to determine its fecundity and habitat preferences.

References:
Dawson, 1985; B. Hutchins, pers. comm. 11/1999; R. Kuiter, pers. comm. 1999; Paxton *et al*., 1989.

Mollisons Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Mitotichthys mollisoni* (Scott, 1955)
Conservation Status:	Data Deficient

Australian Synonyms:
Syngnathus mollisoni Scott, 1955

Current Conservation Status:
All syngnathids are listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Mitotichthys mollisoni is a temperate endemic pipefish known from the holotype (now lost) collected off Bivouac Bay (43^o 08' S, 147^o 58' E) in south-eastern Tasmania (Paxton *et al*., 1989), three specimens from Port Phillip Bay in Victoria (Kuiter, 1993), and one specimen from Westernport, Victoria.

Museum Records - 4 specimens (Standard Length 83-222mm), collected from a depth range of 5-7m, ranging in geographical distribution from Westernport (37^o 16, 142^o 48' E), Victoria westwards to Port Phillip Bay (38^o 19' S, 141^o 36' E), Victoria. The few specimens of this species in collections probably reflect its preference for deep water (Gomon *et al*., 1994).

Habitat:
The holotype was entangled in a handline fished in 45.7m depth at Bivouac Bay, south-eastern Tasmania (Dawson, 1985), and the Port Phillip Bay specimens were found amongst sparse brown algae attached to low reef on sand, in a depth of 7m (Kuiter, 1993). At the time of the sightings in Port Phillip Bay, many Bass Strait species were also sighted in this area, which may suggest that it prefers deeper water offshore (R. Kuiter, pers. comm.).

Behaviour and Biology:
Unknown. Like other members of the family Syngnathidae, this species probably feeds on small crustaceans.

Size:
Mitotichthys mollisoni probably reaches about 230 to 240mm Standard Length (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Protected Areas in Which Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More information is necessary to determine the conservation status for this species as very few specimens have been collected. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
None identified

Recovery Objectives/Management Actions Required:
Further studies on the distributional range, biology and ecology are necessary to accurately determine the conservation status of this species.

References:
Dawson, 1985; Gomon *et al*., 1994; Kuiter, 1993; R. Kuiter, pers. comm. 11/99; Paxton *et al*., 1989.

Halfbanded Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Mitotichthys semistriatus* (Kaup, 1856)
Conservation status:	Data Deficient

Current Conservation Status:
All syngnathids are listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB or IUCN Listings

Distribution:
Mitotichthys semistriatus is a temperate, inshore endemic species known only from the Bass Strait area, Port Phillip Bay, Western Port (Victoria) and north-eastern Tasmania (Kuiter, 1993; Paxton *et al.*, 1989). Records of this species from South Australia have not been verified (Gomon *et al.*, 1994).

Museum Records - 39 specimens (Standard Length 61-194mm), collected from depths of 0-2m (many depths not recorded), ranging in geographical distribution from Port Melbourne (37^{o} 51' S, 144^{o} 58' E), Victoria southwards to Oyster Cove (43^{o} 06' S, 147^{o} 16'E), Tasmania and westwards to Spencer Gulf (34^{o} 30' S, 137^{o} 29' E), SA. Specimens were collected between 1897 and 1991.

Habitat:
Mitotichthys semistriatus has been collected in shallow waters (<3m) with *Heterozostera tasmanica* and *Zostera* seagrass, over sand, algae and rocks (Howard and Koehn 1985; Kuiter 1993).

Behaviour and Biology:
Mitotichthys semistriatus is usually found in small aggregations. The female initiates courtship in this species (Kuiter, 1993). The smallest known brooding male was 139.5mm standard length (Dawson, 1985). The brood pouch of the only gravid male collected by Howard and Koehn (1985) in Western Port (Vic.) contained 64 eggs. This species orients itself horizontally in the water column, probably to mimic leaves of seagrasses, and are relatively strong swimmers (Howard and Koehn 1985). - Howard and Koehn (1985) noted that pelagic or epibenthic copepods and small epibenthic amphipods comprised the bulk of the diet of this species.

Size:
Mitotichthys semistriatus probably reaches about 270mm Standard Length (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines for this species. There is no known trade for this species.

Australian Protected Areas in Which Species Occurs:
None identified.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
More information is necessary to determine the conservation status for this species. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Habitat degradation in shallow, inshore areas within its range potentially threaten this species.

Critical Habitats:
Shallow seagrass and algal habitats within the range of this species appear critical to its survival.

Recovery Objectives/Management Actions Required:
Further studies on the biology and ecology of this species are necessary to provide information for accurate assessment of its conservation status.

References:
Dawson, 1985; Gomon *et al*., 1994; Howard and Koehn, 1985; Kuiter, 1993; Paxton *et al*., 1989

Leafy Seadragon

Family Name:	Syngnathidae
Scientific Name:	*Phycodurus eques* (Günther, 1865)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Phycodurus glauerti Whitley, 1939

Alternative Common Name:
Glauerts seadragon

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

Totally Protected Species in South Australian Waters (Since about 1987)

Listed as Protected Aquatic Biota in Victoria

Totally Protected Fish Status in Western Australian waters (Since about 1991)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Phycodurus eques is endemic to southern Australian waters and is known mainly from South Australia and south Western Australia at a few localities where it is common. It has been found off the Victorian coast near Anglesea and has been reported as far as Wilson's Promontory to the east (Kuiter, 1993). In Western Australia it has been recorded northwards as far as Jurien Bay (B. Hutchins, pers. comm.).

Museum Records - 99 specimens (Standard Length 19-425mm), collected from depths of 12-35m, ranging in geographical distribution from Portsea (38^{o} 19' S, 144^{o} 43' E), Victoria, north-westwards to Yanchep Beach (31^{o} 33' S), WA, collected between 1909 and 1998.

SA Marine and Coastal Community Network (MCCN) Dragon Search Database Records:
Between April 1996 and August 2000 there have been 365 reported sightings (representing an unknown number of individuals) of *Phycodurus eques* in SA waters. These numbers include the repeat sightings of possibly the same individuals from the same locality at the same time. Most (86%) sightings have come from the Gulf St. Vincent bioregion, which may be a reflection of a larger number of divers using these areas in comparison to other localities in SA (Baker, 2000b).

WA Marine and Coastal Community Network (MCCN) Dragon Search Database Records:
Data not yet analysed

Habitat:
In South Australia, *Phycodurus eques* occurs on kelp reef in 4 to 30m or more, but in Western Australia it is usually found deeper than 20m. In Victoria, it is apparently found deeper than 30m, but at Anglesea it is found in about 6 to 10m (Kuiter, 1993). This species usually occurs over sand patches close to reefs with kelp (Kuiter, 1993), particularly in coastal bays protected from the large swells typical of southern waters, but also in waters with moderate surge (Kuiter, 1996). Adults are usually found in depths of 10m or more

(Kuiter, 1996). It is occasionally found in clumps of seaweed on coastal beaches after storms (Hutchins and Thompson, 1983) and is also occasionally trawled by commercial fishers (May and Maxwell, 1986).

Behaviour and Biology:
Phycodurus eques exhibits a spectacular example of camouflage that works in two ways. Firstly, predators do not recognise it as a fish, and secondly its prey is not worried by a piece of "floating weed". Divers usually swim past, often finding it by accident. Sometimes the fish carries a large isopod crustacean, and on several occasions divers have wondered what the isopod was doing on a piece of weed. Only upon investigation did they discover the seadragon as the "weed" swam away. It not only resembles in overall appearance the coastal algae among which it is found, it has a peculiar behaviour of rhythmically rocking back and forth in the fashion of algae being swept by coastal surge (Gomon *et al*., 1994). Males carrying eggs are usually found in deeper water (Kuiter, 1993). The male incubates about 250 eggs (Kuiter 1988) on the underside of its tail where they are embedded in spongy tissue, before hatching after about six weeks (Neira *et al*., 1998). Hatchlings are about 35mm long and move to shallow depths to find tiny mysids (Kuiter, 1996). Spawning occurs during the summer months (Neira *et al*., 1998). This species can survive for at least 2 to 3 years in aquaria if supplied with its specific live food requirements (P. Quong, pers. comm.). Aggregations of up to 100 live leafy seadragons have been sighted in SA (Baker, 2000b). Many beachwashed leafy seadragons have been observed on SA beaches, particularly after storms (Baker, 2000b). The natural mortality of leafy seadragons by unfavourable weather patterns is possibly higher than any other source of mortality, especially for adults (Baker, 2000b). *Phycodurus eques* feeds on mysids (Kuiter, 1993) and amphipods (NOO, 2001a). Its specialised live food requirements make it especially difficult to keep in an aquarium (Gomon *et al*., 1994).

Size:
Phycodurus eques attains a maximum length of about 35cm (Kuiter, 1996).

Evidence for Decline:
Aquarium collectors for the domestic and international marine aquarium trade collect this species in small numbers, although food requirements make it difficult to maintain. Aquarium-reared individuals have proven to be more suitable for this industry (Neira *et al*., 1998). One live leafy seadragon from Western Australia was reputedly sold in Hong Kong for $13,000 (McGlone, 1994). However, the standard price for live aquarium bred and reared individuals, exported for aquarium purposes to countries including the USA and Japan, is between $100 and $400 (P. Quong, pers. comm.). Currently there are very few permits supplied by WA, SA and Victorian State Fisheries organisations to collect wild specimens of this species. Between Feb 1998 and April 2000, 145 live, captive–bred and reared individuals of this species were exported to the USA, Japan, Portugal, China, Switzerland and the UK (EA trade data, unpublished). The current rate of legalised removal of wild specimens should not have any drastic impacts on its populations, but any illegal collecting of wild individuals could threaten its populations.

Australian Marine Protected Areas in Which the Species Occurs:
This species probably occurs in a number of SA Aquatic reserves within its range (see Cresswell and Thomas, 1997).

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
More research is necessary to accurately determine the distribution, abundance, ecology and biology of populations of this species. The designation of suitably located and adequately sized MPAs in WA, SA and possibly Victoria would provide additional protection to this species. The Marine and Coastal Community Network 'Dragon Search' Project may help to provide useful data on the population ecology, biology, behaviour and distribution of this species. It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Over-collecting by the marine aquarium fish trade has the potential to impact on the populations of this species.

Critical Habitats:
Sandy bottom habitats associated with kelp are important to the survival of this species.

Recovery Objectives/Management Actions Required:
The 'Dragon Search' project managed by the Marine and Coastal Community Network monitors numbers of seadragons by recording sightings from the public. The continued collection and analysis of these statistics could prove to be useful in accumulating further information on the abundance, population ecology and biology of this species. The designation of suitably located "no-take" MPAs may be necessary to protect this species from aquarium collecting.

References:
Baker, 2000b; EA trade data, unpublished; Cresswell and Thomas, 1997; Glover, 1987; Gomon *et al*., 1994; B. Hutchins, pers. comm. 1/2000; Hutchins and Thompson, 1983; Kuiter 1988; Kuiter, 1993; Kuiter, 1996; May and Maxwell, 1986; McGlone, 1994; National Oceans Office (NOO), 2001a; Neira *et al*., 1998; P. Quong, pers. comm. 9/2000.

Weedy Seadragon

Family Name:	Syngnathidae
Scientific Name:	*Phyllopteryx taeniolatus* (Lacépède, 1804)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Phyllopteryx lucasi Whitley, 1931

Alternative Common Name:
Common seadragon

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

Protected Species in NSW Waters

Listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Phyllopteryx taeniolatus is endemic to southern Australian waters and occurs in New South Wales (northwards to Port Stephens), Victoria, Tasmania, South Australia and Western Australia (northwards to Geraldton) (Hutchins and Swainston, 1986).

Museum Records - 470 specimens (Standard Length 55-410mm), collected from depths of 0-40m, ranging in geographical distribution from Newcastle, NSW (approx. 32^{o} 56’ S) southwards to Actaeon Island (43^{o} 32’ S), Tasmania and north-westwards to Geraldton (28^{o} 46’ S), WA, collected between 1858 and 1999.

NSW Marine and Coastal Community Network (MCCN) Dragon Search Database Records:
Between the mid 1990s and June 2000 there have been 341 reported sightings (totalling 1001 individuals) of *Phyllopteryx taeniolatus* in NSW waters. These numbers include the repeat sightings of possibly the same individuals from the same locality at the same time. Most sightings have come from Botany Bay (43%) and Jervis Bay (12%), which may be a reflection of a larger number of divers using these areas in comparison to other localities in central and southern NSW (Baker, 2000a).

SA Marine and Coastal Community Network (MCCN) Dragon Search Database Records:
Between April 1996 and August 2000 there have been 292 reported sightings (representing an unknown number of individuals) of *Phyllopteryx taeniolatus* in SA waters. These numbers include the repeat sightings of possibly the same individuals from the same locality at the same time. Most (75%) sightings have come from the Gulf St. Vincent Bioregion, which may be a reflection of a larger number of divers using these areas in comparison to other localities in SA (Baker, 2000b).

WA Marine and Coastal Community Network (MCCN) Dragon Search Database Records:
Data not yet analysed

Habitat:
In the southern part of its range this species is found from shallow estuaries to deep offshore reefs in depths from 1-50m; on the east coast it is usually found deeper (10-50m). It is usually on reefs with kelp and along the edges of sand (Kuiter, 1993). Baker (2000a) found that weedy seadragons are also associated with sponge habitats.

Behaviour and Biology:
The breeding season is early summer and there is one brood per season. Males carry the eggs externally below their tail and the skin forms a cup on each egg during deposition. Incubation time is about eight weeks and up to about 250 young hatch. Some mature in one year, but usually breed in their second year when fully grown (Kuiter, 1993). Baker (2000a) reports that brooding males have been observed in NSW from mid-winter to mid-summer, but never from February to June, despite the sightings of over 350 seadragons during this period. Weedy seadragons are often stranded on beaches (particularly after storms and big seas) due to their poor swimming ability (Baker, 2000a). "Mass" beachwashed (up to 250 dead animals) weedy seadragons have been observed on SA beaches, some of which were associated with pilchard kills of mid 1996 and the summer of 1998/99 (Baker, 2000b). The natural mortality of weedy seadragons by unfavourable weather patterns is possibly higher than any other source of mortality, especially for adult weedy seadragons (Baker 2000a,b). This species can survive for at least 4 to 5 years in aquaria if supplied with its specific live food requirements (P. Quong, pers. comm.). In the Sydney area and in southern NSW, aggregations of between 20 and 40 seadragons have been observed, respectively (Baker, 2000a). *Phyllopteryx taeniolatus* feeds on mysids and other small crustaceans (Kuiter, 1993).

Size:
Phyllopteryx taeniolatus attains about 45cm in total length (Kuiter, 1993).

Evidence for Decline:
There is no evidence of any declines of this species. A small number of licenced collectors legally collect this species for use in aquarium breeding operations. Aquarium bred and reared individuals are exported live to countries including the USA and Japan, and individual specimens sell for between $100 and $400 (P. Quong, pers. comm.). Over 510 live individuals of this species were exported to the USA, Japan, the Netherlands, China, Portugal, Switzerland and the UK between Feb 1998 and May 2000, 66% of which were captive-bred and reared and 34% of which were wild collected from WA and Vic (EA trade data, unpublished). This species is not often trawled by fisherman and not caught by line fisherman.

Australian Marine Protected Areas in Which the Species Occurs:
Fly Point - Halifax Park Aquatic Reserve, Port Stephens, NSW
Jervis Bay Marine Park, southern NSW

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Phyllopteryx taeniolatus currently seems to be reasonably secured as a species in Australian waters, particularly with its listing as a Protected Species in NSW waters, its status as Protected Aquatic Biota in Victoria and its protection in Tasmania. It is recommended that it be listed as Lower Risk (conservation dependent) with continual monitoring of its populations via community programs such as the Marine and Coastal Community Network 'Dragon Search' Program to gain a better understanding of its distribution and abundance.

Threatening Processes:
Over-collecting for the marine aquarium fish trade has the potential to impact on the populations of this species.

Critical Habitats:
Sandy, rocky reef areas with kelp may be important habitats for this species.

Recovery Objectives/Management Actions Required:
Continued monitoring of the numbers of this species taken from the wild by licensed aquarium-trade dealers is essential in assessing the impacts of these collection activities on this species. Additional information on the ecology and biology of weedy seadragons could also be gleaned from information provided to relevant

licensing authorities (e.g. State fisheries organisations and Environment Australia) as part of the requirements of individual licences. The designation of additional adequately sized and suitably located MPAs would help to protect this species within its distributional range. Continual protection in NSW should ensure healthy populations of this species in that State. The 'Dragon Search' project managed by the Marine and Coastal Community Network monitors numbers of seadragons by recording sightings from the public. Continuing collection of these statistics could prove to be useful information in any future analyses of their abundance and population ecology.

References:
Baker, 2000a; Baker, 2000b; EA trade data, unpublished; Hutchins and Swainston, 1986; Kuiter, 1993; P. Quong, pers. comm. 9/2000.

Dunckers Pipehorse

Family Name:	Syngnathidae
Scientific Name:	*Solegnathus dunckeri* Whitley, 1927
Conservation status:	Data Deficient

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A1d + 2d)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Solegnathus dunckeri is an eastern Australian endemic pipehorse known from Lord Howe Island and southern Queensland to around Forster in New South Wales (Dawson, 1985). Johnson (1999) noted that it is regularly washed up on ocean beaches in southern Queensland.

Museum Records - 44 specimens (Standard Length 230-494mm), collected from depths of 29-44m (only 1 record with capture depth and also beach-washed specimens), ranging in geographical distribution from off Fraser Island (25^{o} 48' S), Qld southwards to Booti Booti (32^{o} 16' S), NSW and also from Lord Howe Island. There are also two records with unconfirmed identifications from Western Australia. Specimens were collected between 1910 and 1997.

Habitat:
Solegnathus dunckeri is a benthic species occurring in continental shelf waters (Paxton *et al*., 1989). It is known from a number of stranded specimens and from trawl collections in depths of 29 to 137m.

Behaviour and Biology:
Males may be brooding at 33.7cm total length (Dawson, 1985). Pipehorses probably rely on camouflage to avoid predators. The diet of this species is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Solegnathus dunckeri grows to a maximum total length of about 50cm (Dawson, 1985).

Evidence for Decline:
There is no evidence of any declines of this species. Between February 1998 and May 2000, a combined total of 2380kg of dried *Solegnathus dunckeri* and *Solegnathus hardwickii* were taken in trawls by commercial fishers along the Queensland coastline and exported to Hong Kong (62.3%), Taiwan (31.3%) and China (6.3%) for use in the Traditional Medicine trades (Environment Australia export data, unpublished). These trades could potentially threaten the populations of these two species, particularly if current levels of exploitation continue.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More study is needed on this species to accurately determine its conservation status. Trawled specimens probably do not survive if released due to prolapse (K. Graham, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Commercial trawl fishing is a potential threat to the survival of this species in NSW and Queensland waters.

Critical Habitats:
None identified. Little research has focused on the critical habitats for this species. It is likely that this species has very specific habitat preferences that determine its abundance within its range.

Recovery Objectives/Management Actions Required:
Further research is necessary to accumulate information on the basic biological and population dynamics characteristics of this species. Accurate distributional and depth data are required to identify key habitats. The designation of suitable non-trawl protected areas in the northern NSW and southern Queensland region may be crucial to its survival. Species-specific data on distribution and biology could be obtained by monitoring the catches of this species taken by trawl fishers on the southern Queensland and northern NSW coastline.

References:
Dawson, 1985; EA trade data, unpublished; K. Graham, pers. comm. 1999; Johnson, 1999; Paxton *et al*., 1989.

Pallid Pipehorse

Family Name:	Syngnathidae
Scientific Name:	*Solegnathus hardwickii* (Gray, 1830)
Conservation Status:	Data Deficient

Taxonomy:
Preliminary investigations into the taxonomy of this species suggest that the true *Solegnathus hardwickii* is restricted to the South China Sea and Japan (the type specimen is from China). It is suspected that there are two undescribed species, one distributed on the east coast and the other on the west coast of Australia (Kuiter, 2000), but until the taxonomy is resolved we have treated *Solegnathus hardwickii* as the one species which occurs in all the areas mentioned below.

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A1d + 2d)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Solegnathus hardwickii is known from tropical and subtropical Australia, the South China Sea and Japan (Dawson, 1985). In Australia it occurs in Western Australia, the Northern Territory and in Queensland southwards to the NSW-Queensland borders (Paxton *et al*., 1989). Russell (1983) reported it as rare in the Capricorn-Bunker section of the Great Barrier Reef Marine Park. In Western Australian waters it is has been found north of Onslow (21^{o} 38' S) (Allen and Swainston, 1988).

Museum Records - 29 specimens (Standard Length 235-440mm), collected from depths of 20-180m, ranging in geographical distribution from off Cairns (16^{o} 55' S), Qld, southwards to the Tweed River mouth (28^{o} 10' S), NSW on the east coast of Australia and on the west coast from north-east of Monte Bello Islands (20^{o} 03' S), WA northwards to north-east of Cape Lambert (19^{o} 15' S), WA. There are also two records from the Arafura Sea (08^{o} 53' S, 135^{o} 12' E and 09^{o} 42' S, 133^{o} 58' E), NT and one record from near Kempsey (31^{o} 05' S), New South Wales, but the Kempsey specimen has been destroyed, so the identification cannot be verified. Specimens were collected between 1894 and 1997. Additionally, 40 specimens (381-510mm total length) are housed at Griffith University, Queensland that were collected in October 2000 in a depth range of 16-89m between Shoalwater Bay (22^{o} 32' S) and Hervey Bay (24^{o} 55' S), Qld as part of a scientific trawling survey.

Habitat:
Solegnathus hardwickii is mostly known from trawled specimens captured from 12m to 100m depth (Dawson, 1985), though it has been collected in depths of up to 180m. This species occurs in deeper off-reef waters in the Capricorn-Bunker section of the Great Barrier Reef Marine Park (Russell, 1983).

Behaviour and Biology:
Males may be brooding at about 296mm total length (Dawson, 1985). A scientific trawling survey carried out in October 1999 between Hervey Bay and Shoalwater Bay in Queensland provides the first ever density estimates for this species (Connolly and Thomas, pers. comms.). In the abovementioned study, density estimates for *Solegnathus hardwickii* range from 0 to 120 individuals per km^2. Within this study region populations were very patchily distributed and the sex ratio was even (Connolly and Thomas, pers. comms.), suggesting that habitat structure or other environmental variables may be important to the survival of this

species. Pipehorses probably rely on camouflage to avoid predators. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Solegnathus hardwickii attains a total length of at least 510mm (Connolly and Thomas, pers. comms.).

Evidence for Decline:
There is no evidence of any declines of this species. Between February 1998 and May 2000, a combined total of 2384kg of dried *Solegnathus dunckeri* and *S. hardwickii* were taken in trawls by commercial fishers along the Queensland coastline. The dried specimens were exported primarily to Hong Kong (62%), Taiwan (31%) and China (6%) for use in the Traditional Medicine trades (Environment Australia Trade Data, unpublished). The low export figures for the 2000 calendar year (total of 31kg of dried *S. dunckeri* and *S. hardwickii* combined for Jan to Sep 2000) is of potential concern, considering the high 1998 (2175kg) and 1999 (209kg) export statistics for the abovementioned species combined. Considering that dried pipehorses probably weigh less than 50g, at least 20,000 individuals would be expected to occur in 1t (1000kg). These estimates highlight the vulnerability of species like pipehorses that have a relatively low fecundity. The high prices that pipehorses command from the Traditional Medicine trades potentially threaten the populations of these two species, particularly if previous levels of exploitation resume.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park, Qld
This species possibly occurs in the following MPAs:
Bowling Green Bay Fish Habitat Area A
Repulse Fish Habitat Area B
Mackay-Capricorn Marine Park, Qld
Broad Sound Fish Habitat Area, Qld
Bustard Fish Habitat Area A
Hervey Bay Marine Park, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Additional taxonomic work is necessary to resolve the problems surrounding the identity of this species. More study is needed on this species to accurately determine its status. Trawled specimens probably do not survive if released due to prolapse (K. Graham, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Commercial trawl fishing and scallop dredging are potential threats to the survival of this species in Queensland waters.

Critical Habitats:
None identified. Little research has focused on the critical habitats for this species. It is likely that this species has very specific habitat preferences that determine its abundance within its range.

Recovery Objectives/Management Actions Required:
Further research is necessary to accumulate information on the basic biological and population dynamics characteristics of different populations of this species. Accurate distributional and depth data are required to identify key habitats for this species on both the east and west coasts of Australia. The designation of adequately sized and suitably located non-trawl MPAs in the southern Great Barrier Reef, southern Queensland and west coast regions of Australia may be crucial to its survival. Species-specific data on distribution and biology could be obtained by monitoring the catches of this species taken by trawl fishers on the Queensland east coast.

References:
Allen and Swainston, 1988; R. Connolly and B. Thomas (Griffith University), pers. comms. 1999-2000; Dawson, 1985; EA trade data, unpublished; Kuiter, 2000; Paxton *et al.*, 1989; Russell, 1983.

Günthers Pipehorse

Family Name:	Syngnathidae
Scientific Name:	*Solegnathus lettiensis* (Bleeker, 1860)
Conservation Status:	Data Deficient

Taxonomic Notes:
Kuiter (2000) regards the Indonesian and Western Australian forms to be separate species. According to his taxonomy, the Indonesian form retains the original name *Solegnathus lettiensis* Bleeker, 1860 (the type was from Indonesia), and the Western Australian form uses the name *Solegnathus guentheri* Duncker, 1915. With no difference described except colour pattern by Kuiter (2000), we have treated the two forms as one species in this synopsis.

Current Conservation Status:
<u>2000 IUCN Red List of Threatened Species</u>
Vulnerable (A2d)

<u>All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.</u>

<u>All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*</u>

<u>No ASFB Listing</u>

Distribution:
Solegnathus lettiensis is a temperate to tropical western Pacific pipehorse (Paxton *et al*., 1989) that occurs in Western Australia and Indonesia (Dawson, 1985). In Western Australia it is known from off Albany (117° 52’ E) to off North West Cape (22° S) (Paxton *et al*., 1989).

<u>Museum Records</u> - 25 specimens (Standard Length 230-518mm), collected from a depth range of 42-169m (also beach wash-ups), ranging in geographical distribution from the Indian Ocean (17° 30’ S, 121° 19’ E), WA, southwards to Albany (35° S), WA and also from the Arafura Sea (10° S, 130° 10’ E), NT and Indonesia. Specimens were collected between 1932 and 1990.

Habitat:
Solegnathus lettiensis is a benthic inhabitant of outer continental shelf waters (Paxton *et al*., 1989) that has been captured in depths of 42 to 180m.

Behaviour and Biology:
Nothing is known about the biology of this species. Pipehorses probably rely on camouflage to avoid predators. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Solegnathus lettiensis probably attains a total length of about 525mm (Dawson, 1985).

Evidence for Decline:
There is no evidence of any decline for this species. Catch statistics are unavailable to our knowledge.

Australian Marine Protected Areas in Which the Species Occurs:
Possibly Abrolhos Islands Fish Habitat Protection Area, WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More study is needed on this species to accurately determine its taxonomic and conservation status. Trawled specimens may not survive if released due to prolapse (K. Graham pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Gloerfelt-Tarp and Kailola (1984) list this species as being trawled in northwestern Australia and southern Indonesia. There is limited commercial trawl fishing undertaken within the range of this species in Western Australian waters (B. Hutchins, pers. comm.).

Critical Habitats:
None identified. Little or no research has focused on the critical habitats for this species. It is likely that this species has specific habitat preferences that determine its abundance within its range.

Recovery Objectives/Management Actions Required:
Monitoring of bycatch of this species taken in Western Australian trawl fisheries will help in obtaining baseline data on the species' distribution and abundance in WA waters. Further research is necessary to accumulate information on the basic biological and population dynamics characteristics of this species. Accurate distributional and depth data are required to identify key habitats. The designation of suitably located non-trawl protected areas within its range may be crucial to its survival. Taxonomic research is needed to assess the true status of this and closely related *Solegnathus* species.

References:
B. Hutchins, pers. comm. 4/2000; Dawson, 1985; Gloerfelt-Tarp and Kailola, 1984; K. Graham, pers. comm. 1999; Kuiter, 2000; Paxton *et al*., 1989.

Robust Pipehorse

Family Name:	Syngnathidae
Scientific Name:	*Solegnathus robustus* McCulloch, 1911
Conservation Status:	Data Deficient

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A2d)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Solegnathus robustus is endemic to the coastal waters of southern Australia, and is only known from South Australian waters (Dawson, 1985).

Museum Records - 25 specimens (Standard Length to 300mm), trawled from a depth range of 55-68m (many specimens do not have depths recorded), ranging in geographical distribution from Port Weyland (34^{o} 56’ S, 137^{o} 05’ E), SA westwards to Flinders Island (33^{o} 43’ S, 134^{o} 31’ E), SA. Specimens were collected between 1909 and 1982.

Habitat:
Solegnathus robustus is a temperate-water pipehorse, which occurs in benthic habitats of the continental shelf (Paxton *et al*., 1989) and has been recorded in depths of 42 to 68m (Dawson, 1985).

Behaviour and Biology:
The smallest examined brooding male of this species was 314mm total length (Dawson, 1985). Pipehorses probably rely on camouflage to avoid predators. The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Solegnathus robustus attains a total length of at least 350mm (Dawson, 1985).

Evidence for Decline:
There is no evidence of any decline. This species is not well represented in museum collections, but is apparently fairly common in its depth range, at least in South Australia (Gomon *et al*., 1994).

Australian Marine Protected Areas in Which the Species Occurs:
Possibly occur in the following area:
Great Australian Bight Marine Park, SA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More study is needed on this species to accurately determine its conservation status. Trawled specimens may not survive if released due to prolapse (K. Graham, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Commercial trawl fishing in the Great Australian Bight is potentially a threat to this species.

Critical Habitats:
None identified. Little or no research has focused on the critical habitats for this species. It is likely that this species has specific habitat preferences that determine its abundance within its range.

Recovery Objectives/Management Actions Required:
Further research is necessary to accumulate information on the basic biological and population dynamics characteristics of this species. Accurate distributional and depth data are required to identify key habitats. The designation of suitable non-trawl protected areas within its range may be crucial to its survival.

References:
Dawson, 1985; Gomon *et al*., 1994; K. Graham, pers. comm. 1999; Paxton *et al*., 1989.

Spiny Pipehorse

Family Name:	Syngnathidae
Scientific Name:	*Solegnathus spinosissimus* Günther, 1870
Conservation Status:	Data Deficient

Australian Synonyms:
Solegnathus robustus naso Whitley, 1941

Taxonomic Problems:
Differences in live colouration and snout length between Australian and New Zealand specimens suggests that further taxonomic research is necessary. The Australian and New Zealand populations may actually be two separate species (Kuiter, 2000).

Alternative Common Names:
Banded pipehorse; spiny seadragon

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A1d + 2d)

All syngnathids are listed as Protected Aquatic Biota in Victoria

The *Tasmanian Living Marine Resources Management Act 1995* prohibits the take of all syngnathids in Tasmania (by non-permit holders, since Sep 1994)

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Solegnathus spinosissimus occurs in south-eastern Australia along the coasts of New South Wales, Victoria and Tasmania, and also in New Zealand. This species has also been recorded from off Brisbane (Queensland), and in South Australian waters, but the South Australian identifications need to be confirmed (Gomon *et al*., 1994).

Museum Records - 176 specimens (Standard Length 138-470mm), trawled from depths of 2-640m, ranging in geographical distribution from Caloundra (26^{o} 48' S), Qld southwards to off Lune River (43^{o} 26' S), Tasmania. There are also records from New Zealand. Specimens were collected between circa 1885 and 2000.

Habitat:
Solegnathus spinosissimus is most commonly taken by trawl in areas with muddy bottoms at depths of 29 to 232m, but it occurs as shallow as 2 to 3m in the Derwent Estuary, Tasmania (Gomon *et al*., 1994). It is found in shallow waters in the southern part of its range where waters are shaded or are darkened by tannins. This species is often found over rubble substrates and near rich invertebrate platform reefs (Kuiter, 2000). It is sometimes found on beaches after storms and has occasionally been collected in depths up to 670m. This species probably attaches itself to encrusting animal growths on deep rocky reefs (Ayling and Cox, 1982).

Behaviour and Biology:
Divers in the D'Entrecasteaux Channel in Tasmania have often seen *Solegnathus spinosissimus* living near sea whips (Edgar, 1997). In this habitat, they probably rely on camouflage to avoid predators. The male

seadragon has no broodpouch; instead the female attaches her eggs to the underside of the male's tail, just behind the anus (Francis, 1996b). The mail carries the eggs until they hatch into miniature seadragons (Francis, 1996b). The young are benthic and have no pelagic stage (Kuiter, 2000). *Solegnathus spinosissimus* anchor themselves to seaweed or sea fans while feeding on planktonic crustaceans (Francis, 1996b).

Size:
Solegnathus spinosissimus attains a length of 50cm (Francis, 1996b).

Evidence for Decline:
There is no evidence of any decline. This species is taken as bycatch in the South East Trawl Fishery (AFMA, 1999a). An unquantified number of *Solegnathus spinosissimus* taken in trawls by commercial fishers along the south-eastern Australian coastline are dried and sold to the Traditional Medicine Trade in Australia, and possibly overseas. Traditional Medicine stores in Sydney (NSW) sell an average sized dried specimen of *Solegnathus spinosissimus* for about $3.50 (C. Woodfield, pers. comm.). Their place of origin (Australia or New Zealand) and capture method (though probably trawled) are at this stage unknown, as is the nature of how they are distributed from the collector to the retailer. This species is also taken in crayfish pots set in deep water off eastern Northland in northern New Zealand (Ayling and Cox, 1982).

Australian Marine Protected Areas in Which Species Occurs:
This species possibly occurs in MPAs with suitable habitat along the coasts of Queensland, NSW and Victoria, but particularly Tasmania as they are known to occur in shallow waters in that State.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More study is needed on this species to accurately determine its conservation status. Trawled specimens may not survive if released due to prolapse (K. Graham, pers. comm.). It is recommended to assign the above status, adopting the IUCN categories.

Threatening Processes:
Commercial fish and prawn trawling are potential threats to the survival of this species.

Critical Habitats:
None identified. Little or no research has focused on the critical habitats for this species. It is likely that this species has specific habitat preferences that determine its abundance within its range.

Recovery Objectives/Management Actions Required:
Further research is necessary to accumulate information on the basic biological and population dynamics characteristics of this species. Accurate distributional and depth data are required to identify key habitats. The designation of suitable non-trawl protected areas within its range may be crucial to its survival. Commercial fishers in the South East Trawl Fishery (SETF) are subjected to the rules and regulations set out by AFMA in recording the catch of all syngnathid species (Environment Australia, pers. comm). The SETF management regime as it relates to the take of syngnathids is currently being assessed for export approval under the WP (REI) Act. The bycatch from the SETF needs to be monitored for baseline data to be accumulated on abundances, distributions and habitats.

References:
AFMA, 1999a; Ayling and Cox, 1982; Dawson, 1985; Edgar, 1997; Environment Australia, pers. comm 1999-2000; Francis, 1996b; Gomon *et al*., 1994; K. Graham, pers. comm. 1999; Kuiter, 2000; C. Woodfield (Dragon Search), pers. comm. 9/1999.

Alligator Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Syngnathoides biaculeatus* (Bloch, 1785)
Conservation Status:	Data Deficient

Alternative Common Names:
Double-ended pipehorse; spiraltail pipefish

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Data Deficient

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

No ASFB Listing

Distribution:
Syngnathoides biaculeatus is widespread from the Red Sea and the African east coast to Samoa and the islands of Micronesia (Randall *et al*., 1997). Locally, it occurs in Western Australia, the Northern Territory, Queensland and New South Wales (Paxton et al. 1989).

Museum Records - 106 specimens (Standard Length 100-288mm), collected from a depth range of 0 to 5m, ranging in geographical distribution from the Timor Sea, NT south-eastwards to Batemans Bay (35^{o} 44' S), New South Wales on the east coast of Australia, and from Ashmore Reef (12^{o} 13' S) southwards to Geraldton (28^{o} 46' S) on the west coast of Australia. Outside Australia there are specimens from the Andaman Islands, India, Malay Archipelago, Guam, PNG and the Solomon Islands. Specimens were collected between circa 1879 and 1998.

Habitat:
Syngnathoides biaculeatus is generally found in seagrass beds or algal flats in the protected shallow waters of lagoons and bays, its mottled green colour matching the plants well (Randall *et al*., 1997). Adults are often found in large *Sargassum* rafts (Kuiter, 1996) and juveniles are occasionally found among debris floating offshore (Dawson 1985). In Queensland this species is commonly found in estuaries, usually in association with *Zostera* seagrass, to which it anchors itself by means of its prehensile tail (Grant, 1978).

Behaviour and Biology:
Kuiter (1996) observed one individual jumping on top of floating weeds, out of the water, when he was trying to photograph it. Males begin brooding at a length of about 18cm in length (Dawson, 1985). *Syngnathoides biaculeatus* is a poor swimmer, propelling itself by the winnowing action of the dorsal and pectoral fins. The eggs are green and are carried on the abdomen of the male until they hatch (Grant, 1978). *Syngnathoides biaculeatus* feeds on tiny crustaceans (Allen and Swainston, 1992).

Size:
Syngnathoides biaculeatus grows to a maximum length of 30cm (Kuiter, 1996).

Evidence for Decline:
There is no evidence of any declines of this species.

Australian Marine Protected Areas in Which the Species Occurs:
Ashmore Reef National Nature Reserve, off northern WA
Cartier Island Marine Protected Area, off northern WA (unconfirmed)
Great Barrier Reef Marine Park, Qld
Coburg Marine Park, NT

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species has a wide distribution and its populations appear to be reasonably secure in the wild. However, it is used in the Chinese Traditional Medicine Trade and may be under increasing threat in this regard. It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
This species is used in the Traditional Chinese Medicine (TCM) trade, and has been observed for sale in Sydney TCM stores (C. Woodfield, pers. comm.). However, there is currently no evidence that these specimens are of Australian origin, or if Australian specimens are exported to regions such as South East Asia.

Critical Habitats:
Shallow seagrass and algal habitats appear crucial to this species.

Recovery Objectives/Management Actions Required:
The source (i.e. Australia or overseas) of specimens sold by the Traditional Chinese Medicine trade in Australia requires further investigation.

References:
Allen and Swainston, 1992; Dawson, 1985; Grant, 1978; Kuiter, 1996; H. Larson, pers. comm. 12/1999; Lourie *et al.*, 1999; Paxton et al. 1989; Randall *et al.*, 1997; C. Woodfield (Dragon Search), pers. comm 1999.

Verco's Pipefish

Family Name:	Syngnathidae
Scientific Name:	*Vanacampus vercoi* (Waite and Hale, 1921)
Conservation Status:	Lower Risk (near threatened)

Australian Synonyms:
Syngnathus vercoi Waite and Hale, 1921
Corythoichthys flindersi Scott, 1957

Alternative Common Name:
Flinders pipefish (Australia)

Current Conservation Status:
No IUCN or ASFB Listings

All syngnathids are subject to the export controls of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* from 1 January 1998.

All syngnathids and solenostomids are listed as marine species under s248 of the *EPBC Act 1999*

Distribution:
Vanacampus vercoi is an inshore, endemic temperate-water pipefish that is only known from Spencer Gulf, St. Vincent Gulf and Kangaroo Island localities in South Australia (Gomon *et al*., 1994; Paxton *et al*., 1989. It is only common in Pelican Lagoon, Kangaroo Island, South Australia (Kuiter, 1996).

Museum Records - 22 specimens (Standard Length 73-103mm), collected from a depth range of 2 to 3m, ranging in geographical distribution from St. Vincents Gulf (137^o 45' E) westwards to Spencer Gulf (137^o 21' E) and also from Kangaroo Island (35^o 47' S), SA, collected between 1920 and 1978.

Habitat:
Vanacampus vercoi occurs amongst marine vegetation, such as algae and seagrass, in depths of 2 to 3m (Dawson, 1985; Gomon *et al*., 1994).

Behaviour and Biology:
The brood pouch begins to develop in some males at 88mm standard length, and other males are found to be brooding at 100mm standard length (Dawson, 1985). The diet is unknown, but like other species in the family, it probably feeds on small crustaceans.

Size:
Vanacampus vercoi reaches a length of at least 11cm (Gomon *et al*., 1994).

Evidence for Decline:
There is no evidence of any decline and there is no known trade for this species. However, this pipefish appears to have one of the most restricted distributions of any species in the family Syngnathidae found in southern Australian waters (Gomon *et al*., 1994). Coupled with its inshore, shallow (2 to 3m) habitat, *Vanacampus vercoi* is a species that may be vulnerable to human interference, such as habitat alteration and habitat degradation.

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
This species has a very restricted distribution as currently known. More data is necessary to determine the extent of its range. As a precautionary measure, it is recommended to assign the above status to this species, adopting the IUCN categories.

Threatening Processes:
Inshore habitat degradation is a potential threat to the survival of this species.

Critical Habitats:
Shallow inshore areas associated with algae and seagrass are crucial to this species.

Recovery Objectives/Management Actions Required:
The biology and population ecology of this species needs to be investigated to determine its susceptibility to habitat degradation. The declaration of suitable MPAs within its distributional range may be appropriate to protect this species.

References:
Dawson, 1985; Gomon *et al*., 1994; Kuiter, 1996; Paxton *et al*., 1989

FAMILY SERRANIDAE: GROUPERS, ROCKCODS AND THEIR ALLIES

The family Serranidae is one of the larger teleost fish families, containing some 67 genera and over 400 species worldwide (Heemstra and Randall, 1993). All species are carnivorous, feeding mainly on fishes and crustaceans, although many species feed only on zooplankton. Most groupers feed at dusk, when light levels are low. Groupers are often disruptively coloured so they can blend in with the coral reef or rocky bottom, and many are also able to change their colour rapidly. As many groupers are at or near the upper end of their food chains, there are usually few residents at any one locality. Individual reefs may only have one or two very large groupers in residence, and as large groupers may be in excess of 50 years old, it takes a long time for overfished groupers to be replaced. Sizes range from the 3.5cm *Plectranthias longimanus* to the 2.5m or more *Epinephelus lanceolatus* (Randall, 1998).

Groupers are among the most important and highly valued demersal species of tropical and subtropical coastal waters worldwide, which often leads to heavy fishing of their stocks (Heemstra and Randall, 1993; Sadovy, 1997). Groupers differ from many commercially fished species because they are exploited in a wide variety of ways and at different phases of their life-history. As juveniles they are caught using a range of techniques such as nets, sodium cyanide, lights, small fish traps or various attraction devices for mariculture grow-out in South East Asia. Larger fish are taken by hook and line, speargun, fish trap and gill net to be marketed fresh or chilled. Groupers are also widely valued as sport fishes, for public and private marine aquaria and are a popular attraction for dive businesses (Sadovy, 1997).

Grouper mariculture, which is carried out extensively in South East Asia, relies on the exploitation of juveniles (about 3 to 15cm total length) taken from the wild, often long after settlement, which are then grown out in ponds with floating net cages. The reliance on wild caught juveniles appears to be unsustainable, with supplies becoming depleted in parts of the Philippines, Indonesia and Hong Kong, and demand now exceeding supply (Sadovy, 1997). Because groupers are typically protogynous hermaphrodites, whereby individuals start life as a female and then change sex to reproduce as a male, the larger, rarer males are easily overfished (Heemstra and Randall, 1993; Sadovy, 1997).

Groupers appear to be particularly vulnerable to anything other than low levels of fishing pressure due to their strongly K-selected biological characteristics, including slow growth rate, low reproductive rate, long life, large size at sexual maturation, and low natural mortality. The protogynous mode of reproduction also presents problems for fishery management (Sadovy, 1997). Male groupers (which are produced by sexual transformation of older females) are usually larger, older and less numerous than females; and the commercial, sport and subsistence fisheries are often biased (by means of hook size and fishing techniques) towards the capture of larger adults. Hence, males are generally caught in greater proportions than they exist in local populations (Heemstra and Randall, 1993). Because groupers often aggregate to spawn at well-defined times and locations, aggregations are easily targeted and can be eliminated by heavy fishing (see Colin, 1992; Sadovy, 1997). Groupers have been virtually eliminated by overfishing in at least five Pacific Island locations around Palau, the Cook Islands, the Society Islands, the Tuamotus, and on the Great Barrier Reef, north-eastern Australia (Johannes, 1997). Overfishing of spawning aggregations has been implicated in at least three of these cases of severe population decline, and bans on the fishing of such spawning aggregations are necessary to sustain grouper stocks worldwide (Johannes, 1997). Stock assessments on groupers clearly indicate that stocks are most productively exploited at low levels of fishing effort and at a high size of first capture (Sadovy, 1997).

Important steps towards promoting the sustainability of groupers include:

- Phasing out the capture of wild-caught juveniles for mariculture grow-out.
- Research on the biology of important species to serve both fishery management and mariculture initiatives.
- Recognition of the value of groupers for ecotourism activities (e.g. recreational scuba diving).
- Monitoring of quantity and species composition of landings in mixed species fisheries.
- Emphasis on the protection of adult and juvenile habitats degraded by land-based activities, possibly through the designation of marine reserves.
- Elimination of the use of sodium cyanide and other destructive fishing practices (Sadovy, 1997).

Although groupers are usually the most expensive fishes in local markets, separate catch statistics are not reported for most species, and landings are often summarised as “serranids”, “groupers” or “cods”. This lack of species-specific catch data is due, in part, to the difficulty in identifying many of the species and clearly needs to be overcome to properly manage the fisheries resources in regions where these species occur (Heemstra and Randall, 1993).

Other serranids that are not included in this report (such as the coral trouts *Plectropomus leopardus* and *Plectropomus laevis*) are also known to form spawning aggregations in Australian waters (Samoilys and Squire, 1994) which also makes them susceptible to overfishing by commercial and recreational fishers. These two *Plectropomus* species, along with *Plectropomus areolatus* and *Plectropomus maculatus*, make up a significant component of the live reef fish trade in the Hong Kong markets (Lee and Sadovy, 1998), and much of the live reef food fish from Queensland consist of *Plectropomus* species (QFMA, 1998). We have not included synopses for these species in this publication partly due to time constraints and partly, as they are part of a heavily managed fishery. Any future analyses of potentially threatened reef fishes may, however, need to consider the genus *Plectropomus.* There are now serious concerns developing for *Plectropomus* species based on their formation of spawning aggregations, their regular appearance in the live reef fish trade, and their highly fancied edibility (causing them to be heavily targeted by both commercial and recreational fishers).

