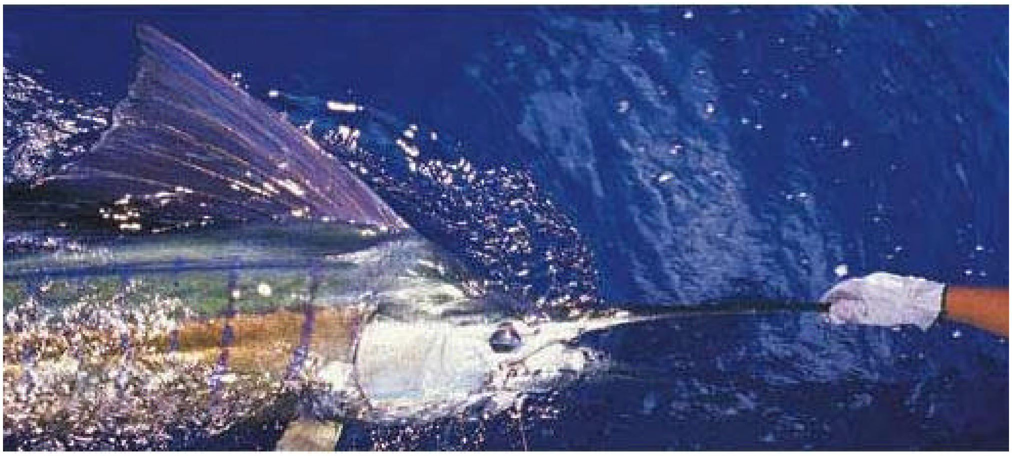
NATIONAL STRATEGY FOR THE SURVIVAL OF RELEASED LINE-CAUGHT FISH: A REVIEW OF RESEARCH AND FISHERY INFORMATION

FRDC Project 2001/101



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November 2002

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NON-TECHNICAL SUMMARY

2001/101. National Strategy for the Survival of Released Line-caught Fish: A Review of Research and Fishery Information.

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This project is part of a national strategy to enhance the survival of released line-caught fish. The objectives of the report are:

1) To collate, synthesise and review the literature and data sources pertaining to post-release survival (PRS) of fish taken in Australian line fisheries.
2) To determine gaps in current information available and prioritise future research options.

To determine how the release of line-caught fish affects a species or population it is necessary to know: why fish are released; the size and distribution of the population; the proportion of a population that is caught and released; spatial and temporal patterns of release; fishing and handling methods; and physical and environmental stresses that affect survival.

Data on the numbers of fish released are available only for the Cwlth pelagic and demersal set-line fisheries, Qld reef-line fishery, charter fisheries in WA, NSW, Qld and NT and parts of the recreational fisheries in each state. Future monitoring systems for all commercial and charter fisheries should collect these data. The National Recreational and Indigenous Fishing Survey (NRIFS) will provide additional information on the total number and spatial and temporal patterns of fish released in Australia's recreational fisheries.

Future research on PRS in Australia's line fisheries should focus on fish and fisheries with high socio-economic importance and high release rates and should aim to assist the establishment of strategies to maximise the rates of PRS. Several species and groups of species were identified as priorities for research in several states. Projects should be coordinated nationally and will benefit from the establishment of a standardised system for classifying stress, condition and injury and the stressors applied during catch-and-release fishing. An advisory group should be established to coordinate technical aspects of the research.

Future studies should involve refined fishery monitoring systems, manipulative experiments using cages, pens and tanks as well as tagging studies. Cages that hold fish may be particularly useful in assessing how barotrauma affects PRS rates in the short term (<3days). Cages, laboratory facilities with tanks or ultrasonic tags may also be appropriate for measuring short term (<3days) PRS of fish in response to the effects of hook damage, handling stress and play length. Experiments that use pens may be better for assessing longer term (>3days) PRS in response to these factors. Tagging programs provide estimates of relative rates of PRS associated with different catch and release procedures. Pop-up satellite archival tags (PSATs) are useful for measuring PRS rates of larger species.

National projects should be ecologically (cf. taxonomically) based. Studies conducted within an ecosystem (*e.g.* temperate reefs) should focus on one or several species (*e.g.* snapper) but could also provide information on co-existing species that are state (cf. national) research priorities.

For temperate reef ecosystems, the priority species is snapper (*Pagrus auratus*), and research should focus on the effects of barotrauma, handling and hook damage. Additional data may be obtained on PRS of blue throat wrasse (*Pseudolabrus* spp.) in Vic, blue groper (*Achoerodus* spp.) and kingfish (*Seriola lalandi*) in SA and teraglin (*Atractoscion aequidens*) in NSW.

The priorities for research in temperate sheltered coastal ecosystems are snapper and flathead (*Platycephalus* spp.) and research should focus on the effects of handling, hook damage and play length. Additional data could be obtained on juvenile mulloway (*Argyrosomus japonicus*) in WA, NSW and SA, juvenile Australian salmon (*Arripis* spp.) in Vic and Tas, bream (*Acanthopagrus* spp.) in Tas, NSW and Vic and King George whiting (*Sillaginodes punctata*) in SA and Vic.

Research is required on many coral reef species and the relative importance of species varies among states. A nationally coordinated project should focus on the effects of barotrauma, handling and hook damage on coral trout (*Plectropomus* spp.) and red-throat emperor (*Lethrinus miniatus*) in Qld; golden snapper (*Lutjanus johnii*) and red emperor (*Lutjanus sebae*) in the NT; spangled emperor (*Lethrinus nebulosus*), red-throat emperor (*Lethrinus miniatus*), red emperor (*Lutjanus sebae*), red snapper (*Lutjanus erythropterus*) and saddle-tail snapper (*Lutjanus malabaricus*) in WA.

Barramundi (*Lates calcarifer*) is the priority for research in tropical sheltered coastal ecosystems. Research on the effects of handling, play length and hook damage on PRS is underway in the NT and will benefit researchers and managers in Qld and WA.

Marlins (*Makaira indica*, *M. mazara*), sailfish (*Istiophorus* spp.), tunas (*Thunnus* spp.) and mackerels (*Scomberomorus* spp.) are the priorities for research in oceanic pelagic ecosystems. Play length, hook and handling damage are the main factors influencing PRS of these large pelagic fishes.

Assessments of relative and total PRS using different gear types could be incorporated into manipulative experiments of key recreational species and/or examined in mark-recapture programs in most ecosystems.

A communication and extension program (FRDC grant 2002/099) has just commenced and will assess current practices and attitudes towards catch and release fishing and promote the use of better practices. This program will be closely linked to future research on PRS in Australia's line fisheries.

OUTCOMES ACHIEVED

This project has collated, synthesised and reviewed current and past literature and data sources relating to PRS in International and Australian line fisheries. It has identified sources of information for release rates in commercial and recreational line fisheries. It has also highlighted the species requiring future research in Australia, the types of information required in future monitoring systems that measure PRS and the strategies best applied to researching PRS of line-caught fish.

Keywords: Review, Australian line fisheries, post-release survival (PRS), catch and release, angling mortality, hooking mortality, hook.

GLOSSARY

AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
ANSA	Australian National Sportfishing Association
ANZECC	Australian and New Zealand Environment and Conservation Council
AUSTAG	Australian tagging program managed by ANSA
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cwlth	Commonwealth
DPIWE	Department of Primary Industries, Water and Environment
FRDC	Fisheries Research and Development Corporation
GFAA	Gamefishing Association of Australia
GTP	Gamefishing Tagging Program
IMCRA	Interim Marine and Coastal Regionalisation for Australia
MAFRI	Marine and Freshwater Resources Institute (Victoria)
NHT	National Heritage Trust
NRIFS	National Recreational and Indigenous Fishing Survey
NSW	New South Wales
NT	Northern Territory
NTDPIF	Northern Territory Department of Primary Industries and Fisheries
PRS	Post-release survival
PSATs	Pop off satellite archival tags
Qld	Queensland
QDPI	Queensland Department of Primary Industries
RFISH	Recreational Fishing Information System (Queensland)
SARDI	South Australian Research and Development Institute
SUNTAG	Queensland component of AUSTAG tagging program managed by ANSA
SA	South Australia
SCFA	Standing Committee on Fisheries and Aquaculture
Tas	Tasmania
Vic	Victoria
WA	Western Australia

BACKGROUND

The commercial and recreational multi-species line fisheries throughout Australia are the most highly participatory of all our fisheries. Many species in these fisheries are regarded as fully exploited or, in some cases, over-exploited. Management arrangements involve a complexity of regulations, including minimum size limits, maximum size limits and quota limitations, that result in a number of fish being released. For these restrictions to be effective, released fish must have a high survival rate. Total mortality estimates of harvested and non-harvested components of the fishery are required to improve stock assessment.

Anecdotal information from national and international media agencies and tourist guides suggest an increased interest by recreational anglers toward catch and release fishing (ANSA, 2001; SA Recreational Fishing Industry Committee Report, 2001; Lucy, 2001; Pope, 2001). In the past, the effectiveness of compulsory regulations and voluntary codes of practice in enhancing the survival of released fish has rarely been addressed within Australia (Kumar *et al.*, 1995). Recently however, a number of state institutes flagged a need for catch and release research on some economically important species in key line fisheries. Some of these were FRDC grant 2000/194: snapper (*Pagrus auratus*) and dhufish (*Glaucosoma hebracium*) in WA; FRDC 2001 grant applications for research on barramundi (*Lates calcarifer*) in the NT, snapper (*Pagrus auratus*), King George whiting (*Sillaginodes punctata*) and black bream (*Acanthopagrus butcheri*) in Vic, mulloway (*Argyosomus japonicus*) and snapper (*P. auratus*) in NSW, and coral and rocky reef fish species, coral trout, (*Plectropomus* spp.), emperor (Family Lethrinidae), pearl perch (*Glaucosoma magnificum*), snappers (Family Lutjanidae) and teraglin (*Atractoscion aequidens*) in Qld.

During May 2001, an FRDC sponsored workshop was held in New South Wales at the Cronulla Fisheries Centre to develop a national approach to research and development on post-release survival of line-caught fish "that would ensure the results of research in any one jurisdiction are as relevant as possible to fisheries managed by others". The workshop comprised local and international fisheries researchers experienced in this field and representatives from the commercial and recreational fishing sectors. A primary recommendation of the workshop was that an initial national review be undertaken to assess:

a) the current published and "grey" scientific literature and data sources on post-release survival (PRS) of line-caught fish; and
b) the perceived priorities relating to PRS issues for government fisheries managers, participants of fisheries and Management Advisory Committees

NEED

Information on catch and release survival has been identified as one of the necessary performance indicators for reporting on the ecological sustainable development of fisheries (see multiple species indicators in SCFA-FRDC Project Report, May 2001). Accurate knowledge of catch, release and survival for key species caught in Australian line fisheries is essential for stock assessments and will aid the development of management strategies in the future.

RATIONALE AND APPROACH

This study was designed to bring together sources of information on survival of released line-caught fish in Australia. Information included published and unpublished reports as well as direct observations from both the commercial and recreational fishing sectors. The study adopted a collaborative approach through contacts within the Steering Committee of the National Strategy for the Survival of Released Line-caught Fish. Using this forum, comprehensive questionnaire forms were designed for each state and territory, which aimed to identify the species potentially susceptible to high levels of catch and release mortality. Meetings were then held with fisheries scientists and managers in each state to confirm research priorities and to identify the best methodologies used in carrying out the research.

OBJECTIVES

1. To collate, synthesise and review the existing published and grey literature and data sources pertaining to survival of fish caught and released in Australian line fisheries.

2. To determine gaps in the current information and prioritise future research options

CHAPTER 1. REVIEW OF INFORMATION RELATING TO POST–RELEASE SURVIVAL OF LINE-CAUGHT FISH IN AUSTRALIAN FISHERIES.

Objective: To collate, synthesise and review the existing published and grey literature and data sources pertaining to survival of fish caught and released in Australian line fisheries.

To achieve this objective we reviewed the information required to determine how variable post-release survival (PRS) may impact on line-fished populations of fish. We considered i) why fish are released, ii) sources of data for catch and release in Australian line fisheries, iii) the physical and physiological effects of catch and release on fish, iv) factors that contribute to injury or death of released fish, v) techniques used to measure the level of injury and percentage survival of fishes caught and released, and vi) harm minimisation procedures that may enhance PRS.

Data on the numbers of fish caught and released are crucial to understanding how changes in post-release survivorship may affect line-fished populations. Data for numbers of fish released in commercial line fisheries are generally poor. Data for numbers of fish released in recreational fisheries are limited to Australian National Sportfishing Association tagging programs and a few area-specific creel surveys in most states and the NT. Not all results from the recent National Recreational and Indigenous Fishing Survey had been released in time for this report.

PRS varies among and within fished populations and in response to the range of stressors applied by different fishing operations. Data from captive experiments, tagging programs, monitoring programs and population models are needed to provide a better understanding of PRS and facilitate the development of management strategies to maximise PRS.

1.1 Introduction

Steady increases over recent years in the numbers of recreational line-fishers, combined with a shift by commercial fishers from netting to line-fishing operations and the rapid expansions in the charter fishing industries, have increased the pressure on Australia's line-fishing resources. As the number of fish taken by line has increased, so has the number of fish released due to (i) increasingly stringent fisheries regulations, such as quota controls, and minimum and maximum size limits and (ii) an increase in the popularity of catch and release fishing in the recreational sector (*e.g*. Grabowski, 2001).

Increasingly stringent fisheries regulations and the trend towards voluntary catch and release fishing by recreational anglers acknowledge the increasing pressure on line fishing resources but rely on the unproven assumption that survival rates of released fish are high. In fact, population models of Australian line-caught fish generally assume 100% survival of released fish and consequently almost certainly underestimate mortality of non-harvested fish. The pressing need to estimate PRS of line-caught fish is indicated by the large number of research proposals on this topic submitted to FRDC over the last few years. An FRDC-sponsored workshop at Cronulla in May 2001 resulted in SARDI Aquatic Sciences being commissioned to produce this report.

Several types of information are required to determine how catch and release practices affect line-caught fish and evaluate the implications for fisheries management. Firstly, useful insights can be obtained by understanding why fish are released. Secondly, it is essential to estimate the number of fish caught within a line fishery and the proportion of these that are released. Thirdly it is necessary to understand the specific stresses applied by different fishing operations. Fourthly, it is essential to consider the species-specific physiological and behavioural responses of released fish to various practices, including sublethal effects such as reduced fitness or reproductive capacity. Fifthly, it is necessary to understand the methods used to measure the effects of catch and release on survival. Finally, it is important to assess the information required to develop and refine protocols for improving PRS.

In this chapter we consider the factors causing fish to be released, and assess information on numbers and PRS of fish caught and released in Australia's commercial and recreational line fisheries. We review the factors contributing to injury and mortality of fish and consider previous, current and proposed Australian and international research approaches to assessing factors that affect post-release fitness and survival. Harm minimisation procedures that could potentially enhance the PRS of line-caught fishes are also reviewed.

1.2. Why fish are released: Factors affecting release patterns and total numbers released.

A diverse array of factors affects the numbers of fish released within a line fishery. The number of fish released reflects not only the number of participants in the fishery but also:

i) the regulations that are in place for that fishery/species,

ii) the social and cultural characteristics of participants and their attitude towards catch and release,

iii) the extent to which a fish's life-history phase or behaviour affects the likelihood of it being caught and/or released, and

iv) the likelihood of the species being taken as bycatch in a line fishery.

1.2.1 Regulations

Management strategies that limit the amount of fish retained by commercial and recreational line fishers have been established for many species in all Australian states and territories. Strategies such as minimum and maximum size limits, seasonal closures for particular species, bag limits, trip limits, total allowable catches and individual transferable quotas assume high rates of PRS.

Regulations for the recreational fishing sector are available through state fisheries magazines and brochures and are provided on state fisheries websites (Table 1.1). Details for commercial fishing operations are available within the Fisheries Management Acts for each state and are listed on the Australasian Legal Institute website: www.austlii.edu.au.

Table 1.1. Sources of recreational fishing regulations for each state of Australia.

STATE	WEBSITE
Queensland	http://www.dpi.qld.gov.au/fishweb/,
Western Australia	http://www.wa.gov.au,
South Australia	http://www.pir.sa.gov.au,
New South Wales	http://www.fisheries.nsw.gov.au/,
Tasmania	http://www.dpiwe.tas.gov.au,
Northern Territory	http://www.nt.gov.au/dpif/fisheries/index.shtml,
Victoria	http://www.nre.vic.gov.au/web/root/domino/cm
Australian Capital Territory	http://www.urbanservices.act.gov.au

Minimum size regulations are a fundamental management strategy for most line-caught species throughout Australia. Nearly all key reef, pelagic, estuarine and inshore species have minimum size limits. Minimum size limits are usually set at the same size for both commercial and recreational line fisheries within each state and aim to allow individuals to reach reproductive maturity before being caught and to prevent growth overfishing. For example, in SA the minimum size limit for King George whiting (Family Sillaginidae; *Sillaginodes punctata*) was increased from 28cm to 30cm (total length) in 1995 to improve the weight and value of harvested fish and to potentially increase the numbers of reproductively mature fish in the population (Jones, 1995).