Recreational bag limits, or ‘in-possession limits’ in Queensland waters are currently under review by the Queensland Fisheries Service (QFS). These in-possession limits are proposed for many grouper species in Queensland waters and are discussed for each species within the text of the corresponding species synopses. Such in-possession limits are proposed to also apply to commercial fishers operating under a L3 fishery symbol. This in effect means that it is proposed that some licenced commercial fishers will be limited to the same in-possession limits that are proposed for recreational fishers. These proposed in-possession limits are, however, subject to further caveats such as if the fish are taken on charter vessels or under the L3 fishery symbol where they are at sea for more than 48 hours (D. Cameron, pers. comm.). These limits will also apply to the humphead Maori wrasse *Cheilinus undulatus* and the humpheaded parrotfish *Bolbometopon muricatum*, discussed further in their respective species that follow.

In WA waters, there is a recreational bag-limit of four serranid fishes per person per day and all serranid fishes over 1.2m or 30kg are protected (http://www.wa.gov.au/westfish; Anon., 2000c). In waters of the NT, where many of the larger groupers are known to occur, there is a total recreational possession limit of 30 fish per recreational fisher per day. This possession limit of 30 includes all fish species except barramundi, Spanish mackerel and mud crabs, for which there are separate regulations. Recreational fishing regulations in the NT are currently under review.

There are a number of useful publications that include species identifications for members of the family Serranidae. Heemstra and Randall (1993) provide a comprehensive overview of the identification of individual grouper species, whilst Lau and Li (2000) have produced an identification guide to fishes in the live seafood trade of the Asia-Pacific region.

References:
Anon., 2000c; D. Cameron, pers. comm. 12/1999; Colin, 1992; Heemstra and Randall, 1993; Johannes, 1997; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; QFMA, 1998; Sadovy, 1997; Randall, 1998

Websites:
http://www.wa.gov.au/westfish (Fisheries Western Australia homepage)

Orange-lined wirrah

Family Name:	Serranidae
Scientific Name:	*Acanthistius paxtoni* Hutchins and Kuiter, 1982
Conservation Status:	Data Deficient

Alternative Common Name:
Striated wirrah

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Acanthistius paxtoni is so far known only from Sydney Harbour and Seal Rocks in New South Wales (Kuiter, 1993). There is also an unconfirmed record from Western Australia (B. Hutchins, pers. comm.).

Museum Records - 2 specimens (Standard Length 215 - 280mm). One specimen was collected from a depth of 64m and the collection depth for the other specimen was not recorded. The specimens ranged in geographical distribution from Watsons Bay (33^o 50' S), NSW northwards to Seal Rocks (32^o 26' S), NSW and were collected between 1973 and 1980.

Habitat:
The only specimens to be collected that have depth information associated with them were taken from 64m (Kuiter, 1993). Its absence from intertidal rock pools, a habitat utilised by the juvenile stages of all other *Acanthistius* species, suggests that this serranid is restricted to deeper reefs (Hutchins and Kuiter, 1982). Further collecting in the years since its discovery has not yielded any more than the two specimens mentioned above, though there has been an unconfirmed sighting from WA.

Biology and Behaviour:
Almost nothing is known about the species-specific biology of this fish.

Size:
This species attains a length of at least 30cm (Kuiter, 1993).

Evidence for Decline:
There is no evidence of any declines for this species. It may be naturally rare and difficult to collect due to its deepwater rocky habitat and secretive habits.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
Given that only a few specimens of this species have been collected, more information is required to make accurate judgements on the conservation status of this species. This species may also occur on the south coast of Western Australia, based on a poor quality photograph of a recently captured specimen (B. Hutchins, pers. comm.). In this context it is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Deeper reefs (to 64m) may be critical habitats for this species, but further investigation is necessary.

Recovery Objectives/Management Actions Required:
More specimens are required to make any judgements about the distribution, ecology and biology of this species.

References:
B. Hutchins, pers. comm. 7/2000; Hutchins and Kuiter, 1982; Kuiter, 1993.

Barramundi Cod

Family Name:	Serranidae
Scientific Name:	*Cromileptes altivelis* (Valenciennes, 1828)
Conservation Status:	Lower Risk (conservation dependent)

Alternative Common Names:
Humpback grouper; humpback rockcod; high-finned grouper

Current Conservation Status:
<u>No 1996 IUCN Listing</u>

<u>2000 IUCN Red List of Threatened Species</u>
Data Deficient

<u>No ASFB Listing</u>

Distribution:
Cromileptes altivelis has a widespread distribution in waters of the tropical Indo-Pacific region and occurs in the western Pacific to east Africa. In Australian waters, this species more commonly occurs from north-western Australia eastwards to the Great Barrier Reef (Allen, 1997). In Western Australia it has been recorded southwards to Shark Bay (B. Hutchins, pers. comm.). Russell (1983) reports this species as uncommon in the Capricornia section of the Great Barrier Reef, occurring in outer reef slope habitats in depths of 2-15m. Adults are uncommon southwards of the Bunker Group (24^{o} S) of the Great Barrier Reef Marine Park (Johnson, 1999), but juveniles have been reported southwards to Sydney (Kuiter, 1993).

<u>Museum Records</u> - 45 specimens (Standard Length larvae to 440mm), collected from depths of 0 to 62m, ranging in Australian geographical distribution from Dirk Harthog Island (25^{o} 45' S), WA north-eastwards to Darwin (12^{o} 27' S), NT and south-eastwards to Moreton Bay (27^{o} 28' S), Qld. There are also records from Malaysia, the Philippines and Kiribati. Specimens were collected between circa 1893 and 1998.

Habitat:
Cromileptes altivelis inhabits coastal reefs, lagoons and deep, silty slopes (Kuiter, 1993) to at least 60m depth. It occurs on well-developed coral reefs as well as in dead or silty reef areas, and in tide pools (Heemstra and Randall, 1993). It is also known from caves and crevices of coral reefs (Allen, 1997). Juveniles occur on shallow protected reefs (Kuiter, 1996).

Biology and Behaviour:
Adults are not often seen due to their secretive and shy nature. Juveniles are seen swimming with their fins towards the substrate, waving their fins in an exaggerated manner like feeding coral polyps (Kuiter, 1996). When alarmed, this species develops a fright colouration, with brownish blotches over the body (QFS, 2000a). This species sometimes shelters under tabular *Acropora* coral (Allen and Swainston, 1992). Growth in captivity is very slow (Heemstra and Randall, 1993). Age estimates indicate that this species lives to a maximum of 20 years of age while abundance estimates suggest that it is widespread, but nowhere it is abundant (H. Choat, pers. comm.). Counts using long visual transects with dimensions of 400 x 20m (8000m^2) on northern Queensland reefs provided estimates of 1 to 2.5 individuals per transect (H. Choat, pers. comm.). Large specimens commonly allow themselves to become tide-bound in the shallow coral pools of Barrier Reef cays (QFS, 2000a). According to Lau and Li (2000), this species matures at a length of 39cm. No dietary information could be found in the literature, but it is assumed that the diet consists of fishes, molluscs and crustaceans.

Size:
This species attains a length of 70cm (Kuiter, 1993; Lau and Li, 2000) and a weight of 4.8kg (Yearsley *et al.*, 1999). It is commonly marketed at 40-60cm and 1.0-2.8kg (Yearsley *et al.*, 1999).

Evidence for Decline:
No documentary evidence of any declines for this species has been found in Australian waters. Juveniles are highly prized as aquarium fishes, and adults are one of the most expensive food fishes in fish markets wherever it occurs. It is caught with hook-and-line, spear, in traps (Heemstra and Randall, 1993) and demersal trawls (QFS, 2000a). Like many groupers, it is traded in the live reef fish trade in Hong Kong (Lee and Sadovy, 1998) and currently sells for about US$64 per kg (Chan, 2000). A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), estimated that *Cromileptes altivelis* made up 3% (approx. 720t) of the total annual volume of fish imported into Hong Kong for this trade. Most of the 720t came from Indonesia (Lau and Parry-Jones, 1999). These statistics may demonstrate that this species is locally common in Indonesia, but the level of effort involved in catching these fish may also be high. Continued high prices in Hong Kong will inevitably lead to localised depletions. Further pressures are likely to be placed on this species in other parts of its range (e.g. Australia or other South-East Asian countries) once Indonesian populations are reduced. The live reef fish trade is a potential threat to the survival of the species, particularly in South-East Asia where it is heavily targeted. This species is reared from fingerlings to marketable size in floating net cages in the Johor Straits in Singapore, after being imported from the South East Asian region (Lim and Low, 1998).

Australian Marine Protected Areas in Which the Species Occurs:
Coburg Marine Park, NT
Great Barrier Reef Marine Park and World Heritage Area, Qld
Possibly Shark Bay Marine Park, WA (unconfirmed)

Suggested Conservation Status:
Lower Risk (conservation dependent)
The minimum legal length for this species under Queensland Fisheries regulations is currently 40cm, but there is currently neither a maximum legal length nor any in-possession limits (http://www.dpi.qld.gov.au/fishweb). In Queensland, the keeping of juveniles captured in the wild (below the minimum legal length of 40cm) is illegal. The Queensland Fisheries Service (QFS) has proposed an in-possession boat limit for any fisher/boat of one with the minimum legal length remaining at 40cm. Biologists at James Cook University (JCU) are undertaking research on this species (D. Cameron, pers. comm.). Until this research is completed and assuming the management measures proposed by the QFS are implemented, it is recommended to assign the status of Lower Risk (conservation dependent) adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing are threats to the survival of this species in Australian waters. The live reef fish trade remains a continuing threat to this species wherever it is targeted for this trade.

Critical Habitats:
This species prefers offshore coral reefs and is quite selective in its habitat preferences.

Recovery Objectives/Management Actions Required:
Research undertaken by JCU may help in determining the biological and/or life history traits for this species. Stricter regulations (i.e. introducing an in-possession limit of one per boat) need to be adopted to ensure that this species is not over-exploited by aquarium collecting and commercial or recreational fishing. The introduction of a maximum size limit for this species in Queensland waters needs to be investigated and may also prove necessary as a precautionary measure to protect the adults from fishing exploitation.

References:
Allen and Swainston, 1992; Allen, 1997; D. Cameron, pers. comm. 12/1999; Chan, 2000; H. Choat, pers. comm. 2/2000; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; Johnson, 1999; Kuiter, 1993; Kuiter, 1996; H. Larson, pers. comm. 12/1999; Lau and Li, 2000; Lau and Parry-Jones, 1999; QFS, 2000a; Randall *et al.*, 1997; Russell, 1983; Yearsley *et al.*, 1999.

Websites:
http://www.dpi.qld.gov.au/fishweb/ (Queensland Department of Primary Industries homepage)

Estuary rockcod

Family Name:	Serranidae
Scientific Name:	*Epinepehelus coioides* (Hamilton, 1822)
Conservation Status:	Lower Risk (least concern)

Australian Synonyms:
Homalogrystes guntheri Alleyne and Macleay, 1877

Taxonomic Problems:
Epinephelus coioides is often misidentified as "*Epinephelus tauvina*" or "*Epinephelus malabaricus*" in the aquaculture and fisheries literature. *Epinephelus coioides* and *E. malabaricus* were not distinguished in most aquaculture work, and both species are cultured in Singapore and Taiwan (Heemstra and Randall, 1993).

Alternative Common Names:
Estuary cod; orange-spotted cod; green grouper

Current Conservation Status:
Totally Protected Species in NSW Waters

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Epinephelus coioides occurs from the Red Sea south to at least Durban and east to the western Pacific where it ranges from the Ryukyu Islands to Australia and eastwards to Palau and Fiji. Other localities include the Persian Gulf, India, Reunion, Mauritius, Andaman Islands, Singapore, Hong Kong, Taiwan, and the Philippines (Heemstra and Randall, 1993). In Australian waters it is most common in Queensland, Northern Territory and Western Australian waters. In Western Australia it is known to occur southwards to Geographe Bay (B. Hutchins, pers. comm.), and on the eastern coast it is known to occur as far southwards as the Sydney area.

Museum Records - 358 specimens (Standard Length 19-510mm), collected from a depth range of 0-25m, ranging in geographical distribution from Lake Budgewoi (33^{o}S), NSW, northwards to Prince of Wales Island (10^{o}41'S), Cape York, Qld, westwards to Cape Leveque (16^{o}25'S, 122^{o}25'E), WA and south-westwards to Shark Bay (25^{o}S), WA. There are also specimens from Indonesia and PNG. Specimens were collected between 1912 and 1998.

Habitat:
Epinephelus coioides occurs mainly in lower estuaries and around protected silty reef habitats. Adults are usually found along the bases of small drop-offs associated with large caves, or in shipwrecks (Kuiter, 1996), but they are also taken offshore to depths of 100m (Heemstra and Randall, 1993). This species usually occurs alone or in small groups (Yearsley *et al*., 1999). Parker (1999) reported adults in 10-24m of water at Julian Rocks Aquatic Reserve (off Byron Bay, northern NSW), noting their occurrence there as uncommon. They may occur on coral reefs in turbid areas and are often encountered in brackish environments (Randall *et al*., 1997). In a study of Alligator Creek, an estuary on the coast of tropical north-eastern Australia, Sheaves (1996) found *E. coioides* to be the dominant serranid in downstream areas, capturing 280 fish between 120 and 500mm FL, with most fish measuring below 350mm. In a survey of the Embley estuary (Gulf of Carpentaria, Queensland) Blaber *et al*. (1989) found juvenile *E. coioides* to be one of the most abundant species (by biomass) in seagrass areas of the lower reaches. In Darwin Harbour (NT), this species has been collected in association with rubble, shell, and soft coral and sponge habitats (Larson and Williams, 1997).

Biology and Behaviour:
Aquaculture trials in the Persian Gulf show that the major spawning period for *E. coioides* is from March to June (Heemstra and Randall, 1993). Females are mature at 25-30cm total length (2-3 years old), and protogynous sexual transition occurs at a length of 55-75cm (Heemstra and Randall, 1993) or slightly smaller (49cm) according to Lau and Li (2000). This corresponds to an age of approx. 4 years (QFS, 2000b). Longevity is reported to be at least 17 years (QFS, 2000b). Fecundity estimates were 850,186 ova for a fish 35cm and 2,904,912 ova for one of 62cm. The eggs are pelagic, and the best survival of larvae was attained at a temperature of 30°C and a salinity of 39ppt (Heemstra and Randall, 1993). This species is common within estuaries of tropical eastern Australia where, despite occurring to sizes of 400mm FL or more, the populations consist almost entirely of pre-reproductive females (Sheaves, 1996). In a mark-release-recapture study in tropical northern Australia, Sheaves (1993) found *E. coioides* to have a relatively small home range, usually being recaptured within 40m of the site of release. Reported stomach contents include fishes, shrimps, crabs and cuttlefish (Heemstra and Randall, 1993).

Size:
It is commonly marketed at 40-120cm and 1-25kg, but it grows to possibly 180cm and 100kg (Yearsley *et al*., 1999). The largest reliable record of this species is of a 1.67m specimen taken at Orpheus Island, Queensland in 1962 (J. Johnson, pers. comm.).

Evidence for Decline:
Epinephelus coioides is caught sporadically mainly using traps, seines, bottom set lines and by demersal fish trawlers. It is a sought after recreational fish (Yearsley *et al*., 1999). As *E. coioides* grows to a large size (over 1m) it is a target species for spearfishers, and is reasonably accessible in this regard as it occurs in shallow as well as deep (to about 100m) waters. Like many groupers, *E. coioides* is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and this is a potential threat in terms of localised depletion of its stocks. In a survey of the Lei Yue Mun live fish market in Hong Kong conducted between December 1995 and February 1996, *Epinephelus coioides* was found to be the most commonly marketed species with 478 fish up to 80cm in length observed (Lee and Sadovy, 1998). A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), revealed that *Epinephelus coioides* made up 20% (approx. 4800t) of the total annual volume of fish imported into Hong Kong for this trade. While these statistics may demonstrate that this species is common in the Indo-Pacific region, continued harvesting at high levels will inevitably lead to localised depletions of populations. Populations of this species in Australia could become increasingly targeted when other countries have depleted their numbers. In Hong Kong and broadly in the region, this species is widely cultured, and juveniles are caught in large numbers. Where harvest is particularly high, numbers of fry appear to be declining (Sadovy, 2000). Small fish to about 8kg are well regarded as table-fish, but the flesh is coarse in large individuals (Yearsley *et al*., 1999). It is now a protected species in NSW, which may reduce the possible impacts of overfishing in that State. Problems are encountered in the accurate identification of this species, which makes it difficult for fishers to provide accurate data on which to base management plans.

Australian Marine Protected Areas in Which the Species Occurs:
Solitary Islands Marine Park, northern NSW
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW
Cook Island Aquatic Reserve, off Tweed Heads, northern NSW
Great Barrier Reef Marine Park and World Heritage Area, Qld
Coburg Marine Park, NT
Kakadu National Park, NT
Shark Bay Marine Park, WA

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis
Epinephelus coioides is a tropical Indo-West Pacific species that seems to have a reasonable abundance throughout most of its known range. It is protected in NSW waters; the central coast of NSW being the southern extreme of its range in eastern Australia. Its status appears to be relatively secure in Queensland waters. Under current QFS fisheries regulations, the minimum and maximum size limits for this species are 35cm (corresponding to approx. 650g) and 120cm (corresponding to approx. 29kg) respectively, and the in-possession limit is 10 fish (QFS, 2000b). A proposed maximum size limit (of 100cm), if adopted, will ensure further protection in Qld waters.

Threatening Processes:
Commercial and recreational line fishing are potential threats to the survival of this species in Australian waters. In other countries threats include the live reef fish trade, involving the removal of many juveniles for mariculture grow-out and the capture of larger fish for sale to restaurateurs.

Critical Habitats:
Lower riverine and estuarine habitats are important nursery areas for this species.

Recovery Objectives/Management Actions Required:
In selected tropical, north-eastern Australia estuaries, Sheaves (1996) has demonstrated that *E. coioides* populations consist almost entirely of reproductively immature fish, indicating that estuaries are important nursery areas for this species. It is assumed that adults leave estuarine areas to spawn offshore, so the protection of specific offshore areas is important for conserving mature individuals of this species. It is likely to be proposed by the QFS for the Subtropical Fishery (Rockhampton to NSW/Queensland Border) that the minimum size remain at 35cm, but the maximum size be reduced to 100cm. It is also proposed that the recreational in-possession limit be reduced to five for a combination of *Epinephelus coioides* and *Epinephelus malabaricus* (D. Cameron, pers. comm.). Further study on the taxonomy of this species is also recommended to accurately assess its distribution and abundance, due to the confusion with other closely related *Epinephelus* species mentioned above.

References:
Blaber *et al*., 1989; D. Cameron, pers. comm. 12/1999; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; J. Johnson, pers. comm. 9/2000; Kuiter, 1996; Larson, pers. comm. 12/1999; Larson and Williams, 1997; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; Parker, 1999; Perry, 1999; QFS, 2000b; Randall *et al*., 1997; Sadovy, 2000; Sheaves, 1993; Sheaves, 1995; Sheaves, 1996; Yearsley *et al*., 1999.

Purple Rockcod

Family Name:	Serranidae
Scientific Name:	*Epinephelus cyanopodus* (Richardson, 1846)
Conservation Status:	Lower Risk (least concern)

Alternative Common Name(s):
Speckled grouper, blue maori (NZ, Papua New Guinea), purple cod

Current Conservation Status:
No IUCN or ASFB Listings

Distribution:
Epinephelus cyanopodus occurs in the western Pacific from southern Japan to southern Queensland and east to Fiji and the Islands of Micronesia. It is also known from Taiwan, Hong Kong, Vietnam, Gulf of Thailand, Indonesia, Philippines, PNG, Irian Jaya, New Caledonia, Lord Howe Island (Heemstra and Randall, 1993) and Norfolk Island (Francis, 1993). It is a tropical expatriate in the Sydney area, but occasionally it reaches a moderate size and has been seen to about 30cm (Kuiter, 1996). It has also been recorded from Western Australia (B. Hutchins, pers. comm.).

Museum Records - 27 specimens (Standard Length 71-566mm), collected from a depth range of 2-110m, ranging in geographical distribution from Sydney Harbour (33^o 51’ S), NSW, northwards to Lizard Island (14^o 38’ S), Great Barrier Reef, Qld, and westwards to Browse Island (14^o 07’ S), off WA. There are also records from PNG, Coral Sea (Saumarez Reef), Gilbert Islands, and Elizabeth and Middleton Reefs. Specimens were collected between circa 1882 and 1996.

Habitat:
Epinephelus cyanopodus is usually found on isolated coral heads in lagoons or bays, but is also caught at depths of up to 150m on the outer reef area (Heemstra and Randall, 1993). It occurs on sandy areas adjacent to coral reefs (Allen and Swainston, 1992) and coastal reefs and silty lagoons, often with isolated outcrops of rock and coral or in shipwrecks. Large adults are usually found very deep, to 150m (Kuiter, 1996) and juveniles occur southwards to the Sydney area (Kuiter 1993). Parker (1999) recorded adult *E. cyanopodus* from Lennox Head (northern NSW) at a depth of 2m, noting their abundance as rare.

Biology and Behaviour:
Myers (1989) reported *E. cyanopodus* to be a solitary species that characteristically swims out in the open, often several metres above the bottom, and is often difficult to approach. Grant (1978) noted that anglers readily catch it at night. Reported stomach contents include fishes and calappid crabs (Heemstra and Randall, 1993). According to Lau and Li (2000), sexual maturity as a male is reached at a total length of 64cm.

Size:
Attains 120cm total length (Heemstra and Randall, 1993) and a weight of at least 5kg.

Evidence for Decline:
No evidence for declining numbers has been found in the literature, but like other species in the *Epinephelus* genus that grow to a large size, it is a potential target of line and spearfishers. This species is occasionally marketed to about 80cm in length as Blue Cod at the Sydney Fish Markets (J. Pogonoski, pers. obs.). Like many groupers, *E. cyanopodus* is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and although it only occurs there in low quantities (Y. Sadovy pers. comm.), this trade is a potential threat to the survival of some populations. Large individuals may be ciguatoxic (Myers, 1989).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Lord Howe Island Marine Park (Tasman Sea)

Elizabeth and Middleton Reefs Marine National Nature Reserve (Tasman Sea)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
Epinephelus cyanopodus is not targeted to the same extent as many other groupers such as *Epinephelus coioides*, but it is taken as part of the catch in the multi-species commercial reef line fishery and also on occasions it is taken by recreational fishers. There is currently no size or catch restrictions on this species in Queensland. The QFS has proposed a recreational in-possession limit of five of this species (D. Cameron, pers. comm.). Little biological information could be found in the literature for this species and further research into the biology and distributional range for *E. cyanopodus* is necessary. It is recommended that it be assigned the above status, adopting the IUCN categories.

Threatening Processes:
Commercial and recreational line fishing are possible threats to the survival of this species.

Critical Habitats:
None identified.

Recovery Objectives/Management Actions Required:
The proposed QFS regulations mentioned above will help in ensuring the survival of this species in Queensland waters.

References:
Allen and Swainston, 1992; D. Cameron, pers. comm. 12/1999; Francis, 1993; Grant, 1978; Heemstra and Randall, 1993; Kuiter, 1993; Kuiter, 1996; Lau and Li, 2000; Lee and Sadovy, 1998; Myers, 1989; Parker, 1999; J. Pogonoski, pers. obs. 10/1999; Y. Sadovy, pers. comm. 3/2000.

Black Rockcod (also known as Black Cod)

Family Name:	Serranidae
Scientific Name:	*Epinephelus daemelii* (Günther, 1876)
Conservation Status:	Vulnerable

Australian Synonyms:
Epinephelus forsythi Whitley, 1937

Alternative Common Names:
Black cod; saddled rockcod (Aust); spotted black grouper (NZ)

Current Conservation Status:
Totally Protected Species in NSW waters (since 1983)

Listed as a Vulnerable Species in NSW under the NSW *Fisheries Management Act 1994* since 1999

Listed under section 15 of the Commonwealth *Fisheries Management Act 1991*, making its take in fishing operations under that Act illegal unless covered by a scientific permit

Totally Protected Species in the Kermadec Islands Marine Reserve (New Zealand)

No IUCN (1996, 2000) Listing

ASFB Threatened Fishes Committee
1988-1989: Requiring investigation of its status
1990-1999: Potentially Threatened

Distribution:
Epinephelus daemelii occurs in warm temperate and subtropical waters of the south-western Pacific: south-east Australia, Lord Howe Island, Norfolk Island, Kermadec Islands and New Zealand (North Island and Poor Knights Islands). The Australian range extends from southern Queensland to Kangaroo Island off South Australia (these latter fish are probably expatriates from the east coast). It has been reported from Bass Strait, but is not known from the coast of Tasmania (Heemstra and Randall, 1993). Gill and Reader (1992) report its occurrence at Elizabeth Reef (where it is common in lagoon and reef slope habitats, but rare on reef flats) and Middleton Reef (where it is common in lagoon and reef slope habitats). They concluded that *E. daemelii* was the dominant serranid on the two reefs. Parker (1999) reported adults at Julian Rocks Aquatic Reserve (off Byron Bay) and at Windarra Bank (9 nm east of Mooball, N of Cape Byron) in a depth range of 5-40m, recording their occurrence as occasional. Kuiter (1997) considered it to be a common NSW species. Johnson notes that the northernmost confirmed record (photographed) was a large specimen taken off Breaksea Spit (24^{o}15'S), Fraser Island in 1998. Francis (1996b) noted that this species was abundant at the Kermadec Islands and common at the Three Kings Islands, but rare elsewhere in New Zealand.

Museum Records - 213 specimens (Standard Length 1.9-121cm), collected from a depth range of 0-40m, ranging in geographical distribution from Bundaberg (approx. 24^{o}52'S), Qld southwards to Mallacoota (37^{o} 34' S), Victoria and westwards to Kangaroo Island (36^{o}03'S, 136^{o}55'E), SA, including Norfolk and Lord Howe Islands and Elizabeth and Middleton Reefs. Specimens were collected between circa 1880 and 1994.

Habitat:
Epinephelus daemelii occurs in reef caves, gutters and beneath bommies (Gill and Reader, 1992) on rocky reefs from near shore to depths of at least 50m (Heemstra and Randall, 1993). This species is generally found on coastal reefs, estuaries and deeper offshore waters, often not seen except when diving with a torch at night (Kuiter, 1996). Recently settled juveniles can be common in coastal rock pools along the NSW coastline (Hutchins and Swainston, 1986).

Biology and Behaviour:
Epinephelus daemelii is an aggressive territorial species that may occupy a particular cave for life (Heemstra and Randall, 1993). Observations by fishermen and divers suggest that this species is slow growing and it is also a slow moving fish (Leadbitter, 1992). Ayling and Cox (1982) noted of *E. daemelii* in NZ: "a single fish can change from one extreme of colour to the other in just a few seconds, depending on its mood and the colour of the background". Small fish are females and change sex to become males at around 100-110cm length (Paulin and Roberts, 1992). *Epinephelus daemelii* is an opportunistic carnivore (Leadbitter, 1992), which preys on fishes and crustaceans (McCulloch, 1922). Juveniles feed on crabs and fishes (Heemstra and Randall, 1993).

Size:
The true maximum size of this species may have been obscured in part in the past due to confusion with other large groupers. In Australian waters, this species attains at least 1.5m total length (Hutchins and Swainston, 1986; Leadbitter, 1992) and a weight of 81kg (Hutchins and Swainston, 1986). At the Kermadec Islands, north of New Zealand, where the population has not been fished commercially, *E. daemelii* may reach 2m in length. In New Zealand waters the maximum recorded size is 1.8m, but they are usually 40-80cm in length (Paulin and Roberts, 1992).

Evidence for Decline:
The territorial and sometimes curious nature of *E. daemelii* makes it extremely vulnerable to spearfishing. The fishing ban in NSW was enforced following a noticeable decline in numbers, mainly attributed to the rise in the popularity of spearfishing in the early 1970's (Leadbitter, 1992). Lincoln Smith *et al.* (1989) noted that in NSW 137 *Epinephelus daemelii* averaging 2.4kg per fish were speared in NSW spearfishing competitions in 1976 alone. Divers at the Kermadec Islands record very large *E. daemelii* to be extremely curious and easily approached, being almost tame. This behaviour makes them easy to spear, and stocks have been quickly reduced by recreational as well as commercial fishing. Recent protection at the Kermadec Islands may help to alleviate this problem (Stewart, 1999). Roughley (1916) reported of *E. daemelii* "at one time it was fairly plentiful in the vicinity of Port Jackson, but has become very scarce in recent years, owing to the havoc wrought by fishermen, and the increased shipping". *Epinephelus daemelii* does not form breeding populations in the North Island waters of New Zealand, but individuals may grow to a large size and so appear to be capable of surviving for a number of years (Stewart, 1999). Their status in New Zealand mainland waters is not secure, as they do not form breeding populations (C. Roberts, pers. comm.). There is some evidence that fish caught in deeper (50-100m) waters of northern NSW by commercial fishers do not survive after being released at the surface, suffering severely from swim-bladder decompression or "bloat". McCulloch (1922) reported that *E. daemelii* was a valuable food fish in NSW, indicating that this species was once quite common in that state.

Australian and New Zealand Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park (southern section, Qld)
Cook Island Aquatic Reserve (off Tweed Heads, northern NSW)
Julian Rocks Aquatic Reserve (off Byron Bay, northern NSW)
Solitary Islands Marine Park (northern, NSW)
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)
Lord Howe Island Marine Park (Tasman Sea)
Kermadec Islands and Poor Knights Islands Marine Reserves (NZ)
Reserves within its range where *Epinephelus daemelii* probably occurs:
Norfolk Island Marine Reserve/Park (Tasman Sea)

Suggested Conservation Status:
Vulnerable on an Australia-wide basis.
Epinephelus daemelii grows to a large size and is considered to be a quality eating fish. It is territorial and curious by nature, making it a species susceptible to overfishing by line and spearfishers. Total protection in NSW and Commonwealth waters should contribute towards conserving the species, but illegal removal of the fish in these areas may continue to harm their chances of survival. In this context, it is recommended to assign the above conservation status to this species, adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing in southern Queensland waters (where it is not protected) has the potential to decrease the populations of this species. Illegal capture in NSW and waters of Lord Howe Island, Elizabeth and Middleton Reefs would also be detrimental to its populations.

Critical Habitats:
Shallow to deep rocky reefs, caves and ledges as adults; coastal rock pools as juveniles.

Recovery Objectives/Management Actions Required:
Limited biological information currently exists for *E. daemelii*, so further studies on the biology of this species are recommended. Specimens that are occasionally sent to the Sydney Fish Markets for sale could be used for this purpose. The ban on selling the black cod in NSW necessitates that they be seized from the market floor. Sending these specimens to an appropriate local museum or research institute for preservation and analysis would at least contribute to an understanding of the biology of the species. In particular, information on age/size classes, the age/size at maturity, sex ratios and fecundity levels would be most useful in determining the proportion of mature adults in a given population. If *E. daemelii* is to survive along the Australian mainland coastline, its continual protection in NSW is crucial, as this state provides the largest area of its distributional range on the Australian coastline. As *E. daemelii* inhabits rocky reef areas with caves and gutters, it may be afforded some protection by any future NSW MPAs designed to protect the grey nurse shark. Educating commercial and recreational fishers of the anatomical and visual characteristics that distinguish the black cod from other similar looking closely related cod species is essential for its continued protection and survival in Australian waters. The first step towards its recovery would be the formation of a National Recovery Team to accumulate information on its distribution, abundance, exploitation, ecology and biology.

References:
Ayling and Cox, 1982; Francis, 1996b; Gill and Reader, 1992; Heemstra and Randall, 1993; Hutchins and Swainston, 1986; Kuiter, 1996; Leadbitter, 1992; Lincoln Smith *et al*., 1989; Parker, 1999; Paulin and Roberts, 1992; C. Roberts, pers. comm. 4/2000; Perry, 1999; Roughley, 1916; Stewart, 1999.
Websites: http://www.fsc.nsw.gov.au (NSW Fisheries Scientific Committee)

Bar Rockcod

Family Name:	Serranidae
Scientific Name:	*Epinephelus ergastularius* Whitley, 1930
Conservation Status:	Data Deficient

Taxonomic Problems:
In fish markets this species is sometimes confused with *Epinephelus daemelii* (J. Pogonoski, pers. obs.) and *Epinephelus octofasciatus* (J. Johnson, pers. comm). Apparently there are at least two, and possibly three, species in this 'group'. *Epinephelus septemfasciatus* occurs on the south-west coast of Australia and *Epinephelus ergastularius* occurs on the east coast of Australia. Recent protein fingerprinting has resulted in the recognition of two species on the east coast, but more taxonomic work is required to determine their identity (Yearsley *et al*., 1999). The main taxonomic differences relate to the differences in the position of the vertical stripes or bands and the characteristics of the dermal structures of the skin. There is possibly one species in NSW waters and a second form from Queensland (P. Last, pers. comm.).

Alternative Common Names:
Bar cod; rockcod

Current Conservation Status:
No IUCN or ASFB listings

Distribution:
The *Epinephelus ergastularius* 'species-complex' occurs along almost the entire east coast of Australia, while *E. septemfasciatus* is restricted to the south-west coast of Australia (Yearsley *et al*., 1999).

Museum Records - 50 specimens (Standard Length 27-781mm), collected from depths of 20-329m, ranging in geographical distribution from southern NSW (37km N of Montague Island, 35^{o} 55' S) northwards to northern NSW (east of Ballina, 28^{o} 52' S). There are also two specimens from Qld (east of Dunk Island, 17^{o} 57' S). Specimens were collected between circa 1886 and 1999.

Habitat:
Epinephelus ergastularius inhabits hard ground and reefs in deep shelf and upper continental slope waters from southern Queensland to central NSW (Rowling, 1995). Adults have been taken in the depth range of 108-370m, the deeper depths (280-370m) being associated with the northerly end of its range. Its occurrence at lesser depths to the south in NSW possibly relates to cooler sea temperatures (Randall and Heemstra, 1991). Juveniles are found in water depths of 15-128m (Randall and Heemstra, 1993). In Queensland waters this species is taken at depths of greater than 200m (D. Brooks, pers. comm.).

Biology and Behaviour:
Little is known about its size at maturity, but it is likely that females are not sexually mature until about 70-80cm FL (6-8kg in weight) (Rowling, 1994). Size composition data suggest that the stock may be subject to fluctuations in recruitment strength from year to year (Rowling, 1995). This diet of this species consists of fish, crustaceans and molluscs.

Size:
It attains at least 157cm total length and a weight of 66kg (Heemstra and Randall, 1993).

Evidence for Decline:
Because of a consistently high market price ($16 per kg for whole fish, $23 per kg for cutlets at the Sydney Fish Markets October 1999, J. Pogonoski pers. obs.), this species has been heavily targeted since about 1990. In NSW, reported landings reached a maximum of about 29t in 1990/91, but declined to about 11t in 1994/95. The majority of the marketed catch is less than 60cm FL (which corresponds to a weight of 4kg). If females are not sexually mature until about 70-80cm FL (6-8kg in weight) (Rowling, 1994), this may explain any population declines, as less females reach maturity due to fishing pressure. This may result in a

low proportion of spawning females and an even lower percentage that reach the male stage. Juveniles are taken as bycatch of traps and prawn trawls. *Epinephelus ergastularius* is the dominant species of the northern NSW line fishery. It is marketed regularly, but in small quantities at the Sydney Fish Market (Yearsley *et al*., 1999). This species appears to be particularly prone to hook and line fishing, the catches being maintained by fishing 'new' grounds or working grounds which have been rested for considerable (6-12 months) periods (Rowling, 1995). There has been anecdotal evidence of a decrease in the average size of this species in catches (Rowling, pers. comm). There appears to be marked fluctuations in catches of this species from season to season and this probably relates to the aggregating and/or spawning behaviour of this species.

NSW Catch Statistics for Bar Cod *Epinephelus ergastularius* 1984/85 to 1998/99

Total catches are for combined fishing methods[7]

FISCAL YEAR	TOTAL CATCH (kg)
1984/1985	2,299
1985/1986	7,092
1986/1987	3,268
1987/1988	6,720
1988/1989	9,792
1989/1990	10,272
1990/1991	29,101
1991/1992	19,520
1992/1993	16,567
1993/1994	14,069
1994/1995	11,285
1995/1996	14,055
1996/1997	15,452
1997/1998	17,370
1998/1999	11,491
1999/2000	16,832[8]

Queensland Catch Statistics for Bar Cod *Epinephelus ergastularius* 1992 to 1999[9]

CALENDAR YEAR	TOTAL CATCH (kg)
1992	70
1993	430
1994	0
1995	240
1996	0
1997	1,222
1998	16,620
1999	4,440

[7] Total catches are mixtures of whole weights and cleaned fish. For catches 1997/98 onwards, whole weights range between 46% and 66% of totals, with remainders being a mixture of gilled and gutted, gutted only, and headed and gutted in order of decreasing magnitudes (M. Tanner, pers. comm. 9/2000).

[8] Some catch forms have not been returned for the 1999/00 fiscal year (M. Tanner, pers. comm. 9/2000).

[9] Total catches are recorded in whole weights from the 'L8' Multiple hook gear fishery, which fish in waters greater than 200m depth. Catches are Qld consignments to Sydney Fish Markets where vast majority of catch is sold. There are likely to be additional catches from other fisheries which target species at depths greater than 200m, but these may have been recorded as "Cod, unspecified" on catch forms. Some catches of another closely related species (i.e. *Epinephelus octofasciatus*) may have been included in these statistics due to the confusion as to their identification (D. Brooks, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
Adult *Epinephelus ergastularius* inhabit deep-water (108-370m), so it is most probably not found in any of the MPAs along the NSW coastline, except maybe as juveniles. Amateur and commercial fishers working offshore are more likely to come into contact with this species.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis
There is no specific input or output controls applying to this species in Queensland (D. Cameron, pers. comm.). However, there is a current freeze on the issue of multiple hook endorsements in waters greater than 200m issued by the QFS, and it is GBRMPA policy not to issue permits to use multiple hook apparatus in the Great Barrier Reef Marine Park (D. Cameron, pers. comm.). Until the taxonomy of this 'species complex' is resolved it would be premature to assign any other conservation category other than Data Deficient, adopting the IUCN categories.

Threatening Processes:
Commercial droplining is the main threat to this species.

Critical Habitats:
Specific habitats may be important as spawning aggregation sites, but more information is required.

Recovery Objectives/Management Actions Required:
Genetic work may be required to sort out the taxonomy of these species. Once the taxonomic impediments are overcome, it would be beneficial to produce a guidebook for fishers to separate the individual species involved in the relevant fisheries. This will hopefully provide more accurate catch statistics for cods taken in these fisheries. Further studies on the biology (e.g. size/age classes, sizes of male and females at sexual maturity, movements and/or migrations, and possible spawning aggregations) and seemingly patchy distribution of this species is necessary for recovery outlines to be implemented. It seems likely that this species forms large aggregations for spawning. This assumption needs to be tested by examining the sexual maturity of specimens where large catches have been made. The designation of seasonal and/or area closures (at specific times and places) may prove to be necessary to protect the breeding stocks of this species.

References:
D. Brooks, pers. comm. 8/2000; D. Cameron, pers. comm. 12/1999; Heemstra and Randall, 1993; P. Last, pers. comms. 1999-2000; J. Pogonoski, pers. obs. 10/1999; Rowling, 1994; Rowling, 1995; K. Rowling, pers. comm. 9/1999; Randall and Heemstra, 1991; M. Tanner, pers. comms. 1999-2000; Yearsley *et al*., 1999.

Flowery Cod

Family Name:	Serranidae
Scientific Name:	*Epinephelus fuscoguttatus* (Forsskål, 1775)
Conservation Status:	Lower Risk (least concern)

Taxonomic Problems:
Epinephelus fuscoguttatus is often confused with *E. polyphekadion*

Alternative Common Name:
Brownmarbled grouper; tiger grouper. The Camouflage Grouper, *Epinephelus polyphekadion* is sometimes also referred to as the Flowery Cod.

Current Conservation Status:
No IUCN or ASFB Listings

Distribution:
Widely distributed in the Indo-West Pacific region, including the Red Sea, but not known from the Persian Gulf, Hawaii or French Polynesia. It occurs at most (probably all) of the tropical islands of the Indian and west-central Pacific oceans (east to Samoa and the Phoenix Islands) (Heemstra and Randall, 1993). It also occurs along the east coast of Africa to Mozambique, and it has also been reported from Madagascar, India, Thailand, Indonesia, the tropical coast of Australia (Qld to WA), Japan, the Philippines, New Guinea, and New Caledonia (Heemstra and Randall, 1993).

Museum Records - 41 specimens (Standard Length 68-430mm), collected from depths of 0-25m, ranging in geographical distribution from One Tree Island (23^o 30’ S), Qld northwards to Darnley Island (09^o 35’ S), Qld, and south-westwards to Exmouth Gulf (approx. 22^o S), WA. There are also specimens from Middleton Reef (most southerly record at 29^o S), Gilbert Islands, Cocos (Keeling) Islands, Tuvalu, Santa Cruz Islands and Indonesia. Specimens were collected between circa 1888 and 1997.

Habitat:
Epinephelus fuscoguttatus inhabits lagoon and seaward reefs in areas of rich coral growth and clear water from the shallows to depths of 60m (Lieske and Myers, 1994). Juveniles are found in seagrass areas (Heemstra and Randall, 1993). It also occurs on coastal reefs, mangrove areas and deep slopes (Kuiter, 1993). Russell (1983) reports the species as being rare in the Capricorn Bunker Group of the Great Barrier Reef (22^o 30’ S - 24^o 15’ S), where it occurs in outer reef slope habitats. In Micronesian waters it inhabits lagoon pinnacles, channels and outer reef slopes (Myers, 1989). This species is one of the largest fish predators of coral reefs and rocky substrata. It is not common and is very difficult to approach underwater (Randall and Heemstra, 1991).

Biology and Behaviour:
Epinephelus fuscoguttatus is secretive and wary and is usually about just before dark (Kuiter, 1993). This species may be ciguatoxic (Lieske and Myers, 1994). Age estimates for a 70cm SL specimen is 15-20 years (Choat, pers. comm). According to Lau and Li (2000), this species reaches sexual maturity as a male at a total length of 50cm. It aggregates to spawn and such spawning aggregations are known to occur in the Cairns regions of Queensland and also the Komodo National Park in Indonesia (Sadovy, pers. comm.). Johannes and Kile (2001) found evidence to suggest that this species spawns in June-July at the Solomon Islands, although they noted that the reproductive season differed over spatial scales. The reported stomach contents include fishes, crabs and cephalopods (Heemstra and Randall, 1993).

Size:
Maximum size is at least 95cm total length, and 11kg (Heemstra and Randall, 1993). Myers (1989) reports it to grow to a weight of at least 15.4kg, and Lau and Li (2000) report it to grow to 120cm in length.

Evidence for Decline:

Like many groupers, *E. fuscoguttatus* is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and this is a potential threat to the survival of the species. A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), revealed that *Epinephelus fuscoguttatus* made up 7% (approx 1730t) of the total annual volume of fish imported into Hong Kong for this trade. While these statistics may demonstrate that this species is common in the Indo-Pacific region, continued harvesting at these scales will inevitably lead to localised depletions of populations. Populations in Australia could become increasingly targeted when other countries have depleted their numbers of this species. Although it has been implicated in ciguatera fish poisonings at some localities in the Pacific, it has attracted interest as a candidate for aquaculture in Singapore, which is further evidence of the quality of the flesh for eating (Heemstra and Randall, 1993).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Rowley Shoals Marine Park, off north-western WA
Middleton Reef Marine National Nature Reserve, Tasman Sea

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
Very little biological information exists for this species at current. However, it is not targeted by commercial fishers in Australia and only appears occasionally in the Sydney Fish Markets as an incidental catch.

Threatening Processes:
Commercial and recreational fishing has the potential to negatively impact on this species.

Critical Habitats:
Coral and rocky reefs with clear water are habitats often utilised by this species.

Recovery Objectives/Management Actions Required:
There are currently no size restrictions or catch restrictions on this species in Queensland waters. The QFS has proposed a recreational in-possession limit of five for this species and a minimum legal length of 50cm (D. Cameron, pers. comm.). Further taxonomic, distributional and biological studies on *E. fuscoguttatus* are recommended to gain a better understanding of this species and may help in overcoming the impediment of confusing this species with *Epinephelus polyphekadion.*

References:
D. Cameron, pers. comm. 12/1999; H. Choat, pers. comm. 2/2000; Heemstra and Randall, 1993; Johannes & Kile, 2001; Kuiter, 1993; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; Lieske and Myers, 1994; Myers, 1989; Randall and Heemstra, 1991; Russell, 1983; Y. Sadovy, pers. comm. 3/2000.

Queensland Grouper

Family Name:	Serranidae
Scientific Name:	*Epinephelus lanceolatus* (Bloch, 1790)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Oligorus terra-reginae Ramsay, 1880

Alternative Common Names:
Giant grouper; giant Queensland grouper; Queensland Groper

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A2d)

Protected Species in NSW Waters (Since 1977)

Protected Species in WA waters

No ASFB Listing

Distribution:
Epinephelus lanceolatus is probably the most widely distributed grouper in the world (Heemstra and Randall, 1993) and is found throughout the tropical waters of the Indo-West Pacific (Gomon *et al*., 1994). In Australia, the species occurs all along the tropical and warm temperate coasts, rarely straying into cool temperate waters. It has been recorded on the south coast only once, a 2.1m beach-washed specimen from the seaward side of the Younghusband Peninsula of The Coorong, South Australia (Kailola and Jones, 1981; Gomon *et al*., 1994). It has been recorded from NSW, Queensland, NT, WA and SA. A large individual (approx. 2m total length) of this species was photographed at the Poor Knights Islands in northern New Zealand in May 1991 (Francis and Evans, 1992).

Museum Records - 33 specimens (Standard Length 10.3-200.8cm), collected from depths of up to 45m, ranging in geographical distribution from the Hawkesbury River (33°30'S), NSW northwards to Darnley Island (09°35'S), Qld, westwards to Mandorah (12°25'S, 130°45'E), NT and south-westwards to Rottnest Island (32°00'S), WA. Specimens were collected between circa 1911 and 1999.

Habitat:
Epinephelus lanceolatus has been caught at depths of up to 100m, but it is more often found in shallower waters. It is commonly seen in caves on coral reefs and around wrecks; adults as well as juveniles are found in estuaries (Heemstra and Randall, 1993). Juveniles may occur in brackish water and adults may be found in deep estuaries (Lieske and Myers, 1994). Along outer reefs it has been found in large lagoons and on reef slopes to at least 50m depth (Kuiter, 1993). Parker (1999) reports adults in 18-24m of water at Julian Rocks Aquatic Reserve (off Byron Bay, northern NSW), noting their occurrence as uncommon.

Biology and Behaviour:
According to Lau and Li (2000), *E. lanceolatus* reaches sexual maturity as a male at a total length of 129cm. It is usually solitary by nature (Randall and Heemstra, 1991). Although potentially dangerous to man because of its enormous maximum size, this species is relatively docile and has not been implicated in serious injuries (Gomon *et al*., 1994), although accidental injuries have been reported (Hutchins and Swainston, 1986). Large individuals are known to travel on the high tide across wide stretches of reef-flat that become bare at low water (Grant, 1978). It has a curious nature and will often approach a diver at close range (Allen and Swainston, 1988). Large individuals are often ciguatoxic (Lieske and Myers, 1994). A favourite food of *E. lanceolatus* on coral reefs and in rocky areas is spiny lobsters. A 177cm (Standard Length) fish, caught from the shore at Maui, Hawaiian Islands, contained two spiny lobsters and several

large crabs. It is known to eat a variety of fishes, including small sharks, batoids and juvenile sea turtles. In South African estuaries the main prey item is the mud crab *Scylla serrata* (Heemstra and Randall, 1993).

Size:
Epinephelus lanceolatus is reported to grow to about 3m and 600kg (Gomon *et al*., 1994). The largest Queensland specimen on record weighed 288kg (Grant, 1978).

Evidence for Decline:
Epinephelus lanceolatus is the largest reef-dwelling fish in the world (Gomon *et al*., 1994) and was much sought after by line and spearfishers in NSW prior to its listing as a protected species in NSW in the early 1980's. The IUCN recognises its vulnerability with respect to exploitation, listing it in their 2000 Red List of Threatened Species. Being such a large predator, it is rare, even in areas unexploited by fishing practices (Randall and Heemstra, 1991) and it has nearly been extirpated in areas where it has been heavily fished (Lieske and Myers, 1994). Smaller specimens are edible, but the flesh of large fish is strong flavoured and stringy (Gomon *et al*., 1994). Specimens of 45 to 90cm in length were commonly seen in a survey of the live fish trade in Hong Kong. This is partly because they are perceived to confer good luck, possess medicinal value, and be an indicator of tank water quality. They are also highly valued. In 1997 retail prices were about US $100 per kg, and in 1996 several large specimens were sold for about US $10,000 each. Because of the preferred market size-range (45-90cm), most fish that are sold by the live reef fish trade are juveniles (Lee and Sadovy, 1998) that are sexually immature, limiting the numbers of fish that can survive to reproduce. A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), revealed that *E. lanceolatus* made up 1.9% (approx. 456t) of the total annual volume of fish imported into Hong Kong for this trade. Most of the 456t came from Indonesia (Lau and Parry-Jones, 1999). These statistics may demonstrate that this species is locally common in Indonesia, but the level of effort involved in catching these fish may also be high. Continued high prices in Hong Kong will inevitably lead to localised depletions. Further pressures are likely to be placed on this species in other parts of its range (e.g. Australia or other South-East Asian countries) once Indonesian populations are reduced.

Australian Marine Protected Areas in Which the Species Occurs:
Ningaloo Marine Park, WA
Kakadu National Park, NT
Great Barrier Reef Marine Park and World Heritage Area, Qld
Cook Island Aquatic Reserve, off Tweed Heads, northern NSW
Julian Rocks Aquatic Reserve, off Byron Bay, northern NSW
Solitary Islands Marine Park, north of Coffs Harbour, northern NSW

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis
Continuing fishing pressure may threaten the survival of the Queensland Grouper in Australian waters. Under current Queensland Fisheries regulations there are minimum and maximum legal size limits of 35cm and 120cm respectively, with a recreational in-possession limit of one fish (QFS, 2000c; http://www.dpi.qld.gov.au/fishweb/). It is likely that the QFS will propose for the Subtropical Fishery (Rockhampton to NSW / Queensland border) that the minimum size limit remain at 35cm, but the maximum size be reduced to 100cm. The recreational in-possession limit is proposed to remain unchanged (D. Cameron, pers. comm.). Adequate protection in Queensland is necessary for it to increase its numbers. Under Northern Territory Regulation 9 of the Fisheries Act, no species of the genus *Epinephelus* above the size of 120cm may be taken (H. Larson, pers. comm.). It is recommended to assign this species the above status, adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing activities, including the live reef fish trade and the marine aquarium fish trade, have the potential to adversely affect the populations of this species.

Critical Habitats:
This species occupies a variety of habitats depending on its stage of growth. Estuaries and coral reef and associated habitats are important to its survival.

Recovery Objectives/Management Actions Required:
The proposed QFS maximum size limit of 100cm needs to be adopted in Queensland waters and enforced to protect the breeding male individuals of this species. More biological information needs to be accumulated. It is uncertain whether it undertakes any form of migration or whether it aggregates to spawn. These are areas where future research could be focused, possibly by radiotracking surveys of individual fish.

References:
Allen and Swainston, 1988; Anon., 1995; D. Cameron, pers. comm. 12/1999; Francis and Evans, 1992; Grant, 1978; Gomon *et al*., 1994; Heemstra and Randall, 1993; Hutchins and Swainston, 1986; Kailola and Jones, 1981; Kuiter, 1993; H. Larson, pers. comm. 12/1999; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; Lieske and Myers, 1994; Parker, 1999; Perry, 1999; QFS, 2000c; Randall and Heemstra, 1991.

Websites:
http://www.dpi.qld.gov.au/fishweb (Queensland Department of Primary Industries homepage)

Malabar Grouper

Family Name:	Serranidae
Scientific Name:	*Epinephelus malabaricus* (Bloch and Schneider, 1801)
Conservation Status:	Lower Risk (least concern)

Taxonomic Problems:
Epinephelus malabaricus is commonly confused with both *Epinephelus coioides* and *E. tauvina.*

Alternative Common Name:
Estuary cod

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Epinephelus malabaricus is known from the Red Sea and Indo-Pacific region (South Africa to Japan, Australia, Palau, Yap and Fiji). It occurs in continental and insular localities. In Australia it occurs from Ningaloo Reef, WA (B. Hutchins, pers. comm.) north-eastwards to the NT and Queensland and southwards to the Sydney area in NSW. It is not known from the Persian Gulf where the closely related *E. coioides* is common (Heemstra and Randall, 1993).

Museum Records - 108 specimens (Standard Length 57-642mm), collected from a depth range of 0-55m, ranging in geographical distribution from Brisbane Water (33^{o} 36' S), NSW northwards to Friendly Point (13^{o} 23' S), Qld, westwards to Darwin (12^{o} 25' S, 130^{o} 50' E), NT and south-westwards to Yardie Creek, WA (22^{o} 20' S). There are also records from British Malaya, Malaysia, Solomon Islands, Indonesia and India. Specimens were collected between circa 1883 and 1998.

Habitat:
Epinephelus malabaricus is a common species that is found in a variety of habitats including coral and rocky reefs, tidepools, estuaries, mangrove swamps and sandy / mud bottom from shore to depths of 150m (Heemstra and Randall, 1993). In a study of Alligator Creek, an estuary on the coast of tropical north-eastern Australia, Sheaves (1996) found *E. malabaricus* numbers increasing from the lower parts of the creek to upstream areas, where this species became the dominant serranid. Sheaves captured 334 fish between 122 and 619mm Fork Length (FL), with most fish measuring below 400mm.

Biology and Behaviour:
In South African waters this species is strongly territorial and solitary, and its mottled colours provide an effective camouflage in the shadows beneath rocky ledges or inside caves (Van der Elst, 1988). Spawning has been recorded from August to October. Smaller specimens venture into estuaries, but are not tolerant of excessive salinity changes (Van der Elst, 1988). Adults are difficult to approach underwater (Randall and Heemstra, 1991). In a mark-release-recapture study in tropical northern Australia, Sheaves (1993) found that three *E. malabaricus* individuals were recaptured in the upper part of the study area during flooding, at which time the salinity had was less than 1ppt. In the same study mentioned above, Sheaves (1993) found this species to have a relatively small home range, usually being recaptured within 40m of the site of release. Sexual maturity is attained at a length of 70-80cm (Van der Elst 1988). According to Lau and Li (2000), sexual maturity as a male occurs at a length of around 114cm. Sheaves (1996) noted that it was common within estuaries of tropical eastern Australia where, despite occurring to sizes of 400mm FL or more, the populations consist almost entirely of pre-reproductive females. In the same study, an *E. malabaricus* tagged at Barramundi Creek (length at release 480mm FL) was captured by an angler seventeen months later on Lodestone Reef, some 75km to the north (Sheaves, 1996). *Epinephelus malabaricus* feeds equally on fishes and crustaceans and occasionally on octopuses (Heemstra and Randall, 1993). Most feeding takes place during the day (Van der Elst, 1988).

Size:
Epinephelus malabaricus is reported to attain a length of at least 120cm and a weight of 150kg (Lieske and Myers 1994), but the maximum size is uncertain because of confusion with other large groupers (Heemstra and Randall, 1993). Sheaves (1995) reports a 119.9cm FL specimen from north-eastern Australia and in August 2000, a 1.28m total length (TL) specimen was taken by commercial fishers at Slashers Reefs, north of Townsville, Queensland (J. Johnson, pers. comm.). According to Lau and Li (2000) this species attains 234cm TL.

Evidence for Decline:
Epinephelus malabaricus is undoubtedly one of the most important groupers in fisheries and aquaculture of the Indo-Pacific region, and is also one of the most common. It is caught with trawls, longlines, traps, spear and hook-and-line (Heemstra and Randall, 1993). Like many groupers, *E. malabaricus* is traded in the live fish trade in Hong Kong, and this is a potential threat to the survival of the species. The species is also reared in Hong Kong via mariculture (Lee and Sadovy, 1998). Being a very territorial species and growing to a large size (>1m), *E. malabaricus* is susceptible to fishing pressures and local abundances could decline at rates faster than which it could recover.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Possibly occurs in the following areas:
Coburg Marine Park, NT
Ningaloo Marine Park, WA
Solitary Islands Marine Park, northern NSW

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
A relatively common species worldwide, *E. malabaricus* may be susceptible to fishing pressures from recreational and commercial fishers.

Threatening Processes:
Commercial and recreational line fishing are potential threats to the survival of this species in Australian waters. In other countries threats include the live reef fish trade, involving the removal of many juveniles for mariculture grow-out.

Critical Habitats:
Estuarine habitats are important nursery areas for this species.

Recovery Objectives/Management Actions Required:
Adults are assumed to leave estuarine areas to spawn offshore, so the protection of specific offshore areas is important for conserving the mature individuals of this species. Under Queensland Fisheries Service (QFS) regulations the current size limits for this species are 35cm minimum and 120cm maximum, whilst the current recreational in-possession limit is 10 for any *Epinephelus* species, of which this species is included. It is likely to be proposed by the QFS for the Subtropical Fishery (Rockhampton to NSW/Queensland Border) that the minimum size remain at 35cm, but the maximum size be reduced to 100cm. It is also proposed that the recreational in-possession limit be reduced to 5 for a combination of *Epinephelus coioides* and *Epinephelus malabaricus* (D. Cameron, pers. comm.). Further study on the taxonomy of this species is also recommended to accurately assess its distribution and abundance, due to the confusion with other closely related *Epinephelus* species mentioned above. Like many species in the genus, further biological study is necessary to determine age / size classes, sex ratios and fecundity.

References:
D. Cameron, pers. comm. 12/1999; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; J. Johnson, pers. comm. 9/2000; Lau and Li, 2000; Lee and Sadovy, 1998; Lieske and Myers, 1994; Randall and Heemstra, 1991; Sheaves, 1993; Sheaves, 1995; Sheaves, 1996; Van der Elst, 1988.

Camouflage Grouper

Family Name:	Serranidae
Scientific Name:	*Epinephelus polyphekadion* (Bleeker, 1849)
Conservation Status:	Lower Risk (least concern)

Taxonomic Problems:
Epinephelus polyphekadion has often been confused with the Flowery Cod *Epinephelus fuscoguttatus,* a species that it shares almost the same distribution with.

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Epinephelus polyphekadion is widely distributed in the tropical and sub-tropical Indo-West Pacific region from the Red Sea and east coast of Africa to French Polynesia. In the western Pacific it ranges from southern Japan to southern Queensland and Lord Howe Island. Gill and Reader (1992) report *E. microdon* (a synonym of *E. polyphekadion*) from Elizabeth Reef and from Middleton Reef. In Australian waters it is known from Shark Bay, WA (B. Hutchins, pers. comm.) north-eastwards to the Northern Territory and northern Queensland and southwards to southern Queensland on mainland Australia, and it is also found at offshore localities such as Elizabeth and Middleton Reefs and Lord Howe Island.

Museum Records - 33 specimens (Standard Length 35-490mm), collected from depths of 0-35m, ranging in geographical distribution from One Tree Island (23^{o} 30' S), Qld northwards to the far northern Great Barrier Reef (10^{o} 34' S), Qld south-westwards to Broome (17^{o} 58' S, 122^{o} 14' E), WA. Offshore and island localities include French Polynesia, Fiji, Solomon Islands, Lord Howe Island, Cocos (Keeling) Island, Gilbert Islands, the Philippines, and Middleton and Elizabeth Reefs. Specimens were collected between circa 1896 and 1998.

Habitat:
Epinephelus polyphekadion is almost always found in clear water on coral reefs, either in lagoons or on the outer reef; it is most abundant at islands, particularly atolls (Heemstra and Randall, 1993). It has been found in reef caves, gutters, beneath bommies (Gill and Reader, 1992), in coastal bays and protected inner reefs (Kuiter, 1996). Gill and Reader (1992) report *E. polyphekadion* (as *E. microdon*) to be uncommon in reef slope and lagoon habitats at Elizabeth and Middleton Reefs, respectively. It occurs at depths of 2 to 46m (Myers, 1989).

Biology and Behaviour:
Heemstra and Randall (1993) noted that females mature at around 38cm SL (approx. 47cm TL) and males mature at about 42cm SL (approx. 52cm TL). Lau and Li (2000) report that males mature at 58cm total length. Spawning occurs from January to February (Heemstra and Randall, 1993). This species is unwary of divers and it is uncommon at localities with heavy spearfishing (Heemstra and Randall, 1993). Johannes and Kile (2001) found evidence to suggest that this species spawns in June-July at the Solomon Islands, although they noted that the reproductive season differed over spatial scales. It is a solitary species (Myers, 1989), except when aggregating to spawn. It feeds mainly on crustaceans (primarily portunid crabs, but also some scyllarid and panularid lobsters) and fishes, though gastropods and cephalopods are lesser important food items (Heemstra and Randall, 1993).

Size:
Epinephelus polyphekadion attains at least 75cm total length and a weight of 4kg (Heemstra and Randall, 1993). Lau and Li (2000) report the maximum size as 109cm total length.

Evidence for Decline:
Epinephelus polyphekadion was formerly common in the markets of Zanzibar and probably throughout its range. It is of considerable importance in the artisanal fisheries of the tropical Indo-Pacific region, but

occasionally implicated in cases of ciguatera fish poisonings. Recently, the aquaculture industry of Singapore has become interested in the culture of this species. It is caught with hook-and-line, spears and traps. Like many groupers, it is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and this is a potential threat to its survival. A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), revealed that *E. polyphekadion* made up 5% (approx. 1200t) of the total annual volume of fish imported into Hong Kong for this trade. While these statistics may demonstrate that this species is common in the Indo-Pacific region, continued harvesting at these scales will inevitably lead to localised depletions of populations. Populations of this species in Australia could become increasingly targeted when other countries have depleted their numbers.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Lord Howe Island Marine Park, Tasman Sea
Middleton and Elizabeth Reefs Marine National Nature Reserve, Tasman Sea
Possibly also occurs in the following areas:
Ningaloo Marine Park, WA (unconfirmed)
Shark Bay Marine Park, WA (unconfirmed)
Hamelin Pool Marine Nature Reserve, WA (unconfirmed)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis
Although *E. polyphekadion* is widely distributed, it may be susceptible to overfishing, especially spearfishing, as it is easy to approach underwater. There are currently no size restrictions or catch restrictions on this species in Queensland waters. The QFS has proposed a recreational in-possession limit of five for this species and a minimum legal length of 50cm (D. Cameron, pers. comm.). It has been recorded at offshore islands in warm temperate waters (Lord Howe Island, Middleton and Elizabeth Reefs), presumably taken southwards as eggs and larvae on the warm, eastern Australian current. It is doubtful whether *E. polyphekadion* would mature and reproduce in these areas. It is recommended to assign the above conservation status, adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing, including the life reef fish trade, are potential threats to this species. Habitat degradation of coral reefs also has the potential to affect its numbers.

Critical Habitats:
Habitats associated with atolls and islands appear to be crucial to this species.

Recovery Objectives/Management Actions Required:
Proposed QFS regulations would help protect the smaller individuals of this species in Queensland waters. Further work on the taxonomy may help in overcoming the impediment of confusing this species with *Epinephelus fuscoguttatus.*

References:
D. Cameron, pers. comm. 12/1999; Gill and Reader, 1992; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; Johannes & Kile, 2001; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; Myers, 1989.

Greasy Rockcod

Family Name:	Serranidae
Scientific Name:	*Epinephelus tauvina* (Forsskål, 1775)
Conservation Status:	Lower Risk (least concern)

Australian Synonyms:
Serranus goldiei Macleay, 1883

Taxonomic Problems:
Most of the literature concerning *E. tauvina* that was published before 1984 was based on misidentifications of *E. coioides*, *E. malabaricus*, and *E. lanceolatus* (Heemstra and Randall, 1993).

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Epinephelus tauvina occurs from the Red Sea to South Africa and eastward to Dulcie in the Pitcairn Group, the easternmost atoll of Oceania; in the western Pacific it ranges from Japan to northern NSW and Lord Howe Island (Heemstra and Randall, 1993). In Australia, it occurs from Shark Bay, WA (B. Hutchins, pers. comm.) north-eastwards to Queensland and southwards to northern NSW. It is fairly common in lightly fished areas of Micronesia (Myers, 1989).

Museum Records - 78 specimens [Standard Length (SL) 28-541mm], collected from depths of 0-79m, ranging in geographical distribution from Manning River Heads (31^o 52’ S), NSW northwards to Thursday Island (10^o 35’ S), Qld, westwards to Ashmore Reef (12^o 13’ S, 123^o 00’ E), Timor Sea and south-westwards to the Abrolhos Islands (28^o 55’ S) WA. Other localities include Lord Howe Island, Solomon Islands, Gilbert Islands, PNG, and the Malay Archipelago. Specimens have been collected between circa 1883 and 1993.

Habitat:
Epinephelus tauvina prefers clear waters on coral reefs; juveniles have been taken on reef flats and in tidepools, but adults are found in depths to at least 50m (Heemstra and Randall, 1993).

Biology and Behaviour:
Epinephelus tauvina is probably solitary by nature. It is occasionally ciguatoxic (Myers, 1989). The adults from Oceania were almost exclusively piscivorous and only 1 of 19 fish examined that contained food had eaten a crab. Fishes consumed included holocentrids (squirrelfishes), mullids (goatfishes) and pomacentrids (damselfishes) (Heemstra and Randall, 1993). According to Lau and Li (2000) this species matures at 61cm Total Length (TL).

Size:
Heemstra and Randall (1993) note that this species attains 61cm SL (75cm TL), but Lau and Li (2000) report it to attain 107cm TL.

Evidence for Decline:
Perhaps due to the limited information available for this species (partly because of taxonomic confusion with other grouper species mentioned above), no evidence of any declines could be found. However, like other species in the genus, they are probably susceptible to exploitation by line and spearfishers. Like many groupers, it is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and this is a potential threat to its survival.

Australian Marine Protected Areas in Which the Species Occurs:
Ashmore Reef National Nature Reserve, off northern WA
Great Barrier Reef Marine Park and World Heritage Area, Qld

Lord Howe Island Marine Park, Tasman Sea
Possibly occurs in the following areas:
Cartier Island Marine Protected Area, off northern WA (unconfirmed)
Ningaloo Marine Park, WA (unconfirmed)
Shark Bay Marine Park, (WA (unconfirmed)
Hamelin Pool Marine Nature Reserve, WA (unconfirmed)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
There appears to be no current size limits for this species under Queensland Fisheries Service (QFS) regulations. The QFS has proposed a recreational in-possession limit of five of this species (D. Cameron, pers. comm.). Further study is recommended on the biology and distribution of *E. tauvina*, especially in Australian waters. It is recommended that this species be listed as Lower Risk (least concern), adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing, including the live reef fish trade, are potential threats to this species.

Critical Habitats:
Undegraded coral reef habitats are crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
The proposed QFS recreational in-possession limit would help ensure the survival of this species in Queensland waters. Further study on the taxonomy and biology is recommended to accurately assess its distribution, abundance and biological parameters, due to the confusion with other closely related *Epinephelus* species mentioned above.

References:
D. Cameron, pers. comm. 12/1999; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; Lau and Li, 2000; Lee and Sadovy, 1998; Myers, 1989.

Potato cod

Family Name:	Serranidae
Scientific Name:	*Epinephelus tukula* Morgans, 1959
Conservation Status:	Lower Risk (conservation dependent)

Alternative Common Name:
Potato grouper

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Protected Species in Western Australian (WA) waters

Protected from Spearfishing in Natal (South Africa) waters

Distribution:
Epinephelus tukula occurs from the western Indian Ocean and Red Sea to the western Pacific. In Australia, it is known from WA and Queensland (Heemstra and Randall, 1993). In WA, it occurs southwards to Shark Bay (B. Hutchins, pers. comm.) and in Queensland waters it is found throughout the northern waters of the Great Barrier Reef (QFS, 2000d).

Museum Records – 5 specimens (Standard Length 48-580mm), collected from a depth range of 3-12m ranging in geographical distribution from the Townsville district (19^{o}20'S), Qld northwards to Tijou Reef (13^{o}04'S), Cape York, Qld and there are also two records from Kendrew Island (20^{o}29'S), Dampier Archipelago, WA. Specimens were collected between 1963 and 1991.

Habitat:
Epinephelus tukula is a coral reef species. Juveniles may be found in tidepools and adults occur in depths of 10-150m (Heemstra and Randall, 1993), although they occasionally occur in depths of up to 400m (QFS, 2000d). It is generally seen on offshore reefs and islands, along the faces of drop offs and channel slopes where it inhabits grottoes and reef channels open to the sea. During the day it sometimes patrols along the sea floor and it is rarely seen far away from the reef (Coleman, 1981). It inhabits coral reefs in the vicinity of caves and crevices, but is more commonly found on offshore reefs (Allen and Swainston, 1988).

Biology and Behaviour:
Morgans (1959) estimated that maturity occurs at about 90cm Standard Length (a weight of about 18kg). Lau and Li (2000) report maturity to be attained at 99cm TL. According to Van der Elst (1988) *E. tukula* is exceedingly territorial and is very aggressive towards unwelcome intruders. It is a large solitary predator (Coleman, 1981) that is bold and easily approached (Lieske and Myers, 1994). This species is hand fed by divers in certain areas, but is potentially dangerous to the inexperienced. A diver has drowned after being knocked in the chest by a large individual (Lieske and Myers, 1994). In captivity, adult *E. tukula* are capable of changing its colours (i.e. turning its spots "on and off") depending on the background colour (J. Pogonoski, pers. obs.). It feeds on a wide variety of reef fishes, skates, crabs and spiny lobsters (Van der Elst, 1988) and occasionally cephalopods (Lieske and Myers, 1994).

Size:
This species attains at least 150cm total length and 90kg. According to Lieske and Myers (1994) it attains 200cm length and a weight of 110kg.

Evidence for Decline:
The large size and territorial behaviour of *E. tukula* makes it especially vulnerable to spearfishers (Heemstra and Randall, 1993). Like many groupers, it is traded in the live fish trade in Hong Kong (Lee and Sadovy, 1998), and this is a potential threat to the survival of the species. However, more accurate data is necessary to validate any perceived declines.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
South Muiron Island Sanctuary Zone, north of Exmouth Gulf, WA
Possibly occurs in the following areas:
Ningaloo Marine Park, WA (unconfirmed)
Shark Bay Marine Park, WA (unconfirmed)
Hamelin Pool Marine Nature Reserve, WA (unconfirmed)

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis
Epinephelus tukula is a large, reef-dwelling fish susceptible to exploitation by line and spearfishers. It is uncommon and localised (Lieske and Myers, 1994). Under Queensland Fisheries Service (QFS) legislation the current legal sizes for this species are 35cm minimum and 120cm maximum, and the current recreational in-possession limit for this species is one fish (http://www.dpi.qld.gov.au/fishweb/). The QFS has proposed that an in-possession boat limit for any fisher/boat is one, and that the minimum legal size is increased to 65cm length, whilst retaining the maximum size of 120cm (D. Cameron, pers. comm.). It is recommended to assign the conservation status of Lower Risk (conservation dependent), adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing, including the live reef fish trade, are potential threats to the survival of this species.

Critical Habitats:
Undegraded offshore coral reefs are crucial to the survival of this species. It is quite specific in its habitat preferences.

Recovery Objectives/Management Actions Required:
It is crucial that the proposed QFS regulations are adopted and enforced for this species to maintain its surviving stocks in the wild.

References:
Allen and Swainston, 1988; D. Cameron, pers. comm, 12/1999; Coleman, 1981; Heemstra and Randall, 1993; B. Hutchins, pers. comm. 1/2000; Lau and Lee, 2000; Lee and Sadovy, 1998; Lieske and Myers, 1994; Morgans, 1959; J. Pogonoski, pers. obs. 5/2000; QFS, 2000d; Van der Elst 1988.

Websites:
http://www.dpi.qld.gov.au/fishweb/ (Queensland Department of Primary Industries homepage)

Kimberley dottyback

Family Name:	Pseudochromidae
Scientific Name:	*Assiculoides desmonotus* Gill and Hutchins, 1997
Conservation Status:	Data Deficient

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Assiculoides desmonotus was recently described from 61 specimens (11.0 - 54.8mm SL), and is only known from the Kimberley coast and adjacent coastal islands of Western Australia, from Jones Island (13^{o} 45' S, 126^{o} 22' E) southwards to Mermaid Island (16^{o} 26' S, 123^{o} 21' E) (Gill and Hutchins, 1997).

Museum Records - 29 specimens (Standard Length 16-52mm), all collected from a depth range of 0.1 - 0.3m from Vansittart Bay (13^{o} 59' S, 126^{o} 20' E), WA in 1995.

Habitat:
Assiculoides desmonotus is currently known from only very shallow (less than 1.5m), muddy reef and seagrass habitats (Gill and Hutchins, 1997). It is very common on intertidal reefs in the Kimberley region (B. Hutchins, pers. comm.).

Biology and Behaviour:
Unknown. Members of the Pseudochromidae family feed on small crustaceans (A. Gill, pers. comm).

Size:
Specimens collected to date have not exceeded 55mm SL (Gill and Hutchins, 1997).

Evidence for Decline:
There is no documentary evidence of decline. This species has a narrow range, is endemic to a small area of the Kimberley coast and adjacent islands, and has been found only in very shallow waters, which could potentially be subject to future habitat degradation.

Australian Marine Protected Areas in Which the Species Occurs:
None identified.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species has a narrow range and inhabits relatively shallow waters, rendering it vulnerable to habitat degradation. It is recommended to assign the conservation status of Data Deficient, adopting the IUCN categories. Further research is necessary to determine the accurate distributional range, abundance and biological characteristics of this species.

Threatening Processes:
Habitat degradation of shallow intertidal areas is a potential threat to this species.

Critical Habitats:
Shallow intertidal reefs associated with mud and seagrass appear to be important to this species.

Recovery Objectives/Management Actions Required:
Adequate protection of the shallow water habitats in which this species occurs is required to ensure the survival of the breeding populations of this species.

References:
A. Gill, pers. comm. 7/1999; Gill and Hutchins, 1997; B. Hutchins, pers. comm. 1/2000.

Pilbara Eelblenny

Family Name:	Pseudochromidae
Scientific Name:	*Congrogadus* (*Pilbaraichthys*) *winterbottomi* Gill, Mooi and Hutchins, 2000
Conservation Status:	Data Deficient

Alternative Common Name:
Winterbottom's eelblenny

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Gill, Mooi and Hutchins first collected *Congrogadus winterbottomi* in 1996. It has a very restricted distribution from the Exmouth Gulf northwards to the Onslow region in Western Australia.

Museum Records – 2 specimens (Standard Length 67-74mm), collected from a depth range of 0 to 0.4m at Middle Mangrove Island (21^{o} 29' S), WA.

Habitat:
Congrogadus winterbottomi has been found in shallow (<1m depth) tidal pools, in limestone reefs, with *Sargassum* and mainly sandy or muddy bottoms (very little coral) (Gill *et al*., 2000).

Biology and Behaviour:
Unknown. Members of the Pseudochromidae family feed on small crustaceans (A. Gill, pers. comm.).

Size:
Congrogadus winterbottomi reaches a maximum Standard Length of at least 85mm.

Evidence for Decline:
There is no documentary evidence of any decline. It has only recently been discovered. However, despite sampling in similar habitat, it was not collected further offshore during the West Pilbara Island survey, nor in comprehensive collections made by Hutchins *et al.,* further to the south (Ningaloo Reef and Shark Bay) and north (Dampier Archipelago and the Kimberley coast) (Gill *et al.,* 2000). Thus the apparently restricted distribution appears to be real. Such narrow distributions are not unusual in the Pseudochromidae family, and several species are confined to the north-western Australian coast (Gill *et al.*, 2000).

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Considering the recent discovery of this species, and its restricted distribution and shallow habitat requirements, it is recommended to assign the above conservation status, adopting the IUCN categories.

Threatening Processes:
None identified.

Critical Habitats:
Specimens found to date have been associated with shallow, sandy or muddy substrate tidal pools with algae. These habitats may prove to be important to this species.

Recovery Objectives/Management Actions Required:
Habitat protection may be required to protect the breeding populations of this species.

References:

A. Gill, pers. comm. 1999-2000; Gill *et al*., 2000.

Multicolour dottyback

Family Name:	Pseudochromidae
Scientific Name:	*Ogilbyina novaehollandiae* (Steindachner, 1880)
Conservation Status:	Data Deficient

Taxonomic Confusion:
Ogilbyina novaehollandiae is very similar to the Queensland dottyback *Ogilbyina queenslandiae*, which usually shows a more barred pattern and ranges further northwards (Kuiter, 1993).

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Ogilbyina novaehollandiae is a tropical to subtropical, inshore endemic species which is distributed from Palm Island (18^{o} 04' S), Great Barrier Reef, Queensland southwards to Cook Island (28 12' S), off northern NSW (J. Johnson, pers. comm.).

Museum Records - 27 specimens (Standard Length 35-73mm), collected from depths of 2-32m, ranging in geographical distribution from Palm Island (18^{o} 04' S), Qld southwards to Moreton Bay (27^{o} 15' S), Qld, collected between circa 1905 and 1998.

Habitat:
Ogilbyina novaehollandiae inhabits coastal and inner reefs in mixed coral and algal reef (Kuiter, 1993).

Biology and Behaviour:
This species is secretive, staying in the shade of ledges when darting between hiding places (Kuiter, 1993). Members of the Pseudochromidae family feed on small crustaceans (A. Gill, pers. comm.).

Size:
Ogilbyina novaehollandiae reaches a maximum length of 10cm (Kuiter, 1993)

Evidence for Decline:
There is no documentary evidence of decline. Its main threat is collection for the aquarium trade. Specimens have been seen in Sydney aquarium shops for $30 each and up to A $150 each in the United Kingdom (A. Gill, pers. comm.). This species is important to the aquarium fish trade in Queensland (QFS, 1999).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
This species inhabits relatively shallow waters, rendering it vulnerable to potential habitat degradation. It is apparently not uncommon throughout its known range. It is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Over-collecting by the marine aquarium fish trade and inshore habitat degradation are potential threats to this species.

Critical Habitats:
Relatively shallow coastal reefs are important habitats for this species

Recovery Objectives/Management Actions Required:

Habitat protection and strict monitoring of aquarium trade collecting may be required to protect the breeding populations of this species. Further information is needed on the numbers of this species collected by the aquarium industry.

References:
A. Gill, pers. comm. 7/1999; J. Johnson, pers. comm. 9/1999; Kuiter, 1993; Paxton *et al*., 1989; QFS, 1999.

Eastern blue devil

Family Name:	Plesiopidae
Scientific Name:	*Paraplesiops bleekeri* (Günther, 1861)
Conservation Status:	Lower Risk (conservation dependent)

Taxonomic Status:
Originally described as *Plesiops bleekeri* by Günther in 1861. Subsequently placed in the genus *Paraplesiops* by Hoese and Kuiter in 1984.

Alternative Common Names:
Bleekers devilfish; blue-tipped longfin

Current Conservation Status:
<u>Protected species in NSW waters</u>

<u>No IUCN (1996, 2000) or ASFB Listings</u>

Distribution:
Paraplesiops bleekeri is an inshore, warm-temperate endemic species which occurs on the east coast from southern Queensland to Montague Island, but is most common in NSW from Sydney southwards to Ulladulla (Kuiter, 1993). Parker (1999) recorded adults from Julian Rocks in depths of 18-30m, noting their abundance as uncommon. Around Sydney it occurs in the more saline parts of estuaries, along the rocky coastline and around offshore islands.

<u>Museum Records</u> - 61 specimens (Standard Length: Larvae to 280mm), collected from a depth range of 0-40m, ranging in geographical distribution from Queenscliff (38^{o} 16' S), Victoria northwards to Nine Mile Reef (28^{o} 10' S), Qld, collected between circa 1881 and 1992.

Habitat:
Paraplesiops bleekeri occurs in shallow waters in estuaries, but in deeper waters offshore from 3-30m (Kuiter, 1993). Juveniles are rarely seen, the few observed were well in the back of narrow ledges (Kuiter, 1979). It is a benthic, inshore reef inhabitant (Paxton *et al.*, 1989).

Biology and Behaviour:
Paraplesiops bleekeri is a shy, secretive fish that breeds in the warmer months from October to March (Parish, 1974). They spend most of their time inside caves and ledges, often solitary and most often active during the night. They are likely mouthbreeders (Kuiter, 1979). Larvae have been taken in the coastal waters off Sydney from November to February and April to May (Neira *et al.*, 1998) which suggests that it is a fecund fish. No dietary information could be found in the literature.

Size:
To about 40cm (Kuiter, 1993)

Evidence for Decline:
There is no documentary evidence of decline. Their secretive habits make their conservation status difficult to assess. The main threat to this species would be collection for the aquarium trade.

Australian Marine Protected Areas in Which the Species Occurs:
Solitary Islands Marine Park (north of Coffs Harbour, northern NSW)
Long Reef Aquatic Reserve (Sydney, NSW)
Jervis Bay Marine Park (off Huskisson, southern NSW)
Bushrangers Bay Aquatic Reserve (Bass Point, southern NSW)

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
This species is not commonly seen, possibly due to its habits of hiding in caves, and under rock ledges.
A conservation status of Lower Risk (conservation dependent) was agreed upon, based on its protection in NSW waters by the NSW State legislation. If the protected status of this species were removed, it could potentially become scarcer.

Threatening Processes:
Collection for the marine aquarium fish trade, which is now limited to licenced collectors only, is a potential threat to this species.

Critical Habitats:
Benthic estuarine and rocky offshore reef areas appear to be critical to the survival of this species.

Recovery Objectives/Management Actions Required:
Habitat protection is required to protect the breeding populations of this species.

References:
Kuiter, 1979; Kuiter, 1993; Neira *et al*., 1998; Parish, 1974; Parker, 1999; Paxton *et al*., 1989.

Ballina Angelfish

Family Name:	Pomacanthidae
Scientific Name:	*Chaetodontoplus ballinae* Whitley, 1959
Conservation Status:	Lower Risk (near threatened)

Current Conservation status:
Protected Species in NSW waters

No IUCN (1996, 2000) Listing

ASFB Threatened Fishes Committee
1994-1999: Requiring Investigation of its status

Distribution:
Currently, this species is known to occur in northern New South Wales (Coffs Harbour, Ballina and North Solitary Islands) and the Balls Pyramid area of Lord Howe Island Marine Park (Allen *et al*., 1998).

Museum Records - 5 specimens (Standard Length 152-160mm), the first from a deep water fish trap off Ballina Bar in the late 1950s, the second from a deep trawl by the Research Vessel Kapala in 1978 off Evans Head in 123m of water, and the remaining three were collected by Peter Parker *et al*., near Balls Pyramid (a seamount approx. 25km south-east of Lord Howe Island) in January 1994 (the same month the first known photographs of live specimens were taken from the same locality). There are also sight records from divers near Kingscliff (northern NSW, 28^{o} 15’ S), Flat Rock (27^{o} 24’ S), off Point Lookout, Stradbroke Island, Queensland (J. Johnson, pers. comm.) and Seal Rocks (NSW).

Habitat:
Chaetodontoplus ballinae inhabits coral and rocky reefs in depths between 25-123m. Near Balls Pyramid it was associated with a large, rocky pinnacle that rose to within 12m of the surface (encrusted with hard corals *Acropora solitaryensis*, *A. palifera*, *A. glauca*, *A. lovelli*, *Porites* spp and *Pocillopora damicornis*) (Parker, 1994).

Biology and Behaviour:
This species is benthic in deep water. Parker (1994) observed three pairs near Balls Pyramid and estimated each pair’s territory to be c. 2500 square metres. Nothing is known about the diet of this species, but other species in this genus feed on sponges, tunicates and algae (Allen *et al*., 1998).

Size:
Chaetodontoplus ballinae grows to about 20cm in length.

Evidence for decline:
The species is perhaps not as rare as museum specimens suggest, as it occurs in generally deeper (at and often below the limits of scuba diving), rocky regions such as seamounts, which are difficult to sample. Angelfishes are much sought after in the aquarium trade, which could be a serious potential threat given its difficulty to collect in the wild.

Australian Marine Protected Areas in Which the Species Occurs:
Lord Howe Island Marine Park, Tasman Sea (includes Balls Pyramid)

Suggested Conservation Status:
Lower Risk (near threatened) on an Australian-wide basis
It is recommended that the species be listed as Lower Risk (near threatened), until the time when better population estimates are available to re-assess its conservation status.

Threatening Processes:
Illegal collecting by the marine aquarium fish trade, where this species would attract high prices due to its rarity and difficulty in collecting, is a potential threat to this species.

Critical Habitats:
Deep (greater than 20m) coral and rocky reefs appear crucial to the survival of this species.

Recovery Objectives/Management Actions Required:
More scientific study is needed to determine the exact range of the species. Legislation should include a total ban against collecting, except perhaps for controlled scientific studies.

References:
Allen *et al*., 1998; D. Hiscoe, pers. comm. 9/2000; J. Johnson, pers. comm. 1999; Parker, 1994.

Bluefish

Family Name:	Kyphosidae
Scientific Name:	*Girella cyanea* Macleay, 1881
Conservation Status:	Lower Risk (near threatened)

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Girella cyanea occurs in the inshore waters of New South Wales, Elizabeth and Middleton Reefs, Lord Howe Island, Norfolk Island, the Kermadec Islands and northern New Zealand (Gill and Reader, 1992). Hutchins and Swainston (1986) remarked that this species is occasionally found on coastal reefs of NSW from Byron Bay to Eden. Randall (1973) observed this species at Lord Howe Island, noting their occurrence as locally abundant at times. In New Zealand (NZ) waters this species occurs from North Cape at the northern tip of the north Island southwards to the Cook Strait, and also at the Kermadec Islands (Francis, 1996b).

Museum Records: 132 specimens (Standard Length 18-485mm), collected from depths of 1-20m, ranging in geographical distribution from Eden (37^{o} 04' S), NSW northwards to Flinders Reef (26^{o} 58' S), Qld for mainland Australia. Island localities include Elizabeth and Middleton Reefs, Lord Howe Island, Norfolk Island, and the Kermadec Islands, north of NZ. Specimens were collected between circa 1886 and 1993.

Habitat:
Girella cyanea is an ocean dweller that does not enter rivers or estuarine areas (Ogilby, 1893). This species prefers coastal reefs and offshore rocky reef areas in NSW (Hutchins and Swainston, 1986). It also inhabits rocky shoals and headlands (Roughley, 1916). Gill and Reader (1992) noted this species as common on the reef flat at Elizabeth Reef and very common on the reef slopes of both Elizabeth and Middleton Reefs. Juveniles inhabit tidal pools and adults form schools over reef areas (Gill and Reader, 1992). It inhabits rocky reefs from 5 to 30m depth in NSW, but is now very uncommon in NSW coastal waters (Coleman, 1980). In NZ, this species inhabits shallow reefs with caves, tunnels and large boulders (Francis, 1996b).

Biology and Behaviour:
Girella cyanea is a strong swimmer and it is known to spawn in December (Roughley, 1916). Ogilby reported the following in 1893 "A large female caught off Botany Heads (Sydney) during the month of December had the ova ready for extrusion, while another taken off Broken Bay (Sydney) within a few days was in poor condition and showed unmistakable signs of having shed its spawn a short time previously". The ova are probably deposited at considerable depth in the vicinity of weed-covered rocks (Ogilby, 1893). Preliminary ageing studies (sample size 69 fish) by NSW Fisheries suggests that fish within the size range of 22 to 52.5cm (Fork Lengths, FL) correspond to ages between 2 and 39 years respectively (D. Ferrell, pers. comm.). The diet of this species consists of crustaceans, smaller fishes, molluscs and other marine organisms, including calcareous seaweeds (Roughley, 1916). They are also known to eat brittlestars, cunjevoi and marine worms (Coleman, 1980). Some foods are taken into the mouth accidentally when feeding on the bottom, and others are taken by choice; this seems to depend on the individual fish and its state of excitement during feeding (Coleman, 1980). Like other members of the family they probably feed at dawn and dusk and are wary and difficult to approach during the day (Francis, 1996b).

Size:
Girella cyanea grows to a length of about 76cm and a weight of about 4.5kg in Australia (Hutchins and Swainston, 1986). In New Zealand, the largest speared bluefish weighed about 8kg and was taken at the Cavalli Islands (Doak, 1972).

Evidence for Decline:
Roughley (1916) noted that *G. cyanea* was rarely seen in the Sydney fish markets, concluding that it did not occur on the NSW coast in any abundance. However, in 1951 he reported of *G. cyanea* as being "at one

time frequently taken on parts of the NSW coast, must now be regarded as a rare fish. It is, however, abundant at Lord Howe Island, and occurs also in NZ and in the Kermadec Islands”. It is difficult to explain the apparent decline of this species in NSW coastal waters, but this, at least in part, can probably be attributed to overfishing in the early half of the twentieth century. Long term residents of Lord Howe Island have reported that large bluefish were once commonly and easily caught from the foreshore of the Lord Howe Island lagoon and from rocky shores of other parts of the island. However, catches of larger bluefish (greater than 30cm) are now mainly restricted to boat-based anglers (G. Kelly, pers. comm.).

Australian and New Zealand Marine Protected Areas in Which Species Occurs:
Lord Howe Island Marine Park (Tasman Sea)
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)
Kermadec Islands Marine Reserve (off northern New Zealand)

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
Girella cyanea seems to prefer offshore island habitats, and may never have been abundant in NSW coastal waters. The rarity of sightings in these waters is difficult to attribute to fishing pressures alone, and on this basis it is recommended to assign the status of Lower Risk (near threatened), adopting the IUCN categories. It is a common species in waters of Lord Howe Island, Elizabeth and Middleton Reefs, and in northern NZ and the Kermadec Islands, so its status is reasonably secure around island localities of Australia and NZ.

Threatening Processes:
Recreational fishing is a potential threat to this species, especially in Lord Howe Island waters.

Critical Habitats:
Coastal and offshore rocky reefs within its range appear critical to the survival this species.

Recovery Objectives/Management Actions Required:
The accurate distribution and abundance of this species needs to be investigated. Monitoring of its numbers is necessary for any future management strategies. As the strongholds of this species appear to be at Lord Howe Island, the Kermadec Islands and Elizabeth and Middleton Reefs, protection from overfishing at these islands is of paramount importance to their survival. Currently research by NSW Fisheries is focusing on the age-structure of populations at Lord Howe Island and the response of its populations to fishing (D. Ferrell, pers. comms.). When coupled with information on sizes at sexual maturity for males and females, this will help determine if current levels of exploitation are sustainable, and will also be useful in the implementation of size and bag limits for this species. The results to date suggest that the species is relatively long lived and over-exploitation of larger individuals may have long-term effects on population numbers.

References:
Coleman, 1980; Doak, 1972; D. Ferrell, pers. comms. 6/2000-5/2001; Francis, 1996b; Gill and Reader, 1992; Hutchins and Swainston, 1986; G. Kelly, pers. comm. 9/2001; Ogilby, 1893; Randall, 1976; Roughley, 1916; Roughley, 1951.

FAMILY LABRIDAE: WRASSES

The wrasses are the second largest family in Australian waters after the Gobiidae (Hoese *et al*., in press). This family contains approximately 425 species worldwide (Choat and Bellwood, 1998) currently assigned to about 60 genera; 162 species in 41 genera are thus far known from Australian waters (Hoese *et al*., in press). Wrasses are widely distributed in all tropical and temperate seas (Hoese *et al*., in press) and contain some of the most conspicuous fishes of coral reefs (Choat and Bellwood, 1998) and temperate reefs alike (Kuiter, 1993).

Wrasses are perhaps the most efficient carnivores among reef fishes (Choat and Bellwood, 1998). They are diurnally active and seek a wide range of small invertebrates (Choat and Bellwood, 1998), both benthic and pelagic, as food (Hoese *et al*., in press). Most species feed upon hard-shelled prey which are captured with a diverse range of feeding structures, enabling them to extract camouflaged prey from a variety of feeding sites (Choat and Bellwood, 1998). Others are plankton-feeders, gathering in active groups where plankton is concentrated on reefs (Choat and Bellwood, 1998). The best known feeding pattern among the wrasses is probably that of the cleaner wrasses (genus *Labroides*), which remove parasites, mucus and scales from the bodies of larger fishes (Choat and Bellwood, 1998). This feeding regime helps to maintain the health of fishes on coral reefs. The majority of species occur in the vicinity of tropical coral reefs over sand, rubble, weed or coral substrata, but temperate species are most common in areas of weed and rocky reef (Hoese *et al*., in press). Female to male sex reversal and associated dichromatism is common in the majority of species which have been studied (Hoese *et al*., in press). Most species are medium-sized (about 20-40 cm), although the humphead Maori wrasse (*Cheilinus undulatus*) attains a maximum length of over 2m (Hoese *et al*., in press). The larger wrasses are often good eating, but do not form the basis of any targeted commercial fishery in Australia (Hoese *et al*., in press). Temperate wrasses of the genus *Pseudolabrus* are, however, targeted by commercial gillnetters in Tasmanian waters for the growing live food fish trade (Cappo *et al*., 1998).

Four wrasses are currently listed as Vulnerable in the 2000 IUCN Red List of Threatened Species, one (*Cheilinus undulatus*) of which occurs in Australian waters (http://www.redlist.org/). Of the 162 species known to occur in Australian waters, eight species are included in detail here.

References:
Cappo *et al*., 1998; Choat and Bellwood, 1998; Hoese *et al*., in press; Kuiter, 1993.