Maximum size limits protect larger fish with significantly greater fecundity and which contribute proportionally more to total egg production than small fish. Maximum size limits are more often imposed on territorial reef fish that are slow-growing, late-maturing and long-lived and aim to ensure the presence of a significant proportion of reproductively mature fish in the population, For example, maximum size limits have been imposed on blue groper (Family Labridae; *Achoerodus gouldii*) and Murray Cod (Family Percichthyidae; *Macullochella peelii peelii*) in SA, and Queensland groper (Family Serranidae; *Epinephelus lanceolatus)* and estuary cod (Family Serranidae; *E. coioides*) in WA, NT and Qld. Maximum size limits are also set for large serranids because of their high tourist value with the diving and glass bottom boat industries. The maximum size limit for barramundi (Family Centropomidae; *Lates calcarifer*), that undergoes a size-dependent sex change from male to female, is set at 80 cm in WA and 120 cm in Qld.

Bag limits, trip limits, total allowable catches (TAC's) and individual transferable quotas (ITQ's) aim to limit the amount of fish retained by recreational and commercial fishers. Levels of release may be low when fishers cease fishing after obtaining their catch limit. However, in some cases fishers may keep fishing after reaching their limit and 'high grade' their catch, retaining high value items in exchange for lower value items that are discarded. In the worst case scenario dead fish of perceived lower quality (*e.g.* smaller size) may be exchanged for newly caught fish of higher quality (*e.g.* larger size). High grading is driven by fishers' subjective assessment of fish quality or (for commercial fishers) by price differentials associated with fish size or type. For example, morphometric differences in pink snapper (Family Sparidae; *Pagrus auratus*) from the Shark Bay region of WA may result in high grading, as large male snapper with lumps on their head command lower prices in export markets (Moran *et al.*, 1999) compared to smaller fish without lumps.

Seasonal restrictions on the taking of individual species protect fishes with predictable migration and spawning patterns. For example, the seasonal closure on the taking of barramundi (*Lates calcarifer*) in the Mary and Daly rivers of the NT between October and January coincides with the spawning season. Similarly, the seasonal closures in NSW, Tas and WA for brown (Family Salmonidae; *Salmo trutta*) and rainbow trout (Family Salmonidae; *Oncorhynchus mykiss*) occur during the spawning period.

Some marine and freshwater species cannot be taken by line (or other methods) in some or all parts of their geographical range. Reasons for full protection include apparent rarity, high vulnerability to fishing, significant conservation status and/or high value for the recreational (tourist) diving industry (Table 1.2).

Table 1.2. List of fully protected species encountered in line fishing operations.

Ecological Region	**Species (Common name)**	**Species name**	**State where protection exists**
Tropical	Potato Cod	*Epinephelus tukula*	WA
	Hump-head maori-wrasse	*Cheilinus undulatus*	WA, QLD (pending)
	Barramundi cod	*Cromileptes altivelis*	QLD (pending)
Sub-tropical	Queensland Groper	*Epinephelus lanceolatus*	NSW
	Estuary Cod	*Epinephelus coioides*	NSW
	Eastern blue devil	*Paraplesiops bleekeri*	NSW
	Grey nurse shark	*Carcharius taurus*	NSW, WA, QLD
Warm Temperate	Great white shark	*Carcharodon carcharius*	All states
	Herbst's nurse shark	*Odontaspis ferox*	NSW
	Black cod	*Epinephelus daemelii*	NSW
	Western blue groper	*Achoerodus gouldii*	SA (Gulfs and Investigator Strait)
	Elegant wrasse	*Ananpses elegans*	NSW
Freshwater (Murray Darling Basin)	Trout cod	*Macculochella macquariensis*	NSW, Vic, SA
	Freshwater catfish	*Tandanus tandanus*	SA, Vic (except Wimmera waters)
	Silver Perch	*Bidyanus bidyanus*	SA
	Macquarie Perch	*Macquaria australasica*	NSW, parts of Vic
	River Blackfish	*Gadopsis marmoratus*	SA
Freshwater (Eastern slopes)	Mary river cod	*Maccullochella peelii meriensis*	QLD
	Eastern freshwater cod	*Maccullochella ikei*	NSW
	Australian grayling	*Prototroctes maraena*	NSW, Vic, Tas
	Queensland lungfish	*Neoceratodus forsteri*	QLD

1.2.2 Social (Voluntary release - fishers attitudes)

Recreational line fisheries operate for different reasons, including sport, food acquisition and relaxation. An increase in voluntary release practices over recent years has stemmed from the realisation by recreational fishers of the need to conserve limited resources. Recreational fishers, who by definition fish for pleasure, often release many fish so that they can continue fishing for extended periods. Further increases in the participation rates in recreational fishing activities may potentially result in increased levels of catch and release mortality.

Guidelines and codes of practice that promote fish release and better release practices are increasingly publicised by fisheries agencies, outdoor media, fishing clubs and conservation organisations. This has lead to a shift in the attitudes of many fishers. Surveys conducted in the USA over a ten-year period (1985-1995) showed increases of 16 to 95% in the numbers of fish released (Quinn 1996). The recent increase in the number of "non-kill" fishing competitions in the US has also resulted in greater numbers of fish being released and reflects an attitudinal shift from "kill and fillet" to "catch and release". A similar shift has occurred in Australia (Prokop, 2002). An example is the annual 'Rocky Barra Bounty' tag and release fishing event in Rockhampton, Qld. Other sport-fishing events such as the 'Boyne Tannum Hookup' in Gladstone, Qld and the 'Noosa Family Fishing Competition' in Southern Qld have also introduced tag and release sections to their competitions.

In a survey of saltwater competition anglers in the USA, several factors were identified as affecting angler attitudes towards the release of fish caught, including age, culture, region, income, fishing experience and association with fishing clubs (Mills, 2000). Such factors relate to how much anglers are exposed to education programs promoting catch and release and the resulting quantity and condition of fish released. Monitoring the social issues behind catch and release enables better understanding of catch and release patterns and allows prediction of catch and release behaviour (Sutton, 2001).

The trend towards catch and release fishing in Australia is highlighted by the formation of the national tagging program 'AUSTAG', initially developed by Queensland Department of Primary Industries but taken over in 1986 by the Australian National Sportfishing Association (ANSA, 2001). Since 1985/86 there have been over 307 000 fish tagged and released with almost 24 000 recoveries. ANSA records indicate over 90% of fish caught over the past decade have been released (ANSA 2001). The percentage of recaptured tagged fish retained by recreational anglers also fell from 100% in 1985/86 to 62.6% in 1998/99. The implementation of tagging programs can increase the numbers of fish released by involving people who otherwise retain most fish. Over the last two years, ANSA has established a code of practice for capturing, handling and releasing fish.

1.2.3 Life-history phases and fish behaviour

The migratory and behavioural patterns of fish can determine the times and places that they are vulnerable to capture in a line fishery. Nursery areas may harbour large numbers of undersize fish and smaller numbers of large fish. Fishers may target nursery areas where catch rates are high due to the presence of large numbers of sub-adult fish. All state capitals are situated adjacent to estuaries and embayments that include fish nursery areas. High catch rates of fish below the minimum legal size in nursery areas result in high release rates and potentially high levels of catch and release mortality. Similarly, strong year classes can initially appear in a fishery as abundant undersize captures and result in high rates of release. Such a situation is common for black bream (Family Sparidae; *Acanthopagrus* spp.) and snapper (Family Sparidae; *Pagrus auratus*) in line fisheries of Vic and SA. (S. Morison, MAFRI, pers. comm.; L. McLeay; SARDI, pers. obs.)

Large fish or fish of a particular sex can be particularly susceptible to high levels of release. For example, the game-fishing and sport-fishing sector specifically target 'records' in areas where larger fish occur. Black marlin (Family Istiophoridae; *Makaira indica*) are specifically targeted by Qld sport fisheries during predictable and seasonal aggregations along the Great Barrier Reef (Pepperell and Davis, 1999). Larger gravid females that are sometimes kept for "weigh-in" are prized, but the fishery is essentially based on pre-spawning fish, >90% of which are released (www.aims.gov.au/pages/research/marlin/black). Fishing tour operators in the NT were recorded as releasing up to 64% of all spanish mackerel (Family Scombridae; *Scomberomorus commerson*) (Buckworth and Bryce, 2000/2001).

Fish are often susceptible to capture due to their reproductive behaviour. Spawning aggregations are prime targets for fishers and, depending on fisher motives and existing regulations, many of the fish taken can be released. The aggregation sites of many reef fish are predictable and subject to high levels of fishing pressure. Some serranids, scombrids and lutjanids form transient spawning aggregations. For example, coral trout (Family Serranidae; *Plectropomus* spp.) form spawning aggregations at the same sites on the Great Barrier Reef each year (Samoilys, 1997) and mulloway (Family Sciaenidae; *Argyrosomus japonicus*) aggregate annually at the mouth of the Murray River. Low bag limits for these species ensure that recreational anglers often release large numbers of fish (McLeay, SARDI, pers. obs.).