Websites:
http://www.redlist.org.au (2000 IUCN Red List of Threatened Species homepage)

Western Blue Groper

Family Name:	Labridae
Scientific Name:	*Achoerodus gouldii* (Richardson, 1843)
Conservation Status:	Lower Risk (conservation dependent)

Current Conservation Status:
Protected from spearfishing in parts of South Australia

No IUCN (1996, 2000) Listing

ASFB Threatened Fishes Committee
1985: Vulnerable in long term (10-15 years)

Distribution:
Achoerodus gouldii is distributed around southern Australia between Port Phillip Bay, Victoria and Houtman Abrolhos, Western Australia (Yearsley *et al*., 1999).

Museum Records - 37 specimens (Standard Length 30-550mm), collected from depths of 0-5m, ranging in geographical distribution from Victor Harbour (35^{o} 33' S, 138^{o} 38' E), SA westwards to Lancelin Island (31^{o} 01' S, 115^{o} 19' E), WA, collected between 1915 and 1995.

Habitat:
Juveniles occur in estuaries and sheltered bays in seagrasses and algae, moving offshore with increasing size to coastal and offshore reef locations, to depths of at least 40m (Kuiter, 1996).

Biology and Behaviour:
Like the eastern blue groper, the western form is almost certainly a protogynous hermaphrodite. The western blue groper appears to live in small social groups that comprise one male, two to three females and a few immature fish (Gillanders, 1999). In SA, fish measuring 400mm in length have been shown to be approximately 8 years old (Gillanders, 1999). At 25 years of age they are 800mm in length and may be as old as 50 years by the time they reach their maximum size (1420mm) (Gillanders, 1999). The diet of this species includes crustaceans, molluscs and echinoderms.

Size:
This species reaches about 160cm in length and 39kg in weight (Hutchins and Swainston, 1986).

Evidence for decline:
Around 1980, divers reported that western blue groper numbers were rapidly declining in areas south of Adelaide, evidently as a consequence of exploitation by commercial and recreational fishermen, including spearfishermen (Glover, 1987). Since 1980 it has been prohibited to sell this species commercially and it was subsequently totally protected in both Spencer Gulf and Gulf St Vincent (Glover, 1987). In SA, a 60cm minimum legal length imposed for all areas except the abovementioned Gulfs (Glover, 1987) remains today, with a bag limit of two fish and a boat limit of six fish (Anon., 1999d). It now appears that the earlier decline of this species south of Adelaide has been arrested (Glover, 1987). In WA waters, there is a daily catch limit of one fish for recreational fishers, and the minimum legal size is 40cm (http://www.wa.gov.au/westfish/). This species is generally found in lower numbers in the more accessible areas of SA and WA due to higher fishing pressures (Hutchins and Swainston, 1986). It is taken as bycatch in the WA shark fishery (Simpfendorfer and Donohue, 1998) and the Southern Shark Fishery (AFMA, 2000d). Product from the latter fishery is sold (AFMA, 2000d).

Reported commercial catches of western blue groper[10] retained by Fisheries WA 1994/95 to 1997/98

Fiscal Year	Live weight (kg)	Landed weight (kg)	Landed / live weight %
1994-1995	37,286	27,408	73.5
1995-1996	33,661	26,388	78.4
1996-1997	35,275	27,196	77.1
1997-1998	35,393	26,852	75.9

Australian Marine Protected Areas in Which the Species Occurs:
This species probably occurs in a number of Aquatic Reserves in SA and possibly the following Marine Parks in WA:
Ningaloo Marine Park, WA
Hamelin Pool Marine Park, WA
Shark Bay Marine Park, WA

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
The continued survival of this species in southern Australian waters may rely on its protection from overfishing by line (commercial and recreational) and spearfishers (recreational).

Threatening Processes:
Inshore commercial fishing activities in WA, such as gillnetting for sharks may be impacting upon this species by taking it as bycatch. Recreational fishing in highly populated areas of SA and WA is also likely to reduce populations, but probably to a lesser extent than commercial fishing activities.

Critical Habitats:
Estuaries are important nursery areas for this species whilst adults prefer coastal and offshore reefs.

Recovery Objectives / Management Actions Required:
This species is closed to fishing in Gulf waters (Spencer Gulf and Gulf St. Vincent), Investigator Strait and Backstairs Passage of SA (Anon., 1999d). The survival of this species should be ensured by the protection gained from the species-specific closed fishing areas in SA mentioned above. Additionally, Marine Parks in southern WA probably provide some protection for this species. Population surveys in WA waters would provide information on abundances, ecology and sex ratios. The impact of commercial gillnetting activities on this species needs to be examined in WA waters. Changes to the logbooks of fisheries which take this species in WA waters may be necessary to prevent any confusion with the Baldchin groper *Choerodon rubescens* in the catch statistics.

References:
AFMA, 2000d; Anon., 1999d; Gillanders, 1999; Glover, 1987; Harris, 1987; Hutchins and Swainston, 1986; Simpfendorfer and Donohue, 1998; Yearsley *et al.*, 1999.

Websites:
http://www.wa.gov.au/westfish/ (Fisheries Western Australia homepage)

[10] Source – Fisheries WA website: http://www.wa.gov.au/westfish/
Apparently, some minor errors have occurred in recording the catches of this species due to the confusion with the similarly named bluebone groper (or baldchin groper) *Choerodon rubescens.*

Eastern Blue Groper

Family Name:	Labridae
Scientific Name:	*Achoerodus viridis* (Steindachner, 1866)
Conservation Status:	Lower Risk (conservation dependent)

Australian Synonyms:
Platychoerops badius Ogilby, 1893

Current Conservation status:
No IUCN or ASFB Listings

Partially Protected Species in NSW waters
The first protective legislation in 1969 banned spearfishing. In 1975, as commercial fishers were still depleting the stocks by taking large catches, bottom-set gill nets were also banned. Commercial fishing was completely banned in 1980 (Smith *et al*., 1996). Today there is a two fish per day bag limit applying to recreational line-fishers.

Distribution:
The distribution of *Achoerodus viridis* extends from Hervey Bay, Queensland, to Wilsons Promontory in Victoria (Hutchins and Swainston, 1986). Gillanders (1999) reports its northerly distribution as Caloundra in southern Queensland. It occurs in greatest numbers in NSW waters (Gillanders, 1995a).

Museum Records: 330 specimens (Standard Length 13-740mm), collected from depths of 0-43m, ranging in geographical distribution from Ballina (28^o 52’ S), NSW, southwards to Gippsland Lakes (approx. 38^o 10’ S, 147^o 30’ E), Victoria, collected between 1895 and 1997.

Habitat:
Juveniles up to about 10cm in length inhabit seagrasses, then move to vegetated rocky reefs, changing their colour to suit their habitat. Large adults venture over large reef sections, males sometimes entering very shallow depths. They occur in estuaries (Kuiter, 1996) and offshore to depths at least 60m (Gillanders, 1995a).

Biology and Behaviour:
Achoerodus viridis is inquisitive and territorial and often follows divers, feeding on animals that the divers may disturb. Up to six or seven individuals form a school. At night it is inactive, often resting in reef crevices (Smith *et al*., 1996). Gillanders (1995a) demonstrated that the eastern blue groper is a protogynous hermaphrodite; all juveniles in the population are females, and sexual transition occurs from female to male at sizes greater than 500mm SL, though experimentally removing males from a population may lower the size of sexual transition. Females generally mature at 200-300mm SL, at an average of 2 to 4 years of age. Spawning typically commences in June or July and continues until October and most settlement occurs between July and September, suggesting that the larval life of *A. viridis* lasts 2 to 4 weeks. All males in a population are greater than 10 years of age and longevity is at least 20 years (Gillanders, 1995a). *Achoerodus viridis* is a benthic carnivore consuming a wide variety of prey items including crustaceans (tanaids, amphipods and crabs), molluscs (mussels, limpets and gastropods) and echinoderms (sea urchins). Diet selectivity depends on the size of the individual, habitat, site-specificity and temporal and spatial changes (Gillanders, 1995b).

Size:
Achoerodus viridis attains a maximum size of 1.2m (Kuiter, 1996) and a weight of at least 18kg (Gillanders, 1999).

Evidence for decline:
Prior to its protection from spearfishers in NSW in 1969, stocks of this species were in serious decline. Angling is now the only allowable method for catching the blue groper in NSW. The bag limit in this state

is two fish per person, and there is no size limit. It is protected from spearfishers in NSW, but not in Queensland and Victoria. There is some evidence that the eastern blue groper is still being overfished in some areas, particularly around areas of large human populations, such as Sydney, Newcastle and Wollongong (Smith *et al*., 1996). This species is occasionally taken incidentally in NSW protective beach-meshing operations (Krogh and Reid, 1996).

Australian Marine Protected Areas in Which the Species Occurs:
The eastern blue groper would occur in most of the MPAs along the southern Queensland and NSW coastlines with rocky shores. Juveniles would occur in many of these MPAs that contain seagrass beds.

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Protection from commercial fishing and spearfishing in NSW waters continues to help *Achoerodus viridis* rebuild its numbers, to the point where it is commonly seen on rocky reefs throughout its range (Smith *et al*., 1996). However, recreational boat and shore fishers still have the potential to deplete numbers, and this species needs to be closely monitored.

Threatening Processes:
Excessive localised recreational fishing and illegal spearfishing has the potential to decrease the numbers of this species within its range.

Critical Habitats:
Seagrasses are an important habitat for juveniles, while adults are often closely associated with vegetated temperate rocky reefs, which harbour the variety of invertebrates on which they feed.

Recovery Objectives / Management Actions Required:
If sex change in *A. viridis* is size dependent and there is little flexibility in terms of size and age of sex change, then it may be easy to overfish large males, resulting in a reduction in the number of spawning males (Gillanders, 1995a). Knowledge of reproductive biology is therefore important for fisheries management of this partially protected species (Gillanders, 1995a). An investigation into the effectiveness of existing regulations (i.e. a bag limit of two fish per person per day, but no size limit) on controlling the effects of recreational fishing on the populations of this species may be necessary. A minimum size limit (of at least 30cm) should be implemented in NSW waters, and a maximum size limit (e.g. 80cm) could also be implemented to protect large adult males. Continued protection from spearfishing in NSW waters is essential. Protection from spearfishers in Victoria and Queensland is also recommended.

References:
Gillanders, 1995a; Gillanders, 1995b; Gillanders, 1999; Hutchins and Swainston, 1986; Kuiter, 1996; Krogh and Reid, 1996; Smith *et al*., 1996; Yearsley *et al*., 1999.

Elegant wrasse

Family Name:	Labridae
Scientific Name:	*Anampses elegans* Ogilby, 1889
Conservation status:	Lower Risk (least concern)

Australian Synonyms:
Anampses variolatus Ogilby, 1889

Current Conservation status:
Protected Species in NSW waters

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Anampses elegans is known from southern Queensland, New South Wales, Elizabeth and Middleton Reefs, Lord Howe Island, Norfolk Island, the Kermadec Islands and New Zealand (Gill and Reader, 1992). This species also occurs at New Caledonia and Rapa, Mangareva, Pitcairn and Easter Islands in the Pacific Ocean (Lieske and Myers, 1994). It is a sub-tropical, warm-temperate endemic species, with stragglers finding their way as far south as Montague Island on the warm, eastern Australian current as eggs and larvae. Parker (1999) recorded adult specimens at Julian Rocks (off Byron Bay, northern NSW) in 15-24m of water, noting their occurrence as uncommon. He reported that this is the near the northern extreme of the known adult mainland range. Lieske and Myers (1994) note that *Anampses elegans* is the second most abundant wrasse at Lord Howe Island.

Museum Records - 90 specimens (Standard Length 22-290mm), collected from depths of 1-20m, ranging in geographical distribution from Port Stephens (32^{o} S) southwards to Sydney Harbour (33^{o} 50' S). Offshore localities include Broughton Island, Lord Howe Island, Norfolk Island and Elizabeth Reef. Specimens were collected between circa 1888 and 1987.

Habitat:
Juveniles are found in algae in coastal bays and harbours. Large juveniles occur in small aggregations on coastal rocky reefs. Adults usually occur deeper to about 30m (Kuiter, 1993). Coleman (1981) reports the habitat as coral reef and rocky reef from 2 to 35m and sighted 80-100 adult females in one school at 28m at Lord Howe Island. Gill and Reader (1992) found it to be common in the lagoons of Elizabeth and Middleton Reefs, occurring around reefs and over rubble. Randall (1974) reported it as one of the more common fishes at Lord Howe Island, especially in the shallow lagoon habitat, but large adults were occasionally seen outside the reef to depths of at least 30m. This species is more prevalent around inshore islands on the NSW coastline. It is basically a coral reef species where there is suitable habitat available.

Biology and Behaviour:
Young fish travel in small schools, feeding together in short bouts between periods of rapid swimming. Terminal males are territorial (Lieske and Myers, 1994) and usually move singly, swimming rapidly from one group of females to another (Ayling and Cox, 1982). This species is carnivorous, feeding on crustaceans and molluscs. It has forward-projecting comb-like teeth that are used to scrape the surface of small seaweeds, removing the small crustaceans and worms on which the fish feed (Ayling and Cox, 1982).

Size:
Anampses elegans grows to approximately 30cm in length.

Evidence for decline:
This species may never have been common on the mainland coast, preferring inshore island habitats. It is difficult to explain or substantiate any declines that may have occurred.

Australian Marine Protected Areas in Which the Species Occurs:
Fly Point-Halifax Bay Aquatic Reserve (Port Stephens, NSW)
Solitary Islands Marine Park (north of Coffs Harbour, NSW)
Julian Rocks Aquatic Reserve (off Byron Bay, northern NSW)
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)
Lord Howe Island Marine Park (Tasman Sea)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
This species appears to have a secure conservation status in NSW waters, where it is protected. Its occurrence within a number of MPAs (see above) should ensure its conservation within its range. It is recommended that it be placed in the Lower Risk (least concern) category, adopting the IUCN categories.

Threatening Processes:
None identified

Critical Habitats:
Juveniles are often found associated with algae in coastal bays and harbours, while coral and rocky reef habitats appear to be important for sub-adults and adults.

Recovery Objectives / Management Actions Required:
Anampses elegans needs further study along the mainland coast (particularly the Port Stephens to Coffs Harbour area, which is the centre of its distributional range) and inshore islands of NSW and Queensland.

References:
Ayling and Cox, 1982; Coleman, 1981; Gill and Reader, 1992; Lieske and Myers, 1994; Parker, 1999; Randall, 1974.

Humphead Maori Wrasse

Family Name:	Labridae
Scientific Name:	*Cheilinus undulatus* Rüppell, 1835
Conservation Status:	Lower Risk (conservation dependent)

Alternative Common Names:
Humphead wrasse; napoleonfish; double-headed maori wrasse; giant wrasse; truck wrasse

Current Conservation Status:
2000 IUCN Red List of Threatened Species
Vulnerable (A1d + 2cd)

Protected species in Western Australian (WA) waters

No ASFB Listing

Distribution:
Cheilinus undulatus is widespread in the tropical Indo-West Pacific, occurring on offshore reefs of north-western Australia, the Great Barrier Reef and throughout South East Asia (Allen, 1997). Russell (1983) reported it as rare in the Capricorn - Bunker Group of the Great Barrier Reef (GBR). Gill and Reader (1992) noted it as rare in the lagoon at Middleton Reef and also rare on the reef slope at Elizabeth Reef. It occurs westwards to at least the Maldives (Allen and Steene, 1987).

Museum Records - 25 specimens (Standard Length 24-920mm [this latter fish weighed 25kg]), collected from depths of 0-8m, ranging in geographical distribution from the Lizard Island area (approx. 14^{o}45'S), GBR, Qld southwards to the Swain Reefs (22^{o}05'S, 152^{o}03'E), GBR, Qld on the east coast of Australia, and also from off Broome (approx. 18^{o}S), WA. There are also records from Cocos (Keeling) Islands, Sabah, PNG, French Polynesia, Fiji and Middleton Reef. Specimens were collected between c. 1914 and 1998.

Habitat:
Cheilinus undulatus inhabits coral environments in lagoons and on seaward reefs. Juveniles occur among branching corals in shallow lagoons while adults prefer the upper margins of clear lagoon pinnacles and steep coral slopes (Lieske and Myers, 1994) to at least 100m (Allen and Swainston, 1992), but occasionally up to 160m depth (QFS, 2000e). In the Capricorn-Bunker Group of the GBR, this species is seen occasionally in outer reef slope habitats (Russell, 1983). Gill and Reader (1992) recorded it from reef and gutter habitats at Elizabeth and Middleton Reefs, South Coral Sea. In WA waters it only occurs at offshore islands (B. Hutchins, pers. comm.).

Biology and Behaviour:
In spite of its size, *Cheilinus undulatus* is extremely wary except where protected and fed by divers, and is usually solitary by nature (Lieske and Myers, 1994), except when aggregating to spawn (H. Choat, pers. comm.). Adults usually have a home cave in which they sleep. This species may be ciguatoxic in certain areas (Lieske and Myers, 1994). Adults move into shallow bays during the day to feed. They crush large chunks of dead coral rubble with their peg-like teeth to feed on the burrowing mussels and worms (QFS, 2000e). The longevity of this species is up to at least 32 years, with females outliving the males (the oldest female recorded was 32 years), and sexual maturity is reached at about 8 years of age (H. Choat, pers. comm.). Histological studies show that sexual maturation is reached at a size of between 40cm and 60cm total length (Sadovy, unpub. data). This species is thought to be a protogynous hermaphrodite, with sex reversal occurring at about 15 years of age (H. Choat, pers. comm.) at a total length of approx. 111cm (Lau and Li, 2000). Males grow very rapidly (H. Choat, pers. comm.). It feeds on a wide variety of molluscs, fishes, sea urchins, crustaceans, and other invertebrates (Randall *et al.*, 1997). This species will even take toxic prey such as crown-of-thorns starfish, boxfishes or seahares (Lieske and Myers, 1994).

Size:
Cheilinus undulatus reaches a very large size. The largest reliably recorded specimen was 229cm in length and weighed 190.5 kg (Randall *et al*., 1997). It is commonly marketed at lengths of 30-60cm and weights of 0.4 – 3kg (Yearsley *et al*., 1999). This species is apparently fast growing (H. Choat, pers. comm.). Abundance estimates on northern Queensland reefs are 2.5-3.5 adults per 8000m^2 (H. Choat, pers. comm.).

Evidence for Decline:
Maori wrasses are high priced fishes with strong demand both as aquarium fishes and for the Asian live reef food fish (LRFF) trade (Yearsley *et al*., 1999). It is close to becoming locally extinct in the Philippines and Indonesia due to cyanide fishing for the LRFF market in large Asian cities such as Hong Kong, Taipei and Singapore (Foale, 1998). Export bans for this species in place in Indonesia, the Philippines and the Maldives are not sufficiently enforced and result in the smuggling of this species out of these countries and into Hong Kong (Lau and Parry-Jones, 1999). In a survey of the Lei Yue Mun live fish market in Hong Kong, conducted between December 1995 and February 1996, *C. undulatus* was observed on at least ten occasions (Lee and Sadovy, 1998). This species fetches one of the highest retail prices per kilogram of any reef fish and in 1997 average retail prices were over US$100 per kilogram (Lee and Sadovy, 1998), though more recently prices are US$64 per kg (Chan, 2000). Of 143 fish examined, sizes ranged from about 25cm to 90cm, and because of the preferred market size range (about 0.6 to 1.5 kg), most specimens seen in these markets are juveniles (Lee and Sadovy, 1998). A survey of the imports of 39 of the 114 companies that trade live fish in Hong Kong by Lau and Parry-Jones (1999), revealed that *C. undulatus* made up 2.8% (approx. 672t) of the total annual volume of fish imported into Hong Kong for this trade. Traders of live reef food fish have revealed that although Indonesia and the Philippines were the main countries of origin for Humphead maori wrasse imports, other countries exporting this species also include Australia, China, Malaysia, the Maldives, PNG, the Solomon Islands, Thailand and Vietnam (Lau and Parry-Jones, 1999). Twenty-five per cent of traders surveyed in the abovementioned study reported importing this species from Australian waters (Lau and Parry-Jones, 1999). This species may be locally common in parts of South-East Asia, but the level of effort involved in catching these fish may also be high. Continued high prices in Hong Kong will inevitably lead to localised depletions, especially if targeting of spawning aggregations continues. The fact that many juveniles are captured and sold for this market results in a lower percentage of juveniles reaching sexual maturity. In Guam, commercial fishers use up to three 120 cubic-foot scuba tanks per diver per night and venture as deep as 55m on their first and second dives, to target this and other species. Spearguns and bang sticks (devices employing 12-gauge shotgun cartridges that can stop even sharks and very large bony fish) are used to maximise catches of popular Napolean wrasse *C. undulatus* (Anon., 1999). *Cheilinus undulatus* forms spawning aggregations and is therefore susceptible to overfishing if these aggregations are targeted (H. Choat, pers. comm.). They may still be common on some outer reefs in Queensland, but catches are much lower than historic levels (J. Johnson, pers. comm.). In Australian waters, they are most commonly caught using spears, lines and traps (Yearsley *et al*., 1999).

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area (Qld)
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
Cheilinus undulatus is totally protected in WA waters, so its conservation status in this State should be ensured. In Queensland waters the current recreational in-possession limit for this species is one fish, with a minimum size limit of 75cm (approx. 8kg) and no maximum size limit (QFS, 2000e; http://www.dpi.qld.gov.au/fishweb/). The Queensland Fisheries Service (QFS) has proposed a recreational in-possession boat limit for any fisher/boat of one with the minimum legal length remaining the same. Biologists at James Cook University (JCU) are undertaking work on this species (D. Cameron, pers. comm.). Until this research is completed and assuming the management measures proposed by QFS are implemented it is recommended to assign the status of Lower Risk (conservation dependent) adopting the IUCN categories.

Threatening Processes:
Any forms of fishing (e.g. cyanide, dynamite, and linefishing) that target the spawning aggregations of this species have the potential to adversely affect its populations in Australian and overseas waters.

Critical Habitats:
Healthy coral reef habitats are crucial to the survival of this species.

Recovery Objectives / Management Actions Required:
Research undertaken by James Cook University (JCU) may help in determining the biological and /or life history traits for this species. Stricter regulations (see above) need to be adopted by the QFS to ensure that this species is not over-exploited by aquarium collecting and commercial or recreational fishing activities.

References:
Allen, 1997; Allen and Steene, 1987; Allen and Swainston, 1992; Anon., 1999; D. Cameron, pers. comm. 12/1999; Chan, 2000; H. Choat, pers. comm. 1999-2000; Foale, 1998; Gill and Reader, 1992; B. Hutchins, pers. comm. 1/2000; J. Johnson, pers. comm. 9/1999; Lau and Li, 2000; Lau and Parry-Jones, 1999; Lee and Sadovy, 1998; Lieske and Myers, 1994; QFS, 2000e; Randall *et al*., 1997; Russell, 1983; Yearsley *et al*., 1999.

Websites:
http://www.dpi.qld.gov.au/fishweb/ (Queensland Department of Primary Industries homepage)

Baldchin groper

Family Name:	Labridae
Scientific Name:	*Choerodon rubescens* (Günther, 1862)
Conservation Status:	Lower Risk (least concern)

Alternative Common Name(s):
Baldchin tuskfish; bluebone groper

Current Conservation status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Choerodon rubescens is endemic to Western Australian (WA) waters, occurring from Geographe Bay (33^{o} 33' S) northwards to Coral Bay (approx. 23^{o} S) (Allen and Swainston, 1988). Hutchins and Swainston (1986) noted that it was abundant at the Houtman Abrolhos Islands off the WA coastline, but is only occasionally found on the deeper offshore reefs along the lower western coast of WA.

Museum Records - 13 specimens (Standard Length 42-390mm), collected from a depth range of 1-30m, ranging in geographical distribution from Shark Bay (25^{o} 21' S), WA southwards to Garden Island (32^{o} 12' S), WA, collected between 1957 and 1998.

Habitat:
Choerodon rubescens is a demersal marine fish which occurs as solitary individuals or in small groups, over seagrass beds and coral reefs on the inner continental shelf to at least 40m depth (Yearsley *et al*., 1999). It is also known from rocky and weedy areas (Allen and Swainston, 1988), is occasionally found on deeper offshore reefs, and juveniles are often sighted in shallow protected sand and weed areas (Hutchins and Swainston, 1986).

Biology and Behaviour:
Choerodon rubescens is a protogynous hermaphrodite that spawns on multiple occasions; the main spawning times being from September to January (K. Nardi, pers. comm.). Otolith examination has demonstrated that this species is slow growing, and a 49cm specimen was found to be 20 years old (Nardi, pers. comm). Like many reef fishes, there is considerable variability in growth rates of this species, and at a legal size of 40cm, a fish may be between 4 and 10 years of age (K. Nardi, pers. comm.). Females reach sexual maturity at approximately 30cm in length. The size at which males reach sexual maturity is very variable depending on the sex structure of each population (K. Nardi, pers. comm.). *Choerodon* wrasses possess powerful teeth that they use to lift rocks off the bottom in search of molluscs (Allen and Steene, 1987; Walker, 1983) and sea urchins (Walker, 1983). One individual at the Houtman Abrolhos was photographed eating a turban shell (Gastropoda: Turbinidae) (Allen and Steene, 1987).

Size:
Choerodon rubescens is one of the largest tuskfish and grows to a maximum length of about 69cm and a weight of about 7.3kg (B. Hutchins, pers. comm.). It is commonly marketed at 40-50cm length and a weight of 3-4kg (Nardi, pers. comm).

Evidence for decline:
Allen (1997) reports this species to be an excellent food fish. Catches from the central western coast of WA (including the Abrolhos Islands) have varied between 27 and 40t over the years 1991-2 and 1996-7, with only small changes in catch per unit effort (Fisheries WA unpublished data, 1998). There is little evidence of any declines in its populations, however this species needs to be closely monitored as it is highly sought after by recreational spear and line fishers. There have been reports of localised stock depletion caused by overfishing in the Houtman Abrolhos Islands, WA (K. Nardi, pers. comm.). It is caught mainly using handlines and in smaller quantities by gillnets, spears and traps (Yearsley *et al*., 1999). In the state of WA, the minimum legal length for this species is 40cm and the catch limit is eight fish per person per day

(http://www.wa.gov.au/westfish/). Most targeted fish are probably males due to the size structure of the population (K. Nardi, pers. comm.).

Australian Marine Protected Areas in Which the Species Occurs:
Abrolhos Islands Fish Habitat Protection Area (WA)
Shark Bay World Heritage Area (WA)
Ningaloo Marine Park (WA)

Suggested Conservation Status:
Lower Risk (least concern) on an Australia-wide basis.
Choerodon rubescens is one of the more common reef fishes on the central coast of WA (B. Hutchins, pers. comm.). However, owing to its large adult size and excellent eating qualities, this species need to be closely monitored to ensure survival of its breeding populations in WA waters. The current minimum legal length of 40cm needs to be enforced.

Threatening Processes:
Commercial and recreational fishing practices have the potential to decrease the numbers of this species in WA waters.

Critical Habitats:
Rocky and coral reefs associated with seagrass and algae are important habitats for this species.

Recovery Objectives / Management Actions Required:
The current minimum legal length of 40cm may have to be increased if populations are found to be declining as a result of overfishing. Further biological studies on the age and size at maturity and the percentage of mature fish in any given population will help in determining if the current minimum legal length is appropriate for this species.

References:
Allen, 1997; Allen and Steene, 1987; Allen and Swainston, 1988; B. Hutchins, pers. comm. 1999-2000; Hutchins and Swainston, 1986; K. Nardi, pers. comms. 1999-2000; Fisheries WA unpublished data, 1998; Walker, 1983; Yearsley *et al*., 1999.

Double-header

Family Name:	Labridae
Scientific Name:	*Coris bulbifrons* Randall and Kuiter, 1982
Conservation status:	Lower Risk (conservation dependent)

Australian Synonyms:
Coris cyanea Whitley, 1937

Current Conservation Status:
Protected Species from Spearfishing at Lord Howe Island

No IUCN (1996, 2000) or ASFB Listings

Distribution:
Coris bulbifrons is only known from the Lord Howe Island region and central New South Wales. It is common in the lagoon at Lord Howe Island, which has a maximum depth of 8m. Outside the lagoon it occurs to depths of at least 20m (Kuiter, 1993). Gill and Reader (1992) noted that this species was common in the lagoon and on the reef slope at both Elizabeth and Middleton Reefs in the South Coral Sea. Francis (1993) records it as occurring at Norfolk Island.

Museum Records - 29 specimens (Standard Length 15-465mm), collected from a depth range of 0-20m, ranging in geographical distribution from Byron Bay (28^{o} 38' S), NSW on the mainland coastline (type specimen), southwards to Lord Howe Island, Elizabeth and Middleton Reefs and eastwards to Norfolk Island. Specimens were collected between circa 1888 and 1987. No specimens have been collected from the mainland coastline since the paratype in 1970.

Habitat:
Coris bulbifrons occurs in lagoon and reef slope environments, and over rubble (Gill and Reader, 1992). It is also known from shallow, rocky and coral reefs to about 25m depth (Lieske and Myers, 1994). The young have been collected in tidepools (Randall, 1999). In the Lord Howe Island lagoon it is mainly restricted to a few sandy bottomed, coral-fringed holes just inshore of the reef crest, but a few young individuals are seen over shallow coral beds (G. Kelly, pers. comm.).

Biology and Behaviour:
Coris bulbifrons occurs in schools with the largest male being the dominant individual (Kuiter, 1993). Preliminary ageing studies (sample size 14 fish) by NSW Fisheries suggests that fish within the size range 40.5 - 65.5cm correspond to ages between 6 and 19 years respectively (D. Ferrell, pers. comm.). This species feeds on molluscs and crabs (Lieske and Myers, 1994).

Size:
Coris bulbifrons is the largest species in the *Coris* genus, attaining a size of at least 1m. It is reported to grow to 1.4m (Kuiter, 1993), though no such sizes have been confirmed (Randall, 1999). The angling record for this species is 6.35kg (Randall and Kuiter, 1982).

Evidence for Decline:
There is no evidence of any decline for this species. It may be naturally rare on the Australian mainland, preferring offshore island localities. Populations are recreationally fished in waters around Lord Howe Island, however there is no known commercial fishing for this species in any waters (D. Ferrell, pers. comm.; D. Hiscoe, pers. comm.). This species has been recognised as being susceptible to overfishing, so the current ban on spearfishing in Lord Howe Island waters is necessary (D. Hiscoe, pers. comm.)

Australian and New Zealand Marine Protected Areas in the which species occurs:
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)
Lord Howe Island Marine Park (Tasman Sea)

Suggested Conservation Status:
Lower Risk (conservation dependent) on an Australia-wide basis.
The protection of this species from spearfishing within the Lord Howe Island Marine Park should contribute to its conservation. This species also occurs in the Middleton and Elizabeth Reefs National Nature Reserve, which provides some additional protection. It is recommended to assign the conservation status of Lower Risk (conservation dependent), adopting the IUCN categories.

Threatening Processes:
Uncontrolled recreational fishing or spearfishing could potentially threaten this species, but these threats currently appear to be minimal.

Critical Habitats:
Shallow rocky and coral reefs and lagoons are important habitat for this species.

Recovery Objectives / Management Actions Required:
Further research is necessary to determine the accurate distribution, abundance, ecology and biology of this species, especially on the Australian mainland, but also in other localities. Currently, research by NSW Fisheries is focusing on the age-structure of populations at Lord Howe Island (D. Ferrell, pers. comm.). This information, when coupled with data on sizes at sexual maturity for males and females, will be important in determining if current levels of exploitation are sustainable. The knowledge gained from this study could also be used in the implementation of size and bag limits for this species, especially within the waters of the recently declared Lord Howe Island Marine Park.

References:
D. Ferrell, pers. comm. 6-9/2000; Francis, 1993; Gill and Reader, 1992; D. Hiscoe, pers. comm. 9/2000; G. Kelly, pers. comm. 9/2001; Kuiter, 1993; Lieske and Myers, 1994; Randall and Kuiter, 1982; Randall, 1999.

Eastern king wrasse

Family Name:	Labridae
Scientific Name:	*Coris sandeyeri* (Hector, 1884)
Conservation Status:	Data Deficient

Australian Synonyms:
Coris rex Ramsay and Ogilby, 1886
Coris trimaculata Ogilby, 1888

Taxonomic Status:
Formally described as *Cymolutes sandeyeri* by Hector in 1884. Hector noted that Mr. S. Sandeyer collected his type specimen, which was a misspelling of the name Mr F.S. Sandager. Sandager corrected the species name to *sandageri*, as have most recent authors, and this name has been widely used in the literature. However, in accordance with Article 18 of the International Code of Zoological Nomenclature, the availability of a name is not affected by being inappropriate. *Coris sandeyeri* is therefore to be regarded as the valid name for this species (Randall, 1999).

Alternative Common Name:
Sandagers wrasse

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Off mainland Australia, this species is distributed from central NSW to northern Victoria, but it also occurs in waters of New Zealand (NZ) (Kuiter, 1993), Lord Howe Island, Elizabeth and Middleton Reefs, Norfolk Island, and the Kermadec Islands (Gill and Reader, 1992). In NZ, it is most abundant around the offshore islands of Northland and the Bay of Plenty where it is one of the most common of the larger reef fish, maintaining densities of one fish for each ten square metres of bottom space. They are also moderately common along the mainland NZ coast between North Cape and East Cape and have occasionally been reported from the Cook Strait region (Ayling and Cox, 1982). Parker (1999) reported adults as occurring in depths of 10-24m at Julian Rocks (Byron Bay, northern NSW), noting their occurrence there as rare.

Museum Records - 14 specimens (Standard Length 44 - 329mm), collected from a depth range of 0-20m, ranging in geographical distribution from Sydney (33^{o} 51’ S) northwards to Broughton Island (32^{o} 36’ S) along the NSW coast, and also from Lord Howe Island and Norfolk Island. Specimens were collected between circa 1886 and 1975.

Habitat:
Coris sandeyeri inhabits coastal and offshore reefs near weed-covered rocks and sand. It usually occurs in small aggregations of juvenile or sub-adult individuals over deep sand-slopes from 20 to 40m, with larger adults nearby (Kuiter, 1993). Gill and Reader (1992) found it to be common in the lagoons of Elizabeth and Middleton Reefs, occurring around reefs and over rubble. In NZ they range from depths of a few metres down to about 60m in the clear waters around islands, but are rarely seen below 30m on the coast. They prefer rocky reefs where there are numerous sand patches that may be used for night shelter, and are seldom found over vast expanses of rock (Ayling and Cox, 1982).

Biology and Behaviour:
Coris sandeyeri is only active during daylight; at night it sleeps buried under the sand, protecting itself from predators (Ayling and Cox, 1982; Edgar, 1997). The bright horizontal stripe of small individuals is a cleaning signal indicating to other fishes that they are potential cleaners (Ayling and Cox, 1982). In NZ waters, it has been observed cleaning goatfish (*Upeneichthys porosus*), demoiselle (*Chromis dispulis*), mado (*Atypichthys strigatus*), blue maomao (*Scorpis aequipinnis*), blackfish (*Girella tricuspidata*), whitear (*Parma microlepis*), spotty (*Pseudolabrus celidotus*), banded parrotfish (*Pseudolabrus fucicola*), porae

(*Cheilodactylus douglasi*) and koheru (*Decapterus koheru*) (Doak, 1972). Fully-grown males are often seen turning over small rocks with sideways flicks of their heads to get at the invertebrates sheltering beneath. These males maintain territories from which they exclude all other males and which fluctuate markedly from day to day. Instead of keeping a harem of females within their territory these fish maintain a variable patch of bottom space and court the females that are within that area at any one time; the females are free to wander from one male's territory to another's. The spawning season is during the summer from December to March, and during this time the males behave more aggressively towards each other. Females are courted frequently by males with spread fins, and if she responds the male mounts on her back with his pelvic fins straddling her body. In this position the two fishes undulate upward into open water, the male slips underneath and both release white clouds of gametes. While male aggression is common in this species, fights between two females have also been seen, usually over some choice food item, and during these episodes the normal colour pattern reverses, the pale body flushing dark red-brown and the dark brown splotches fading to a pale fawn. The loser of these bouts quickly reverts to normal colouration; an admission of defeat (Ayling and Cox, 1982).

Coris sandeyeri has typical labrid teeth with sharp canines in the front and similar shaped, but smaller, teeth toward the back of each jaw. In small individuals these teeth are ideally suited to parasite picking and juveniles spend much of their time cleaning larger fishes, often members of the same species. Larger specimens feed amongst the kelp plants and on the bottom, selecting crustaceans, molluscs, small echinoderms and worms (Ayling and Cox, 1982). The diet includes most of the small animals, which encrust the rocks or live in crevices, most importantly brittlestars, amphipods, chitons, and gastropods. A variety of other invertebrates appear less important, including limpets, bivalves, polychaete worms and small crustaceans (Doak, 1972). In NZ waters the eggs of nesting *Chromis dispulis* and triplefins (Tripterygiidae) are also eaten (Francis, 1996b).

Size:
Coris sandeyeri attains 50cm (Francis, 1996b). The largest recorded individual from NZ weighed about 2.7kg and was speared near Whangarei (Doak, 1972).

Evidence for Decline:
McCulloch (1922) reported that it was a rare species. Coleman (1980) noted their occurrence as common in the juvenile and female growth stages, but the larger males are hard to find, especially in areas where spearfishers abound. In 1984, the Underwater Research Group of NSW wrote to NSW Fisheries requesting that *C. sandeyeri* be placed on the Protected Species List. However, evidence from spearfishing competitions did not indicate that population numbers were declining. This species is rarely taken as an incidental catch by reef anglers and is reputedly good to eat (Smith and Pollard, 1996).

Australian and New Zealand Marine Protected Areas in the which species occurs:
Julian Rocks Aquatic Reserve (off Byron Bay, northern NSW)
Solitary Islands Marine Park (northern NSW)
Jervis Bay Marine Park (southern NSW)
Middleton and Elizabeth Reefs Marine National Nature Reserve (Tasman Sea)
Lord Howe Island Marine Park (Tasman Sea)
Poor Knights Islands Marine Reserve (New Zealand)
Kermadec Islands Marine Reserve (off northern New Zealand)

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Based on the lack of biological data for the NSW and offshore Australian populations of the species, it is recommended to assign the status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
None identified.

Critical Habitats:
Coastal and offshore reefs associated with algal-covered rocks and sand are important to this species.

Recovery Objectives / Management Actions Required:
Further research on the ecology and biology of this species may help in accurately determining its conservation status.

References:
Ayling and Cox, 1982; Coleman, 1980; Doak, 1972; Edgar, 1997; Francis, 1996b; Gill and Reader, 1992; Kuiter, 1993; McCulloch, 1922; Parker, 1999; Randall, 1999; Smith and Pollard, 1996.

Braun's Wrasse

Family Name:	Labridae
Scientific Name:	*Pictilabrus brauni* Hutchins and Morrison, 1996
Conservation Status:	Lower Risk (near threatened)

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings (but submitted to ASFB by B. Hutchins in 1999)

Distribution:
Pictilabrus brauni is so far known only from the region of Cheyne Beach in Western Australia. Its shyness and similarity in appearance with juveniles of other members of the genus have possibly masked its true distribution (Hutchins and Morrison, 1996).

Museum Records - 5 specimens (all types: Standard Length 58-74mm), all collected from Cheyne Beach (34^o 54' S), WA in 1994.

Habitat:
Pictilabrus brauni appears to prefer shallow areas of reef and weed (Hutchins and Morrison, 1996).

Biology and Behaviour:
Most wrasses are protogynous hermaphrodites (i.e. the initial phase may be male or female, but the terminal phase is always a large male. It is unknown whether this is the case with *Pictilabrus brauni*, as the gonads of the specimens examined had underdeveloped organs (Hutchins and Morrison, 1996). The diet of this species is currently unknown.

Size:
Pictilabrus brauni is a small species, the holotype being the largest known specimen (74mm SL).

Evidence for Decline:
There is no evidence of any decline for this species. However, Hutchins has only seen one specimen in 25 years of surveying and collecting fishes on the southern reefs of Western Australia. The professional fish collector who collected the type series has never seen specimens anywhere except in the type locality (B. Hutchins, pers. comm.). It may be naturally rare and/or cryptic and difficult to find. Searching in the area around Cheyne Beach in the time since its description has failed to locate any more specimens (Hutchins, pers. comm).

Australian Marine Protected Areas in the which species occurs:
None identified.

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
Accurate data are necessary to determine the conservation status of this species in Australian waters. However as a precautionary measure, it is recommended to assign the conservation status of Lower Risk (near threatened), adopting the IUCN categories.

Threatening Processes:
Habitat degradation has the potential to adversely affect this species within its narrow range.

Critical Habitats:
The few specimens found to date have been in shallow areas associated with reef and weed in a very small area around Cheyne Beach in Western Australia.

Recovery Objectives / Management Actions Required:
Habitat protection, through the location of a MPA in the Cheyne Beach area in which this species was first discovered, may be necessary as a precautionary approach until further populations are found.

References:
B. Hutchins, pers. comms. 1999-2000; Hutchins and Morrison, 1996.

FAMILY SCARIDAE: PARROTFISHES

The parrotfishes, so named for the fusion of their teeth into a distinctive beak, represent a moderately diverse group of fishes with 10 genera and 84 species (Choat and Bellwood, 1998). The Australian fauna contains 32 species belonging to seven genera (Hoese *et al*., in press). The family occurs worldwide in tropical seas (Hoese *et al*., in press) with the great majority of species occurring on coral reefs – only a small number of species occur in seagrass beds and over rocky reefs (Choat and Bellwood, 1998).

With few exceptions parrotfishes are herbivores and their jaw structure allows them to graze intensively on the small plants that cover the exposed calcareous (high in calcium carbonate) matrix of coral reefs (Choat and Bellwood, 1998). Their feeding can modify the reef environment by removing some species of coral and larger algae when they are newly established or small (Choat and Bellwood, 1998). Some species, such as the humpheaded parrotfish *Bolbometopon muricatum*, can alter the fine scale topography of reefs by consuming large amounts of live and dead coral (Choat and Bellwood, 1998). Individuals of some species are known to secrete an envelope of mucus at night in which they rest (Choat and Bellwood, 1998; Hoese *et al*., in press), presumably to deter nocturnal predators which hunt by scent (Choat and Bellwood, 1998).

Parrotfishes are hermaphroditic (one individual is capable of being male or female) and sexually dichromatic (the sexes have different colour patterns) (Choat and Bellwood, 1998). Females of most species are able to transform to the male sex (Hoese *et al*., in press). Juveniles, initial adult stage males and females, and terminal stage males may exhibit different colour patterns (Hoese *et al*., in press). The brightest colours are generally found in terminal males (Hoese *et al*., in press). The presence, absence, and relative number of primary males appear to be related to a complex set of behavioural and demographic factors (Bellwood and Choat, 1998).

Most parrotfish species appear to have relatively rapid growth rates, reaching maturity in 2 to 4 years and reaching a maximum lifespan of 5-20 years (Choat and Bellwood, 1998). The maximum length is 1.2m, but most species are under 50cm (Hoese *et al*., in press).

One species, the rainbow parrotfish *Scarus guacamaia* (not known from Australian waters), is listed as Vulnerable in the 2000 IUCN Red List of Threatened Species (http://www.redlist.org/). Only the humpheaded parrotfish *Bolbometopon muricatum* is considered here in detail in the following species synopsis.

References:
Choat and Bellwood, 1998; Hoese *et al*., in press.

Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species homepage)

Humpheaded parrotfish

Family Name:	Scaridae
Scientific Name:	*Bolbometopon muricatum* (Valenciennes, 1840)
Conservation Status:	Data Deficient

Alternative Common Name:
Bumphead parrotfish

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Bolbometopon muricatum has a wide distribution extending from eastern Africa and the Red Sea to the central Pacific. It reaches Okinawa (approx. 26^o 30' N, 128^o E) in the northern Pacific and the Great Barrier Reef (GBR) in the south (Choat and Randall, 1986). On the GBR it occurs on the middle and outer shelf reefs, but rarely extends into the Swain or Capricorn-Bunker reefs at the southern end (Choat and Randall, 1986). The most southerly records for this species on the GBR were in the Swain Reef Group on Reef 21-072 (21^o 08' S) and Elusive Reef (21^o 06' S) (Choat and Randall, 1986). None were observed during surveys of Creal, Little Bugatti, Whitetip and Little Stevens Reefs off Mackay (21^o 36' S) (Choat and Randall, 1986). *Bolbometopon muricatum* was observed at Clerke Reef, Rowley Shoals (off the north-western coastline of Western Australia) for the first time in 1982 (Allen and Russell, 1986) and at Scott / Seringapatam Reefs (off the north-western coastline of Western Australia) for the first time in 1993 (Hutchins *et al*., 1995). In north-western Australia, this species occurs northwards of Ningaloo Reef (22^o 22' S, 113^o 45' E) (Allen and Swainston, 1988).

Museum Records - 3 specimens (Standard Length 60-613mm), collected from a depth range of 4-21m, ranging in geographical distribution from Lizard Island (14^o 41' S), Qld northwards to Yonge Carter Reef passage (14^o 35' S), Qld, and also from the Philippines (19^o 35' N). Specimens were collected between 1975 and 1986 This species is poorly represented in museum collections as it is usually difficult to approach and collect (Choat and Randall, 1986).

Habitat:
Bolbometopon muricatum occurs on coastal coral reefs to outer reef slopes (Kuiter, 1996). It is most commonly observed on reef fronts but also ranges over reef crests and flats (Choat and Randall, 1986). Juveniles occur in lagoons, and adults occur in clear lagoons and on seaward reefs in depths to over 30m (Lieske and Myers, 1994).

Biology and Behaviour:
Bolbometopon muricatum is the largest of the parrotfishes, forming great schools like herds of bison or buffalo. Only adults develop the large hump on the head. They graze on corals during the day and sleep in crevices at night (Kuiter, 1996). They may ram their heads into the coral to break coral pieces off to facilitate feeding (Lieske and Myers, 1994). Although usually harmless, large sleeping parrotfishes can be potentially dangerous if suddenly awakened by divers (Allen and Swainston, 1992). At least two divers have received heavy blows from parrotfishes that panicked when suddenly disturbed, one of which was nearly rendered unconscious (Allen and Swainston, 1992). This species is quite wary and vulnerable to overfishing (Lieske and Myers, 1994). Choat and Randall (1986) observed no spawning, although Choat observed what appeared to be a group spawning assemblage of 40-50 fish on the outer face of Yonge Reef during December 1983 (Choat and Randall, 1986). The longevity of this species is at least 35 years (maximum age probably 38-40 years), and maturity is not reached until about 9 years of age (H. Choat, pers. comm.). In a study by Choat, abundances on the central and northern GBR varied from 0.5 to 2 individuals per 300m^2 (H. Choat, pers. comm.). This species consistently schools in numbers ranging from 8 to 55 individuals, with the median about 25-30 fish (Choat, pers. comm). It may penetrate into surprisingly shallow water for such a large fish. Schools of up to 60 were regularly observed feeding on the lagoon coral flats at Aldabra, Indian Ocean (approx. 10^o S, 45^o E) in water slightly deeper than their body

depth (Randall and Bruce, 1983). The noise of a group of these large fish feeding can be heard from a greater distance underwater than they can be seen (Randall and Bruce, 1983). This species appears to be monochromatic (i.e. there are no distinct initial and terminal colour phases) in Australian waters (Choat and Randall, 1986). *Bolbometopon muricatum* feeds on encrusting algae (Lieske and Myers, 1994), benthic algae and live coral (Randall *et al.*, 1997). It is the only species of parrotfish which relies on live coral as a major dietary constituent (>50%) (Bellwood, 1994), and by biomass it is the most important nominal herbivore on the northern GBR (Choat, pers. comm). A single large specimen consumes approximately one cubic metre of coral skeletons per year, releasing the material again as fine silt (Choat and Bellwood, 1998).