1.2.4 Incidental capture

The rates of incidental capture (as non-target species) can also affect the total number of a species that are released, as fishers will often discard non-preferred species. Numbers of released fish can be high in regions where many different species and several size classes co-occur. Operations targeting smaller fish using smaller hook types cause high mortality of larger non-target species through an increased incidence of gut hooking. This is an issue in the King George whiting (Family Sillaginidae; *Sillaginodes punctata*) fisheries in Vic and SA where significant numbers of undersize snapper (Family Sparidae; *Pagrus auratus*) are incidentally caught on small hooks (S. Morison, MAFRI, pers comm.). Similar problems occur on coral reefs where large numbers of species coexist, and where many non-targeted fish are discarded because they are not preferred as table fish or are poisonous. Examples include sharks and rays (Class Chondrichthyes), poisonous toadfish/blowfish (Family Tetraodontidae; *Lagocephalus* spp.) and chinaman fish (*Symphorus nematophorus*) that contain ciguatera toxin.

1.3 Sources of data for catch and release in Australian line fisheries

Historically, few data have been collected on the numbers of fish released in Australia's commercial and recreational line fisheries. More recently data have been collected for recreational fisheries through creel surveys implemented by state and federal agencies. However, most commercial line fisheries are still not required to record information on the number of fish discarded.

1.3.1 Recreational surveys

The results of some of the previous recreational surveys are listed below.

a) ***Queensland.*** Data collected by the Queensland Fisheries Service in 1997 and 1999 as part of the Queensland RFISH program showed percentages of finfish released by resident recreational fishers were 53% and 48% respectively (Higgs, 1999; 2001). Ferrell and Sumpton (1998) surveyed recreational snapper fishers in southern Queensland in 1994-95, and reported higher percentages of released undersize fish caught in inshore waters compared to those in in deeper offshore waters.

b) ***South Australia***. During 1994-96, a "bus route" creel survey was undertaken to estimate the annual harvest and number of fish released by recreational boat fishers in the Gulf of St Vincent, Spencer Gulf and along the west coast (McGlennon & Kinloch, 1997). Percentages of finfish species released for the three areas were estimated at 31.5, 42.5 and 44.6 % respectively. Pillar (1979) opportunistically surveyed recreational anglers along the mid and upper reaches of the South Australian section of the River Murray between 1973 and 1978, and estimated release of native freshwater species at 29.8%.

c) ***New South Wales***. West and Gordon (1994) reported on release rates of recreational line-caught fish during daylight hours in the Richmond and Clarence coastal rivers (37 and 40 % respectively).

d) ***Western Australia***. Three major regional "bus route" creel surveys have been undertaken in WA coastal waters over the past 5 years (Sumner and Williamson, 1999; Sumner *et al.*, 2002). The regions included: Augusta to Kalbarri, Pilbara and the Gascoyne bioregions. The overall proportion of released finfish varied significantly between regions.

e) ***Northern Territory.*** A multi-faceted recreational survey (FISHCOUNT) was conducted among visitors and residents from late 1994 to early 1996 (Coleman, 1998). Data on the catch, species composition and numbers released may be useful for defining the species potentially affected by catch and release mortality. Percentages of reef fish and barramundi released were 40 and 59 % respectively.

f) ***Victoria.*** Since 1990, information on percentages of released fish has been collected during surveys of marine and freshwater recreational fisheries. A diverse range of survey methods was used to collect the data. Information on surveys is available from MAFRI (S. Morison, MAFRI, pers. comm.).

g) ***Tasmania.*** An assessment of the licensed recreational fishery was undertaken for the period spanning December 1996 to April 1998. Data on the harvest taken by line fishing methods was collected through phone interviews and voluntary diary schemes however information on release was not collected (Lyle, 2000).

The largest source of information on the fish released in recreational line fisheries will be the 2000/01 National Recreational and Indigenous Fishing Survey (NRIFS) funded by the NHT and the FRDC (Project 98/169). Data from the NRIFS are used to identify the species most affected by low PRS in Chapter 2 of this report.

The NRIFS also obtained data on the reasons why people go fishing. This information may be useful for determining why fish are released and for identifying opportunities to alter patterns of catch and release in the future.

Most previous creel surveys have focussed on particular geographic regions or sections of the fishing community (boat, land, etc). By combining these surveys with information from the NRIFS, important spatial and temporal trends in patterns of release may be identified.

1.3.2 Charter-boat/Land based tour data sources.

Amounts and types of data available vary among states. Charter-boat and tour operators in Qld, NSW, NT and WA are required to provide trip return information to fisheries agencies as part of their licence agreement. Information includes numbers and types of fish released. Currently, charter-boat operators in SA, Vic and Tas are not required to log any catch information although Victorian charter operators have kept voluntary logbooks since 1997. Since 1997 over 42 000 fish have been captured with approximately 24 000 released (57%). Over 37 % of fish released in this time have been snapper (Family Sparidae; *Pagrus auratus*) (S. Conron; MAFRI, pers. comm.). Some data on catch composition and percentage of undersize fish released are available from observer programs on Qld's reef charter fisheries (B. Mapstone, JCU, pers. comm.). These data have been used to help identify species that require research in chapter 2 of this report. Fishing tour operators in the NT are required to keep daily logbook data on numbers and types of fish caught and released. Over 133 000 fish were caught during 2000, with over 74% of fish being released. Over 30% of fish caught were barramundi (Family Centropomidae; *Lates calcarifer*) (R. Griffin, NTDPIF, pers. comm.).

1.3.3 Commercial line catch information

Little data exist on release rates in commercial line fisheries. Some data on the numbers of fish released are available for the Cwlth managed pelagic and demersal long-line and dropline operations of the South East Non-trawl fishery and from observer programs on the Great Barrier Reef (Knuckey et al, 2000, 2001; B. Mapstone, JCU, pers. comm.). SEANET has recently begun a project investigating bycatch and release mortality in the commercial long-line fishery for snapper (Family Sparidae; *Pagrus auratus*) in SA (C. Heyes, SEANET, pers. comm.).

Commercial catch reporting requirements vary significantly between fisheries. Species from coral reef systems are often misreported or broadly classified as "mixed reef A" or "mixed reef B" as is the case in Qld. Discard patterns of species reported in this way cannot be assessed and this system hinders analysis and interpretation of species-specific fishery characteristics. Data on weight of line-caught species in State and Cwlth waters are presented in section 2.3.1. The total catches can be broken down according to the fishing method (drop-line, set-line, long-line, handline etc) but for confidentiality reasons these data cannot be published unless 5 or more fishers in each state use a particular method.

1.3.4 Indigenous sector

Historically, few data have been collected on catch and release patterns in indigenous line fisheries, however, the recent NRIFS collected information from 46 indigenous fishing communities in the NT, Qld and WA. These data were not made available for this review.

1.4 Effects of catch and release on fish

The effects of catch and release on line-caught fish range from immediate (generally measured up to three days) and delayed (greater than 3 days) mortality to small sublethal physiological and behavioural changes. Responses to catch and release vary between species and according to life-history stage and show marked variation in response to the physical stressors associated with various fishing methods.

1.4.1 Stress

Stress has been defined as the effect of any environmental alteration or force that extends homeostatic or stabilising processes beyond their normal limits (Chopin *et al.,* 1996). There is a considerable literature on the effects of stress on fish. Stress effects vary not only according to the type of disturbance but also among species and individuals, and in response to reproductive condition. Stress from fishing practices can be exhibited in short term changes in physiological processes, manifested in changes of reproductive development, growth rate, behaviour, or immune response or result directly in death. Physiological responses to stressors include changes in levels of blood plasma cortisol, blood glucose, haemoglobin, chloride, lactic acid, osmolality and heart rate. Intracellular acidosis also occurs. The interval of stress response is related to the length and severity of stress applied (Pickering *et al.,* 1982). Davis *et al.* (2001) suggest a possible maximum of physiological stress response in sablefish (Family Anoplopomatidae; *Anoplopoma fimbria*).

1.4.2 Changes in reproductive potential

Species targeted during spawning can undergo significant decreases in reproductive success due to changes in reproductive development or reproductive behaviour resulting from stress. Effects may be manifested in reduced recruitment where spawning fish are targeted heavily by fishers. The level of impact of such processes on populations is difficult to determine and there are few such data for Australian species.

The effect of physiological stress on reproductive development is documented for snapper (Family Sparidae; *Pagrus auratus*). Plasma cortisol rapidly depresses concentrations of gonadal steroids causing cessation of reproductive development (Carragher and Pankhurst, 1991). Similarly, rainbow trout (Family Salmonidae; *Salmo gairdneri)* exhibit significant depression of gonadal steroids when stressed (Pankhurst and Dedual 1994).