Size:
Bolbometopon muricatum is the largest of the parrotfishes, reaching at least 120cm in length. One of 117cm in length weighed 46 kg (Randall *et al.*, 1997), and they may obtain a weight of about 80kg (Allen and Steene, 1987). This species is typically fast-growing (H. Choat, pers. comm.).

Evidence for Decline:
In Guam, commercial fishers use up to three 120 cubic-foot scuba tanks per diver per night and venture as deep as 55m on their first and second dives, to target this and other species. Spearguns and bang sticks (devices employing 12-gauge shotgun cartridges that can stop even sharks and large fish) are used to maximise catches of these popular Humpheaded parrotfish (Anon., 1999). Bellwood and Choat (1989) reported juveniles as very rare in the Lizard Island area (approx. 14^{o} 40' S) of the GBR, collecting only a single specimen.

Australian Marine Protected Areas in Which the Species Occurs:
Great Barrier Reef Marine Park and World Heritage Area, Qld
Rowley Shoals Marine Park, off north-western WA

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
There is currently no minimum or maximum legal lengths or in-possession limits for this species under Queensland Fisheries Service (QFS) regulations. The QFS has proposed a recreational limit of five for this species (D. Cameron, pers. comm.). Similarly, in WA waters there are no regulations in place for this species (http://www.wa.gov.au/westfish/). This species grows to a large adult size and fishing pressures placed on it in many parts of its range may threaten its survival. However, more biological data are needed to accurately assess its conservation status in Australian waters. It is recommended to assign it the conservation status of Data Deficient, adopting the IUCN categories.

Threatening Processes:
Commercial and recreational fishing, and habitat degradation (e.g. cyanide fishing, excessive coral collecting and/or destruction) may threaten the survival of this species.

Critical Habitats:
As live coral is an important part of the diet of this species, healthy coral reefs are essential to its survival.

Recovery Objectives / Management Actions Required:
Catch limits need assessing and reviewing to ensure this species is not being overfished in Australian waters. The proposed QFS catch limit needs to be adopted and enforced. More biological data for this species will help in accurately assessing its vulnerability to the abovementioned threats. Biological work could focus on tracking possible breeding/spawning migrations, which may render it more susceptible to overfishing, and further research on the age, size and sex structures of populations are needed to determine its growth and longevity.

References:
Allen and Russell, 1986; Allen and Steene, 1987; Allen and Swainston, 1988; Allen and Swainston, 1992; Anon., 1999; Bellwood, 1994; Bellwood and Choat, 1989; D. Cameron, pers. comm. 12/1999; H. Choat, pers. comms. 1999-2000; Choat and Bellwood, 1998; Choat and Randall, 1986; Hutchins *et al.*, 1995; Kuiter, 1996; Lieske and Myers, 1994; Randall and Bruce, 1983; Randall *et al.*, 1997.

Websites:
http://www.wa.gov.au/westfish/ (Fisheries Western Australia homepage)

Patagonian toothfish

Family Name:	Nototheniidae
Scientific Name:	*Dissostichus eleginoides* Smitt, 1898
Conservation Status:	Data Deficient

Synonyms:
Macrias amissus Gill and Townsend, 1901

Alternative Common Names:
Australian sea bass; sea bass; toothfish

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Dissostichus eleginoides is known from Southern Chile, Patagonia, Falkland Islands, Shag Rocks, South Georgia, sub-Antarctic islands and seamounts of the Indian Ocean sector, Macquarie Island (Gon and Heemstra, 1990), Heard Island and MacDonald Island (Yearsley *et al*., 1999). It is confined to sub-temperate and sub-Antarctic latitudes (40^{o}S-55^{o}S) (Gon and Heemstra, 1990; AFMA, 2000e). The fisheries in Australian Commonwealth waters that take this species are located at:
1) Heard Island and MacDonald Island Fishery (HIMIF) in the southern Indian Ocean, approx. 4,000km south-west of Perth; and
2) Macquarie Island (MQI) Fishery in the Southern Ocean, approx. 1,500km south-east of Hobart (AFMA, 2000e).

Museum Records - 2 specimens (Standard Length 279-370mm), collected from a depth range of 246-384m from the vicinity of Heard Island (52^{o}30'S, 75^{o}09'E) in 1993.

Habitat:
Dissostichus eleginoides is a midwater species that is reported to be pelagic during some periods of its life. It has been taken in demersal trawls at depths of 70-1500m (Gon and Heemstra, 1990), but is known to inhabit waters of up to 3,500m depth around seamounts and continental shelves of most sub-Antarctic islands (Pockley, 1999; AFMA, 2000e). Generally they are found just off the bottom (Smith *et al*., 2000).

Biology and Behaviour:
Dissostichus eleginoides is a slow-growing species (Pockley, 1999), reaching sexual maturity at lengths of 70 to 110cm (6.5-10 years of age) and living for at least 40 (Chesson, 2000a) to 50 years (Pockley, 1999; Smith *et al*., 2000). In the Atlantic Ocean sector of the Southern Ocean, sexual maturity is reached at about 90 to 100cm total length (9-10 years of age) in most fishes, but a few males were mature by 80cm total length (Gon and Heemstra, 1990). Spawning in the Kerguelen Islands (north-east of Heard and McDonald Islands) takes place on the bottom in April and May (Gon and Heemstra, 1990). Eggs and larvae are large; post larvae (49 to 62mm SL) were caught in December and January off South Georgia, and from mid-October onwards on the southern Patagonian Shelf (Gon and Heemstra, 1990). Fecundity is moderate and, as yet, no spawning, spent or developing fish have been detected in the fishing season (December to March) of the Macquarie Island Fishery (Chesson, 2000a). The sex ratio of the catch in this fishery is 1:1 (Chesson, 2000a). *Dissostichus eleginoides* is not found in waters colder than 2^{o}C as it lacks antifreeze and has at least a few glomeruli in its kidneys (Gon and Heemstra, 1990). They are large, active predators, although individuals appear to feed infrequently (Chesson, 2000a). Toothfish do not have a swim bladder to provide neutral buoyancy; they achieve this with the fats and oils distributed throughout their body (producing the oily flesh) and with reduced mineralisation of some bone (Smith *et al*., 2000). In the Kerguelen Islands, larvae and juveniles feed on krill (*Euphausia similis*) and as they grow, they feed increasingly on fishes (primarily mackerel icefish *Champsocephalus gunnari*, grey rockcod *Lepidonotothen squamifrons* and members of the family Myctophidae), which dominate the stomach contents of immature and adult specimens (Gon and Heemstra, 1990). In the South Georgia area, juveniles feed on fishes (primarily

nototheniids) and, to a lesser degree, on the decapod *Crangon antarcticus* (Gon and Heemstra, 1990). They also feed on mid-water squid, but benthic animals such as prawns, crabs and echinoderms occur regularly enough in their diet to indicate that bottom feeding is also important (Chesson, 2000a). This species plays an important role in the food chain as it is the staple diet of elephant seals (98% of the diet) and sperm whales (Pockley, 1999).

Size:
Dissostichus eleginoides grows to a maximum size of 215cm and 100kg, and is commonly marketed at 40-65cm and 1-3.5kg (Yearsley *et al*., 1999).

Evidence for Decline:
Dissostichus eleginoides is a lucrative delicacy that is highly prized for its white flesh (Pockley, 1999). It is exported frozen, but there is a developing local market (Yearsley, 1999). Illegal fishing has probably resulted in a significant decline in abundance (Pockley, 1999). Although some toothfish are caught under licence in Antarctic territorial waters, the vast majority are caught illegally and sold (under other names) for the people of Japan, Asia, the USA and several other Antarctic Treaty nations, including Australia (Pockley, 1999). Covert fishing in the Southern Ocean is thought to be worth $600-$800 million annually (Pockley, 1999). Access at Heard and McDonald Islands is restricted to two boats and there is a total allowable catch (TAC) (Chesson, 2000b). Toothfish are easily caught by longline or trawl (Smith *et al*., 2000). In 1997 the Australian catch from the HIMIF was 1927t, but illegal foreign fishing in the region is estimated to have taken 10,000-18,000t in the same year, far exceeding the TAC of 3,800t (Chesson, 1998b). The TAC for the HIMIF was reduced slightly to 3700t for the year 1998 and this revised assessment assumed that there would be no further illegal fishing (Chesson, 1998b). However, the TAC for the HIMIF was met and illegal catch estimates for the region in 1998 ranged from 520-3,500t, further threatening the sustainability of the fishery (Chesson, 2000b). The TAC for the HIMIF in 1999 was set at 3690t (Chesson, 2000b) and this TAC was also reached (AFMA, 2000e). At MQI access is restricted to a single boat and the 1996-97 catch was within the TAC of 1,000t (Chesson, 1998a). The 1997-98 TAC for MQI was raised to 1,500t (Chesson, 1998a) and catches were within this limit (Chesson, 2000a). Prior to 1999 the fishing season at MQI ran from 1 September to 31 August, but from 1999 the season operates to the calendar year (Chesson, 2000a). The TACs at MQI were set at 600t and 510t for the 1999 and 2000 calendar years, respectively (Chesson, 2000a; AFMA, 2000e), but at this stage it is unknown if those figure were adhered to. To date there has been no direct evidence of illegal fishing in the MQI area (Chesson, 2000a).

Australian Marine Protected Areas in Which the Species Occurs:
Macquarie Island Marine Park (1500km south-east of Tasmania)
Heard Island Marine Park, Australia (not declared yet, EA, pers. comm.)

Suggested Conservation Status:
Data Deficient on an Australia-wide and worldwide basis.
At current rates of exploitation, *Dissostichus eleginoides* may become threatened with commercial extinction in the next few years. However, more data are necessary to accurately determine the conservation status of this species. At this stage it is recommended to assign it the above status, adopting the IUCN categories.

Threatening Processes:
Overfishing, especially by illegal poaching in the Heard and McDonald Island regions, is the major threat to the survival this species.

Critical Habitats:
None identified.

Recovery Objectives / Management Actions Required:
The Australian and New Zealand Antarctic Divisions are planning joint studies of fish and krill populations in an attempt to monitor and conserve the stocks of Patagonian toothfish. Measures to save the toothfish are based on:

- the introduction of mandatory systems to monitor vessels by satellites;
- placing scientific observers on board licenced vessels to report on other vessels sighted and on the catch of toothfish and bycatch species;
- uniform licensing and marking systems for vessels; and

- making it difficult to land and sell illegally caught fish (Pockley, 1999).

The HIMI Fishery has implemented a minimum mesh size of 120mm for fishers targeting Patagonian toothfish (AFMA, 2000e). Additionally, all vessels engaging in fishing activities in Australia's Sub-Antarctic Fisheries must be equipped with a satellite Vessel Monitoring System (VMS) to provide automatic position reports at standard reporting intervals (AFMA, 2000e). A three-year research program for the MQI fishery was completed in June 2000 (Chesson, 2000a), but the final results were unavailable at the time of writing this summary. An interim management policy is in force until July 2001, when a Statutory Management Plan will be implemented (Chesson, 2000a).

References:
AFMA, 2000e, Chesson, 1998a; Chesson, 1998b; Chesson, 2000a; Chesson, 2000b; Gon and Heemstra, 1990; Pockley, 1999; Smith *et al*., 2000; K. Truelove, pers. comm. 9/1999; Yearsley *et al*., 1999.

Tasmanian robust triplefin

Family Name:	Tripterygiidae
Scientific Name:	*Grahamina gymnota* (Scott, 1977)
Conservation Status:	Data Deficient

Australian Synonyms
Fosterygion gymnotum Scott, 1977

Alternative Common Names:
Bare-backed threefin; bully

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Grahamina gymnota has a very restricted distribution in south-eastern Tasmania. It has been recorded from the eastern shore of the Derwent River from Montague Bay to Droughty Point, where it was once common (Edgar and Last, pers. comms.) and also from Spring Bay, near Triabunna in south-eastern Tasmania. No observed or collected specimens have been recorded for the past 10 years. This lack of records is, however, not unexpected given a lack of specific research.

Museum Records - 2 specimens (Standard Length 31-63mm), collected from a depth range of 1-8m, ranging in geographical distribution from Spring Bay (42^{o} 32’ S), Tasmania southwards to Montague Bay, Derwent River (42^{o} 51’ S), Tasmania, collected between 1976 and 1982.

Habitat:
Grahamina gymnota inhabits mainly shallow, rocky areas in large estuaries and bays. It was once common around wharfs and piers in the Derwent estuary near Hobart (Last *et al*., 1983).

Biology and Behaviour:
The biology of this species is unknown, but other members of the Tripterygiidae family lay eggs in clumps on the bottom, usually on a sloping rock surface (Francis, 1996b). Each nest, which is guarded by the male against predators, may contain eggs laid by several females (Francis, 1996b). The male fans the eggs with his fins to aerate them and prevent silt accumulating (Francis, 1996b). When the eggs hatch the larvae become planktonic before settling on the bottom again during spring or summer (Francis, 1996b). Most triplefins are short-lived, reaching a maximum age of about three years (Francis, 1996b). The diet of this species is unknown, but other members of this family feed on small crustaceans and other small invertebrates (Doak, 1972).

Size:
Grahamina gymnota attains a length of about 95mm (Last *et al*., 1983).

Evidence for Decline:
The habitat of *Grahamina gymnota* is badly degraded by a variety of impacts, including the introduced Northern Pacific seastar *Asterias amurensis* and heavy metal pollution. Coupled with the restricted range of this species, there is reason for concern. Another triplefin that occurs in Tasmania and New Zealand, *Fosterygion varium*, may be out-competing *Grahamina gymnota* for food and resources. It is unknown whether *F. varium* naturally occurs in Tasmania or is introduced. Regardless, its range along the east coast of Tasmania has expanded in the past 20 years (G. Edgar, pers. comm.), and the effects of competition between these species needs to be researched.

Australian Marine Protected Areas in Which the Species Occurs:
Grahamina gymnota does not occur in any MPAs throughout its narrow range (G. Edgar pers. comm.).

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Accurate data are necessary to determine population numbers and range, and the extent and/or existence of the abovementioned threats.

Threatening Processes:
Inshore habitat degradation potentially threatens this species within its narrow range.

Critical Habitats:
Shallow rocky areas in large estuaries and bays within its distributional range are critical to this species.

Recovery Objectives / Management Actions Required:
Nothing is known about the biology of this species or the possible competition with *Fosterygion varium* and the suite of other introduced species inhabiting the Derwent River (including the Northern Pacific seastar *Asterias amurensis*). This would be a future area of research from which to base a recovery plan.

References:
Doak, 1972; G. Edgar and P. Last pers. comms. 1999; Francis, 1996b; Fricke, 1997; Last *et al*., 1983

Earspot snakeblenny

Family Name:	Clinidae
Scientific Name:	*Ophiclinops hutchinsi* George and Springer, 1980
Conservation Status:	Data Deficient

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Taxonomic Confusion:
This species may prove to be the same as the spotted snakeblenny *Ophiclinops pardalis* when specimens at localities between the two areas of known distribution are examined. However, since there are considerable differences between individuals in the two populations they are considered to be different until shown otherwise (Gomon *et al*., 1994).

Distribution:
Ophiclinops hutchinsi is known only from a small part of the Recherche Archipelago in Western Australia (Gomon *et al*., 1994).

Museum Records - 13 specimens (as *Heteroclinus hutchinsi*) (Standard Length 27-89mm), collected from a depth range of 0-15m, ranging in geographical distribution from Israelite Bay (33^o 37’ S, 123^o 53’ E) south-westwards to Rob Island (34^o 02’ S, 122^o 14’ E), on the Recherche Archipelago in WA. Specimens were collected between 1978 and 1984.

Habitat:
Ophiclinops hutchinsi occurs in seagrass beds and reef and weed habitats to depths of about 15m (Gomon *et al*., 1994).

Biology and Behaviour:
No information could be found on the biology of this species.

Size:
Ophiclinops hutchinsi reaches a length of about 9.5cm (Gomon *et al*., 1994).

Evidence for Decline:
There is no evidence of any decline, but pollution and habitat degradation are potential threats.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More information needs to be gathered to accurately assess the conservation status of this species. However, its very restricted (known) distribution may make it vulnerable to habitat degradation.

Threatening Processes:
None identified.

Critical Habitats:
Shallow areas with seagrass, reef and algae appear crucial to this species.

Recovery Objectives / Management Actions Required:
Habitat protection is required in areas where this species is known to occur. The biology and accurate range of this species needs to be clearly defined.

References:
Gomon *et al*., 1994.

Eelblenny

Family Name:	Clinidae
Scientific Name:	*Peronedys anguillaris* Steindachner, 1884
Conservation Status:	Data Deficient

Australian Synonyms
Ophioclinus devisi Ogilby, 1894
Eucentronotus zietzi Ogilby, 1898

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Peronedys anguillaris is endemic to Australian waters, occurring at Kangaroo Island and in St Vincents Gulf (South Australia) and also being reported from Moreton Bay (Queensland) (Gomon *et al*., 1994). The latter record is doubtful according to Kuiter (1997). It is also known from the Recherche Archipelago on the southern coast of Western Australia (D. Hoese, pers. comm.).

Museum Records - 24 specimens (Standard Length 46-123mm), collected from a depth range of 0-6m, ranging in geographical distribution from Moreton Bay (27^{o} S), Qld southwards to Kangaroo Island (35^{o} 50' S), SA and westwards to the Recherche Archipelago (34^{o} 01' S, 122^{o} 15' E), WA. Specimens were collected between circa 1886 and 1984.

Habitat:
Peronedys anguillaris lives among seagrass roots (Gomon *et al*., 1994). It is found in calm bays with prolific seagrasses forming mats over decaying ones (Kuiter, 1996).

Biology and Behaviour:
No information could be found on the biology of this species.

Size:
Peronedys anguillaris attains a size of about 13cm (Gomon *et al*., 1994).

Evidence for Decline:
There is no evidence of any decline, but pollution and habitat degradation may be a threat to this species, as it probably has a very restricted distribution.

Australian Marine Protected Areas in Which the Species Occurs:
None identified

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
More information needs to be gathered to accurately assess the conservation status of this species. It is therefore recommended to assign the status of Data Deficient at this stage.

Threatening Processes:
Habitat degradation within its range is a potential threat to this species.

Critical Habitats:
Protected bays associated with seagrass habitats appear critical to the survival of this species.

Recovery Objectives / Management Actions Required:

Habitat protection is required in areas where this species is known to occur. The biology and accurate distributional range of this species need to be investigated to determine its susceptibility to abovementioned threats.

References:

Gomon *et al.*, 1994; D. Hoese, pers. comm. 9/1999; Kuiter, 1996.

FAMILY GOBIIDAE: GOBIES

Gobies are one of the largest fish families in the world, representing slightly less than 10 percent of all fish species (Hoese *et al*., in press). However, the family is so poorly known that 10 to 20 new species are described each year (Hoese, 1998). Approximately 90 species undescribed or of unknown identity are currently known from Australia (Hoese *et al*., in press). Currently 230 genera and around 1,500 species are recognised worldwide, with 87 genera and 316 species from Australia (Hoese *et al*., in press).

Gobies are small sized, tropical and temperate fishes, ranging up to 16cm in Australia, and ranging from less than 1cm to over 30cm in other regions of the world (Hoese *et al*., in press). Most adult gobies are in the range of 4 to 10cm in length (Hoese, 1998). Gobies have two fins on the back, a tail fin, a fin along the midline of the lower part of the body, two ventral fins (which in most gobies are fused into a cupshaped disk), and paired fins on the side (Hoese, 1998). Species are commonly found in a variety of habitats, including coral reefs, estuaries, freshwaters and the continental shelf to depths of over 900m (Hoese *et al*., in press).

Most gobies spend the majority of their time sitting on the substrate, but some species are active swimmers and may occur in schools of up to 100 fish (Hoese, 1998). Gobies feed mainly on small invertebrates, although some with large mouths may eat other fishes, and a few feed on algae (Hoese, 1998). Feeding habits vary from selectively attacking an individual prey item to sifting out invertebrates or minute algae from the mud or sand to feeding on tiny plankton for the free-swimming species (Hoese, 1998).

Most, if not all, gobies have a similar life cycle (Hoese, 1998). The female lays from five to a few hundred eggs and attaches them to some form of vegetation, shell, rock or coral, and the male then fertilises the eggs (Hoese, 1998). The female departs and the male is left to guard the eggs and keep them clean until they hatch (one to a few days) into small, transparent larval stages of 2-10 mm in length (Hoese, 1998). The larvae are dispersed into the water column and swim for 3 to 20 days (depending on the species) before settling into suitable habitat where they rapidly develop colouration to match their surroundings (Hoese, 1998). In warm waters fish grow rapidly and mature in a few months, but in cooler areas growth is slower and maturity is not reached until one or two years of age (Hoese, 1998). Longevity for most warm water species is probably only a year, while cooler water species are thought to survive for two to ten years (Hoese, 1998). Sex change (from female to male) occurs in some gobies, but most species are thought not to change sex (Hoese, 1998).

Many marine gobies form associations with marine invertebrate hosts, and the conservation of these goby habitats is essential to conserve both the gobies and the invertebrates they rely on for survival. Due to the large number of gobies and our inherent lack of basic biological and ecological knowledge for many of these species, there are likely to be additional species with conservation concerns, both in Australia and worldwide. Some goby species may become extinct even before they are discovered (Hoese, 1998). Others gobies (e.g. from Japan) have caused some conservation problems for local species by being introduced into non-native Australian waters through the ballast water of cargo ships (Hoese, 1973; Hoese, 1998).

According to the 2000 IUCN Red List of Threatened Species, 58 gobies are listed. Five species are listed as Critically Endangered, 18 are listed as Vulnerable, 12 are listed as Lower Risk (near threatened), one is listed as Lower Risk (conservation dependent) and 22 are listed as Data Deficient (http://www.redlist.org/). Detailed discussion, through a species conservation synopsis, is confined to one Australian species *Silhouettea hoesei*.

References:
Hoese, 1973; Hoese, 1998; Hoese *et al*., in press.
Websites:
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species)

Hoese's Silhouette Goby

Family Name:	Gobiidae
Scientific Name:	*Silhouettea hoesei* Larson and Miller, 1986
Conservation Status:	Data Deficient

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

Distribution:
Silhouettea hoesei is known from the types collected at Coral Bay on the Coburg Peninsula in the Northern Territory, bordering the Arafura Sea (Larson and Miller, 1985) and also from the Monte Bello Islands in Western Australia (Hoese *et al*., in press).

Museum Records – 5 specimens (Standard Length 11-15mm), collected in 5-6m of water at Coral Bay (approx. 11^{o} 11' S), Coburg Peninsula (NT) in 1981. Specimens have also been collected from Monte Bello Islands in WA (H. Larson, pers. comm.).

Habitat:
Silhouettea hoesei has been collected from shallow depths (5-6m) on flat silty sand bottom habitats, with isolated dead coral rocks, and a few gorgonians and sponges (Larson and Miller, 1985).

Biology and Behaviour:
Unknown, but as it grows to only a very small size, it is unlikely to produce many offspring in any one breeding season.

Size:
Silhouettea hoesei attains a size of at least 20mm (Larson and Miller, 1985). Allen (1997) reports the maximum size to be 3.5cm.

Evidence for Decline:
There is no evidence of any declines for this species.

Australian Marine Protected Areas in Which the Species Occurs:
Coburg Marine Park (NT)
The only known locality for this species is within a 'buffer zone' of the Park, beside which a wilderness lodge is built (H. Larson, pers. comm.).

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Accurate data on population numbers and distributional range are necessary to determine the conservation status of this species.

Threatening Processes:
Coastal development potentially degrades the inshore habitats of this species.

Critical Habitats:
Shallow, soft-bottom habitats appear to be important to this species.

Recovery Objectives / Management Actions Required:
Further monitoring of the existing populations of this species is required to determine its abundance and distributional range.

References:
Allen, 1997; Larson and Miller, 1985; H. Larson, pers. comms. 12/1999 – 9/2000.

Gemfish

Family Name:	Gempylidae
Scientific Name:	*Rexea solandri* (Cuvier, 1831)
Conservation Status:	***Eastern Stock:** Lower Risk (conservation dependent) or Vulnerable **Western Stock:** Data Deficient

*Depending on future management decisions made by the Australian Fisheries Management Authority (AFMA).

Australian Synonyms:
Thyrsites micropus McCoy, 1873

Current Conservation Status:
No IUCN (1996, 2000) or ASFB Listings

This species was submitted in March 1994 to the Commonwealth's Endangered Species Scientific Sub-Committee for consideration as threatened. Its listing was rejected mainly because there were several stocks (at least four in Australian and New Zealand waters) of gemfish and only the 'eastern Australian stock' was presented as being under any threat. However, this legislation now allows 'populations' (=stocks) to be listed as threatened.

Alternative Common Names:
Hake; king couta; kingfish; silver kingfish; southern kingfish

Stock Structure:
Colgan and Paxton (1997) demonstrated that the eastern Australian stock and the southern/western Australian stock (herein referred to as the western stock) are biochemically (genetically) different, with very little gene flow or mixing between the two stocks. For fisheries management purposes these eastern and western populations can be considered separate breeding stocks. These authors also demonstrated that the eastern Australian stock is closely related to the southern New Zealand stock.

Distribution:
Rexea solandri is distributed throughout southern Australian waters, from off Cape Moreton in southern Queensland to waters off Shark Bay, Western Australia. It is also present in New Zealand waters (Colgan and Paxton, 1997).

Museum Records - 518 specimens (Standard Length: larval stage to 102cm), collected from depths of 0m (larvae) to 1254m (adults), ranging in geographical distribution from east of Caloundra (26^o 48' S), Qld southwards through NSW and Victoria to Tasmania, and westwards through SA to central-northern WA (northernmost record for WA is off Pt Cloates, 23^o 23' S). Specimens were collected between circa 1884 and 1995. There are also museum records from both the north and south islands of New Zealand.

Habitat:
The eastern Australian stock of *Rexea solandri* inhabits deeper continental shelf and upper slope waters from 100m to at least 700m, but these fish are most commonly caught at depths of 300-500m. Western stock fish are caught mainly in waters of about 250 to 500m depth (Tilzey and Chesson, 1998; Tilzey, 2000a). This species is normally caught close to the sea bed but probably moves into midwater at times (Kailola *et al*., 1993).

Biology and Behaviour:
Females mature later (4-6 years of age), live longer (up to 17 years) and attain a greater length (116cm Fork Length, FL) than males (age at maturity 3-5 years, longevity up to 13 years and maximum length 106cm FL) (Tilzey and Chesson, 1998; Tilzey, 2000a). Genetic research indicates that the eastern stock of gemfish, extending from Cape Moreton in southern Queensland to the western edge of Bass Strait, and fished mainly

by the South East Fishery (SEF) and NSW dropliners, is distinct from the western stock, which extends across the Great Australian Bight (GAB) northwards to off Shark Bay in Western Australia (Colgan and Paxton, 1997), and is fished by the GAB Trawl Fishery (Tilzey and Chesson, 1998) as well as the SEF (Tilzey, 2000a). The eastern stock undertakes a pre-spawning migration along the upper continental slope off NSW at depths of about 400m, commencing in waters off eastern Bass Strait around early June and finishing off the NSW mid-north coast (latitude about 31^{o} S) around August, when spawning occurs. The available information suggests that at this time gemfish are very vulnerable to capture using demersal trawl nets, and also droplines (Anon., 1999c), and the bulk of the commercial catch is taken during the pre-spawning migration (Tilzey, 2000a). The biology of western gemfish appears to be similar to that of eastern gemfish, except that spawning is thought to occur in summer rather than in winter (Tilzey and Chesson, 1998). Further biological work is required to test this hypothesis. Another difference is that western gemfish do not appear to aggregate to spawn (or at least the aggregations have not been found), and therefore should not be as vulnerable to exploitation as the eastern stock. Larvae have been caught in coastal and offshore waters of northern and central NSW from August to September, and in coastal waters off Sydney from July to September (Neira *et al*., 1998). In New Zealand waters, two gemfish stocks are indicated on the basis of patterns of year class strengths, trends in commercial landings, and likely spawning areas. One stock occurs off the eastern and northern sides of the North Island, and another stock occurs off the western and southern sides of the South Island (Horn and Hurst 1999). *Rexea solandri* is a carnivorous species, feeding mainly on fish such as whiptails (Macrouridae) and deepwater cardinalfish *Apogonops anomalus*. They also feed on royal red prawns *Haliporoides sibogae* and squid (Ommastrephidae) (Kailola *et al*., 1993).

Size:
Rexea solandri grows to a maximum total length of about 1.2m and a weight of about 15kg (Rowling, 1997).

Evidence for Decline:
<u>Eastern Gemfish</u>
During the late 1970s, the eastern gemfish was the most important species in the winter fishery of the South East Trawl area, with a peak catch of over 5000t being taken in 1980. Declining catch rates and a reduction in the mean size of fish caught led to the imposition of a Total Allowable Catch (TAC) of 3000t in 1988. Concerns about declining levels of recruitment to the spawning stock and declining catches led to successive reductions in the TAC, resulting in a zero TAC in 1993, which remained in place until 1996. Continued bycatch of gemfish from 1993 to 1996 was managed using trip limits. Based on a trawl survey undertaken in 1996 and a subsequent quantitative stock assessment by the Eastern Gemfish Assessment Group (EGAG), the fishery was reopened in 1997. The 1997 TAC for the trawl sector of 1000t was not reached, with trawl landings totalling only 393t, and non-trawl landings estimated at approximately 100t. Subsequent assessments by EGAG showing the stock to be below the AFMA reference level (40% of the 1979 level) have resulted in zero “targeted” trawl TACs since 1997. However, bycatch in these years for the SEF trawl sector has been managed by an allocated “bycatch” TAC (of 300, 250 and 200t in 1998, 1999 and 2000, respectively) rather than by trip limits. These arrangements were set in place to try to minimise dumping of fish and collect data on bycatch levels, and catches have been well within the limits set. Bycatch by NSW dropliners has continued to be managed by trip limits, but bycatch levels by these dropliners are increasing. The 1999 stock assessment (Anon., 1999c) suggests that the current exploitable biomass of eastern gemfish lies somewhere between 6 and 25% of the virgin biomass. There is disagreement in the assessment group as to which end of this range is more plausible. The 1999 biomass is estimated to lie between 700 and 2600t, depending on the assumptions underlying the assessment. If catch rate is a poor indicator of abundance at low population levels (“hyperstability”) then the actual biomass may be lower than these estimates (K. Rowling, pers. comm.). This biomass is predicted to decline further in 2000 owing to the entry into the fishery of generally poor year-classes since those spawned in 1990 and 1991. There is, however, some evidence that the 1996 year-class will be stronger than recently recruiting year-classes (Anon., 1999c).

Recent catches have been about 200 to 300 t/year. Trawl catches under the AFMA bycatch TAC of 300t were 214t in 1998. Dropline catches under the NSW Fisheries trip limit quotas totalled 105t in 1997-98 (Fletcher and McVea, 2000). In 1999, trawl catches totalled about 200t (including an estimated 38t discarded), while landings by NSW dropliners declined to 74t (Punt *et al*., 2000). Additionally, 4t (including 2t discarded) were taken by the Commonwealth SENTF in 1999 (Punt *et al*., 2000). Therefore the total catch for 1999 was about 277t (including 40t discarded) (Punt *et al*., 2000). The 2000 winter catch appears to have been significantly lower at an estimated 130t (K. Rowling, pers. comm.).

<u>Western Gemfish</u>
Western gemfish are caught in both the SEF and the GAB Trawl Fishery and are taken exclusively by trawling. Catches in the SEF declined from 1986 to 1992 but have remained comparatively stable since. Catches and catch rates improved in 1996 and again in 1997 when 227t were landed. A further 65t were landed from the GAB Trawl Fishery in 1997 (Tilzey and Chesson, 1998). In 1998, 185t were landed from the SEF and 85t were landed from the GAB Trawl Fishery, totalling 270t (Tilzey, 2000a). There are no yield estimates for western gemfish, and it is unknown if current catches are sustainable. The agreed TAC for 1999 remained at 300t. The actual 1999 TAC, incorporating carryover, was 346t (Tilzey, 2000a)

<u>New Zealand Gemfish</u>
The New Zealand gemfish fishery developed in the 1970s with catches increasing significantly in the early 1980s to peak at about 8250t in 1985-6 (Horn and Hurst, 1999). Catches subsequently declined to less than 1400t in 1997-8 (Annala *et al*., 1999). The catches of southern New Zealand stock peaked at 6914t in 1985-6, but subsequently collapsed, and in 1997-8 only 71t were caught (Annala *et al*., 1999), primarily as bycatch of trawl fisheries for hoki *Macruronus novaezelandiae,* and squid (Horn and Hurst, 1999).

<u>Possibility of Depensation</u>
Depensation in fish stocks describes a situation where recruitment declines more quickly than expected as spawning stock size declines. Liermann and Hilborn (1997) have compiled evidence for depensation in some fished species, although it is not very common. So-called "critical" depensation occurs when the population fails to replenish itself, even in the absence of fishing, and can theoretically result in extinction. There are no well documented case studies of critical depensation for exploited fish stocks. Recent assessments for eastern gemfish (e.g. Anon., 1999c) have found some evidence for depensation in this stock. An alternative explanation is that there has been a "regime shift" such that mean recruitment levels are now much lower than in the 1970s and 1980s. Both of these scenarios fit the data better than the more conventional assumption of a Beverton-Holt stock recruitment relationship. The 1999 assessment for eastern gemfish (Anon., 1999c) includes projections for the stock under these varying scenarios for future levels of recruitment.

Australian Marine Protected Areas in Which the Species Occurs:
This species is not likely to be afforded any protection from existing MPAs in Australian waters as it is wide ranging and inhabits relatively deep waters.

Suggested Conservation Status:
Eastern Stock:
Vulnerable or Lower Risk (conservation dependent) depending on future management decisions made by AFMA.
The eastern Australian stock of gemfish is clearly at a low level of abundance relative to unexploited levels. Whether this is due to overfishing or a possible "regime shift" is not clear. Whatever the cause, the eastern Australian stock is well below the reference point, which has been set at 40% of the mature biomass in 1979, by AFMA. Recruitment levels have been low for the last 10 years, with the exception of the stronger year classes spawned in 1990 and 1991, and a suggestion of a possibly stronger year class in 1996 (Anon., 1999c). Stock projections under the various future recruitment scenarios considered by EGAG show a wide range of outcomes under current levels of catch, from recovery to continued decline. Because at least some scenarios suggest further decline, there is some cause for concern about whether current management arrangements are adequate to allow stock recovery. Adopting the IUCN categories and criteria, the eastern gemfish would be classified as Critically Endangered, based on a reduction of at least 80% over the last three generations (approximately 20 years, i.e. 1980 to 2000). The authors think that critically endangered is a gross exaggeration of the extinction risk of this species, and consider that a conservation status of Vulnerable or Lower Risk (conservation dependent) should be adopted at this stage, depending on future management decisions made by the AFMA.

Western Stock – Data Deficient
The status of the western Australian stock needs to be accurately assessed and is considered to be data deficient at this stage. There is no conclusive evidence that demonstrates that the western Australian stock aggregates to spawn, so it may not be as vulnerable to exploitation as the eastern Australian stock. However, given the overfishing of the eastern Australian stock, care should be taken in allocating appropriate TACs to the western stock before an accurate stock assessment is made.

Threatening Processes:
Commercial fishing (i.e. trawling and droplining) particularly in waters inhabited by the eastern gemfish (i.e 300-500m depth) during crucial times of the year, such as during their migratory and/or spawning aggregations.

Critical Habitats:
None identified. Virtually nothing is known about the habitat of gemfish at most life history stages. There is also very little known about environmental conditions required for successful spawning and juvenile survival.

Recovery Objectives / Management Actions Required:
Restrictive management has been in place for the eastern stock of gemfish for the past decade, but this has not resulted in any significant recovery of the stock, which continues to decline because of very poor levels of recruitment - yet fishing continues in the areas where spawning aggregations occur. A precautionary approach is essential in determining future management arrangements for this species, to help build up the spawning biomass of the eastern stock. Given that much larger spawning populations than exist at present resulted in very poor recruitments during the late 1980s, there is cause for concern about the current status of the mature population of eastern gemfish, and the implications for future recruitment to the eastern stock (Anon., 1999c). A trip limit of 50kg for eastern gemfish has been implemented for the South East Non-trawl Fishery (SENTF) (AFMA, 2000d) and the NSW Dropline fishery (K. Rowling, pers. comm.). The SENTF fishery uses demersal droplining methods, demersal gillnets, trotlines and longlines (AFMA, 2000d). Holders of permits for the Southern Shark Fishery who do not hold permits for the SENTF are also permitted to take up to 50kg of eastern gemfish (AFMA, 2000d). The SENTF and the SSF combined only took an estimated 4t (including discards) in 1999, so their impact on gemfish populations is limited. The Commonwealth SETF and the NSW Dropline fisheries take over 95% of the catch between them. Seasonal area closures to protect the pre-spawning (or spawning) aggregations appears to be the most useful management option to prevent the bycatch of mature eastern gemfish. The capture of juvenile gemfish (i.e. less than 55cm) should be discouraged or prevented, to increase the number of fish entering the mature population in coming years (K. Rowling, pers. comm.). Reducing or eliminating the capture of juvenile gemfish from the SETF is only likely to be possible by increasing the mesh sizes of nets used. This may also reduce the catches of other species, by allowing the smaller fish to escape, but appears to be necessary to reduce the gemfish catch. Catches of juvenile eastern gemfish in the NSW Dropline Fishery are limited due to the hook selectivity of the gear (K. Rowling, pers. comm.). As all gemfish that are brought to the surface do not survive release, changes in the gear selectivity and/or the closure of grounds to fishing are the only alternatives available to reduce the catches of the dwindling eastern gemfish population.

References:
AFMA, 2000d; Annala *et al.*, 1999; Anon., 1999b; Anon., 1999c; Colgan and Paxton, 1997; Fletcher and McVea, 2000; Gomon *et al.*, 1994; Horn and Hurst, 1999; Kailola *et al.*, 1993; Last *et al.*, 1983; Liermann and Hilborn, 1997; Neira *et al.*, 1998; Punt *et al.*, 2000; A. Punt, pers. comms. 1999-2000; K. Rowling, pers. comms. 8/1999-12/2000; Rowling, 1997; T. Smith, pers. comm. February 2000; Tilzey, 2000a; Tilzey and Chesson, 1998.

Southern bluefin tuna

Family Name:	Scombridae
Scientific Name:	*Thunnus maccoyii* (Castelnau, 1872)
Conservation Status:	Lower Risk (near threatened)

Alternative Common names:
Bluefin; bluefin tuna; southern tuna; southern tunny; tuna; SBT

Current Conservation Status:
1996 IUCN Red List of Threatened Animals
Critically Endangered (A1b, d)

2000 IUCN Red List of Threatened Species
Critically Endangered (A1bd) with a Marine Caveat, C

ASFB Threatened Fishes Committee
1989-1999: Requiring investigation of its status

This species was submitted to both the Commonwealth Endangered Species Scientific Sub-Committee (twice) and the NSW Fisheries Scientific Committee, but was rejected by both. It has also been submitted to the Victorian and Tasmanian Endangered Species Scientific Sub-Committees, as threatened species nominations.

Distribution:
Thunnus maccoyii (SBT) is distributed mainly in the pelagic zone between 30^{o}S and 45^{o}S (Robins *et al*., 1998), occasionally occurring southwards to 50^{o} S (Farley and Davis, 1998) and northwards to 10^{o} S during spawning (R. Tilzey, pers. comm.). In Australian waters, this species is found from northern NSW around the south of the continent to northern Western Australia (Kailola *et al*., 1993).

Museum Records - 28 specimens (Standard Length: 23.5-90cm), ranging in geographical distribution from Jibbon Beach (34^{o}05'S), NSW southwards to Esk River (41^{o}30' S), Tasmania and north-westwards to Cape Cuvier (24^{o}14'S), WA, collected between 1907 and 1981.

Habitat:
SBT occurs pelagically in the open ocean in cool-temperate waters (Yearsley *et al*., 1999), though their spawning migration takes them through warm-temperate and into tropical waters (Farley and Davis, 1998).

Biology and Behaviour:
SBT is a long-lived (up to about 40 years), slow growing, late maturing (8-12 years) and highly migratory species that is considered to form a single stock throughout their range (Robins *et al*., 1998). Their only known spawning area is around latitudes 10-20^{o}S between Australia and Java where they occur in greatest abundance from September to April (Robins *et al*., 1998), though females have been found on the spawning grounds in all months except July (Farley and Davis, 1998). Individuals are capable of multiple spawning, but do not spawn over a whole season, and there is a turnover of fish on the spawning grounds (Farley and Davis, 1998). The highest larval catches are made from January to February (Kailola *et al*., 1993) and the early life-history is restricted to warm waters (Farley and Davis, 1998). This species has a high fecundity and large adults spawn millions of eggs (Collette and Nauen, 1983). Farley and Davis (1998) estimated that on average females spawn every 1.1 days. Davis (1995) estimated that the average size at first maturity was 157cm. Juvenile and adult SBT are opportunistic feeders, chiefly on cephalopods, crustaceans, fish and salps (Thaliacea). Smaller fish feed mainly on crustaceans and adults feed mainly on fish (Kailola *et al*., 1993).

Size:
Thunnus maccoyii reaches a maximum size of 225cm (fork length) and a weight of around 200kg (commonly to 180cm and 100kg) (Yearsley *et al.*, 1999).

Evidence for Decline:
No boundaries apply to the SBT Fishery and as such, holders of SBT statutory fishing rights may fish for SBT throughout the AFZ, and on the high seas (AFMA, 2001a). Most (95%) SBT caught in the AFZ is taken by purse seining operations. Large surface schools are captured and towed back to in-shore facilities in South Australia where the fish are fed and grown-out for the sashimi market in Japan. Pelagic longlining is also used to provide fresh-chilled product to overseas markets. Poling and minor line methods take a small volume of the catch (AFMA, 2001a). Large SBT when aggregated on their spawning grounds are vulnerable to longlining. Catches of SBT in Australian waters declined steadily from 1961 to 1991, and excessive fishing has reduced the spawning stock to a level well below that regarded as biologically safe. An annual quota (11,750t from 1990 to 1997) set by Australia, Japan and New Zealand, and now under the control of the Convention for the Conservation of Southern Bluefin Tuna (CCSBT), was intended to allow the spawning stock of this species to rebuild. However, Taiwan, Indonesia, Korea and others (not subjected to convention control) caught an estimated 4500t of this species in 1997, bringing the global catch to about 15500t, undermined the stock rebuilding measures. Divergent views between Australia - New Zealand and Japan on the probability that the parent stock was rebuilding prevented their agreement on a global quota for 1998. Australia and New Zealand are maintaining 1997 limits, but, despite strong objections from these countries, Japan has increased its catch by 1400t in an ‘experimental’ fishing program. The total world catch was 15500t in 1997 of which the Australian catch was 4975t (1996-7 quota year), worth A$40 million (1996-7 financial year), the Japanese catch 5588t (1997), and the New Zealand catch 334t (1997) (Robins *et al.*, 1998). Japan’s catches in 1998 and 1999 were about 1,500t and 2,200t, respectively (R. Tilzey, pers. comm. 2000).

Australian Marine Protected Areas in Which the Species Occurs:
The pelagic behaviour of this species means that it is probably afforded little protection by any MPAs in which it occurs (Robins *et al.*, 1998).

Suggested Conservation Status:
Lower Risk (near threatened) on an Australia-wide basis.
The probability of extinction for this species in the wild in the next few decades is extremely low. However, if recent declines continue, the fishery will increasingly progress towards commercial extinction, as this species comprises only a single population in the southern hemisphere.

Threatening Processes:
Directed commercial fishing threatens the survival of this species. The high demand for this species as a quality eating fish (especially in Asian countries) contributes to its over-harvesting.

Critical Habitats:
Spawning habitats in the north-east Indian Ocean where surface waters exceed 24^{o}C are critical to the survival of this species.

Recovery Objectives / Management Actions Required:
The major CCSBT objective is to attain the 1980 spawning stock biomass level by 2020 (R. Tilzey, pers. comm. 2000). The major management objectives for the SBT fishery are to rebuild the spawning stocks of the species and to minimise seabird bycatch. Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations is recognised as a key threatening process under the Endangered Species Protection Act, 1992 (now the *EPBC Act 1999*). Endangered albatross species are particularly vulnerable (to being caught as bycatch) in latitudes where SBT longlining occurs (R. Tilzey, pers. comm. 2000). The long-term potential yield is much higher than the current yield assuming that the spawning stock is allowed to rebuild. The inability to monitor and control catches outside the control of the CCSBT remains a key deficiency in the management of this species (Robins *et al.*, 1998).

References:
AFMA, 2001a; Collette and Nauen, 1983; Davis, 1995; Farley and Davis, 1998; Kailola *et al.*, 1993; Robins *et al.*, 1998; R. Tilzey, pers. comm. 6/2000; Yearsley *et al.*, 1999.

Swordfish

Family Name:	Xiphiidae
Scientific Name:	*Xiphias gladius* Linnaeus, 1758
Conservation Status:	Data Deficient

Alternative Common Name:
Broadbill swordfish

Current Conservation Status:
In Australian Waters
No ASFB Listing

On a Global Basis
1996 IUCN Red List of Threatened Animals
North Atlantic Stock: Endangered (A1b,d)
Worldwide: Data Deficient

2000 IUCN Red List of Threatened Species
North Atlantic Stock: Endangered (A1b,d) with a marine caveat, C
Worldwide: Data Deficient with a marine caveat, C

Distribution:
Xiphias gladius is an oceanic fish distributed throughout tropical and temperate waters of the Pacific, Indian and Atlantic oceans between 45^{o} N and 45^{o} S. It inhabits all Australian waters beyond the edge of the continental shelf. Japanese longline vessels have reported high catch rates in the south-western Pacific between latitudes 15^{o} S and 40^{o} S, from the edge of the Australian continental shelf to northern New Zealand. In the Indian Ocean, catch rates by Japanese longliners are high in a region south of the south-western corner of Western Australia (Kailola *et al.*, 1993).

Museum Records - 42 specimens (Standard Length: larvae to 143cm), collected from a depth range of 0-121m, ranging in its Australian distribution from off Tweed Heads (27^{o} 01' S), NSW, southwards to south-east of Tasmania (approx. 43^{o} S) and north-westwards to Geraldton (28^{o} 46' S), WA. There are also records from the Arafura Sea and the Gilbert Islands. Larvae and juveniles have been collected from Hawaii, the Coral Sea, and the Western Indian Ocean and off the US east coast. Specimens were collected between circa 1885 and 1997.

Habitat:
Xiphias gladius is a marine species that is nomadic in the open ocean. It is thought to migrate to the surface at night and mainly descend to depths of about 600m during the day (Yearsley *et al.*, 1999).

Biology and Behaviour:
The swordfish is primarily a warm-water species and, generally speaking, its migrations consist of movements toward temperate or cold waters for feeding in summer and back to warm waters in autumn for spawning and overwintering. Female gonads contain 2 to 5 million eggs (Nakamura, 1985), but estimates range as high as 29 million eggs (Kailola *et al.*, 1993). This species is solitary in habit and rarely occurs in large numbers. Most swordfish caught by longline over 140kg are females. It first spawns at 5 to 6 years of age and about 150-170cm eye-fork length in the Pacific and Indian Oceans. Males reach sexual maturity at a length of around 100cm and females at a length of 70cm in the Atlantic, however, other research off the eastern coast of the USA indicates that males mature at a smaller size than females (Nakamura, 1985). DeMartini and Boggs' analysis of 816 female swordfish show 50% maturity at 144cm eye-fork length (which corresponds to approximately 3.5 years of age according to their growth curve). Male swordfish are mature at smaller sizes (P. Ward, pers. comm.). The distribution of larval swordfish in the Pacific Ocean indicates that spawning occurs mainly in waters of 24^{o}C or more. In Australian waters, larvae are common in spring in the Coral Sea. Females with mature ovaries have been caught in this area in October.

Fertilisation is external and pairing of solitary males and females is thought to occur when spawning (Kailola *et al*., 1993). The stock structure of swordfish in the Pacific Ocean is unclear (Ward *et al*., 1998). DeMartini and Boggs (1999) analysed annual rings and daily growth increments of nearly 300 otoliths and over 1200 fin spines and tag-recapture data for swordfish in the north Pacific. Their analyses show a wide size range for one year-old swordfish (50-117cm eye-fork length), averaging about 85cm. This is equivalent to about 100cm lower jaw fork length or 15kg whole weight. Microincrement counts suggest that one year old swordfish are about 100cm eye-fork length, which is about 115cm lower jaw fork length or 20kg whole weight. In the Mediterranean and North Atlantic, swordfish can be considered as fully recruited to the fishery at this size (P. Ward, pers. comm.). Its carnivorous diet is made up of a wide variety of fishes and squid for adult fish, and squid, fish and pelagic crustaceans for juveniles (Kailola *et al*., 1993).

Size:
Xiphias gladius grows to about 450cm and 540kg. It is typically marketed at about 100 to 160kg whole weight (Yearsley *et al*., 1999).

Evidence for Decline:
This species is caught by domestic tuna longliners mainly off the east coast, but catches are increasing off Western Australia. It is a popular foodfish in major urban centres, although mercury levels are high in some large individuals (Yearsley *et al*., 1999). The swordfish longline catch off Australia for 1997 was 1388t (A$7.6m) by Australia and 261t (A$2.4m) by Japan. Improved access to markets in the US has encouraged targeting of swordfish and important domestic markets are developing. Japanese longliners were the main fishers of swordfish in Australian waters, but are now excluded. Swordfish catches increased substantially in 1997 (Ward *et al*., 1998). Longlines have adversely affected the Atlantic swordfish populations because they interrupt the lifecycle by catching large numbers of immature fish (Safina, 1998). Catches of swordfish in the North Atlantic have declined from a peak of 20,236t in 1987 to 12,175t in 1998. The decline is partly due to catch restraints and declining catch rates and some fishers responded to the new regulations and lower catch rates by relocating to the south Atlantic. There are suggestions that the decline in swordfish biomass has slowed and there were strong recruitments of young swordfish in 1997 and 1998 (P. Ward, pers. comm.). The Mediterranean has sustained remarkably high catch levels of swordfish for over 15 years. Since 1984, catches have ranged between 10,695t and 15,298t per year and the 1997 catch estimate for Mediterranean swordfish was 14,670t (P. Ward, pers. comm.). If swordfish harvested in the Eastern Tuna and Billfish Fishery (ETBF) are a predominantly local stock, it is reasonable to expect that there will be a decline in catch rates as the accumulated biomass is fished. Changes in the size composition of the catch may provide a signal to reduce fishing effort for this species (Ward *et al*., 1998). In northern waters of the SENTF, swordfish are taken by droplining methods (AFMA, 2000d).

Australian Marine Protected Areas in Which the Species Occurs:
This species is not likely to be afforded any protection from any MPAs in Australian waters, as it is wide-ranging and pelagic by nature.

Suggested Conservation Status:
Data Deficient on an Australia-wide basis.
Preliminary assessments suggest that north Pacific swordfish were not exploited at levels likely to cause a change in catch rates until at least the early 1980s. More recent analyses have been inconclusive. However, there is at yet no clear evidence that swordfish are being harvested above levels of maximum sustainable yield. The conservation status is uncertain in the eastern Australian Fishing Zone, pending clarification of stock structure, but it is thought that swordfish are moderately fished, possibly with local depletion off southern Queensland (Ward, *et al*., 2000). It seems likely that on the east coast of Australia fishers exploit a western Pacific stock, while on the west coast fishers exploit an entirely different, pan-Indian Ocean or eastern Indian Ocean stock. Off the western coast less than 300t are caught annually, but off the eastern coast more than 2000t are taken (J. Gunn, pers. comm). Reliable stock assessment requires more information on swordfish biology such as stock structure, growth and reproduction. However, there is an apparent wealth of fisheries data available on swordfish in the Australian Fishing Zone, e.g. Japan’s longline logbook and observer databases (P. Ward, pers. comm.), and this information needs to be analysed before the conservation status can be accurately assessed. Continual monitoring of catch statistics around Australian waters is necessary to provide more data for this species.

Threatening Processes:
Commercial longline fishing in Australian waters has the potential to threaten this species, but it is unclear to what extent this species is being exploited.

Critical Habitats:
None identified.

Recovery Objectives / Management Actions Required:
Management has imposed precautionary fishing restrictions pending advice on stock structure. The major management objectives are to:

- control fishing effort until the stock status is better understood;
- Expand longline fishing to underutilised areas;
- Hold catches below historical peak levels.

The methods to achieve these goals include input controls, limited entry, area and boat size restrictions, and bycatch restrictions. Management must closely monitor the rapid expansion in swordfish targeting and establish controls well before local depletion or stock problems arise. The 1997 catch doubled the 'trigger' catch level for swordfish recommended by the Eastern Tuna Management Advisory Committee in 1995 (800t was the historical average annual catch by Australian and Japanese longliners in the ETBF). The breaching of the trigger catch should be grounds for serious attention to the ETBF swordfish component, given experience elsewhere of swordfish fishery declines (Ward *et al*., 1998).

References:
AFMA, 2000d; DeMartini and Boggs, 1999; J. Gunn, pers. comm. 2/2000; Kailola *et al*., 1993; Nakamura, 1985; Safina, 1998; P. Ward, pers. comm. 1999-2000; Ward *et al*., 1998; Ward *et al*., 2000; Yearsley *et al*., 1999.

5 Discussion

5.1 Critical Habitats

A critical habitat in the context of this report is defined as a habitat that is deemed to be crucial at some phase of the life-history of a particular species. Without this critical habitat, either the species could not fully complete its reproductive or breeding cycles, and/or the offspring could not reach sexual maturity. Broadly speaking, all marine and estuarine habitats (e.g mudflats, seagrass beds, rocky reefs, coral reefs, continental shelf, continental slope, etc.) will be critical to some species of fishes. However, in the context of this report we have attempted to focus on the habitats of those species that are listed as threatened (i.e. Critically Endangered, Endangered and Vulnerable).

5.1.1 Introduction

Various marine and estuarine habitats have been identified as being critical to particular phases of the life histories of specific fishes. These habitats may provide refuges and/or territories that harbour resident populations, be part of migratory routes, spawning or breeding aggregation areas, juvenile nursery areas, or simply provide essential feeding opportunities. Many of these habitats are not well understood, such as the deepwater continental shelf and slope habitats inhabited by many sharks and teleosts, but these are by no means any less important to conserve and protect from degradation caused by fishing activities. There are obvious logistical problems in assessing the physical characteristics of some deepwater (e.g deeper than diving depths) demersal habitats. However, technological advances (e.g. side-scan sonar, video sleds, remotely operated video, submersibles and remotely operated vehicles, see Cappo *et al.*, 1998) should help in bridging this information gap in future years. In many cases we have not been able to find substantiated evidence of declines in marine fish species that can be directly correlated with particular habitat related threatening processes. However, it is thought that threats such as habitat degradation are often contributing factors to the overall health of an ecosystem, and hence directly affect the populations of those fish species that any particular ecosystem may support. Marine and estuarine habitat research in Australia is ongoing, and is vital to the increased understanding of the ecosystem processes that govern fish communities. Marine and estuarine fish habitat research in Australia should be focused more intensely on the habitats occupied by species listed in the threatened categories (i.e. Critically Endangered, Endangered and Vulnerable). This research is especially important for species with specialised habitat requirements and /or restricted distributions (e.g. river sharks, sawfishes, and handfishes). Further discussion on the management of fish habitats as they relate to fisheries is provided in Hancock (Ed.) (1993) *Sustainable Fisheries through Sustaining Fish Habitat.* Additionally, Cappo *et al.* (1998) provide *A Review and Synthesis of Australian Fisheries Habitat Research* that discusses the history of fish habitat research in Australian waters, as well as indicating directions for future research.

5.1.2 Soft-bottom estuarine and lower riverine habitats

Estuaries (or river mouths) are important nursery areas for myriad fish species, the juveniles of which use these sheltered areas (e.g. seagrasses, mangroves and saltmarshes) to seek refuge from predators and also to feed on the organisms which thrive on the nutrients present in the trapped sediments (see Fletcher and McVea, 2000). Although they account for only a small percentage of the aquatic habitat, estuaries typically display a broad range of both salinity and temperature conditions, and are important transition zones between fresh water and the sea (Paxton, 1998). Some fish species rely on estuaries at a young age (e.g estuary rockcod, see Sheaves, 1996), while the adults of other species may utilise estuarine habitats to breed (e.g. school sharks in Tasmania use sheltered estuarine areas, see Stevens and West, 1997). Healthy estuarine areas provide rich habitats, such as mangroves, saltmarshes, seagrasses, algae, mud, sand and rocks, that support a wide array of invertebrate prey (e.g. molluscs and crustaceans) for fishes, as well as protection from fish predators. Estuaries are also particularly important areas in terms of nutrient recycling (e.g. the breakdown of mangrove detritus by shore crabs). Estuaries can also be dynamic (e.g. changeable) environments subject to flooding after heavy rainfall, which can markedly change salinity and/or water temperature. Fish diversity in estuaries is linked to water quality, which in turn can determine the quality of available habitat. There are, for instance, over 100 major estuaries along the NSW coastline alone (Fletcher and McVea, 2000).

The Derwent River estuary in Tasmania, an important habitat for the critically endangered spotted handfish *Brachionichthys hirsutus,* has been degraded by the combined effects of industrial pollution, sewerage associated pollution and urban runoff over many decades (Bruce *et al.*, 1999). Polluted estuarine areas such as these can take a long time to recover as toxicants such as heavy metals accumulate in their sediments. The fact that most population centres in Australia are located within close proximity to coastal and/or estuarine environments means that estuarine habitats and their associated communities are often vulnerable to the effects of habitat degradation and overexploitation by humans. Some species of sawfishes, stingrays and skates (families Pristidae, Dasyatididae and Rajidae, respectively), which primarily feed on soft-bottom invertebrates and fishes, are reliant on lower riverine areas and estuaries for their food resources. *Raja* sp. L., an endangered skate endemic to only two estuaries on the western coast of Tasmania, is one such species that is apparently totally reliant on the estuarine environment. *Himantura chaophraya*, a vulnerable freshwater stingray that occurs in fresh and brackish water environments of northern Australia, has not been recorded from fully marine waters in any part of its range (Compagno and Cook, 1995). *Pristis microdon*, a critically endangered freshwater sawfish from northern Australia, is also restricted to the freshwaters and the upper estuarine waters of some of our larger tropical rivers. The abovementioned elasmobranch species have limited dispersal potential due to their habitat selectivity, which endangers their survival when their habitats are affected by human-induced pressures.

5.1.3 Subtidal rocky reef habitats

Broadly speaking, much of the southern temperate Australian coastline consists of rocky reef habitats in some shape or form. These habitats support a rich diversity of endemic invertebrate and fish species that contribute to the maintenance of healthy ecosystems. Threatened species that inhabit such rocky reef areas include the grey nurse shark *Carcharias taurus* and the black rockcod *Epinephelus daemelii.* Other protected or partially protected species that inhabit these rocky reef habitats include the elegant wrasse *Anampses elegans,* eastern and western blue gropers, *Achoerodus viridis and A. gouldii,* respectively, eastern blue devilfish *Paraplesiops bleekeri* and weedy and leafy seadragons, *Phyllopteryx taeniolatus* and *Phycodurus eques,* respectively. Overfishing in general of fishes and invertebrates is the most common threat to subtidal rocky reef fish communities, but fortunately there are a number of marine parks and reserves (particularly in NSW waters) that help to protect these habitats from over-exploitation (Anon., 1999e). The designation of suitably located MPAs, and especially marine harvest refugia (Pollard, 1993), is essential for providing sanctuary for the many fish species that inhabit subtidal rocky reefs.

5.1.4 Continental shelf habitats (0 - 200m)

Continental shelf habitats (including coral reefs, surf beaches, rocky headlands, etc.) harbour most of the well-known fishes that occur worldwide (Paxton, 1998). Continental shelves around the world have supported large fisheries over hundreds of years of continuous exploitation. Many of the species that occur in continental shelf habitats are now showing signs of overfishing, and about half of the targeted commercial fish species in Australian waters are regarded as fully fished or overfished (Caton, 2000). The continental shelf of Australia has been relatively well sampled in comparison to that of the continental slope, but new species are still being discovered, especially in the more remote areas. Fishes living in continental shelf waters are prone to the effects of both habitat degradation and overfishing, and are often some of the first fishes to become threatened due to the accessibility of the waters in which they occur.

5.1.5 Continental slope habitats (200m – 2000m)

Fisheries on continental slope habitats in Australia first developed in the early 1970s, initially targeting deepwater prawns (Gorman and Graham, 1975; Graham *et al*., 1997). Three decades later, almost all trawlable ground on the upper continental slope off NSW (and probably most of south-eastern Australia) is now continually fished. This constant fishing maintains pressure on the fishes in these habitats, particularly the remnant stocks of sharks and skates that live in these slope depths (Graham *et al*., 2001). High initial trawl catch rates were recorded from the South East Fishery (SEF) area in 1976-77, before the area was heavily fished (Graham *et al*., 2001). Although this suggests many elasmobranch species were previously abundant over these trawlable substrates, little is known about their distributions and abundances in non-trawlable areas (Graham *et al*., 2001). Surveys of these non-trawlable areas are necessary to fill data gaps in relation to habitat structure (e.g. by using Remotely Operated Vehicles and/or Underwater Video techniques) and species composition and species abundances (e.g. by line fishing or trapping methods for fishes). It is unknown whether the designation of some of these non-trawlable areas as MPAs will enhance the survival of deepwater fish species such as dogfishes, which have been seriously reduced by the SEF. Two such species of vulnerable dogfishes (family Squalidae) included in this report (*Centrophorus harrissoni* and *C. uyato*) occur demersally on the continental slopes off the south-eastern Australian coastline. Other dogfishes occurring in continental slope waters around Australia await formal description (P. Last, pers. comm.) and/or analysis of their conservation status. The specific habitat requirements of most continental shelf fish species are unknown. Intensive demersal trawling in south-eastern Australia (particularly off NSW) continues to threaten the survival of particular groups such as dogfishes (some species of which are included in this report), angel sharks, skates and chimaeras (Graham *et al.*, 1997). Continental slope bottoms are usually steep, and the total area of seabed is thus small in comparison with flatter areas on the continental shelves and on the abyssal plains of the deep oceans (Walker, 1998). Recent surveys of the continental slope off Western Australia have yielded up to 100 new species, many of which are undescribed taxa (Williams *et al.*, 1996). The knowledge gaps in relation to continental slope fishes are slowly being bridged, but much is still to be learnt of the fish faunaa of these habitats in Australia. As intensive fishing pressure on demersal fishes of inshore and continental shelf waters increases worldwide, there is also likely to be increasing pressure placed on species that occur on the continental slope in greater depths.

5.2 Threatening Processes

Not surprisingly, rising human populations are the greatest threat to marine, estuarine and freshwater fishes and their associated habitats (Lowe-McConnell., 1990). Most declines in fish species considered here have been attributed to anthropogenic (or human induced) factors, namely overfishing, habitat degradation and the introduction (both deliberate and accidental) of aquatic pest species. Human overpopulation leads to increasing consumer demand for fishes as food and places pressures on the habitats occupied by them. Shipping and aquaculture activities cause pest species to be transferred from place to place, further threatening the survival of native fish populations. Some species have particular biological characteristics that render them more vulnerable to human induced pressures than others (see Table 5.1 below). Often, a number of the characteristics listed below combine to produce synergistic (and / or cumulative) effects to the detriment of the species. For example, some sharks are vulnerable to over-exploitation because of the combined effects of their slow growth, late age at first maturity, relatively low fecundity, and also their occurrence as bycatch. The assumption that marine fish populations are not vulnerable to extinction because they are ‘open’, with large geographic ranges and potentially unlimited migrations, is unfounded (Camhi *et al.*, 1998), and increasing attention is now being directed at the conservation of marine and estuarine fishes worldwide. Population decline prior to biological extinction is a process that can have detrimental and irreversible ecological effects long before a particular species actually disappears. If a species’ abundance drops too far, it may no longer adequately perform its function as a predator or prey species in the ecosystem - a situation often referred to as ‘ecological extinction’ (Camhi *et al.*, 1998). The carry-over (or domino) effects of extinction are largely unknown and unquantifiable in terms of measuring the potential loss of or change to biodiversity in any particular area. However, a precautionary approach would assume that any extinction is detrimental to an ecosystem.

Table 5.1: Biological and Ecological Characteristics that Render Species Susceptible to Extinction

Characteristic	Species examples from synopses
Slow growth	Most sharks and rays, orange roughy
Long-lived (>15 years)	Most sharks, many groupers, orange roughy
Large size and/or late age of sexual maturity	Most sharks, orange roughy, some groupers and wrasses (especially the males in the populations)
Low reproductive potential	Most sharks and rays, syngnathids, handfishes
Restricted larval dispersal (e.g. demersal eggs)	Handfishes, sharks and rays, some syngnathids
Small and /or restricted populations	Spotted handfish, Bizant River shark, freshwater sawfish
Form concentrated spawning aggregations	Humphead maori wrasse, Queensland grouper, orange roughy, eastern gemfish
Undergo sex change (or sex reversal)	Many groupers and wrasses
Susceptibility to capture by fishing techniques (as bycatch species)	Sawfishes, deepwater dogfishes, other sharks, pipehorses
Valuable target species	Orange roughy, gemfish, school shark, southern bluefin tuna, humphead maori wrasse, Queensland grouper, some syngnathids
Low natural mortality	Large shark species, larger groupers, seahorses, orange roughy

5.2.1 Overfishing

5.2.1.1 Commercial fishing

There is debate over the potential for fisheries to drive marine fishes (both teleosts and chondrichthyans) to extinction. Some argue that a species will become commercially extinct well before it becomes extinct, and therefore will be relieved of fishing pressure, which should allow the species to recover (Camhi *et al*., 1998). Long-term fishing can alter the size at which particular fish species mature, and this has been suggested to be the case for the King George whiting (*Sillaginodes punctata*) in South Australian estuaries (Cockrum and Jones, 1992). Cockrum and Jones (1992) found that the length at first maturity for *Sillaginodes punctata* decreased for both males and females between the 1950's and 1980's.

Targeted fisheries may collapse when stocks become so reduced that they are no longer profitable to pursue. However, the notion that a fish will reach economic extinction before biological extinction is uncertain in cases where the value of the product is so high that it is economical for fishers to pursue an extremely small surviving stock (Camhi *et al*., 1998). Southern bluefin tuna is such a high-value commodity that feasibly it could be still targeted when stocks are very small. Similarly, in a mixed-species fishery where all species are subject to the same fishing effort and similar levels of fishing mortality, less abundant species subjected to fishing activity throughout their range could be driven to extinction, while numerically dominant species continue to support the fishery (Camhi *et al*., 1998). Many commercial fishing techniques thus have the potential to detrimentally affect fish populations by both direct exploitation of target species and indirect exploitation of bycatch species (see below). Some fisheries are expanding rapidly into deeper parts of the Australian Fishing Zone, even before the habitat within these areas is studied and understood (Cappo *et al*., 1998). It is essential that basic research on the potential impacts of fishing be carried out before new fisheries develop to accurately assess the implications of any such fishing operations on the environment.

5.2.1.2 Recreational and charter boat fishing

Recreational fishing is a popular and important part of the Australian lifestyle and culture. An estimated five million Australians participate in recreational and sportfishing annually, and there are over 1,200 fishing clubs in Australia (Newton, 1999). It is suspected that recreational and charter boat fishing practices can cause at least localised depletions of fish populations. This may be more pronounced when the species involved are territorial by nature and/or have a relatively small home range (e.g. some grouper species), or are easily accessed by fishers (e.g inshore species which can be fished from shore). Additionally, some species aggregate at specific stages of their lifecycles (and at specific times and places) to breed (e.g. some tunas, groupers and wrasses). Technological advances such as global positioning systems (GPS) and echo-sounding fish finders are now readily available to recreational and charter boat fishers, enhancing their ability to locate and relocate aggregations of particular species of fishes. The extent to which recreational and charter boat fishing activities may deplete fish populations is not well known for the majority of marine and estuarine fish species in Australia. However, for some highly populated metropolitan areas (e.g Botany Bay, Sydney Harbour and Broken Bay, NSW), total catches by recreational fishers probably exceed the catches of commercial fishers (G. Henry, NSW Fisheries, pers. comm. 7/2000).

There are limited data on statewide estimates of the catches of the recreational charter boat fishery in Australia. Steffe *et al*. (1999) described the charter fishing boat industry operating in coastal and estuarine waters of NSW. The most recent estimate for the total fish catch by recreational charter boat fishers for the Sydney region alone was 100t per year in 1994-95 (Fletcher and McVea, 2000). In Queensland waters, a compulsory logbook program has operated since 1996 for the charter vessel fleet. A total of 324 charter vessel operators harvested 376t of fish from Queensland waters in 1998 (J. Higgs, QDPI, pers. comm. 9/2000). There are approximately 250 charter fishing boats licenced in NSW (Steffe *et al*. 1999; Fletcher and McVea, 2000) and at least 350 charter fishing boats licenced in Queensland waters (http://www.dpi.qld.gov.au/fishweb/). The impact of these activities needs to be accurately assessed to determine any necessary changes to their operations. A review of the charter boat fishing industry in NSW is being conducted by NSW Fisheries to ensure that this industry is conducted on a sustainable basis (Fletcher and McVea, 2000). New licensing arrangements, including conditions on species that can be caught and the keeping of records were introduced in NSW waters in November 2000. Other states and territories in Australia (i.e. Victoria, Tasmania, SA, WA and NT) need to implement similar logbook programs in order to obtain quantitative data on the catches of such charter vessels. Surveys of shore-based and boat-based recreational fishers can provide estimates of fish catches over spatial and temporal scales, with fishing effort factored into the equations (e.g. see Steffe *et al*., 1999).

Spearfishing during the 1960s and 1970s appears to have had a significant effect on the abundance of at least two rocky reef species in NSW waters, i.e. the grey nurse shark (Pollard, 1990b; Smith and Pollard, 1996) and the eastern blue groper (Smith *et al*., 1996). Spearfishing was the primary threat implicated in the decline of the grey nurse shark in NSW (Pollard, 1990b; Pollard, 1991), and the eastern blue groper was also protected from spearfishing in NSW because of perceived population declines due to spearfishing activities (Smith *et al*., 1996).

5.2.1.3 Fisheries bycatch

Bycatch is that portion of the catch, whether retained or discarded, that is taken while targeting other species. The extent of bycatch and discarded fish species, both in domestic fisheries and worldwide, is often poorly documented. However, in Australia, and especially in recent years, bycatch issues have increasingly become a focus of fisheries research. While the bycatch of some fisheries has now been described in terms of the species caught (e.g. in NSW, Kennelly, 1993; Kennelly *et al.*, 1998; and in northern Australia, Stobutski *et al*., 2000), many fisheries still lack a basic description of the species composition of their bycatch (Stobutski *et al*., 2000). Despite this fact, many Bycatch Action Plans have been drafted (e.g. AFMA, 2000a, b, c, d, e, f; AFMA, 2001). Although catches of non-target species can be difficult to manage (AFMA, 2000g), fisheries managers cannot address the effects of fishing on bycatch without first knowing what species are taken and the quantities of each species taken by each fishery. Monitoring of bycatch is vital for producing baseline information and also for determining whether changes in the catch rates of bycatch species occur (Stobutski *et al*., 2000). The Australian Commonwealth has recently adopted a Commonwealth Policy on Fisheries Bycatch, which commits all major Commonwealth fisheries to complete a Bycatch Action Plan (BAP) by 31 March 2001 (Anon., 2000b). These BAP's are to be developed in partnership with industry and other stakeholders and will focus on practical solutions and management measures (Anon., 2000b). Integrated Scientific Monitoring Programs (ISMP's) have been established for some fisheries (e.g. SETF and GABTF) to provide measurable statistical information on the total catch of quota species and other bycatch species through the use of observers (AFMA, 2000b). Information from these projects will contribute to the implementation of BAP's.

In the Patagonian toothfish fishery, the Australian Antarctic Division and CSIRO scientists regularly provide briefings on the taxonomy of bycatch species for observers and Data Collection Officers (DCOs) to assist with the onboard identification of bycatch. Observers and DCOs are also required to take samples of any species they have difficulty identifying (AFMA, 2000e). Ideally, this system needs to be implemented in all Australian Commonwealth fisheries, so that species of unknown status are retained for further identification. Providing identification guides to fishers will theoretically improve logbook recording and provide more information to fisheries managers for decision-making processes. The constraints on achieving these tasks for all Australian Commonwealth fisheries may be related to limited resources (on the part of management agencies) and/or lack of industry co-operation. Whatever the constraints, as much bycatch documentation as possible is needed to produce the greatest environmental benefit.

Prawn trawling has long been documented as one of the worst offenders in terms of the proportion of bycatch to prawns caught, with the bycatch to prawn ratio being as high as 10.4:1 for oceanic prawn trawling in NSW (Kennelly *et al*., 1998), and possibly even higher for some tropical Australian prawn fisheries. Alverson *et al*. (1994) estimated that 27 million tonnes of bycatch were discarded globally each year, a third of which was estimated to come from prawn trawls. The "sustainability" of a bycatch species is determined by the susceptibility of the species to capture and its mortality due to the fishing method (its susceptibility), and the capacity of the species to recover once depleted (its recovery) (Stobutski *et al*., 2000). In terms of prawn trawling, species least likely to be "sustainable" due to their low recovery capacity are soft-sediment associated benthic or demersal species, which often include prawns in their diet (Stobutski et al., 2000).

Elasmobranchs are more susceptible to overfishing than bony fishes because of their well-documented life-history characteristics (see Compagno, 1990; Last and Stevens, 1994). While some elasmobranchs are landed and reported in official statistics, a large proportion of their catches is undoubtedly discarded unreported. Elasmobranchs are caught incidentally, as bycatch, in most fisheries worldwide (Camhi *et al*., 1998). Mortality of incidentally caught sharks and rays is thought to be significant, especially in trawl nets, gillnets, purse seines and longlines, and may exceed mortality from directed fisheries (Camhi *et al*., 1998). Most elasmobranchs (56%) taken as bycatch in the Northern Prawn Fishery are dead when landed on deck and survival is lower for smaller individuals (Stobutski *et al*., 2000). Some fisheries for oceanic teleost species (e.g. tunas and billfishes) catch more sharks as bycatch than they do the target species (Marin *et al*., 1998; Camhi *et al*., 1998), and this may threaten the survival of these bycatch species (Safina, 1998). The Draft Bycatch Action Plan for Australian tuna fisheries (AFMA, 2001a) has listed the following as one of it's actions: "To reduce the bycatch of sharks, AFMA will amend permits to prevent the use of wire traces and long-shanked hooks in tuna fisheries". Such initiatives may help to reduce the bycatch of sharks in such fisheries.

An increase in elasmobranch fin prices has encouraged the practice of 'finning' sharks that were previously discarded intact or released alive. Fins are easily air-dried and stored and do not require refrigeration, whereas retention of whole shark carcasses can compete for freezer space with more valuable species like tunas (Camhi *et al*., 1998; AFMA, 2000g). The high prices paid for shark fins presumably increases the incentive for operators to retain the fins from sharks caught (AFMA, 2000g). Finned sharks thrown overboard alive invariably die. Rare species of elasmobranchs taken as bycatch and entering this trade (e.g. sawfishes) are of particular concern (Camhi *et al*., 1998; Stobutski *et al*., 2000). Batoid and small coastal shark populations are seriously affected as bycatch in bottom trawl fisheries. These impacts are rarely monitored, but are thought to be significant locally, particularly for regionally endemic species (Camhi *et al*., 1998). The practice of shark finning at sea is now illegal in the States of NSW (Anon., 1999g; B. Talbot, NSW Fisheries, pers. comm.), Victoria, South Australia and Western Australia. Sharks brought back to shore whole may be finned and then sold, and sharks may also be headed and gutted at sea, but the fins must remain attached until the shark is landed (SAG, 2000). The Bureau of Rural Resources has recently completed a report entitled *A Review of Shark Finning in Australian Fisheries* (Rose and McLoughlin, in press). Following the release of the draft report the Minister for Agriculture, Fisheries and Forestry (AFFA), asked AFMA on 5 October 2000 to introduce interim measures to ban the practice of shark finning in Australian Commonwealth Tuna and Billfish Fisheries. AFMA has now amended the permit conditions for longline concession holders in the Eastern and Western Tuna and Billfish Fishery, the Southern and Western Tuna and Billfish Fishery, and the Christmas and Cocos Tuna Fishery (AFMA, 2000g). This followed a technical review of the situation and discussions with major stakeholders. Tuna fishers are now required by law to land whole sharks at a port before the fins can be removed (http://www.affa.gov.au:80/ministers/truss/releases/00/00181wt.html). The prevention of shark finning at sea needs to be implemented in waters of all Australian states and territories to adequately protect sharks in Australian waters from this wasteful practice. Rose and McLoughlin (in press) estimated that approx. 4500t of whole shark was finned and discarded in Australian waters in 1998/99, yet remained unrecorded. This is indicative of the substantial levels of unrecorded non-targeted shark catch, particularly considering that this excludes other non-commercial species of shark that are not finned, but that are also discarded and unrecorded (SAG, 2000).

There are independent monitoring programs operating in several Commonwealth fisheries that provide validated information on shark bycatch. These programs are expensive, but can be relied upon to deliver accurate data on shark bycatch (to species level), which can be used to compliment logbook data (AFMA, 2000g). These include:

- AFMAs Observer Program, which records species and numbers of all sharks caught on all observer trips.
- The Integrated Scientific Monitoring Program (ISMP), which is administered by the Marine and Freshwater Research Institute (MAFRI) and places field scientists on vessels in the SETF and the SENTF.
- On a more opportunistic basis, when field scientists employed to work on fishing vessels as part of agreed Research Programs are able to collect detailed bycatch information, i.e. NPF and SSF.

Bycatch Reduction Devices (BRD's) are being phased in for many fisheries around Australia, especially for prawn trawlers, and these devices have been demonstrated to significantly reduce the quantities of non-target species retained in the catch. BRD's are now mandatory for the NSW Ocean Prawn Trawl and Estuarine Prawn Trawl fisheries (Fletcher and McVea, 2000) and the Northern Prawn Fishery (Stobutski *et al*., 2000). A comparison of bycatch from nets with and without BRD's has shown that the ratio of bycatch to prawns may be reduced by 55% using BRD's (Stobutski *et al*., 2000). Similarly, Turtle Exclusion Devices (TED's) are mandatory for all trawl fisheries in northern Australia, and these devices have been demonstrated to be successful in reducing the bycatch of turtles and also excluding some sharks and rays (Stobutski *et al*., 2000). Many fisheries use hook and line methods whereby the bycatch is difficult to minimise as any fish within the vicinity of the bait that is large enough to swallow the hook can potentially be caught. Generally, bycatch and undersized fish cannot be returned alive to the bottom in deeper waters due to embolism or swim-bladder bloat (in teleosts). Similarly, large rays such as sawfishes find it very difficult to escape from a net.

5.2.1.4 Shark control programs

Off selected NSW and Queensland beaches (and also off KwaZulu-Natal beaches in South Africa), shark meshing control programs are designed and implemented to maintain a safe swimming environment for humans. In these three areas, about 2500 sharks are taken annually, of which an average of about 1300 are taken in South African waters, 1000 in Queensland waters and 200 in NSW waters (Dudley and Gribble, 1999). In NSW waters, the program began in 1937 and operates mainly in the greater Sydney region where the bulk of the NSW coastal human population resides (Dudley and Gribble, 1999). In Queensland waters the program began in 1962 and operates over a wider area at selected locations that are popular tourist attractions (Dudley and Gribble, 1999). Both mesh-nets and drumlines are used in the Queensland and South African shark control programs, while only mesh-nets are used in the NSW program (Dudley and Gribble, 1999), though drumlines may be trialed in the near future in NSW (D. Reid, pers. comm. 2000). Shark control programs not only remove or reduce the numbers of large (i.e. >2m) and potentially dangerous sharks from an area, but also incidentally catch many small and harmless sharks and rays, some larger bony fishes and occasionally dolphins, whales, sea turtles and dugongs (Dudley and Gribble, 1999). Between 1962 and 1978, 10,889 rays, 2,654 turtles, 468 dugongs and 317 dolphins were caught in the Queensland Shark Control Program alone (Last and Stevens, 1994). Concern is rising about the effects of shark control programs on numerous threatened species of sharks (e.g. white sharks and grey nurse sharks), rays (e.g. sawfishes), sea turtles and dugong. Drumlines are possibly more selective in catching dangerous sharks than mesh-nets, but further study is necessary to test this theory, and baited drumlines could possibly also attract sharks to an area. In NSW waters there is some evidence that the shark control program is outdated and kills too many sharks and rays unnecessarily, as very few dangerous sharks are now caught. The number of human fatalities due to Australian shark attacks has averaged 1.1 per year for the last 30 years (J. West, Taronga Zoo, pers. comm. Feb. 2001). Also, there is considerable wastage of potential biological information in the Australian shark control programs, as contractors are generally required to dispose of the carcasses at sea. Beach meshing to reduce the threat to humans from shark attack was nominated as a key threatening process under the *Endangered Species Protection Act 1992* in May 1997 (Environment Australia, 2000b). However, the Endangered Species Scientific Subcommittee rejected the nomination that this threatening process be added to Schedule 3 of the ESP Act (Environment Australia, 2000b).

5.2.1.5 Live reef food fish trade

Large quantities of reef fish are exported live for food (herein referred to as Live Reef Food Fish – LRFF) to Asian cities such as Hong Kong. Imported LRFF are kept alive until cooking to ensure freshness. In 1997, Hong Kong imported an estimated 32,000t of LRFF from over 10 countries of origin, of which an estimated 80-90% was consumed locally and 10-20% re-exported to mainland China (Lau and Parry-Jones, 1999). The total value of imported LRFF far exceeds the value of Hong Kong’s annual seafood production from capture fisheries (Lee and Sadovy, 1998).

Several species of serranid (particularly coral trout, *Plectropomus* spp.) and labrid (e.g. humphead wrasse *Cheilinus undulatus*) fishes from the Great Barrier Reef are captured and exported for the LRFF trade (D. Cameron, pers. comm. 9/2000; QFMA, 1998). By 1998 over 100 licenced fishing boats had changed over to LRFF operations in Queensland, and production for the years 1996-1997 averaged 400t per year (QFMA, 1998). Strict monitoring mechanisms are necessary to track the volumes, values and species of LRFF leaving Australia. There is also an urgent need to conduct further biological research on LRFF species to help establish clear minimum and maximum fish sizes, realistic bag limits and to implement closures over spawning aggregations. Another reason for prohibiting the live reef food fish trade from targeting spawning aggregations is that female fish are reputedly more susceptible to stress when they are ready to spawn and, therefore, they do not survive handling and caging as well as at other times (Johannes & Kile, 2001). Particular attention needs to be focused on species in high demand that are increasingly threatened by the LRFF trade (e.g. especially *Cheilinus undulatus*, *Epinephelus lanceolatus* and *Cromileptes altivelis*, and to a lesser extent *E. fuscoguttatus*, *E. polyphekadion*, *E. coioides*, *Plectropomus* species, etc.). Australia exports over 100t of *Plectropomus* species alone to Hong Kong every year (Lau and Parry-Jones, 1999). Reduced effort in the LRFF fishery in Queensland may be necessary to ensure that these fishing practices do not deplete stocks.

5.2.2 Habitat degradation

5.2.2.1 Introduction

The IUCN has identified habitat loss or degradation as a major reason for the threatened status of 55 per cent of endangered fishes (Almada-Villela, 1998). Sensitive marine environments, valuable as fish habitat, have become degraded through a variety of polluting and extractive activities (Jones, 2000) and coastal habitat is being destroyed at an alarming rate (Camhi *et al*., 1998). Human activity threatens coastal and estuarine habitats through coastal development, fisheries activities, chemical and nutrient pollution (such as agricultural runoff, freshwater diversion from inflowing rivers, ocean effluent outfalls), and the dumping of plastics and other man-made garbage (Camhi *et al*., 1998). In Australia most people live within 50km of the coastline, where the associated destruction of habitat has been most prevalent in the functionally important estuarine environments (Fletcher and McVea, 2000). There are over 40 ocean sewage outfalls in NSW alone, which is a potential problem for inshore rocky reef and soft bottom habitat associated species close to urban areas (Anon., 1999e). The problem of acid sulphate soils is also impacting estuaries and their habitats, especially in northern NSW, where coastal development continues at an alarming rate (Fletcher and McVea, 2000). Further research is necessary to evaluate the implications and adverse effects of habitat degradation in a variety of fish habitats. Effects of habitat change on fish populations are generally more difficult to study and historically have been less intensively studied than the effects of fishing (Walker, 1998).

5.2.2.2 Bottom trawling and dredging

Possibly the most threatening processes to the survival of Australian marine and estuarine fish species in terms of the effects of existing fishing methods are those of bottom trawling and dredging. Trawls or related fishing gear are now used on every kind of bottom type from subpolar to tropical waters (Watling and Norse, 1998). This mobile fishing gear crushes, buries and exposes marine animals and structures on and in the substratum, sharply reducing structural diversity (Watling and Norse, 1998). Mobile fishing gear can have large and long-lasting effects on benthic communities, including young stages of commercially important fishes, although some species may benefit when structural complexity is reduced (Watling and Norse, 1998; Sainsbury *et al*., 1993). The frequency of trawling (in terms of the percentage of the continental shelf trawled per year) is orders of magnitude higher than other severe seabed disturbances, annually covering an area equivalent to perhaps half of the world's continental shelf, or 150 times the land area that is clearcut yearly (Watling and Norse, 1998). These operations not only degrade benthic habitat and limit habitat diversity and available prey species for fishes, but also take considerable amounts of bycatch species (see above). In a study of the seamount fauna off southern Tasmania, Koslow and Gowlett-Holmes (1998) reported that the species endemicity of individual seamounts was high. This study concluded that the seamount fauna is highly vulnerable to trawling and is likely to have limited resilience, as its slow growth and low natural mortality are adapted to an environment with little natural disturbance (Koslow and Gowlett-Holmes, 1998). Fishing-generated changes to the seabed differ in different areas according to the characteristics of the gear, the site and their interaction (Jones, 2000). Natural environmental variability can be greater than fishing-induced change (Jones, 2000) on localised scales.

Using a precautionary approach to management, modifying fishing methods, and creating refuges free from mobile fishing gear, are ways to reduce these effects on biodiversity and fish habitat (Watling and Norse, 1998). A portion of the Tasmanian seamount area has been declared as a MPA to protect fauna that is possibly found nowhere else in the world from the effects of fishing.

5.2.3 Species introductions

5.2.3.1 Introduction

Exotic species can be introduced accidentally (e.g. from ballast water) or deliberately (e.g for recreational purposes such as fishing, as has been the case for many freshwater species around the world, such as trout). Introduced or exotic marine pest species are perhaps one of the greatest threats to Australia's fisheries in that these introduced species can do widespread damage not only to fisheries, but also to entire ecosystems. For example, the introduced Northern Pacific seastar *Asterias amurensis* is changing the structure of local benthic habitats off Tasmania and affecting fisheries such as those for scallops, oysters and abalone in parts of southern Australia, as well as being implicated in the decline of the spotted handfish (Newton, 1999). Mostly brought in by ships' ballast water or hull fouling, 300 to 400 introduced species are estimated to exist in Victoria's Port Phillip Bay alone (Hewitt *et al*., 1999). In the early 1960s, the large, predatory Nile perch *Lates niloticus* was introduced into Lake Victoria, East Africa from other African lakes with devastating effects (Greenwood and Stiassny, 1998). The Nile perch has directly endangered many of the endemic freshwater cichlids (family Cichlidae) known to occur in Lake Victoria, and today there are 86 species listed as these Critically Endangered, Endangered or Vulnerable by the IUCN (Greenwood and Stiassny, 1998).

More than half of the approximately 1300 ships serviced in Botany Bay in Sydney, NSW, during 1997 discharged ballast water. A number of species of non-indigenous fauna and flora have been recorded from Botany Bay, including a small number of crustaceans, molluscs, worms, toxic dinoflagellates and Japanese gobies (Anon., 1998). More recently, outbreaks of a cool-water strain of the normally tropical seaweed *Caulerpa taxifolia* have been discovered in Port Hacking and Lake Conjola in NSW (NSW Fisheries, 2000a). Such outbreaks have the potential to significantly alter the ecology and biodiversity of marine and estuarine ecosystems. Stricter regulations are required to stem the flow of such marine and estuarine pest species into Australian waters.

5.2.3.2 Aquaculture

Environmental problems associated with aquaculture derive from habitat degradation (e.g. wastes) and overfishing (e.g. removal of wild fish for broodstock, removing juveniles for grow-out, or removing other species to supply food). However, potentially, the major environmental side effect of aquaculture is the spread of pests associated with the aquaculture species into the wild, and the escapees of the aquaculture species themselves into the wild. Hence, we have included aquaculture as a sub-section of species introductions.

Aquaculture is a major domestic and export industry in Australia, enhanced by technological advances in feed production, genetic improvement of culture species and improvements in husbandry practices (Cordover *et al*., 2000). Aquaculture production in Australia for 1998/99 was worth A$602 million, including over A$182 million for pearls and about A$167 million for farmed tuna (ABARE, 2000). Aquaculture production therefore comprises nearly 30% of the total value (A$2039 million) of Australian fisheries production (ABARE, 2000). Problems involving aquaculture activities worldwide include the following (Naylor *et al*., 2000; Sadovy, 1997):

- The accidental release of marine and freshwater organisms (i.e. escapees) into natural environments. In Australia, this is an escalating environmental concern as many aquaculture species are now cultured in regions where they are not native.
- The potential for the spread of disease or parasites from introduced or translocated populations to natural populations. New diseases (like new species in the wild) are continually being discovered in cultured species and may not only harm the species affected and the aquaculture operation, but also can be transmitted to wild stocks.
- The removal of fish from the wild to be used as breeding stock.
- Capture of fish from the wild for feeding aquaculture species, and of juveniles for grow-out into adults. Obtaining feed for cultured species can be damaging to the environment if live fishes are harvested from the wild to provide the diet of aquaculture species.
- Pollution of natural environments from the by-products and wastes of aquaculture activities. Increased nutrient output into the adjacent natural environment can detrimentally alter natural ecosystems and hence alter food chains.
- Additional habitat degradation, e.g. from converting wetlands into ponds for aquaculture.
- Altering the natural genetic diversity of wild stocks by mixing aquaculture stocks with the wild stocks, which may potentially decrease the viability and resistance of these wild stocks to parasites and diseases. Once the resistance of wild stocks is reduced, this not only endangers the species in the wild, but also endangers the species for use in future aquaculture operations.

Escapees from Atlantic salmon and trout farms in Tasmanian marine and estuarine environments have the potential to adversely affect native species in these areas by direct predation, competition for resources and parasite transfer (R. Freeman, Inland Fisheries Commission, Tasmania, pers. comm. 5/2000). Worldwide, more than 220 species of finfish and shellfish are farmed (Naylor *et al*., 2000), at least 60 of which are farmed in Australia (Newton, 1999). Global aquaculture production has doubled over the last 15 years (Naylor *et al*., 2000) and this rapid expansion means that the management, regulatory and monitoring bodies which control these industries have to be increasingly aware of the potential environmental problems associated with these activities and must address them accordingly. The biggest challenge faced by the aquaculture industry appears to be in controlling the spread of pest species into the wild.

5.2.3.3 Aquarium fish trade and non-food fishes

Whilst habitat destruction and overfishing for food are the main threats facing fish populations in the wild, the ornamental fish trade (or recreational fish-keeping in aquariums and ponds) may have adverse effects as a result of the introduction of non-native organisms and the direct depletion of wild stocks (Andrews, 1990). The aquarium fish trade brings into Australia some 6 to 10 million live fish every year, mostly from South-East Asian farms where diseases are common (Low, 1999). There is only a two-week quarantine period in Australia for imported freshwater species and no quarantine period currently exists for marine fish species (Low, 1999). Clearly, stricter quarantine regulations are necessary to prevent an influx of fish diseases into Australia.