Displacement of released fish from schools or territories may result in alterations in reproductive behaviour. For example, male largemouth bass (Family Centrarchidae; *Micropterus salmoides*) are particularly vulnerable to capture during nesting periods (Philipp *et al.*, 1997; Cooke *et al.*, 2000). Fish abandon nests after release, thereby potentially reducing their reproductive success.

1.4.3 Changes in immune response

While stress responses may not prove immediately fatal they can compromise resistance to infectious diseases and thereby reduce fitness or cause death. Brown trout (Family Salmonidae; *Salmo trutta*) are more susceptible to disease when cortisol levels are high (Pickering & Pottinger, 1985). Similarly, the introduction of exogenous cortisol in Coho salmon (Family Salmonidae; *Oncorhynchus kisutch*) reduces resistance to diseases (Maule & Schreck, 1987). Handling may also reduce a fish's susceptibility to disease or parasites through removal of scales and protective mucous (Broadhurst *et al.*, 1999; Nowak, 1999).

1.4.4 Changes in behaviour

Stress after release from line fishing can be manifested in behavioural changes. Male largemouth bass (Family Centrarchidae; *Micropterus salmoides*) exhibit locomotory impairment after exhaustive angling and this is significantly greater in nesting fish (Cooke *et al.*, 2000). Feeding rates can also decrease in response to handling stress. Brown trout (Family Salmonidae; *Salmo trutta)* have been observed not to feed for three days after handling (Pickering *et al.*, 1982). Similarly, Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*) ceased feeding for up to 60 days after capture by long-line (Davis & Olla, 2001).

In contrast, Atlantic salmon (Family Salmonidae; *Salmo salar*) show no change in locomotor behaviour after multiple captures (Whoriskey *et al.*, 2000). There is also considerable anecdotal information from tagging programs in Australia of tagged fish being recaptured on the same day, or within a week of release (*e.g.* barramundi, estuary cod, and King George whiting). This contrast highlights the variability among species in the effects of stress on behaviour. The fact that Atlantic salmon and other species do not appear to alter swimming and/or feeding behaviour suggests that they may be relatively tolerant to catch and release angling.

1.4.5 Growth

A decrease or cessation of growth may result from decreases in feeding rates associated with physiological stress responses or physical damage to mouthparts. Additionally, fish may disgorge food in response to pressure on the foregut during ascent thereby adding to overall energy loss. More than 90% of venus tuskfish (Family Labridae; *Choerodon venustus*) disgorge food during capture from depth (J. Platten, University of Qld, pers.comm.).

Effects of catch and release on growth rates are difficult to determine for some species. Cessation of feeding due to stress did not significantly effect growth rates of brown trout (Family Salmonidae; *Salmo trutta)* in laboratory conditions, however decreased growth rates were thought likely in wild situations particularly where fish are susceptible to multiple capture and release events (Pickering *et al.*, 1982). Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*) with severe hook injuries to cheek and jaw showed reductions in annual growth of up to 40% (Kaimmer & Trumble, 1996).

1.4.6 Barotrauma effects

The physiological effects of barotrauma on fish removed from deep water are well documented as decreasing PRS. Rupture or over-inflation of the swim-bladder disables fish brought to the surface and may cause haemorrhaging of organs. Gas expansion may also be aggravated by increases in temperature associated with depth change.

Physostomous fish (*i.e.* those with a pneumatic duct connecting the swim bladder to the digestive tract) are believed to have better PRS than fish without this duct (physoclistous) (Hogan, 1940). Similarly barotrauma effects are likely to be less severe for fish without swimbladders (sharks and rays). While the effects of barotrauma are determined mainly by species-specific differences in morphology, ascent speed is also likely to influence how well fish are able to adapt to depth changes (Rogers *et al.*, 1986). Fish severely affected by barotrauma are vulnerable to changes in environmental conditions and predation both during capture and after release.

In WA a study on line-caught pink snapper (Family Sparidae; *Pagrus auratus*) in Shark Bay, showed depth of capture to affect PRS more than hook type, hooking location, ascent time or handling time (St John and Moran, 2001). Survival varied from 93-96% at shallow sites (15-30 metres) and from 16-29% at deep sites (45-65 metres). In a current study of post-release survivorship of Western Australian dhufish (Family Glaucosomatidae; *Glaucosoma hebracium)* researchers recorded 10% survival in fish from depths of 40-57 m and 60%

survival in fish from 6-17 m. A study conducted in the NT used video techniques to assess barotrauma in deepwater snappers caught at depths of 80-90m (Lloyd, 2000). Inter-specific differences in PRS were observed among red emperor (Family Lutjanidae; *Lutjanus sebae*), saddletail snapper (Family Lutjanidae; *Lutjanus malabaricus*), goldband snapper (Family Lutjanidae; *Pristipomoides multidens*) and red snapper (Family Lutjanidae; *Lutjanus erythropterus*). Tuskfish (Family Labridae; *Choerodon venustus*) are also reported as being particularly susceptible to barotrauma. Of 70 tuskfish caught and released on the Great Barrier Reef, only 22 % were observed to swim away strongly. Most of the fish suffering observable barotrauma effects were eaten by sharks (J. Platten, unpublished data).

Research on groupers (Family Serranidae; *Epinephelus morio*) combined tagging with *in situ* observations to show PRS of 84-91% for fish caught in depths less than 44 metres. Survival was around 25% for fish caught from greater depths (Wilson and Burns, 1996). Field experiments on PRS of red snapper (Family Lutjanidae; *Lutjanus campechanus*) used cages to demonstrate decreased PRS in response to increased depth of capture (99% at 21-24m vs. 56% at 37-40m) (Gritschlag and Renaud, 1994). Feathers and Knable (1983) simulated depressurisation changes in a hyperbaric chamber to show 60% survival of largemouth bass (Family Centrarchidae; *Micropterus salmoides*) taken from depths greater than 18m.

1.4.7 Effects of deflation

Deflation of the swimbladder or “venting” has been recommended in recent education campaigns to enhance survival of fish caught at depth. This involves puncturing the distended swimbladder with a sharp object and has been shown to significantly enhance survival in largemouth bass (Family Centrarchidae; *Micropterus salmoides*), black sea bass (Family Serranidae; *Centropristis striata*) and vermillion snapper (Family Lutjanidae; *Rhomboplites aurorubens)* (Collins *et al.*, 1999; Shasteen and Sheehan, 1997). Benefits of deflation were shown to increase with capture depth, however survival varied between species and was influenced by ascent speed. Similarly survival in response to the effects of barotrauma increased from 80% (unvented) to 98% (vented) for yellow perch (Family Percidae; *Perca flavescens*). Additionally, fish not deflated were found to float for up to 72 hours before regaining neutral buoyancy making them extremely susceptible to predation in a ‘real’ fishery situation. Only 2% of deflated fish remained on the surface after 24 hours (Keniry *et al.*, 1996).

The effectiveness of venting varies between species. Deflating the swimbladder of burbot (Family Lotidae; *Lota lota*) had no effect on PRS (Bruesewitz *et al.*, 1993). Fish recaptures indicated that swim bladder healing began within the first week of release and was complete in 8 weeks. Punctured swimbladders of largemouth bass (Family Centrarchidae; *Micropterus salmoides*) were shown to function immediately (Shasteen and Sheehan, 1997). For some species the benefit of this practice may be outweighed by the physical damage caused during its application. McGlennon and Partington (1997) reviewed New Zealand experiments that investigated the effects of venting snapper (Family Sparidae; *Pagrus auratus*) caught by trawls at depths to 100 m, and found that the average survival of vented fish was 70%, compared with 89% for unvented fish. Similarly, non-deflated blue rockfish (Family Sebastidae; *Sebastodes* sp.) showed greater survivorship than deflated fish (Gotshall, 1964). Behavioural patterns were also significantly altered in punctured fish after release.

Differences in PRS between species highlight the need for species-specific research into the benefits of swimbladder deflation. Moreover, puncturing damage incurred by fish during scientific experimentation is likely to be less invasive than puncturing carried out by fisherman in the 'heat of battle'. If applied correctly, however, it may offer a short-term solution for some species unable to return immediately to the depth from which they were caught.

1.4.8 Thermal shock

Elevated water temperatures magnify the physiological stress incurred during capture and may decrease survival of fishes after release. Air temperatures may be particularly high on landing platforms where fish are held prior to release. Lower temperatures are generally associated with lower metabolic rates and higher survival, although variation occurs between species and individuals.

"Exhaustively angled" Atlantic salmon (Family Salmonidae; *Salmo salar*) were shown to recover more slowly in summer (water temperatures 16.5-20°C) than in winter (8°C) (Anderson *et al.*, 1998). Survival rates of sablefish (Family Anoplopomatidae; *Anoplopoma fimbria*) and Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*) were low in elevated water temperatures, irrespective of the other stresses (handling, net towing) applied (Davis *et al.*, 2001; Davis and Olla, 2001). Strange *et al.* (1977) demonstrated that stress levels in trout (Family Salmonidae; *Salmo clarki clarki*) increased rapidly (to 3 times basal level in 25 mins) in response to increased water temperature. Similarly, largemouth bass (Family Centrarchidae; *Micropterus salmoides*) suffered severe hyperglycaemia (an indicator of stress) when hooked and played in elevated water temperatures (Gustaven *et al.*, 1991).

The relation between water temperature and PRS is not simple and varies among species and individuals. PRS rates of striped bass (Family Moronidae; *Morone saxatalis*) caught and tagged in winter were 86% compared to 33-46% survival in summer (Bettoli and Osborne, 1998). Surface air temperature was found to be the major factor contributing to changes in survival in that study; no effect was detected for water temperature. Kumar *et al.* (1995) suggested that PRS of King George whiting (Family Sillaginidae; *Sillaginodes punctata*) due to hooking decreased by 4.7% as a result of lower water temperature.

Booth *et al.* (1995) recorded 100% PRS in Atlantic salmon (Family Salmonidae; *Salmo salar*) angled and released at a water temperature of 6°C. In a separate study, PRS was shown to increase as water temperature decreased (100% survival at 8-16.5°C and 20% at 20°C) (Anderson *et al.*, 1998).

1.4.9 Osmoregulatory stress

Research on migratory sportfish in the northern hemisphere suggests that PRS may be lower in fish with pre-existing stress caused by changes in osmoregulatory processes associated with migratory behaviour. PRS decreased in Atlantic salmon (Family Salmonidae; *Salmo salar*) entering freshwater compared with fish caught and released in saltwater (88 vs. 100%) (Brobbel *et al.*, 1996). This was attributed to the osmoregulatory stress experienced by fish adapting to changes in salinity when moving from saltwater to freshwater. Species-specific differences in post-release responses to changes in salinity are highlighted in research of freshwater-acclimated sub-adult striped bass (Family Moronidae; *Morone saxatilis*) (Cech *et al.*, 1996). Fish recovery improved through modification of the recovery environment. Fish returned to slightly brackish waters exhibited lower post-exercise acidosis than fish returned to freshwater or water of higher salt concentration.

Estuarine fishing operations may operate on the boundary where fresh meets saltwater. Fish caught may be translocated from one salinity regime to another. Post-capture handling can cause scale and mucous damage leading to osmoregulatory failure through excess sodium accumulation (for saltwater species) or loss of body salts (for freshwater species) (Nowak, 1999).

1.4.10 Oxygen deprivation and ammonia toxicity

Oxygen deprivation after capture significantly disturbs endocrine and metabolic processes and is likely to be a major factor influencing PRS in many fish species. Oxygen deprivation is strongly related to the length of time a fish is exposed to air when it is handled. This issue is discussed further in section 1.5.6.

Fish may also undergo stress through exposure to lower oxygen concentrations when held by fishers in tanks. These tanks may also be characterised by higher concentrations of ammonia. High grading is commonplace where fish of lower perceived or market values are exchanged for more highly valued fish. For example, in the line fisheries of Western Australia larger male snapper (Family Sparidae; *Pagrus auratus*) are often exchanged for smaller females due to their lower acceptance in the export market (Moran *et al.*, 1999). Poor water quality (low levels of dissolved oxygen and high concentrations of metabolites, such as ammonia) in holding tanks can significantly affect the survival of released fish (Muoneke and Childress, 1994). Kwak and Henry (1995) found the percentage of dead largemouth bass (*Micropterus salmoides)* in live wells to be significantly correlated with pH, reflecting the effects of oxygen depletion. Fish with low bag limits or caught in tournaments may be held in captivity for extended periods prior to release through high grading. Survivorship of smallmouth (Family Centrarchidae; *Micropterus dolomieu)* and largemouth bass (Family Centrarchidae; *Micropterus salmoides)* in tournaments in the USA was increased from 90.8 to 96.5% through the use of continuous recirculating systems (Muoneke and Childress, 1994).

Stress via decreased oxygen availability can also occur when fish are caught and released in warm water containing low levels of dissolved oxygen. Lower PRS (12.5 vs. 88.3%) was observed in lake trout (Family Salmonidae; *Salvelinus namaycush*) during summer when surface waters with higher temperatures contained inadequate dissolved oxygen (3 mg/L) (Lee and Bergersen, 1996).

1.4.11 Predation after release

Damage incurred by line fishing can increase a fish's susceptibility to predation through its displacement from its school or territory or alterations to swimming behaviour. Sharks, predatory birds and seals often prey on fish released after capture by line. One out of eight black marlin (Family Istiophoridae; *Maikara indica*) caught by line on the Great Barrier Reef was taken by sharks after being tagged and released (Pepperell and Davis, 1999). Anecdotal reports of sharks attacking hooked marlin are common in that area. Shark predation on tusk fish (Family Labridae; *Choerodon venustus*) has also been observed on the Great Barrier Reef after catch and release (see section 1.4.6).

1.5 Factors that influence post release survival of line-caught fish

A variety of factors affect the level of injury, stress and survival of fish caught and released in a line fishery. Fishing methods vary according to the size and species of fish targeted and the fisher's objectives. Understanding the specific stressors applied during a fishing operation is critical for measuring the impact on released fish. In many cases the factors reducing PRS are obvious and regulations or education campaigns could be implemented to minimise harm.

1.5.1 Fish vulnerability to multiple captures

There are species-specific differences in the numbers of times fish can be captured and released and in their responses to multiple captures. Variations can be related to population density, home ranges of individual fish, feeding behaviour, fish size and the level of fishing effort. Time elapsed between hooking episodes can also affect the level of accumulated damage and stress.

Seasonal growth of striped bass (Family Moronidae; *Morone saxatalis*) can be reduced by 13 to 30% through decreases in feeding rates resulting from being caught and released two or more times (Stockwell *et al.*, 1999). For fish subjected to repeated recapture, post-release survivorship decreases with each hooking episode (Newman and Storck, 1986 in Muoneke and Childress, 1994). Some largemouth bass (Family Centrarchidae; *Micropterus salmoides*) may be caught up to 16 times in a single season (Burkett *et al.*, 1986). PRS in this species may be high, yet survival rates of individuals may be low due to the cumulative effects of repeated catch and release. Schill *et al.* (1986) estimated that PRS of cutthroat trout (Family Salmonidae; *Oncorhynchus clarki clarki*) taken several times was significantly lower than the PRS of fish taken once.

The SUNTAG program has developed relatively large data sets on multiple recaptures of at least ten species, including barramundi, that could be used to investigate the effects of repeated catch and release on the growth rates of fish (B. Sawynok, ANSA, pers. comm.).

1.5.2 Size, age and gender effects on post-release injury and survivorship

Differences in PRS occur within and between populations. Size, age, gender and differences in habitat usage associated with life-history stage all influence behaviour and affect the vulnerability of individuals to the stresses of capture and release.

Variations in PRS between species can be attributed not only to differences in morphology and physiology but also to differences in feeding behaviour. Staff at Mote Marine Laboratory noted major differences in PRS between red snapper (Family Lutjanidae; *Lutjanus campechanus*) and red grouper (Family Serranidae; *Epinephelus morio*) that they attributed to the effects of hook damage. Feeding behaviour was differed between the species. Grouper mouthed their food before swallowing while red snapper immediately swallowed their food making them more susceptible to deep hooking (http://www.mote.org).

Larger fish are potentially harder to handle and may exhibit lower PRS than smaller fish of the same species. However, fish size has been shown to have a variable effect on catch and release responses. Smaller rainbow trout (Family Salmonidae; *Salmo gairdneri*) exhibited less severe stress responses to hooking than larger fish (Wydoski *et al.*, 1976). Ferguson *et al.* (1993) demonstrated that disruptions in intracellular pH, increases in levels of lactic acid in white muscle, and increases in metabolic processes were positively correlated with size in rainbow trout (*Salmo gairdneri*). Other researchers have shown PRS to increase with fish size (see Loftus *et al.*, 1988; Schisler and Bergersen, 1996). In contrast to Wydoski *et al.* (1976), Schisler and Bergersen (1996) found that the PRS in response to play duration, temperature and oxygen deprivation of rainbow trout (*Salmo gairdneri*) increased with size.