If exploitation for the aquarium trade is linked with other risk factors such as restricted range or fishing pressure, then species may be threatened (Morris *et al*., 2000). The growing trade in tropical aquarium fishes has become an important source of income for local populations in many parts of the developing world (Almada-Villela, 1998). As many as 800 species are listed as ‘commonly available’ in the aquarium trade, and some individuals such as the Asian bonytongue can sell for up to US$18,000 (Almada-Villela, 1998). Roughly 90% of the marine species in the trade are thought to be taken directly from the wild in countries such as the Philippines, Singapore and Indonesia (Almada-Villela, 1998). In the Philippines alone, at least 386 species of coral reef fishes belonging to 79 families are utilised in the aquarium trade, supplying up to 80% of the market (Almada-Villela, 1998). In Australian waters, there has been little research directed into the effects of removal of wild stocks for the marine aquarium fish trade, though anecdotal evidence suggests that at least localised depletions of some sought after species have occurred.

In Queensland, more than 100,000 specimens of fishes per year were collected for the aquarium trade between 1988 and 1991, with higher levels of catch occurring in more recent years (QFMA, 1999b). However, with only a few angelfish (family Pomacanthidae) as exceptions, no catch statistics are currently available at the species level (S. Breen, pers. comm. 9/2000). The industry seems reluctant to abandon the virtually useless (for conservation needs) family catch record system. Currently it is unknown whether the rarest species are threatened by the industry. A new management plan is currently under discussion (QFMA, 1999b). Until the relevant regulatory bodies adopt a new catch records system whereby the individual fishers in the industry are required to record each species caught, no accurate figures can be used to reliably assess the conservation status of fishes collected for this trade in Queensland. Similar catch statistics are necessary to monitor the aquarium trade in other states and territories of Australia.

The use of non-food fishes (e.g. for bait) in Australia, though widespread, is not well documented or reported. Some fish species are targeted for use and/or for sale as bait to catch other species, but catch reporting for these fishes is often lacking. Bycatch species are also often sold or used as bait, but the extent of reporting is unknown. There is a need for improved recording and reporting methods for those commercial fishers who use and/or sell bait in considerable quantities.

5.2.3.4 Domino effect or chain of extinctions effect

When a species becomes biologically extinct, and is therefore completely removed from an ecosystem, there are likely to be carry-over effects to other species (vertebrates and invertebrates alike) in that ecosystem. Predator and prey relationships in any particular area (without human interference) are naturally balanced towards sustaining the needs of species in an ecosystem, and the removal of species through extinction is likely to benefit some species, but adversely affect others. Extinctions of species that play a role in providing habitat, food or any advantage to another species can ultimately lead to a chain of extinctions effect (see Diamond, 1990). An extreme example would be the resultant extinction of an anemonefish species if its host anemone became extinct. We know little about the effects that extinction can have on a community or ecosystem, but we can surmise that they would be detrimental to other organisms reliant on those species for their own survival.

5.3 Protective Legislation and Management

Protection of threatened marine and estuarine fishes in Australia involves both State and Commonwealth legislation, with State marine waters generally being limited to those within three nautical miles off the coastline. The Commonwealth Government typically has jurisdiction of all waters between three nautical miles and 200 nautical miles of the coastline (see also Appendix 7). The exceptions to this rule are where Offshore Constitutional Settlements (OCS's), or agreements, exist between individual Australian States or Territories and the Commonwealth. OCS's exist in most states, including NSW, Queensland, NT and WA, and are currently being discussed for Victoria, Tasmania and South Australia. Also see Appendix 7 for a summary table of legislation pertaining to the conservation of Australian fishes.

5.3.1 Commonwealth

The *Environment Protection and Biodiversity Conservation Act 1999* (herein abbreviated as *EPBC Act 1999*), which came into force on 16 July 2000, is now the key Commonwealth legislation for the conservation of Australian fishes. This Act replaced five prior pieces of legislation, namely:

- *Environment Protection (Impact of Proposals) Act 1974*
- *Endangered Species Protection Act 1992*
- *National Parks and Wildlife Conservation Act 1992*
- *Whale Protection Act 1980*
- *World Heritage Properties Conservation Act 1983*

(http://www.ea.gov.au/biodiversity/threatened/action/index.htmllists/esp_lists).

The *EPBC Act 1999* will profoundly influence conservation and management of marine species, particularly those taken as bycatch. In particular, s.248 of the *EPBC Act 1999* lists as marine species all species in the family Syngnathidae (seahorses, seadragons, pipefishes and pipehorses) and all species in the family Solenostomidae (ghost pipefishes). That listing makes it an offence under this Act to recklessly kill, injure, take, trade, keep or move a member of either family, unless duly authorised by a permit. The *EPBC Act 1999* also requires the strategic assessment of Commonwealth-managed fisheries.

Schedule 1 – Listed Species of the *EPBC Act 1999*

As part of the transitional arrangements under the *Environmental Reform (Consequential Provisions) Act 1999*, the species listed in Schedule 1 of the *Endangered Species Protection Act 1992* will be automatically listed in the *EPBC Act 1999*. It is emphasised here, however, that the three categories previously used to list threatened species (i.e. Presumed Extinct, Endangered and Vulnerable) under the *Endangered Species Protection Act 1992* remain, and three additional categories (Extinct in the Wild, Critically Endangered and Conservation Dependent) have been added. A six-month transition period (16 July 2000 to 16 January 2001) has been allocated to modify, as necessary, the threatened species lists due to the abovementioned changes to the categories. As our report was scheduled for completion before the end of this period, we have used the 1996 IUCN categories as contracted.

As of March 2000, there were 30 fish species listed under the *EPBC Act 1999*. Of these, 13 are listed as Endangered and 17 are listed as Vulnerable. Of the 7 marine and estuarine (including brackish water) species, one is listed as Endangered and six are listed as Vulnerable. Six out of these seven species are included in this report. The omitted taxon is the Waterfall Bay Handfish *Sympterichthys* sp., for which there was considered to be insufficient information on its taxonomic status to warrant its inclusion. Of the remaining 23 species, all of which occur in freshwater habitats, 21 were discussed by Wager and Jackson (1993) in the *Action Plan for Australian Freshwater Fishes.* The remaining two species have only recently been listed under the *EPBC Act 1999* (http://www.biodiversity.environment.gov.au/).

It is a requirement of the *EPBC Act 1999* to prepare recovery plans for all endangered and vulnerable species that occur in Commonwealth waters. The recovery plan must provide for the research and management actions necessary to stop the decline of the species so that its chances of long-term survival in nature are maximised. Once prepared, all draft recovery plans are to be released for public comment. Recently, recovery plans for the grey nurse shark and the great white shark were posted for public comment (http://www.ea.gov.au/marine/species_protection/greynurse.htm) and these recovery plans are currently being finalised.

Schedule 1 of *EPBC Act 1999*
Listed marine and estuarine (including brackish water) species discussed in this report

Part 1 - Species that are Endangered

1. *Brachionichthys hirsutus* Spotted handfish

Part 2 - Species that are Vulnerable

1. *Carcharodon carcharias* Great white shark
2. *Carcharias taurus* Grey nurse shark
3. *Glyphis* sp. A Speartooth shark
4. *Pristis microdon* Freshwater sawfish
5. *Sympterichthys* sp. Ziebells handfish
6. *Sympterichthys* sp. Waterfall Bay handfish (see discussion above)

Part 3 – Species which are Presumed Extinct

Nil

Schedule 2 of *EPBC Act 1999* – Endangered Ecological Communities

No endangered marine ecological communities are listed

Schedule 3 of *EPBC Act 1999* – Key Threatening Processes

No key threatening processes to marine or estuarine fish species are listed.

Wildlife Protection (Regulation of Exports and Imports) Act 1982

The export of most Australian native organisms, including animals (invertebrates, freshwater fish, amphibians, reptiles, birds and mammals) and plants (including flowering plants, algae, mosses, liverworts, lichen and fungi), and products derived from them, is controlled under the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* (the Act). The object of the Act itself is *to comply with the obligations of Australia under the Convention (being CITES) and otherwise to further the protection and conservation of the wild fauna and flora of Australia and of other countries*. In addition to commercial trade in wildlife, the Act controls other transactions such as those between museums, zoological organisations and scientific bodies.

Any proposal to commercially export Australian native wildlife generally requires the development and approval of an appropriate management regime. The requirement for such a management regime is based on the general premise that, before allowing a species to be harvested, an approved management regime should ensure that harvesting would not be to the detriment of the species or the ecosystem. Such an arrangement should be in place before exports take place.

Schedule 4 of the Act is a list of Australian native species that do not require the grant of an export permit under the Act. Other Schedules to the Act list specimens that are under the control of the Act because they are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), or are listed on Australian endangered species legislation. Still other Schedules include the text of the CITES Convention, live animals and live plants which can be imported, native Australian animals eligible to be treated as household pets, and exotic birds that, for the purposes of the Act, are not classified as exotic birds.

Australia's Oceans Policy contains a commitment that Schedule 4 will be revised so that only exports of wild-caught species assessed as being harvested in accordance with sustainable and ecologically based management arrangements can proceed without export authorisation under the Act. Exports of any wild-caught species assessed as not being managed in an ecologically sustainable way will be subject to the export controls of the Act. Once revised, the Schedule is to be reviewed in five years.

The amendment to Schedule 4 provides for a period up to 1 December 2003 during which exports of marine products will continue as if under the previous Schedule 4. During this time Environment Australia will undertake a series of assessments of management arrangements to determine which species should be exempt from export controls from 1 December 2003.

Commonwealth *Fisheries Management Act 1991*
The Commonwealth *Fisheries Management Act 1991* contains a number of provisions appropriate to the protection of marine fishes, as follows:
(1) The following objectives (Section 3) must be pursued by the Minister in the administration of this Act and by AFMA in the performance of its functions:
(a) Implementing efficient and cost-effective fisheries management on behalf of the Commonwealth; and
(b) Ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular, the need to have regard to the impact of fishing activities on non-target species and the long-term sustainability of the environment; and
(c) Maximising economic efficiency in the exploitation of fisheries resources; and
(d) Ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources; and
(e) Achieving government targets in relation to the recovery of the costs of AFMA.
(2) In addition to the objectives mentioned in subsection (1), or in section 78 of this Act, the Minister, AFMA and Joint Authorities are to have regard to the objectives of:
(a) ensuring, through proper conservation and management measures, that the living resources of the AFZ are not endangered by over-exploitation; and
(b) achieving the optimum utilisation of the living resources of the AFZ, while ensuring, as far as practicable, that measures adopted in pursuit of those objectives are not inconsistent with the preservation, conservation and protection of all species of whales.

Marine Protected Areas (MPAs) in Commonwealth waters
In Australian Commonwealth waters, MPAs (including ten Historic Shipwrecks, six Marine Parks, two Marine Reserves and five Marine National Nature Reserves) occupy an area of over 52 million hectares. These combined areas provide significant protection to marine fishes, especially in the Great Barrier Reef Marine Park (over 34 million hectares in size) (Cresswell and Thomas, 1997), the Macquarie Island Marine Park (over 16 million hectares), the Great Australian Bight Marine Park (1.7 million hectares), the Tasmanian Seamounts Marine Reserve (370 square kilometres) and the recently gazetted Lord Howe Island Marine Park (0.3 million hectares).

5.3.2 New South Wales
The *Fisheries and Oyster Farms Act 1935* (amended in 1979) had wide powers, including the regulation of exploitation by commercial and recreational fisheries, aquatic habitat controls, fishing gear restrictions, protected fish species, and the creation of aquatic reserves. The NSW *Fisheries Management Act 1994* (and its 1997 amendments - Part 7a) has since replaced this Act. The 1997 amendments included legislation related to threatened species conservation and established a Fisheries Scientific Committee responsible for recommending listing of endangered species, populations and communities, vulnerable species, species presumed extinct, and key threatening processes. Various other pieces of NSW legislation are used to protect fish habitats, including: the *Water Act 1912*, *Soil Conservation Act 1938, Rivers and Foreshores Improvement Act 1948*, *Clean Waters Act 1970, Pesticides Act 1978, National Parks and Wildlife Services Act 1974*, *Environmental Offences and Assessment Act 1979*, *Crown Lands Act 1989*, *Environmental Offences and Penalties Act 1989, Catchment Management Act 1990, Mines Act 1973* (Wager and Jackson, 1993) and more recently, the *NSW Aquatic Biodiversity Strategy* (in preparation). A Section 8 Fishing Closure of the *Fisheries Management Act 1994*, gazetted on 4 June 1999, prevents the taking and landing of all shark species mutilated in any manner other than by heading, gutting or removing gills, and further prohibits the possession of any shark fins on any boat in all waters of NSW. Additional information on threatened aquatic species of fishes, invertebrates and marine plants in NSW can be obtained from the NSW Fisheries website (http://www.fisheries.nsw.gov.au/) and the NSW Fisheries Scientific Committee website (http://www.fsc.nsw.gov.au/).

In NSW waters, Marine Protected Areas (seven small Aquatic Reserves and three large Marine Parks) occupy an area of over 155,000 hectares that provides significant protection to marine fishes, especially in the Lord Howe Island, Solitary Islands and Jervis Bay Marine Parks.

5.3.3 Northern Territory

The Northern Territory *Fisheries Act 1988* provides legislation that contributes to the management and conservation of marine fishes. Part III (Fisheries Management Plans) aims to conserve, enhance, protect, utilise, and manage the fisheries of the Territory in order to:
a) Promote and develop commercial and amateur fishing;
b) Provide for optimum yields of the fishery and maintain the quality of the yield;
c) Ensure that the fisheries of the Territory are not endangered or overexploited; and
d) Ensure that the habitats of fish or aquatic life and the general environment are not detrimentally affected (http://www.austlii.edu.au/).

Marine Protected Areas (two small Aquatic Life Reserves and one large Marine Park) occupy an area of over 223,000 hectares, which provides some protection to marine fishes, especially in the Coburg Marine Park (Cresswell and Thomas, 1997).

5.3.4 Queensland

The *Fisheries Act 1974* and the *Fishing Industry Organisation and Marketing Act 1982* provide legislation for the management of fishes and invertebrates in marine and fresh waters (Wager and Jackson, 1993). The *Nature Conservation Act 1992* combines a number of existing acts including:

- the *National Parks and Wildlife Act 1975,*
- the *Fauna Conservation Act 1974,*
- the *Native Plants Protection Act 1930, and*
- parts of the *Land Act 1962* which deal with environmental parks.

This legislation is similar to the Victorian *Flora and Fauna Guarantee Act 1988* and allows for the listing of threatened species, communities and habitats. Management plans are required for all listed species and interim conservation orders may be placed over habitats to allow their short-term protection whilst longer-term plans are prepared. In addition, threatening processes may also be listed and will require management plans to decrease their impact. This legislation provides increased powers to protect fish species, fish communities and fish habitats (Wager and Jackson, 1993).

In Queensland waters, Marine Protected Areas (including over 70 Fish Habitat Areas, two Fish Sanctuaries, and seven large Marine Parks) occupy an area of over 5.3 million hectares that provides significant protection to marine fishes, especially in the Marine Parks (Cresswell and Thomas, 1997).

5.3.5 South Australia

No specific threatened species legislation in the form of an Act currently exists in South Australia. However, it is possible that legislation to protect biodiversity may be proposed soon. The protection of threatened and endangered fish species and other aquatic biota is currently encompassed within the Fisheries Regulations 1984.

In terms of the obligations of the state of SA to contribute to maintaining ecological sustainability in fisheries, in the administration of the South Australian *Fisheries Act 1982*, the Minister, the Director and management committees have (as outlined in Section 20) the principal objectives of:
a) Ensuring, through proper conservation, preservation and fisheries management measures, that the living resources of the waters to which this Act applies are not endangered or overexploited; and
b) Achieving the optimum utilisation and equitable distribution of those resources (http://www.austlii.edu.au/).

In South Australian waters, Marine Protected Areas (14 relatively small Aquatic Reserves and the much larger Great Australian Bight Whale Sanctuary) together occupy an area of over 59,000 hectares, which provides some protection to marine fishes (Cresswell and Thomas, 1997).

5.3.6 Tasmania

Section 7 of the Tasmanian *Living Marine Resources Management Act 1995* has the purpose of achieving sustainable development of the living marine resources, having regard to the need to:

a) Increase the community's understanding of the integrity of the ecosystems upon which fisheries depend;
b) Provide and maintain sustainability of living marine resources;
c) Take account of the community's need in respect to living marine resources; and

d) Take account of the community's interests in living marine resources.

In Tasmanian waters, Marine Protected Areas (three Marine Nature Reserves) occupy an area of less than 200 hectares that provides very little protection to marine fishes. This is a serious concern considering that Terrestrial Protected Areas in the state total over 2.1 million hectares (Cresswell and Thomas, 1997). Additionally, two of the most threatened species discussed in this report, the critically endangered spotted handfish *Brachionichthys hirsutus* and the Maugean skate *Raja* sp. L also occur in these waters.

5.3.7 Victoria

In Victoria the key piece of legislation for the listing of threatened species is the *Flora and Fauna Guarantee Act 1988*. The details of this Act can be accessed via http://www.dms.dpc.vic.gov.au ("Victorian Law Today – F – Flora and Fauna Guarantee…"). Under the Act, a taxon, ecological community or potentially threatening process can be nominated for listing by any person or organisation, and is assessed by an independent Scientific Advisory Committee (SAC). To be listed, a taxon, ecological community or potentially threatening process must pass at least one of the primary criteria as judged by the SAC through its guidelines. This assessment of the inclusion of listed taxa is based on two primary criteria as well as the guidelines for eligibility established by the SAC, or 'sub-criteria'. These primary criteria and sub-criteria comprise **Schedule 1** of the Act. The two primary criteria are: a taxon is eligible to be listed if it is in a demonstrable state of decline that is likely to result in extinction or if it is significantly prone to future threats which are likely to result in extinction (http://www.nre.vic.gov.au/). The degree of threat is not scaled; i.e. there are no categories such as extinct, endangered and vulnerable. Public comment is invited on the SAC's recommendation, but the Minister for Conservation and Land Management makes the decision on whether to accept or reject the listing (http://www.nre.vic.gov.au/). When a listing takes place an Action Statement must be prepared. Action statements identify actions that have or will be taken to conserve the species or community, or manage the potentially threatening process (http://www.nre.vic.gov.au/). Threatened taxa and communities of flora and fauna are listed in **Schedule 2** (the southern bluefin tuna was recently listed), while potentially threatening processes are listed in **Schedule 3.** No marine or estuarine fish taxa are listed in Schedules 1 or 3, but Schedule 2 lists the southern bluefin tuna and one marine community (at San Remo, mainly for its opisthobranchs and bryozoans) which harbours fish populations (http://www.nre.vic.gov.au/).

The Victorian *Fisheries Act 1968* covers marine and fresh waters and includes management of fisheries, commercial and amateur licences, fish culture, noxious fishes, fish diseases, research and development, enforcement and legal proceedings (Wager and Jackson, 1993). The Fisheries Act also provides the basic powers to protect threatened fish listed under the *Flora and Fauna Guarantee Act* (Wager and Jackson, 1993).

In Victorian waters, Marine Protected Areas (three Marine and Coastal Parks, two Marine Parks, and eight Marine Reserves) occupy an area of over 50, 000 hectares, which provides some protection to marine fishes (Cresswell and Thomas, 1997). At the State level in Victoria, the Environment Conservation Council recommended a package of MPAs for Victorian Proclaimed Waters, as a means of contributing to the protection of biodiversity (Walker, 2000). Twelve Marine National Parks and ten Marine Sanctuaries were recently proposed for Victorian waters which would have protected c. 5 % of the State's coastal waters, but unfortunately none of these protected areas were implemented.

5.3.8 Western Australia

In WA, the piece of legislation most relevant to the conservation of fishes is the *Wildlife Conservation Act 1950* that is currently administered by the Department of Conservation and Land Management (CALM). Three schedules of the *Wildlife Conservation Act 1950* exist to identify invertebrate species in need of protection. To be listed on Schedule 1, a species must be "rare or likely to become extinct". Schedule 2 lists species presumed to be extinct, and Schedule 3 lists otherwise specially protected species. A threatened species scientific committee was established in 1997 to consider nominations for listing. Nominations are assessed for their "adequacy of survey" and "taxonomy" and ranked according to the IUCN criteria. Marine and estuarine expertise is not formally represented on the committee. This Act has been under review for several years.

Other acts of relevance to the protection of fishes and/or their habitat include:

- *Conservation of Land Management Act 1985*

- *Environment Protection Act 1971-1980*
- *Fisheries Act 1905*
- *National Park Authority Act 1976*

Western Australian law relating to the ecological sustainability of the state's fisheries is addressed in Section 3 of the WA *Fish Resources Management Act 1994*, which has the following objectives:

1) to conserve, develop and share the fish resource of the State for the benefit of present and future generations
2) in particular, this Act has the following objectives
    a) to conserve fish and protect their environments
    b) to ensure that the exploitation of fish resources is carried out in a sustainable manner
    c) to enable the management of fishing, aquaculture and associated industries and aquatic eco-tourism
    d) to foster the development of commercial and recreational fishing and aquaculture
    e) to achieve the optimum economic, social and other benefits from the use of fish resources
    f) to enable the allocation of fish resources between users of those resources
    g) to provide for the control of foreign interests in fishing, aquaculture and associated industries
    h) to enable the management of fish habitat protection areas and the Abrolhos Islands Reserve

In WA waters, Marine Protected Areas (including seven large Marine Parks) occupy an area of over 1.14 million hectares, which provides a significant degree of protection to marine fishes, especially in the Shark Bay and Ningaloo Marine Parks (Cresswell and Thomas, 1997).

5.4 Research Inventory and Monitoring Requirements

5.4.1 Introduction

In our analysis of the recovery actions needed for individual species, special consideration has to be given to those species that are deemed to be the most threatened in determining priorities for recovery planning. In most cases, these are species that are listed in the Critically Endangered, Endangered or Vulnerable categories, but in some instances Data Deficient species are also in need of relatively urgent action (see Table 5.4.1). The first step in recovering threatened (i.e. Critically Endangered, Endangered and Vulnerable) species in Australia involves listing the individual species on the *EPBC Act 1999*. To assist in the recovery of a threatened species, a National Recovery Team is formed to produce a National Recovery Plan for the species. This Recovery Team should consist of a group of relevant experts who can assist with the writing, implementation and monitoring of the Recovery Plan.

There may be special cases of marine and estuarine fishes where emergency recovery actions may be required in spite of inadequate information, research, survey or other actions necessary for a full and complete Recovery Plan to be written. In these cases an Interim Recovery Plan may be necessary. For example, for the two *Glyphis* (river sharks) species, only a dozen or so specimens are known for both species combined. Further urgent research and interim management measures may, however, be necessary in such cases to gain the maximum benefit before planning for the recovery of such species.

5.4.2 Marine Protected Areas

The Commonwealth's Marine Protected Areas program's primary goal is to establish and manage a comprehensive, adequate and representative system of MPAs in Commonwealth waters to contribute to the long-term viability of marine and estuarine systems, maintain ecological processes and systems, and protect Australia's biological diversity at all levels. The secondary goals are to promote integrated ecosystem management, to manage human activities, to provide for the needs of species and ecological communities, and to provide for the recreational, aesthetic, cultural and economic needs of indigenous and non-indigenous peoples, where these are compatible with the primary goal.

Suitably placed, adequately sized and appropriately managed MPAs can provide significant benefits to marine and estuarine fishes in Australia. The lack of information on the needs for conservation of threatened marine and estuarine fishes (e.g. syngnathids) and the multiple-use framework within which this program operates, mean that MPAs alone cannot be relied upon to ensure the conservation of species. Appropriate management of fisheries and other threats outside of MPAs is also necessary.

5.4.3 Catch statistics and logbooks

Accurate and comprehensive data such as catch composition and catch rates, which fishers or observers can collect, will aid in not only the appropriate management of sustainable fisheries, but also appropriate conservation measures outside of fishing grounds. One of the problems encountered over the duration of this project has been the lack of species-specific recording in catch statistics. This is particularly obvious for non-target species, which are often not listed on fishers logbooks. Alterations to logbooks to encourage the recording of incidental catches and discards are a crucial step towards improving the catch statistics of individual species and fisheries. This will often need to be carried out in conjunction with an educational program (e.g. dissemination of identification guides to fishers or seminars to educate fishers) to be successful.

5.4.4 Management Options

Numerous species have been identified as being threatened or at risk of becoming threatened due to commercial and/or recreational fishing activities (whether taken as the target species or incidentally) and/or by habitat degradation. In these cases, management options include:

- In the case of the bycatch of protected species, operators will need to take action which minimises incidental captures and optimises survival rates of individuals upon release (SAG, 2000). Research into the effectiveness of particular Bycatch Reduction Devices may be necessary to help alleviate the interactions with these species.

- Studies into the post-release mortality of fishes (particularly for protected species, but also for commercial species and bycatch 'trash' species) are necessary to determine the survivability of different fishes using different collection methods. This information would help in evaluating the survivability of released fish and could be used to alter methods and gear to limit the catch of protected species, undersized commercial species and vulnerable bycatch 'trash' species. It could also potentially be used to implement seasonal and /or area closures.

- For shark and ray species, additional protection would be provided by making illegal (in all State and Commonwealth waters), the practice of shark finning at sea. The practice of shark finning has do far been made illegal in the States of NSW (since 4 June 1999), Victoria (year of ban unknown), South Australia (year of ban unknown), Western Australia (since October 2000) (SAG, 2000) and in Australian Commonwealth tuna fisheries (since October 2000) (AFMA, 2000g). Queensland and the Northern Territory are the only states that have not yet agreed to the ban on shark finning at sea.

- Technical measures such as temporal (e.g. seasonal) and/or area closures should be implemented where appropriate. For example, closing a fishery over the main breeding/spawning season to prevent excessive capture of mature spawning (or pupping) adults and reduce fishing effort at ‘critical’ times of the year), and size and sex selectivity (to restrict the sizes and sexes of fish that can be taken and landed).

- MPAs (or marine harvest refugia) should be designed and implemented to include a ‘representative’ part of the population of particular species over which no fishing or minimal fishing is permitted.

- “No-take” MPAs should be designed and implemented of where all forms of harvesting or fishing are excluded, to act as sanctuary areas for particular species.

- Fishing for a species may be continued fishing, but with changes being introduced to the input and/or output controls implemented. Changes to input controls can include limiting licences, lowering individual effort quotas, and/or introducing other gear and vessel restrictions (e.g. by improving gear selectivity). Changes to output controls can include lowering TACs, limiting Individual Quotas (IQs) and introducing or lowering vessel catch limits. These changes can reduce the fishing pressure on individual species by reducing catch and/or effort to ‘sustainable’ levels, as well as possibly reducing bycatch and damage to habitat caused by fishing gears. A recent positive example is the decision by the Northern Territory Department of Primary Industries and Fisheries to ban the use of bottom set nets to afford protection to "charismatic megafauna", such as sharks and rays (NTDPIF, 2000).

- Fish markets need to try and market products that would otherwise be wasted. If bycatch can be turned into byproduct, higher profits can be made from the existing catches and fishing effort can possibly be reduced.

Table 5.4.1 Research Inventory Table

Species Name	Proposed Conservation Category	IUCN (2000) Conservation Category	*EPBC Act 1999* Category	Suggested Research Actions	Suggested Management Actions
Glyphis sp. A	Critically Endangered	Not listed	Vulnerable	• Undertake surveys of previously known distribution to try and locate any extant populations[1].	• Once surveys have been completed, implement seasonal and/or area closures to fishing where populations are known to occur.
Pristis microdon	Critically Endangered	Endangered	Vulnerable	• Undertake surveys of northern Australian estuaries and middle and upper reaches of freshwater rivers and creeks within known range to accumulate information on distribution and abundance, behaviour (e.g. seasonal movements), biology (e.g. age and sex structures of populations, sizes at sexual maturity) and ecology (e.g. diet, preferred habitat)[1]. • Research into possible exclusion devices for trawlers in association with other sawfishes.	• Once surveys have been completed, implement seasonal and/or area closures to fishing where populations are known to occur.
Brachionichthys hirsutus	Critically Endangered	Critically Endangered	Endangered	• Continue to carry out recovery plan actions such as providing artificial spawning substrate in areas where populations are known to occur. • Continue to monitor populations and any changes to habitats in which populations occur.	• Design and implementation of suitably located MPAs to protect remaining populations.

[1] Surveys of *Glyphis* sp. A, *Glyphis* sp. C, *Pristis microdon* and *Himantura chaophraya* could be carried out concurrently as their general habitat requirements may overlap (though their specific habitat requirements are likely to differ).

Carcharias taurus	Endangered	Vulnerable	Vulnerable	• Further studies on abundances in WA waters, by either scientific surveys or scientific observers on appropriate commercial vessels. • Monitor catches in fisheries in WA waters. • See recovery objectives of Grey Nurse Shark synopsis for additional research actions (adopted from Draft National Recovery Plan).	• Need to implement an arrangement so that incidentally killed Grey Nurse Sharks taken by commercial fishers can be deposited at the nearest ichthyological research institution (e.g. Fisheries WA, NSW Fisheries, etc.). • See also management actions of Grey Nurse synopsis (adopted from Draft National Recovery Plan).
Glyphis sp. C	Endangered	Not listed	Not listed	• See *Glyphis* sp. A[1].	• List as a threatened species under the Commonwealth's *EPBC Act 1999.*
Centrophorus harrissoni	Endangered	Not listed	Not listed	• Further studies needed on taxonomy. • Further studies needed on biological and ecological characteristics.	• List as a threatened species under the Commonwealth's *EPBC Act 1999.* • Implement adequately sized 'No-take' fishing zones within range.
Pristis clavata	Endangered	Endangered	Not listed	• Undertake surveys of northern Australian estuaries and inshore waters in association with those mentioned for other members of the family Pristidae to determine accurate distributions, abundances, habitat descriptions and biological attributes (e.g. age and sex structures of populations, sizes at sexual maturity, seasonal migrations, diet)[2]. • Research into possible exclusion devices and most effective release methods for trawl fishers in association with *Pristis zijsron* and *Anoxypristis cuspidata.*	• List as a threatened species under the Commonwealth's *EPBC Act 1999.* • Attempt to reduce bycatch from commercial trawling activities in northern Australian waters.
Pristis zijsron	Endangered	Endangered	Not listed	• As for *Pristis clavata* above[2].	• As for *Pristis clavata* above.

[1] Surveys of *Glyphis* sp. A, *Glyphis* sp. C, *Pristis microdon* and *Himantura chaophraya* could be carried out concurrently as their general habitat requirements may overlap (though specific habitat requirements are likely to differ).

[2] Surveys of *Anoxypristis cuspidata*, *Pristis clavata* and *Pristis zijsron* could be carried out concurrently as their general habitat requirements may overlap (though specific habitat requirements are likely to differ).

Raja sp. L	Endangered	Endangered	Not listed	• Implementation of MPAs in the two estuaries where this species occurs is necessary to protect remaining populations.	• List as a threatened species on the Commonwealth's *EPBC Act 1999.*
Carcharodon carcharias	Vulnerable	Vulnerable	Vulnerable	• See recovery objectives in species synopses for research actions (adopted from Draft National Recovery Plan).	• See management actions of great white shark synopsis (adopted from Draft National Recovery Plan).
Brachaelurus colcloughi	Vulnerable	Vulnerable	Not listed	• Further studies needed on biology (e.g. age and size at maturity, longevity, home range, and possible migrations).	• List as a threatened species on the Commonwealth's *EPBC Act 1999.* • Implement adequately sized no-take zones within range. • Monitor catches of species in commercial fisheries (adjust logbooks to include this species).
Centrophorus uyato	Vulnerable	Not listed	Not listed	• Further studies needed on taxonomy. • Further studies needed on biological (e.g. age and size at maturity, longevity, movements and migrations) and ecological characteristics (e.g. specific habitat preferences).	• List as a threatened species under the Commonwealth's *EPBC Act 1999.* • Implement adequately sized 'No-take' fishing zones within range.
Anoxypristis cuspidata	Vulnerable	Endangered	Not listed	• As for *Pristis clavata*, *Pristis zijsron*[2].	• List as a threatened species under the Commonwealth's *EPBC Act 1999.*
Himantura chaophraya	Vulnerable	Vulnerable	Not listed	• Undertake surveys of northern Australian estuaries and middle and upper reaches of freshwater rivers and creeks within known range to accumulate information on distribution and abundance, behaviour (e.g. seasonal movements), biology (e.g. age and sex structures of populations, sizes at sexual maturity) and ecology (e.g. diet, preferred habitat)[1]	• List as a threatened species under the Commonwealth's *EPBC Act 1999.*

[1] Surveys of *Glyphis* sp. A, *Glyphis* sp. C, *Pristis microdon* and *Himantura chaophraya* could be carried out concurrently as their general habitat requirements may overlap (though their specific habitat requirements are likely to differ).

[2] Surveys of *Anoxypristis cuspidata*, *Pristis clavata* and *Pristis zijsron* could be carried out concurrently as their general habitat requirements may overlap (though their specific habitat requirements are likely to differ).

Brachionichthys politus	Vulnerable	Not listed	Not listed	• Undertake surveys of known habitat within range to accumulate information on biology.	• List as a threatened species under the Commonwealth's *EPBC Act 1999.*
Sympterichthys sp.	Vulnerable	Not listed	Vulnerable	• Further work on taxonomy needed. • Undertake surveys to accumulate information on abundance, distribution, biology (e.g. age and size at maturity, fecundity, home range, etc.), and ecology (e.g. specific habitat preferences, diet).	• Design and implementation of suitably located MPAs to protect remaining populations.
Epinephelus daemelii	Vulnerable	Not listed	Not listed	• Undertake surveys to accumulate information on abundance, distribution, biology (e.g. age and size at maturity, fecundity, home range, etc.), ecology (e.g. specific habitat preferences, diet).	• List as a threatened species under the Commonwealth's *EPBC Act 1999.* • Commercial fishers in NSW waters to record interactions with species to help accumulate information on distribution and threats.
Solegnathus spp.	Data Deficient	Vulnerable	Not listed	• Assess bycatch of commercial fishing (particularly trawling) activities in all Australian waters, but especially in Queensland, NSW, SA and WA. • Assess survival rates of *Solegnathus* returned to the water via experimental techniques to determine the survival success of individuals released after trawling. • Undertake taxonomic and biological research on all species in order to improve our understanding of individual species, their biological characteristics and their ecological requirements.	• Implement catch monitoring by logbook changes in relevant Australian fisheries (e.g. Queensland East Coast Trawl, NSW Ocean Prawn Trawl, SEF, SA & WA trawl fisheries, etc.)

5.5 Educational Requirements

Educating the public (including fishers) about the threats faced by marine and estuarine fish species (e.g. by using flagship taxa for public education programs) is possibly the most important factor in ultimately changing the ways in which we use marine and estuarine ecosystems and exploit the resources within them. The political will to conserve fishes originates from public perception of the importance of maintaining healthy aquatic ecosystems. In order for the public to understand the needs of threatened and potentially threatened species, the following educational strategies could be adopted:

- Publication of written and web-based “Fishnotes” or similar accessible publications by state fisheries organisations outlining ways that the general public can help to protect marine and estuarine fish habitats.
- Production by State fisheries organisations of easily accessible publications educating the public about the plight of protected (and non-protected) marine and estuarine fish species that occur in their respective states and the threats to their habitats.
- Involvement of natural history museums in conservation education programs that address the issues of threatened species and their habitats.
- Involvement of public aquariums in helping to educate about threatened fish species and their habitats through displays of live fishes, particularly inshore species that are relatively easy to keep in aquaria.
- Fisheries management authorities need to educate commercial fishers about the relevant conservation problems inherent in the fishery in which they work. This may involve distributing species identification guides and holding seminars to educate fishers about taxonomic traits to enable them to record their catches to the species level, where feasible.
- Encourage community groups to participate in habitat protection and habitat restoration programs that may improve fish habitat and lessen the effects of pollution.
- State fisheries organisations in conjunction with local councils could improve signage in relation to fishing regulations and educate about threatened fish species, particularly in more populated areas where threatened species may occur and/or where fishing intensity is high

Clearly, some external support may be necessary to assist in achieving the above goals, but the net benefits of preserving species far outweigh any short-term costs involved in such educational programs.

6 Acronyms and Abbreviations

ACT	Australian Capital Territory
AFMA	Australian Fisheries Management Authority
ANZECC	Australia and New Zealand Environment and Conservation Council
approx.	Approximately
ASFB	Australian Society for Fish Biology
CALM	Department of Conservation and Land Management, Western Australia
c.	Circa (about)
c.f.	Compare with
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	centimetres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ESP Act	Endangered Species Protection Act, 1992 (Commonwealth; replaced by the EPBC Act)
EA	Environment Australia
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FAO	Food and Agriculture Organisation of the United Nations
FL	Fork Length
FRDC	Fisheries Research and Development Corporation
GAB	Great Australian Bight
GABTF	Great Australian Bight Trawl Fishery
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
IUCN	International Union for the Conservation of Nature (now World Conservation Union)
ITQ	Individual Transferable Quota
km	kilometres
nm	nautical miles (1 nm = 1.83km)
m	metres
MAFRI	Marine and Freshwater Research Institute, Victoria
MCCN	Marine and Coastal Community Network
mm	millimetres
MPA	Marine Protected Area (plural MPAs)
n. sp.	New species
NIWA	National Institute of Water and Atmospheric Research, New Zealand
NPF	Northern Prawn Fishery
NSW	New South Wales
NT	Northern Territory
NZ	New Zealand
OCS	Offshore Constitutional Settlement
pers. comm.	personal communication
PhD	Doctor of Philosophy
PNG	Papua New Guinea
ppt	parts per thousand; a measure of the salt content (salinity) of water
QDPI	Queensland Department of Primary Industries (the fisheries component of this organisation has now amalgamated with the Queensland Fisheries Management Authority, QFMA, to become the Queensland Fisheries Service, QFS)
QFMA	Queensland Fisheries Management Authority (now amalgamated with the fisheries component of the QDPI to become the Queensland Fisheries Service, QFS)
QFS	Queensland Fisheries Service (recently formed from the amalgamation of the QFMA and the fisheries component of QDPI)
Qld	Queensland
QPWS	Queensland Parks and Wildlife Service
SA	South Australia
SBT	Southern Bluefin Tuna

SENTF	South East Non-Trawl Fishery
SETF	South East Trawl Fishery
SSF	Southern Shark Fishery
SL	Standard Length
sp.	Species (singular)
SPP.	**SPECIES (PLURAL, I.E. MORE THAN ONE SPECIES)**
SSG	Shark Specialist Group
SSC	Species Survival Commission
t	tonnes
TAC	Total Allowable Catch
Tas	Tasmania
TCM	Traditional Chinese Medicine
TL	Total Length
Vic	Victoria
WA	Western Australia
WAMRL	**WESTERN AUSTRALIAN MARINE RESEARCH LABORATORIES**

7 Glossary

abyssal plain – the ocean bottom from about 2000m to 6000m depth; the upper abyssal plain (2000-4000m) is also often referred to as the continental rise

anadromous - refers to fishes that migrate from salt water to fresh water to spawn

antitropical – found in both hemispheres, but not in equatorial regions

ascidian – a sea squirt; a soft, leathery bodied invertebrate of the tunicate class Ascidiacea often resembling a simple barrel-shaped sponge

Australian fishing zone (AFZ) – waters adjacent to Australia and its external territories (excluding Torres Strait and the Antarctic Territories) which extend from defined baselines to 200nm seawards, but not including coastal and excepted waters. Agreed boundaries apply where these zones intersect the 200nm zones of other nations. Within the AFZ, Australia exercises jurisdiction over all fishing by Australian and foreign boats

bathypelagic – living in ocean depths of 1000m to 4000m, but not close to the bottom

benthic - pertaining to the sea-floor, bottom-dwelling; associated with bottom habitat

biomass – total quantity or weight of organisms in a given area

brackish -water of intermediate salinity between fresh water and sea water

bycatch – species that are discarded from the catch or retained for scientific purposes, and that part of the "catch" that is not landed, but is killed as a result of the interaction with fishing gear. This includes discards of commercially valuable species (see also '**by-product**'). Various definitions of bycatch exist and some definitions in the past included the 'incidental catch' or 'by-product'.

by-product – species that are retained because they are commercially valuable, but are not the main target species (also referred to as incidental catch)

carnivorous – (noun - carnivore) preying on other animals

cartilaginous – refers to fishes which have a skeleton made of cartilage (soft and flexible gristle-like material which helps to provide support for the body), i.e. sharks, rays and chimaeras

catadromous - refers to fishes that migrate from freshwater to estuarine or saltwater habitats to spawn

cephalopod – a class of soft bodied molluscs, which includes squids, octopuses and cuttlefishes

chimaeras – cartilaginous fishes with a peculiar snout and tail in the family Chimaeridae, consisting of spookfishes, ghost sharks and elephantfishes

chondrichthyans – cartilaginous fishes comprising sharks, rays and chimaeras

ciguatoxin – a toxic substance accumulated up the food chain in the flesh and viscera of some fishes

ciguatera – a condition caused by the ingestion of ciguatoxic fishes

circumglobal – occurring worldwide

circumtropical – occurring worldwide in the tropics

clasper – a tubular modified part of each ventral fin in male sharks, used to transmit sperm during copulation

commercial species - all species in the catch that are kept and sold due to their commercial value

common name – the informal vernacular name for a fish (or other organism), which may vary from place to place

continental shelf – the gently sloping sea bed extending from the shore to a depth of about 200m

continental slope – the rather steeply sloping seabed extending from the outer margin of the continental shelf to a depth of about 2000m

cryptic – applied to fishes that live amongst sheltering and concealing cover or which have protective colouration, or both

Danish seine – a method of boat seining with a large net, but landing the catch on the vessel

diadromous - pertaining to fishes that migrate between freshwater habitats and the sea, in either direction

dimorphism – a situation where two different body shapes and/or colourations (often between the two sexes) are present in the one species

discards - the portion of the catch that is disposed, dumped or trashed as it is unsaleable or of lower value, dead or alive, during or after fishing operations

demersal - living at or occurring near or on the bottom substrate (c.f. **pelagic)**

demersal longline – bottom set line fishing method comprising a mainline to which are attached branch lines, each fitted with one or more baited hooks or artificial lures, sometimes called snoods or traces. Buoys are attached to each end of the mainline for retrieval of the gear

dermal – pertaining to the skin
dredge – equipment for collecting and bringing up objects from the seabed by dragging
dropline – a deepwater fishing method involving the use of a vertical line bearing rows of baited hooks
East Australian Current – the arm of the South Equatorial Current which turns southward down the northeastern coast of Australia forming a warm episodic, southwestern Pacific boundary current. The East Australian Current provides a mechanism for the dispersal of pelagic larvae from north to south along the coasts of Queensland and NSW. The extent of its southerly penetration varies from year to year.
ecologically sustainable – use of natural resources within their capacity to sustain natural processes while maintaining the life-support systems of nature and ensuring that the benefit of the use to the present generation does not diminish the potential to meet the needs and aspirations of future generations
ecosystem – the biotic (living) community and its abiotic (non-living) environment
elasmobranchs – cartilaginous fishes comprising sharks and rays
endangered species - under Endangered Species Protection Legislation, a species in danger of extinction because of its low numbers or degraded habitat; or a species likely to become so if factors affecting its status change. Note that the term Endangered has different meanings according to the criteria used by different organisations (cf. **vulnerable species**)
endemic – native and restricted to a defined area
epipelagic – the upper part of the oceanic zone from the surface to about 200m depth
estuarine – living mainly in estuaries
fecundity - a measure of the ability to produce offspring by the maternal adult
filter feeding – filtering suspended food particles from water current by means of the gill rakers
fishing effort - the amount of fishing taking place, usually described in terms of gear type and frequency or period for which it is in use: e.g. 'fishing days'
fork length (FL) - the horizontal distance from the tip of the snout to the fork of the tail (or caudal fin)
gelatinous – like jelly
gillnet – a net used to tangle or snare fishes
global positioning system (GPS) – a device that uses satellite signals to determine a vessel’s position and course accurately
gregarious – tending to live in groups
herbivorous – feeding on plant material
hermaphrodite – having both male and female organs in the same body, although not necessarily functionally developed at the same time
holotype – a single specimen designated as the ‘type’ (i.e. name bearer) of a new species by the author of the original description (**c.f.** paratype)
incidental catch - see ‘**by-product**’
Individual Transferable Quota (ITQ) - a catch limit or quota allocated to an individual fisher, who then has a guaranteed share (which may be either harvested or traded) of the Total Allowable Catch of a particular species
input controls – restrictions placed on the amount of effort input into a fishery, for example by restricting types and size of fishing gear and boats and the amount of fishing time
intertidal – the regions between the edges of the high and low extremes of the tide
larva - newly hatched fish in which the yolk sac is still present (plural - larvae, adjective - larval)
Leeuwin current - a current that flows along the Australia's western coastline transporting warm water from north westen Australia to Cape Leeuwin off the south western corner of Australia, and then further east into the Great Australian Bight
limited entry – management arrangements whereby only a fixed number of operators are allowed to fish in a particular fishery. New operators may only gain access to the fishery by purchasing an existing right
longline fishing – a method of fishing which can be either surface set (pelagic) or bottom set (demersal) line fishing. Both methods comprise a main line to which are attracted branch lines, each fitted with one or more baited hooks or artificial lures
management regime – policies, plans, action plans, strategic research plans, and all documentation that relates to the operations and management of a specific fishery

marine protected area – an area of sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means

mesopelagic – pertaining to the region of the open ocean at depths from 200m to 1000m

monotypic – having only a single species

mysids - an order of crustaceans belonging to the class Malacostraca, which superficially resemble shrimps and make up the diet of many fishes, especially syngnathids

offshore constitutional settlement (OCS) – an agreement between the State(s) and the Commonwealth whereby the State or the Commonwealth (or in some cases a joint authority) is given jurisdiction for a particular fishery occurring in both coastal waters and the AFZ. Where no OCS agreement has been reached the fishery remains under the jurisdiction of the State out to 3nm, and the Commonwealth from 3 to 200nm

omnivorous – feeding on both plant and animal material

oophagous (or oviphagous) - egg-eating; pertains to the feeding habits of the developing embryos inside the uterus of some sharks (e.g. grey nurse shark)

output controls – restrictions imposed on the quantity of fish that can be taken from a fishery in a specified period of time. This can be either a competitive TAC or a TAC allocated to participants as ITQs (c.f. **input controls**)

ovum – egg (plural - ova)

ovaries – female reproductive organs, containing ova

overfishing - can be defined in two ways which can act independently or concurrently: 1) "recruitment overfishing": where fishing activities are causing a reduction in recruitment in succeeding years and cause the mortality of too many fish in total, too many pre-productive fish, or too many fish that have only spawned a few times. The end result is that the stock can no longer replenish itself adequately. 2) "growth overfishing": where fishing activities lead to a reduction in the size of the individuals of a species, as a consequence of which few specimens grow to size for optimum yield

oviparous - reproductive mode in which eggs are spawned and hatch outside the maternal body (c.f. **ovoviviparous**, **viviparous**)

ovoviviparous - reproductive mode in which eggs are retained and hatch within the maternal body, with the release of live young (c.f. **oviparous**, **viviparous**)

paratype – a specimen, other than the holotype, on which the description of a new species is based

pelagic - refers to fishes which inhabit open waters or near the surface, or to eggs or larvae which occur in these areas; pelagic eggs are buoyant or semi-buoyant (c.f. **demersal**)

planktivorous - describes a fish that eats plankton (small floating animals or plants that drift with the ocean currents)

population – a biological unit; representing the individuals of a species living in a particular area

precautionary approach – used to adopt the precautionary principle. In the application of the precautionary principle, public and private decisions should be guided by : 1) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and 2) an assessment of the risk-weighted consequences of the various options

precautionary principle – where there are threats of serious or irreversible environmental damage to habitats or species, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation to these habitats or species

predator - (adjective predatory) feeding on other animals

productivity – when applied to fish stocks the term productivity gives an indication of the birth, growth and death rates of a stock

protogynous – pertaining to hermaphrodites in which the reproductive organs develop first as ovaries (female) and then transform into testes (male), e.g. most groupers of the genus *Epinephelus*

purse seine – fishing net used to encircle surface-dwelling fish; it is usually landed aboard a boat rather than beached

recovery plan – a comprehensive plan that details, schedules and costs all actions including research necessary to support the recovery of a species or ecological community; there should be a national recovery plan for each threatened species or ecological community

recovery team – a group of people of relevant expertise and responsibility charged with assisting the lead agency/agencies in the writing, implementing and monitoring of a recovery plan

biological reference point – an indicator level of fishing (or stock size) to be used as a benchmark for assessment or decision making

rostral teeth – tooth-like projections on the sides of the snout of sawfishes and sawsharks

salps – pelagic animals with generally transparent, barrel-shaped bodies, belonging to the class Thaliacea

scientific name – the formal binomial name of an organism consisting of the genus and specific names; a species has only one valid scientific name

seine – a fishing net designed to hang vertically in the water, the ends being drawn together to encircle fish; to fish with a seine net (see also **purse seine** and **Danish seine**)

spawning ground – geographic area where shedding and fertilisation of eggs takes place

species – actually or potentially inter-breeding populations that are reproductively isolated from other populations; the basic rank of biological nomenclature

speciose – rich in numbers of species

squalene – oil produced in the liver of some sharks

standard length (SL) - the horizontal distance from the tip of the snout to the edge of the hypural plates

stock – in the strict sense, a distinct, reproductively isolated population. In practice a group of individuals of a species in a defined spatial range that is regarded as having a relatively low rate of exchange with others of the species

substrate - the substance forming the bottom of the sea or ocean floor

subtidal – below the low tide mark

sustainable yield – the maximum catch that can be taken from a fishery over an indefinite period without causing the stocks to be depleted

sympatric – living together in the same spatial or geographic area

synonym (adjective synonymous) – each of two or more scientific names of the same rank used to denote the same taxon

target catch - the catch resulting from specifically aiming for or fishing selectively for particular species or sizes of fish

taxon (plural taxa) – any formal taxonomic unit or category of organisms (genus, species, family, etc.)