Size also influences the feeding behaviour of Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*), and smaller fish are hooked in the jaw less often than larger ones (Kaimmer, 1998). Similarly large brook trout (Family Salmonidae; *Salvelinus fontinalis*) ingest lures more deeply than smaller fish (Nuhfer and Alexander, 1992). Such behaviour influences the amount of damage incurred by a fish and its rates of survival upon release.

Few studies have focussed on the effects of age on PRS. Age may influence PRS and fitness indirectly through its effects on morphology, physiology and reproduction. Ontogenetic shifts in habitat usage can influence the stresses applied during fishing operations. For example, King George whiting (Family Sillaginidae; *Sillaginodes punctata*) spend several years inhabiting shallow nearshore areas before moving out to deeper offshore waters, where rates of PRS may be reduced by the effects of barotrauma (Fowler *et al.*, 2000).

Gender-related differences in catchability and PRS are noted for some species. Differences are generally related to characteristics of reproductive behaviour or physiology. Male smallmouth bass (Family Centrarchidae; *Micropterus dolomieu*) and largemouth bass (Family Centrarchidae; *Micropterus salmoides*) guard nests during the reproductive season and are thus more susceptible to capture than females (Phillip *et al.*, 1997).

1.5.3 Capacity of line fished populations to withstand catch-and-release mortality.

Catch and release practices can be a significant source of mortality in populations where large numbers of fish are released. The effect on a population is partly dependent on the capacity of the population to withstand negative effects. This capacity is not only dependent on the exploitation rate of the fished population and the regulations to control the amount of fish harvested, but also the life-history strategy and distribution pattern of the species. Short-lived, fast-growing fishes with high fecundity may be less vulnerable to high levels of catch and release mortality than longer-lived, slow-growing species with low fecundities.

1.5.4 Terminal gear type, hooking location and hook shedding

The type and size of hook affects not only where the fish is hooked, the damage inflicted during capture and the size of the fish hooked but also the handling time prior to release. Terminal gear types reflect the goals of fishers participating in the fishery and there are large variations in the types and sizes of hook used. The bait-type also influences hooking location. Considerable information is available on these issues for overseas fisheries, but few data have been collected from Australia's line fisheries.

Over 97% of King George whiting (Family Sillaginidae; *Sillaginodes punctata*) taken from shallow waters in SA by recreational anglers survive being released (Kumar *et al.*, 1995). Injuries were classified according to hook location: minor injury, hooked in the outer area of the mouth with no observed damage; fish hooked near eyes or gills, obvious bleeding; fish hooked in stomach, difficult to extract.

Gut or deep hooking causes damage to gills and viscera and is thought to be a major contributor to decreasing PRS (McKenzie, 1999; Lucy, 2001; Moran and St John, 2000). Although sample sizes were small, Moran and St John (2000) found that 0% of deep hooked dhufish survived (Family Glaucosomatidae; *Glaucosoma hebracium*). Similar results were observed for undersize (<34 cm) snapper (Family Sparidae; *Pagrus auratus*) in New Zealand. Low (10-25%) PRS was observed in oesophageal hooked fish under 'favourable' conditions compared with 90-95% PRS for lip hooked fish (McKenzie and Holdsworth, 1997).

Cutting the line has been proposed as a harm minimisation strategy for deep hooked fish. This strategy increased PRS by up to 42% in wild caught rainbow trout (Family Salmonidae; *Oncorhynchus mykiss*) over a 34-day period (Schill, 1996).

1.5.4.a Hook composition (stainless steel v non) and shedding

Much conjecture exists over the potential benefits of different hook materials and the degree to which fish are able to shed hooks is likely to be species-specific. Approximately 60 % of rainbow trout (Family Salmonidae; *Oncorhynchus mykiss*) shed hooks during a 34-day period, however the composition of hooks and hook location were not recorded (Schill, 1996; Mason and Hunt, 1967). Stainless steel hooks have been proposed over non-stainless in promoting survival by minimising the amount of infection caused by rusting (Horst, 2000b). Currently views are polarised among fishers on the benefits of stainless and non-stainless steel hooks. Controlled experiments are needed. The SUNTAG program already has data that may provide insights on this topic for some species (M. Dohnt, SUNTAG, pers. comm.).

1.5.4.b Hook shape and hooking location

Circle hooks, are most common in multi-hook set-line commercial operations, but are gaining favour in the USA recreational sector due to education campaigns highlighting low gut hooking rates, safety of use, fast removal, comparable catch rates and the notion that fish caught on circle hooks fight better than deep hooked fish (Horst, 2000a). Recent tagging programs in Florida have used cash prizes to reward anglers for using circle hooks when fishing for red snapper (Family Lutjanidae; *Lutjanus campechanus*). Information from tag returns may identify differences in PRS associated with circle and J-shaped hooks (http://www.mote.org).

Sailfish (Family Istiophoridae; *Istiophorus* spp.) hooked with circle hooks had only 15% gut hooking rates compared to 46 % with J-shaped hooks (Lucy, 2001). Trials comparing J-shaped and circle hooks showed the catching efficiency of circle hooks to be superior for halibut (Family Pleuronectidae; *Hippoglossus hippoglossus*), hake (Family Merlucciidae; *Merluccius productus*) and some species of elasmobranch (Lokkeborg and Bjordal, 1992). Conversely, advocates of J-shaped hooks such as McEachron *et al.* (1985) found circle hooks to catch more small red drum (Family Sciaenidae; *Sciaenops ocellatus*), black drum (Family Sciaenidae; *Pogonias cromis*) and catfish (Family Ariidae; *Arius felis*) than straight-shanked hooks, implying a greater potential for decreased PRS when using circle hooks. More research is required to determine the benefits of using different hook types. Species-specific differences in morphology and feeding behaviour are likely to influence hook placement and damage incurred during hook removal.

Attaching wire appendages to the snood of hooks has been shown to significantly lower the rates of gut hooking (between 78% and 96%) and catches of undersize snapper (Family Sparidae; *Pagrus auratus*) in commercial setline fishing operations in New Zealand (Willis and Millar, 2001). While a modest reduction in catch weight of legal sized snapper was observed, fish retained were of significantly higher quality and value compared to gut-hooked fish which died more quickly after being hooked (Willis and Millar, 2001).

1.5.4.c *Barbed v barbless hooks*

Barbless hooks are generally assumed to cause less damage to fish than barbed hooks, as barbless hooks are easier to remove and reduce handling times and fish stress (Schaeffer & Hoffman, 2002). The use of barbless hooks has been encouraged as a conservation strategy in North American sport fisheries. Research has been generally focused on reviews of old data sets for salmonids (Wydoski, 1977, Mongillo, 1984, Taylor and White, 1992 *in* Schill and Scarpella, 1997; Muoneke and Childress, 1994) and has shown little difference in PRS of fish caught with barbed or barbless hooks. These reviews contain a range of opinions on the overall influence of these hook types on PRS, suggesting survival rates may vary among species.

Australian research shows that handling time was significantly reduced for yellow stripey (Family Lutjanidae; *Lutjanus carponotatus*) and wire netting cod (Family Serranidae; *Epinephelus quoyanus*) taken on barbless hooks, however no differences in PRS were recorded (Diggles and Ernst, 1997).

The performance of barbed and barbless hooks was compared in a controlled experiment in a marine recreational fishery in Florida using voluntary recreational anglers who collected information on catch rates, unhooking times and injury status (Schaeffer and Hoffman, 2002). It was concluded that single barbless hooks may not have promoted PRS and that barbless hooks conferred only slight benefits at the expense of reduced catches.

1.5.4.d *Size of hook and bait*

The size of hook used is an important determinant of the type of wound sustained and consequent damage inflicted. Increasing the hook size has been shown to promote PRS. New Zealand blue cod (Family Pinguipepidae; *Parapercis colias*) caught on large (6/0) hooks showed 100% PRS after two weeks compared with 75% survival on smaller (1/0) hooks (Carbines, 1999). Several researchers have shown that changing the hook size alters the minimum size of fish captured but not the capture rates of larger fish (McCracken, 1963; Ralston, 1990; Saestersdal, 1963; Otway and Craig, 1993). Otway and Craig (1993) showed that increasing hook size by 26.5% resulted in significantly fewer snapper (Family Sparidae; *Pagrus auratus*) below the minimum legal size being caught. Increasing the hook size by 64% did not result in a further decrease in the number of undersize snapper caught, but reduced the capture rates of larger individuals. However, such hook selectivity is not always apparent. For example, a study that involved increasing the hook sizes up to 71%, detected no differences in the size or numbers caught for several species of Lutjanid (Ralston, 1990). This was attributed to variability in the size of fish between sites and days. Hook size also had no apparent effect on the minimum size of capture of several species of bream in an artisanal long-line fishery in Portugal, although larger hooks did catch less fish (Erzini *et al.*, 1996).