taxonomy - the science of classification of animals and plants

teleost – a large group containing most bony fishes

testes – the male reproductive organs

Total Allowable Catch (TAC) - the total amount of fish of a particular species that can be taken from a fishery in a prescribed period

total length (TL) - the horizontal distance from the tip of the snout to the tip of the tail

trawl – a fishing net that is dragged behind a boat; to fish with a trawl net

trotline – a method of fishing that involves a horizontal set mainline that has small floats attached to suspend it off the seabed to avoid snagging. Short, weighted lines, sometimes called snoods or trots, are attached at intervals along the length of the mainland. These are set vertically in the water and act like a series of short droplines

viviparous - live-bearing reproductive mode whereby the embryos develop within the maternal body and receive nutrition, and the young are released as larvae (in bony fishes) or juveniles (in sharks and rays) (cf. **oviparous, ovoviviparous**)

vulnerable species – under Endangered Species Protection Legislation, a species that within 25 years will become endangered unless mitigating action is taken. Note that the term Vulnerable has different meanings according to the criteria used by different organisations (cf. **endangered species**)

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http://www.affa.gov.au:80/ministers/truss/releases/00/00181wt.html (Media Release by Australian Federal Government to ban shark finning in Australian tuna fisheries)

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http://www.abare.gov.au/pubcat/statistics.htm (Publications – Statistics)

Australian Fisheries Management Authority
http://www.afma.gov.au (home page)

Australian Legal Information Institute
http://www.austlii.edu.au/ (home page)

Australian Museum
http://www.austmus.gov.au (home page)

Bureau of Rural Sciences
http://www.brs.gov.au (home page)

CSIRO
http://www.csiro.au/ (home page)

Department of Natural Resources and Environment, Victoria
http://www.nre.vic.gov.au/ (home page)

Department of Primary Industries and Fisheries, Northern Territory
http://www.nt.gov.au/dpif/ (home page)

Environment Australia
http://www.environment.gov.au (home page)
http://www.ea.gov.au/biodiversity/threatened/action/index.html (Threatened Species and Ecological Communities)
http://www.environment.gov.au/marine/species_protection/sharks/greynurse.htm (Draft Recovery Plan for Grey Nurse Sharks in Australia)

Fisheries Scientific Committee, NSW Fisheries
http://www.fsc.nsw.gov.au/ (home page)

Fisheries Western Australia
http://www.wa.gov.au/westfish/ (home page)

Great Barrier Reef Marine Park Authority
http://www.gbrmpa.gov.au/ (home page)

IUCN (The World Conservation Union)
http://www.iucn.org/ (home page)
http://www.redlist.org/ (2000 IUCN Red List of Threatened Species)
http://www.iucn.org/themes/ssc/siteindx.htm#table1 (Species Survival Commission)
http://www.iucn.org/themes/ssc/redlists/ssc-rl-c.htm (Red List Categories and Criteria)

Marine and Coastal Community Network
http://www.ozemail.com.au/~mccnet/ (home page)
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NSW Fisheries
http://www.fisheries.nsw.gov.au (home page)

Primary Industries and Resources, South Australian
http://www.pir.sa.gov.au (home page)

Project Seahorse:
http://www.seahorse.mcgill.ca (home page)
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Queensland Department of Primary Industries
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Seahorse Australia:
http://www.seahorseaquaculture.com.au/ (home page)

Tasmania Department of Primary Industries, Water and Environment
http://www.dpif.tas.gov.au/ (home page)

Appendix 1
Authorities Consulted and Specialist Workshop Participants

Listed alphabetically by surname

Name	Organisation
Allen, Tim	Marine and Coastal Community Network, Melbourne, Vic
Armstrong, Mark	Environment Australia, Canberra, ACT
Arney, Larissa	AFMA, Canberra, ACT
Ayvazian, Suzanne	Fisheries WA – WAMRL, North Beach, WA
Bardsley, Tania	Museum of Victoria, Melbourne, Vic
Bateman, David	Sunfish, Brisbane, Qld
Bathgate, Rachel	Victorian National Parks Association, East Melbourne, Vic
Bax, Nicholas	CSIRO Marine Research Laboratories, Hobart, Tas
Beumer, John	Queensland Fisheries Service, Brisbane, Qld
Bohm, Craig	Marine and Coastal Community Network, Sydney, NSW
Bray, Dianne*	Museum of Victoria, Melbourne, Vic
Breen, Sian	Queensland Fisheries Service, Brisbane, Qld
Brooks, Danny	Queensland Fisheries Service, Brisbane, Qld
Bruce, Barry*	CSIRO Marine Research Laboratories, Hobart, Tas
Caddy, Sara	AFMA, Canberra, ACT
Calogeras, Chris	Department of Primary Industries and Fisheries, Darwin, NT
Cameron, Darren*	Great Barrier Reef Marine Park Authority, Townsville, Qld
Camhi, Merry	National Audubon Society, New York, USA
Choat, Howard	James Cook University, Townsville, Qld
Compton, Tanya*	University of NSW, Kensington, NSW
Connolly, Rod	Griffith University, Gold Coast Campus, Nathan, Qld
Coyle, Troy*	University of NSW, Kensington, NSW
Crook, David	Murray Darling Freshwater Research Centre, Albury, NSW
Dunn, Kathy	AFMA, Canberra, ACT
Edgar, Graham*	University of Tasmania, Hobart, Tas
Eiler, John*	National Marine Fisheries Service, Alaska, USA
Farley, Jessica	CSIRO Marine Research Laboratories, Hobart, Tas
Ferrell, Doug	NSW Fisheries Research Institute, Cronulla, NSW
Fisher, Joanna	AFMA, Canberra, ACT
Forteath, Nigel	Seahorse Australia Pty. Ltd., Tasmania
Fowler, Sarah	Nature Conservation Bureau, Newbury, Berkshire, UK
Freeman, Rob	Inland Fisheries Commission, Derwent Park, Tas
Gibbs, Philip*	NSW Fisheries Research Institute, Cronulla, NSW
Gill, Tony	Natural History Museum, London, UK
Gomon, Martin*	Museum of Victoria, Melbourne, Vic
Graham, Alastair	CSIRO Marine Research Laboratories, Hobart, Tas
Graham, Ken	NSW Fisheries Research Institute, Cronulla, NSW
Grey, Darryl	NSW Fisheries Research Institute, Port Stephens, NSW
Gunn, John	CSIRO Marine Research Laboratories, Hobart, Tas
Hall, Kylie*	MAFRI, Queenscliff, Vic
Henry, Gary	NSW Fisheries Research Institute, Cronulla, NSW
Herr, Alexander*	Charles Sturt University, Bathurst, NSW
Higgs, Jim	Queensland Fisheries Service, Brisbane, Qld
Hiscoe, Dean	NPWS, Lord Howe Island, NSW
Hoese, Doug*	Australian Museum, Sydney, NSW

Hudson, Russell	MAFRI, Queenscliff, Vic.
Hutchins, Barry	Western Australian Museum, Perth, WA
Jackson, Jean	Inland Fisheries Commission, Derwent Park, Tas
Jenkins, Aaron	Wetlands International, Canberra, ACT
Johnson, Jeff*	Qld Museum, South Brisbane, Qld
Keech, Simone*	NSW Fisheries, Port Stephens, NSW
Kelly, Geoff	Lord Howe Island Marine Park, Lord Howe Island
Koehn, John*	Arthur Rylah Institute, Heidelberg, Vic
Kuiter, Rudie*	Museum of Victoria, Melbourne, Vic
Lane, Baden	Queensland Fisheries Service, Qld
Larson, Helen*	Museum and Art Gallery of the Northern Territory, Darwin, NT
Last, Peter	CSIRO Marine Research Laboratories, Hobart, Tas
Lemm, Stephanie	Queensland Parks and Wildlife Service, Cleveland, Qld
Lewis, Ron*	Native Fish Australia, Vic
Maguire, Katrina	AFMA, Canberra, ACT
Malcolm, Jane	AFMA, Canberra, ACT
McAuley, Rory	Fisheries WA – WAMRL, North Beach, WA
McGuckin, John*	Streamline Research Pty Ltd, Eltham, Vic
McGrouther, Mark	Australian Museum, Sydney, NSW
McPherson, Geoff	Queensland Fisheries Service, Qld
Mednis, Astrida	Environment Australia, Canberra, ACT
Michaelis, Frances*	Australian Quarantine Inspection Service, Canberra, ACT
Morrison, Sue	Western Australian Museum, Perth, WA
Musick, Jack	Virginia Institute of Marine Science, Gloucester Point, Virginia, USA
Nardi, Kim	Fisheries Western Australia, Geraldton, WA
Otway, Nick	NSW Fisheries, Port Stephens, NSW
Paxton, John*	Australian Museum, Sydney, NSW
Pepperell, Julian*	Pepperell Research and Consulting, Caringbah, NSW
Pollard, David*	NSW Fisheries Research Institute, Cronulla, NSW
Pogonoski, John*	Australian Museum, Sydney, NSW
Punt, Andre*	CSIRO Marine Research Laboratories, Hobart, Tas
Pursey, John*	NSW Fisheries, Port Stephens, NSW
Quong, Pang	Ascidian Aquarium Systems, Victoria
Reid, Dennis	NSW Fisheries Research Institute, Cronulla, NSW
Roberts, Clive	Museum of New Zealand Te Papa, Wellington, NZ
Rowling, Kevin*	NSW Fisheries Research Institute, Cronulla, NSW
Rose, Cassie	Bureau of Rural Sciences, Kingston, ACT
Sadovy, Yvonne	University of Hong Kong, Hong Kong
Sanger, Andrew*	NSW Fisheries, Albury, NSW
Scandol, James*	University of Sydney, NSW
Schultz, Diane*	NIWA, Hamilton, NZ
Sim, Terry	South Australian Museum, Adelaide, SA
Simpfendorfer, Colin	Mote Marine Laboratories, Florida, USA
Skousen, Thim	AFMA, Canberra, ACT
Smith, Dave*	MAFRI, Queenscliff, Vic
Smith, Brian	Queen Victoria Museum, Launceston, Tas
Smith, Tony	CSIRO Marine Research Laboratories, Hobart, Tas
Squire, Lyle	Cairns, Qld
Stevens, John*	CSIRO Marine Research Laboratories, Hobart, Tas
Stobutzki, Ilona	CSIRO, Cleveland, Qld
Stone, John*	Australian Quarantine Inspection Service, ACT
Tanner, Marnie	NSW Fisheries Research Institute, Cronulla, NSW
Talbot, Bill*	NSW Fisheries, Port Stephens, NSW

Thomas, Bonnie	Griffith University, Gold Coast Campus, Nathan, Qld
Tilzey, Richard	Bureau of Rural Sciences, Canberra, ACT
Truelove, Kerry*	Environment Australia, Canberra, ACT
Vincent, Amanda	McGill University, Montreal, Canada
Walker, Terry	Marine and Freshwater Research Institute, Vic
Wang, John*	Centre for Marine Conservation, Washington DC
Ward, Peter	Bureau of Rural Sciences, Canberra, ACT
Warland, Tracy	SA Seahorse Marine Services, SA
Watene, Erina*	NIWA, Hamilton, NZ
West, John	Taronga Zoo, Mosman, NSW
West, Ron*	University of Wollongong, NSW
Williams, Erica*	NIWA, Hamilton, NZ
Wilmore, Steve	Department of Primary Industries and Fisheries, Darwin, NT
Wise, Brent*	Bureau of Rural Sciences, Canberra, ACT
Woodfield, Craig	Marine and Coastal Community Network, Sydney, NSW

*Experts who attended the Marine Threatened Fishes Workshop at Bendigo, Victoria, 27 September 1999.

Appendix 2: ASFB Threatened Species Nomination Form

AUSTRALIAN SOCIETY FOR FISH BIOLOGY

NOMINATION FORM FOR AUSTRALIAN THREATENED FISH

- **[A] ASFB Categories**
- **[B] IUCN Red List Categories**

This form has been designed to accommodate listing under both ASFB and IUCN categories. For the latter it must be used in conjunction with the IUCN Red List Categories booklet published 30 November 1994. Wherever possible supporting evidence should be appended to the form, e.g. maps to indicate evidence of distribution decline. Wherever possible cite published information or otherwise name the authority from which the information was obtained.
NB Remember, only one taxon per form

<table>
<tr><td colspan="2">1. Name of nominated taxon:</td></tr>
<tr><td colspan="2">Scientific name:

Common name:</td></tr>
<tr><td colspan="2">2. Proof that taxonomy of taxon is correct:
(reference to accepted text or report)</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">3. Nominator</td></tr>
<tr><td colspan="2">Name: Date:

Address:</td></tr>
<tr><td colspan="2">4. Present status of nominated taxon:</td></tr>
<tr><td>ASFB</td><td>IUCN</td></tr>
<tr><td colspan="2">5. Proposed status of nominated taxon:</td></tr>
<tr><td>ASFB</td><td>IUCN</td></tr>
</table>

6. Supporting evidence: **[A] ASFB CATEGORIES**
Evidence to support proposed status: (Evidence must support the criteria outlined in the relevant category. Cite published papers, reports, etc., wherever possible. Include details of past and present distributions in map form, if possible. Is the decline in distribution continuing? What are the threats? What are the habitat requirements of the taxon?)

6. Supporting evidence (continued) **[B] IUCN RED LIST CATEGORIES**
Refer to attached explanatory sheet for a summary of IUCN categories. However, classification should not be undertaken without reference to the IUCN Red List Categories booklet (1994). State Threatened Fishes Committee members will have copies of this publication. Note that only one of A to E (below) is necessary to list a taxon. However, if information is available on more than one category, it should be recorded.
A. Declining population (state particular criterion/criteria used, e.g. Critically Endangered: A1(b) or Endangered: A2, etc., and document evidence)
B. Small distribution and decline or fluctuation (state particular criterion/criteria used as above and document evidence)
C. Population estimation - small population size and decline (state particular criterion/criteria used and document evidence)

D. Population estimation - very small or restricted (list criterion used e.g. Critically Endangered, Vulnerable, etc., and document evidence)
E. Quantitative analysis - probability of extinction (state particular criterion used, e.g. Vulnerable (E), and document evidence)
Lower Risk (If taxon considered: Conservation Dependent, Near Threatened or Least Concern. Provide evidence)

Summary
(e.g. Critically Endangered A2(c), (d), C2(a), etc. Note - if adequate assessment of risk cannot be made based on observation, inference or projection it should be listed as Data Deficient (DD))

7. Threatening processes
(tick the key threatening processes for the taxon nominated)

- Introduced species ☐
- Instream habitat removal / destruction ☐
- Riparian vegetation removal ☐
- Sedimentation ☐
- Water extraction / Flow regulation ☐
- Reduced water quality ☐
- Overfishing / collection ☐
- Barriers to movement ☐
- Loss of genetic diversity ☐
- Other ☐

Comments:

8. Received by Convenor of Threatened Fishes Committee

Signature Date

9. Committee's Decision

Signature Date

10. Ratified by Society

Signature Date

Australian Society for Fish Biology (ASFB) Categories

EXTINCT
Taxa that are no longer found in the wild or in a domesticated state.

ENDANGERED
Taxa which have suffered a population decline over all or most of their range, whether the causes of this decline are known or not, and which are in danger of extinction in the near future. (Special management measures are required if the taxa are to continue to survive).

VULNERABLE
Taxa not presently endangered, but which are at risk by having small populations and/or populations which are declining at a rate that would render them endangered in the near future. (Special management measures are required to prevent the taxa becoming endangered or extinct.)

POTENTIALLY THREATENED
Taxa which could become vulnerable or endangered in the near future because they have a relatively large population in a restricted area; or they have small populations in a few areas; or they have been heavily depleted and are continuing to decline; or they are dependant on specific habitat for survival. (Require monitoring.)

INDETERMINATE
Taxa which are likely to fall into one of the Endangered, Vulnerable or Potentially Threatened categories, but for which insufficient data are available to make an assessment. (Require investigation.)

RESTRICTED
Taxa that are not presently in danger, but which occur in restricted areas, or which have suffered a long-term reduction in distribution and/or abundance and are now uncommon.

UNCERTAIN STATUS
Taxa whose taxonomy, distribution and/or abundance are uncertain, but which are suspected of being Restricted.

Summary of the IUCN Categories and Criteria

The following table outlines the IUCN Red List categories and criteria. The table is provided as a conceptual framework and should not be used in isolation of pages 15-21 of the IUCN Red List Categories (IUCN, 1996, to add). Use any of the following A-E criteria:

<table>
<tr><th>A.
DECLINING POPULATION</th><th>Critically Endangered</th><th>Endangered</th><th>Vulnerable</th></tr>
<tr><td>Population decline rate at least:</td><td>80% in 10 years or 3 generations</td><td>50% in 10 years or 3 generations</td><td>20% in 10 years or 3 generations</td></tr>
<tr><td colspan="4">Using either (1) population reduction observed, estimated, inferred, or suspected in the past
or (2) population decline projected or suspected in the future

based on a) direct observation
b) an index of abundance appropriate for the taxon
c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
d) actual or potential levels of exploitation
e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites</td></tr>
<tr><th>B.
SMALL DISTRIBUTION AND POPULATION DECLINE OR FLUCTUATION</th><th>Critically Endangered</th><th>Endangered</th><th>Vulnerable</th></tr>
<tr><td>Either extent of occurrence
or area of occupancy</td><td>≤ 100 km²
≤10 km²</td><td>≤5000 km²
≤500 km²</td><td>≤20000 km²
≤2000 km²</td></tr>
<tr><td colspan="4">And two of the following three:</td></tr>
<tr><td>(1) either known to exist at # locations fragmented</td><td>1</td><td>≤5</td><td>≤10</td></tr>
<tr><td colspan="4">Or severely fragmented = isolated sub-populations with a reduced probability of recolonisation, if once extinct</td></tr>
<tr><td>(2) continuing decline</td><td>Any rate</td><td>any rate</td><td>any rate</td></tr>
<tr><td>In any of the following:</td><td colspan="3">a) extent of occurrence
b) area of occupancy
c) area, extent and/or quality of habitat
d) number of locations or subpopulation
e) number of mature individuals</td></tr>
<tr><td>3) fluctuating</td><td>>1 order of magnitude</td><td>>1 order of magnitude</td><td>>1 order of magnitude</td></tr>
<tr><td>In any of the following</td><td colspan="3">a) extent of occurrence
b) area of occupancy
c) Number of locations or subpopulation
d) number of mature individuals</td></tr>
</table>

C. **SMALL POPULATION SIZE AND DECLINE**	**Critically Endangered**	**Endangered**	**Vulnerable**
Critically Endangered	**Endangered**	**Vulnerable**	**Vulnerable**
And one of the following two			
(1) rapid decline rate	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
(2) continuing decline and either	any rate	any rate	any rate
(a) fragmented or	all sub-pops ≤50	all sub-pops ≤250	all sub-pops ≤1000
(b) all individuals in a population			

D. **VERY SMALL OR RESTRICTED POPULATION**	**Critically Endangered**	**Endangered**	**Vulnerable**
Either (1) number of mature individuals or (2) population is susceptible	≤50 (not applicable)	≤250 (not applicable)	≤1000 area of occupancy <100 km^2 or # locations <5
E. QUANTITATIVE ANALYSIS	**Critically Endangered**	**Endangered**	**Vulnerable**
Indicating the probability of extinction in the wild to be at least:	50% in 10 years or 2 generations	20% in 20 years or 5 generations	10% in 100 years

APPENDIX 3 : Current (2000) ASFB List of Australian Threatened Fishes

*NOTE: Marine and estuarine species only; listed by category of threat, not phylogenetically

CONSERVATION STATUS OF AUSTRALIAN FISHES 2000
As Listed by the Australian Society for Fish Biology (IUCN codes adopted)
IUCN categories: (CR) Critically Endangered; (EN) Endangered; (VU) Vulnerable; (LR (nt)) Lower Risk (Near Threatened); (LR (lc)) Lower Risk (Least Concern); (DD) Data Deficient; (NE) Not Evaluated.
* Denotes taxa where formal taxonomic description has not been published, but where listing is essential because of concern over their conservation status. Early formal publication will be encouraged to resolve the taxonomic status of these species.

ASFB CATEGORY	SCIENTIFIC NAME	COMMON NAME	Equivalent IUCN STATUS
EXTINCT	No species		
ENDANGERED	*Brachionichthys hirsutus*	Spotted Handfish	CR
VULNERABLE	*Carcharias taurus*	Grey Nurse Shark	VU
	* *Sympterichthys* n.sp.	Ziebell's Handfish	VU
	* *Sympterichthys* n.sp.	Waterfall Bay Handfish	VU
POTENTIALLY THREATENED	*Epinephelus daemelii*	Black Cod	DD
	Pristis microdon	Freshwater Sawfish	DD
INDETERMINATE	*Rhincodon typus*	Whale Shark	NE
	Brachionichthys politus	Red Handfish	DD
UNCERTAIN STATUS	*Anoxypristis cuspidata*	Narrow Sawfish	DD
	Carcharodon carcharias	Great White Shark	NE
	Pristis clavata	Estuarine Sawfish	DD
	Pristis pectinata	Wide Sawfish	DD
	Pristis zijsron	Green Sawfish	DD
REQUIRING INVESTIGATION OF THEIR STATUS	*Chaetodontoplus ballinae*	Ballina Angelfish	NE
	Thunnus maccoyii	Southern Bluefin Tuna	NE
	Glyphis sp. A	Bizant River Shark	NE
	Glyphis sp. C	Northern River Shark	NE

APPENDIX 4: Current (2000) IUCN List of Australian Threatened Fishes

Marine and estuarine species only, EN = Endangered, VU = Vulnerable, LR (nt) = Lower Risk (near threatened), LR (cd) = Lower Risk (conservation dependent); DD = Data Deficient

2000 IUCN THREATENED AUSTRALIAN FISH SPECIES LIST

TAXA (listed phylogenetically)	2000 IUCN CATEGORY	ENDEMIC (YES/NO)
Brachaeluridae		
Brachaelurus colcloughi	VU	YES
Rhincodontidae		
Rhincodon typus	DD	NO
Triakidae		
Furgaleus macki	LR (cd)	YES
Galeorhinus galeus	VU	NO
Galeorhinus galeus (Australasian subpopulation)	LR (cd)	NO
*Hypogaleus hyugaensis**	LR (nt)	NO
*Mustelus antarcticus**	LR (cd)	YES
Carcharhinidae		
*Carcharhinus amboinensis**	DD	NO
*Carcharhinus amboinensis** (SW Indian Ocean subpopulation)	LR (nt)	NO
*Carcharhinus amblyrhynchoides**	LR (nt)	NO
*Carcharhinus amblyrhynchos**	LR (nt)	NO
*Carcharhinus brevipinna**	LR (nt)	NO
*Carcharhinus brevipinna** (NW Atlantic subpopulation)	VU	NO
*Carcharhinus leucas**	LR (nt)	NO
Carcharhinus limbatus	LR (nt)	NO
Carcharhinus limbatus (NW Atlantic subpopulation)	VU	NO
*Carcharhinus longimanus**	LR (nt)	NO
*Carcharhinus melanopterus**	LR (nt)	NO
Carcharhinus obscurus	LR (nt)	NO
Carcharhinus obscurus (NW Atlantic & Gulf of Mexico subpopulation)	VU	NO
Carcharhinus plumbeus	LR (nt)	NO
Carcharhinus plumbeus (NW Atlantic subpopulation)	LR (cd)	NO
*Galeocerdo cuvier**	LR (nt)	NO
*Prionace glauca**	LR (nt)	NO
Sphyrnidae		
*Sphyrna lewini**	LR (nt)	NO
*Sphyrna mokarran**	DD	NO
*Sphyrna zygaena**	LR (nt)	NO
Odontaspididae		
Carcharias taurus	EN	NO
Pseudocarchariidae		
*Pseudiocarcharias kamoharai**	LR (nt)	NO
Megachasmidae		

Megachasma pelagios	DD	NO
Alopiidae		
*Alopias vulpinus**	DD	NO
Cetorhinidae		
Cetorhinus maximus	VU	NO
Cetorhinus maximus (North Pacific subpopulation)	EN	NO
Cetorhinus maximus (Northeast Atlantic subpopulation)	EN	NO
Lamnidae		
Carcharodon carcharias	VU	NO
*Isurus oxyrinchus**	LR (nt)	NO
*Lamna nasus**	LR(nt)/ LR(cd)	NO
*Lamna nasus** (Northeast Atlantic subpopulation)	VU	NO
*Lamna nasus** (Northwest Atlantic subpopulation)	LR (cd)	NO
Hexanchidae		
Hexanchus griseus	LR (nt)	NO
Notorynchus cepedianus	DD	NO
Notorynchus cepedianus (East Pacific subpopulation)	LR (nt)	NO
Squalidae		
Centrophorus granulosus	VU	NO
Dalatias licha	DD	NO
Dalatias licha (Northeast Atlantic subpopulation)	LR (nt)	NO
Pristidae		
Anoxypristis cuspidata	EN	NO
Pristis clavata	EN	YES
Pristis microdon	EN	NO
Pristis microdon (SE Asian subpopulation)	CR	NO
Pristis pectinata	EN	NO
Pristis pectinata (NW & SW Atlantic subpopulation)	CR	NO
Pristis zijsron	EN	NO
Rhynchobatidae		
*Rhynchobatus djiddensis**	VU	NO
Rajidae		
Raja sp. L	EN	YES
Dasyatididae		
Himantura chaophraya	EN	NO
Himantura chaophraya (Thailand subpopulation)	CR	NO
*Taeniura lymma**	LR (nt)	NO
Urogymnus asperrimus	VU	NO
Myliobatididae		
*Aetobatus narinari**	DD	NO
Brachionichthyidae		
Brachionichthys hirsutus	CR	YES
Pegasidae		
Eurypegasus draconis	DD	NO
Eurypegasus draconis (Indian Ocean & Pacific stock)	VU	NO

PEGASIDAE (CONTINUED)		
Pegasus lancifer	DD	YES
Pegasus volitans	DD	NO
Pegasus volitans (Philippines stock)	VU	NO
Pegasus volitans (South China Sea stock)	VU	NO
Syngnathidae		
Dunckerocampus dactyliophorus	DD	NO
Hippocampus abdominalis	VU	YES
H. angustus	VU	YES
H. bargibanti	DD	NO
H. breviceps	DD	YES
*H. histrix****	VU	NO
*H. kuda***	VU	NO
H. minotaur	DD	YES
H. planifrons	VU	YES
*H. spinosissimus***	VU	NO
H. whitei	VU	YES
Phycodurus eques	DD	YES
Phyllopteryx taeniolatus	DD	YES
Syngnathoides biaculeatus	DD	NO
Solegnathus dunckeri	VU	YES
S. hardwickii	VU	NO
S. lettiensis	VU	NO
S. robustus	VU	YES
S. spinosissimus	VU	NO
Serranidae		
Cromileptes altivelis	DD	NO
Epinephelus lanceolatus	VU	NO
Scombridae		
Thunnus maccoyii	CR	NO
Xiphiidae		
Xiphias gladius	DD	NO
Xiphias gladius (North Atlantic stock)	EN	NO

* No synopses are included for these species as they were not listed on the 1996 IUCN Red List of Threatened Animals and were not regarded to be threatened in Australian waters (see section 2.2: Selection of taxa for inclusion)
** No records of these species have yet been confirmed from Australian waters
***This species has rarely been found in Australian waters, and only recently have specimens been confirmed from Australia. Therefore, no detailed synopsis has been included for this species

APPENDIX 5: Current (1996) IUCN Red List Categories and Definitions*

* From http://www.iucn.org/themes/ssc/redlists/ssc-rl-c.htm

(For IUCN CRITERIA refer back to the ASFB Nomination Form in Appendix 2)

IUCN CATEGORIES

EXTINCT (EX)
A taxon is Extinct in the wild when there is no reasonable doubt that the last individual has died.
EXTINCT IN THE WILD (EW)
A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, and annual)' throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxons life cycle and form.
CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) on pages 15,16, and 17 of the IUCN Red List Categories Handbook (1994).
ENDANGERED (EN)
A taxon is endangered when it is not Critically Endangered, but is facing a very high risk of extinction in the near future, as defined by any of the criteria (A to E) on p17-18.
VULNERABLE (VU)
A taxon is Vulnerable when it is not Critically Endangered or Endangered, but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to D) on pages 19,20 and 21.
LOWER RISK (LR)
A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:
1. **Conservation Dependent (cd).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will shoe that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)
A taxon is Not Evaluated when it has not yet been assessed against the criteria.

IUCN DEFINITIONS (From http://www.iucn.org/themes/ssc/redlists/ssc-rl-c.htm)

POPULATION
Population is defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life forms, population numbers are expressed as numbers of mature individuals only. In the case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used.

1. Subpopulations
Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little exchange (typically one successful migrant individual or gamete per year or less).

3. Mature individuals
The number of mature individuals is defined as the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity the following points should be borne in mind:

- Where the population is characterised by natural fluctuations the minimum number should be used.
- This measure is intended to count individuals capable of reproduction and should therefore exclude individuals that are environmentally, behaviourally or otherwise reproductively suppressed in the wild.
- In the case of populations with biased adult or breeding sex ratios it is appropriate to use lower estimates for the number of mature individuals which take this into account (e.g. the estimated effective population size).
- Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (e.g. corals).
- In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle, when mature individuals are available for breeding.

4. Generation
Generation may be measured as the average age of parents in the population. This is greater than the age at first breeding, except in taxa where individuals breed only once.

5. Continuing decline
A continuing decline is a recent, current or projected future decline whose causes are not known or not adequately controlled and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing decline, but an observed decline should not be considered to be part of a natural fluctuation unless there is evidence for this.

6. Reduction
A reduction (criterion A) is a decline in the number of mature individuals of at least the amount (%) stated over the time period (years) specified, although the decline need not still be continuing. A reduction should not be interpreted as part of a natural fluctuation unless there is good evidence for this. Downward trends that are part of natural fluctuations will not normally count as a reduction.

7. Extreme fluctuations
Extreme fluctuations occur in a number of taxa where population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e., a tenfold increase or decrease).

8. Severely fragmented
Severely fragmented refers to the situation where increased extinction risks to the taxon result from the fact that most individuals within a taxon are found in small and relatively isolated subpopulations. These small subpopulations may go extinct, with a reduced probability of recolonisation.

9. Extent of occurrence
Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary, which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy. This measure may exclude discontinuities or disjunctions within the overall

distributions of taxa (e.g., large areas of obviously unsuitable habitat) (but see 'area of occupancy'). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

10. Area of occupancy
Area of occupancy is defined as the area within its 'extent of occurrence' (see definition) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may, for example, contain unsuitable habitats. The area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. colonial nesting sites, feeding sites for migratory taxa). The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon. The criteria include values in km2, and thus to avoid errors in classification, the area of occupancy should be measured on grid squares (or equivalents) which are sufficiently small (see Figure 2).

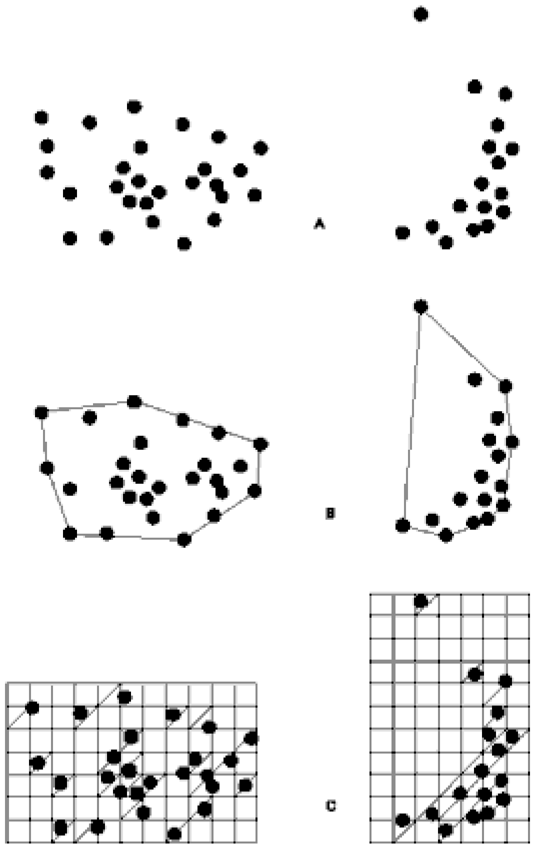


Figure 2. Two examples of the distinction between extent of occurrence and area of occupancy. (a) is the spatial distribution of known, inferred or projected sites of occurrence. (b) shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (c) shows one measure of area of occupancy which can be measured by the sum of the occupied grid squares.

11. Location
Location defines a geographically or ecologically distinct area in which a single event (e.g. pollution) will soon affect all individuals of the taxon present. A location usually, but not always, contains all or part of a subpopulation of the taxon, and is typically a small proportion of the taxons total distribution.

12. Quantitative analysis
A quantitative analysis is defined here as the technique of population viability analysis (PVA), or any other quantitative form of analysis, which estimates the extinction probability of a taxon or population based on the known life history and specified management or non-management options. In presenting the results of quantitative analyses the structural equations and the data should be explicit.

APPENDIX 6 – AMERICAN FISHERIES SOCIETY (AFS) CRITERIA*

*Adapted from Musick (1999) with permission from the author.

Suggested values for productivity index parameters: intrinsic rate of increase r, von Bertalanffy k, fecundity (Fec), age at maturity (T_{mat}), and maximum age (T_{max}). Distinct Population Segments (DPSs) may be classified according to their production as High, Medium, Low, and Very Low. The parameters are suggested only as guidelines and may not be consistent within all DPSs because of the great diversity of life history strategies among fishes.

Productivity

Parameter	High	Medium	Low	Very Low
r (yr^{-1})	>.50	.16-.50	.05-.15	<.05
von Bertalanfy k	>.30	.16-.30	.05-.15	<.05
Fec. (yr^{-1})	$\geq 10^4$	10^2-10^3	10^1 <10^2	<10^1
T_{mat}	≤ 1 yr	2-4 yr	5-10 yr	> 10 yr
T_{max}	1-3 yr	4-10 yr	11-30 yr	> 30 year

Decline thresholds for four categories of DPSs based on population resilience. If a decline reaches a threshold, the DPS would be listed as *Vulnerable* and subjected to close scrutiny for further listing.

Threshold

Productivity	Decline (over the longer of 10 years or 3 generations)
High	.99
Medium	.95
Low	.85
Very Low	.70

APPENDIX 7:

SUMMARY TABLE OF COMMONWEALTH, STATE and TERRITORY LEGISLATION PERTAINING TO AUSTRALIAN FISHES
(After Hutchings and Ponder, 1999; Ponder *et al.*, in prep.).

	COMMON-WEALTH	NSW	VIC	QLD	SA	WA	TAS	NT
Principal Legislation	*Environment Protection and Biodiversity Conservation Act 1999* (replaces the *Endangered Species Protection Act 1992*)	*Fisheries Management Act 1994*; *Fisheries Management Amendment Act 1997*	*Flora and Fauna Guarantee Act 1988*	*Nature Conservation Act 1992* **CHANGES PENDING**	1. *National Parks and Wildlife Act 1972* 2. *Fisheries Act 1982*	*Wildlife Conservation Act 1950* **ACT IN REVIEW** WA Government Gazette 1996 Wildlife Conservation (Specially Protected Fauna) Notice 1996	Threatened Species Protection Act 1995	Territory Parks and Wildlife Conservation Act 1980 + Regulations **CHANGES PENDING**
Agency Responsible	Environment Australia	NSW Fisheries	Department of Natural Resources and Environment	Dept. of Environment	1. Dept. of Environment and Natural Resources 2. Dept. Primary Industry SA Fisheries.	Dept. of Conservation and Land Management	Dept of Environment and Land Management	Parks and Wildlife Commission of NT
Area covered	Terrestrial Aquatic	Aquatic (marine, estuarine or freshwater)	Terrestrial Aquatic	Terrestrial Aquatic	Terrestrial Aquatic	Terrestrial Aquatic	Terrestrial Aquatic	Terrestrial
Groups Covered	All non-human 'biological entities' Native species which are 'nationally threatened'	'Fish' = non-tetrapod aquatic animals at any stage of their life history (whether alive or dead); marine vegetation	Vertebrates, Invertebrates, Vascular and non-vascular plants	Vertebrates, Invertebrates, Vascular, non-vascular Plants, Protista, Procaryotes, Viruses	1. Mammals, birds, reptiles, Plants 2. Fish defined as aquatic organism of any species	All indigenous animals (non human), All flora	Vertebrates, Invertebrates, Vascular and non-vascular Plants, Marine flora and fauna	Vertebrates (not fish and some specified animals) Plants Amendment: future consideration of invertebrates

	COMMON-WEALTH	NSW	VIC	QLD	SA	WA	TAS	NT
Threat Categories	Extinct, Extinct in the wild, Critically endangered, Endangered, Vulnerable, Conservation dependent species (including sub-species or populations); Critically endangered, Endangered, Vulnerable communities; Key Threatening Processes	Endangered species, Endangered populations, Endangered ecological communities, Species presumed extinct, Vulnerable species, Key Threatening Processes	Threatened taxa, Threatened Communities, Potentially Threatening Processes	Presumed Extinct, Endangered, Vulnerable, Rare, Common	1. Endangered, Vulnerable, Rare. 2. *Protected*	All fauna is wholly protected. Threatened (includes IUCN critically endangered, endangered and vulnerable categories). In need of special protection.	Endangered , Vulnerable, Rare, Special Need.	Protected, Specially Protected.
Other Categories				International Wildlife, Prohibited Wildlife, Critical Habitats, Threatening Processes. (Populations being considered)			Threatening Processes, Ecological Communities and Critical habitats not specifically listed, but can be addressed	

APPENDIX 7: (continued)

SUMMARY TABLE OF COMMONWEALTH, STATE and TERRITORY LEGISLATION PERTAINING TO AUSTRALIAN FISHES
(After Hutchings and Ponder, 1999; Ponder *et al*., in prep.).

	COMMON-WEALTH	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Criteria used for status assessment	As defined in the Act, with consideration of specific Taxa Action Plans and Conservation Overviews. IUCN and Milsap criteria for ranking also considered where relevant	As defined within the amendment to *the Act*	As defined in the Act, with more detailed criteria considered ,as published in: Flora and Fauna Guarantee Information Paper No.1	As defined in the Act, with consideration of CITES lists. Changes moving towards IUCN criteria with consideration of modified Milsap ranking for fauna	1. Not strictly defined within Act. Species are listed on basis of advice from biologists within Dept. Environ and Nat. Res., State Herbarium and SA Museum., with consideration of IUCN and CITES criteria. 2. *Evaluated on individual species and case by case basis with Scientific, Industry and Policy input. IUCN , CITES and Federal lists considered*	Defined in Dept. Conservation and Land Management Policy Statement 33 criteria for Threatened Fauna and Specially Protected Fauna. Ranking of Threatened species based on IUCN criteria (CALM Policy Statement 50.)	**CHANGES PENDING** Currently based on IUCN, but criteria are being redeveloped with a view to relevance to invertebrates and marine life. Based on IUCN, also considering criteria being developed by David Keith NSW NPWS	IUCN criteria considered. Commission intends to use “current “ criteria as they develop, ie. IUCN and other state’s criteria	As defined in: “Threatened Species and Communities in the A.C.T Criteria for Assessment 1995”

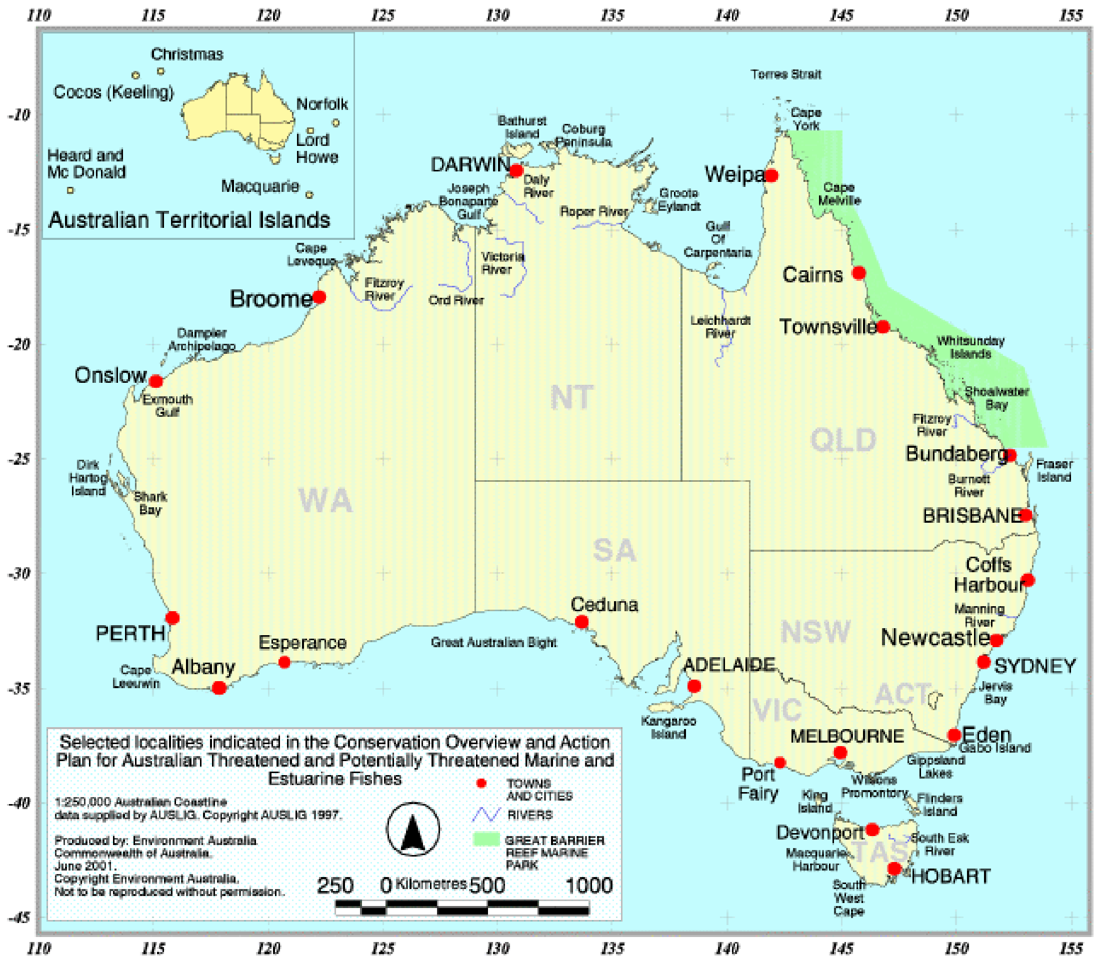
APPENDIX 7: (continued)

SUMMARY TABLE OF COMMONWEALTH, STATE and TERRITORY LEGISLATION PERTAINING TO THE CONSERVATION OF AUSTRALIAN FISHES (After Hutchings and Ponder, 1999; Ponder *et al*., in prep.).

	COMMON-WEALTH	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Nominations	Public	Any person							
Assessment of nominations	Threatened Species Scientific Committee	Fisheries Scientific Committee							
Decision-making	Minister for the Environment and Heritage accepts or rejects nomination. Additions to or deletions from lists published in Gazette.		Scientific Advisory Committee advises Minister on listings and any other flora and fauna conservation matters after assessment of nominations	Scientific Advisory Committee advises Minister on listings after assessment of nominations.	*No formal committees*	Threatened Species Scientific Committee responsible for listing and ranking within IUCN categories. Makes recommendations to the Minister	Scientific Advisory Committee prepares guidelines for application of criteria. Is currently reworking these.	Parks and Wildlife Commission makes recommendations to the Minister after full public process. (Commission must have at least 3 Scientists	ACT Flora and Fauna Committee makes recommendations to the Minister

** For specific exemptions refer to the NSW Fisheries Management Act 1994

APPENDIX 8 – MAP OF SELECTED LOCALITIES



INDEX TO AUSTRALIAN THREATENED MARINE and ESTUARINE FISH TAXA

(Includes both common and scientific names; scientific names are alphabetical by genus then species. Bold font indicates the page on which the species synopsis occurs).