Bait size can also influence the size of fish caught with larger baits reducing catch rates of undersized fish. A study of cod (Family Serranidae; *Gadus morhua*) in Norway showed that the overall length frequency distribution of catches increased with bait size (Lokkeborg, 1990). Similar results have been obtained for haddock (Family Gadidae; *Melanogrammus aeglefinus*), where plastic was attached to the hook making the baits appear larger and thereby decreasing the proportion of undersized fish caught (Lokkeborg and Bjordal, 1995).

1.5.4.e Treble hook v single hook

Longer handling times and higher stress levels are associated with removal of treble hooks than single hooks. Regulations for the shady camp barrage in the NT require the use of single point hooks on lures based on this premise. However, substantial variability in PRS exists between species caught on treble and single hooks (Muoneke and Childress, 1994). For example, Nuhfer and Alexander (1992) observed lower survival for trout (*Salvelinus fontinalis*) caught with single hook lures than by treble hook lures, yet no significant difference in PRS was detected between single and treble hooks for red drum (Family Sciaenidae; *Sciaenops ocellatus*) or spotted sea-trout (Family Sciaenidae; *Cynoscion nebulosus*) (Matloch *et al.*, 1993). Conversely, research on several species of freshwater trout in Maryland showed fish caught on lures with treble hooks sustained more damage and lower PRS than fish caught on single hooks (Pavol and Klotz, 1995). In the Western Australian recreational boat and shore based tailor (Family Pomatomidae; *Pomatomus saltatrix*) fishery, Ayvazian *et al.* (2001) found significantly lower PRS for fish caught with treble hook lures compared to single hook baits. The use of 'ganged' hooks (hooks linked in series) is also common in Australian line fisheries and particularly favoured by shore based recreational fishers. No studies in Australia have compared PRS of fish caught by ganged and single hooks, however ganged hooks may increase the damage to fish by causing multiple puncture wounds.

1.5.4.f *Bait v lure*

Lure fishing often involves the use of treble hooks and can result in increased penetration and subsequent tissue damage, however, bait fishing with single J-type hooks has been shown in some studies to decrease PRS by increasing the incidence of gut hooking (Lucy, 2001).

Bait fishing with single hooks caused significantly lower PRS than lure fishing with single or treble hooks (94.9% c.f. 99.5%) for two shallow-water species of coral reef fish (Family Lutjanidae; *Lutjanus carponotatus* and Family Serranidae; *Epinephelus quoyanus*). However, total PRS for both gear types over a 48 hr observation period was high (98.2%) (Diggles & Ernst, 1997). Nelson (1998) observed that the use of live bait increased the incidence of deep hooking (gills, pharynx and oesophagus) in striped bass (Family Moronidae; *Morone saxatilis*) (14%) when compared to artificial lures (3%). PRS in spotted seatrout (Family Sciaenidae; *Cynoscion nebulosus*) was increased by up to 20% when treble hook lures were used rather than bait (Thomas *et al.*, 1995). Higher post-release survivorship has also been reported for smallmouth bass (Family Centrarchidae; *Micropterus dolomieui*) and walleye (Family Percidae; *Stizostedion vitreum*) caught on treble hook lures (100% survivorship) compared to baited single hooks (89 and 90% respectively) (Clapp & Clark, 1989; Payer *et al.*, 1989).

In some studies single hook baits have been shown to cause lower PRS than single hook lures. Organic baits increased 'deep hooking' and caused lower PRS for rainbow trout (Family Salmonidae; *Oncorhynchus mykiss*) compared to lures (71.8 vs. 82.8%) (Schisler & Bergersen, 1996). In contrast, short-term (72 hrs) survival rates were similar for weakfish (Family Sciaenidae; *Cynoscion regalis*) and cutthroat trout (Family Salmonidae; *Salmo clarki*) caught on single hook lures or baits (Malchoff & Heins, 1996; Dotson, 1982).

1.5.5 Capture duration/ Play length

The length of time a fish remains hooked before being landed affects the severity of the physiological stress response and the amount of physical damage inflicted by terminal gear. Extended play length may result in sublethal changes in growth, reproduction, and behaviour or in death up to several hours after the event.

Capture duration varies according to the techniques and objectives of fishers. Commercial operations generally aim to reduce the time needed to land hooked fish. Conversely recreational fishers can increase the length of stress responses and the likelihood of tissue damage by prolonging fight times through the use of light lines.

Capture duration (1-18 h) had no significant effect on plasma cortisol levels in red sea bream (Family Sparidae; *Pagrus major)* caught by set-line (Chopin *et al.*, 1996). Levels were elevated after one hour but remained constant or declined after that time as fish ceased intensive struggling. This differs from the findings of Pankhurst and Sharples (1992) who found cortisol levels in snapper (Family Sparidae; *Pagrus auratus*) to increase in relation to soak time of longlines.

Rainbow trout (Family Salmonidae; *Salmo gairdneri*) exhibited PRS of 60% after intensive exercise lasting six minutes (Wood *et al.*, 1983). Death was ascribed to intracellular acidosis rather than excessive lactic acid accumulation. While low PRS has been well demonstrated in exercised fish, survival rates vary between species. Research has highlighted high survival rates in many catch and release fisheries (see Wydoski *et al.*, 1976; Barnhart, 1989 and Tufts *et al.*, 1991). For example, playing time had no significant effect on PRS of striped bass (Family Moronidae; *Morone saxatalis*) despite proportional increases in concentrations of plasma cortisol (Tomasso *et al.*, 1996).

1.5.6 Handling

Handling time refers to the period between when the fish is brought alongside or on to the landing platform until its final release back into the water. The stress and damage caused to a fish after capture is related to the amount of handling needed to control the fish. This in turn is influenced by the size of fish, landing technique, terminal gear (*e.g.* single v treble hooks, barbed v barbless), type of platform from which fishing is conducted (*e.g.* boat, shore, jetty) and experience of the angler. Fish are subject to oxygen deprivation and may be damaged through removal of scales and mucus, thereby exposing them to pathogens, parasites and heat loss. Handling time can be increased when fish are entangled by terminal or landing gears, or where they "thrash" around the fishing platform. The extent to which handling affects PRS is dictated largely by species-specific stress responses and 'durability'.

Most data on handling effects is for recreationally caught freshwater species or captive studies in aquaculture operations where fish may already suffer stress due to overcrowding and confinement (Chopin and Arimoto, 1995; Strange *et al.*, 1977).

Analysis of stress effects due to handling in King George whiting (Family Sillaginidae; *Sillaginodes punctata*) showed fish undergoing repeated handling over a three week period exhibited a 13% decrease in survival and a 10% decrease in weight gain (Coates, 1998). Laboratory-based research on post-hooking scale loss in yellowfin bream, *Acanthopagrus australis* (Family Sparidae), concluded that while overall scale loss due to handling was low

(<3%), cumulative fatigue stresses (decreased oxygen blood content, elevations in plasma cortisol concentrations, hook damage) may have caused increased susceptibility to pathogens and decreased survivorship (Broadhurst *et al.*, 1999). Conversely, no effects on PRS were detected for undersize blue cod in New Zealand (Family Serranidae; *Parapercis colias*) when subjected to two handling treatments (Carbines, 1999):

1) optimal handling: wet gloves, no sun, gentle return
2) normal handling: bare hands, direct sun, thrown into water

Oxygen deprivation during handling significantly disturbs endocrine and metabolic processes and is likely to be the major handling factor decreasing PRS in many fish species. However, hypoxia endurance times vary markedly between species. A study of rainbow trout (Family Salmonidae; *Salmo gairdneri*) showed survival rates 62% to 28% for fish exposed to air for 30 and 60 seconds respectively (Ferguson and Tufts, 1992). (Mazeud *et al.*, 1977). In contrast, Loftus *et al.* (1988) reported 100% survival for trout (*Salvelinus namaycush*) kept out of water for up to 5 minutes.

1.6 How to measure the effects of catch and release on fish

Historically, several approaches have been used to estimate the effect of catch and release on line-caught fish, including diagnostic measurements of stress responses, mark recapture techniques, manipulative experiments in laboratory and field environments, mortality projections for injured fish, inferences from fishing competitions and population modelling using assumed or derived estimates of PRS (Muoneke and Childress, 1994). Realistic estimates of PRS are difficult to obtain. PRS varies between and within species at different spatial and temporal scales and in response to different stressors applied during fishing operations. The effects that factors such as displacement and predation have on line-fished populations are also difficult to measure except by direct observation in the wild.

1.6.1 Measuring stress responses

Measurements of plasma cortisol, blood glucose, haemoglobin, chloride, lactic acid, osmolality, intracellular acidosis and heart rate have been used to assess stress and fatigue in fish. The measurement of cortisol (a corticosteroid hormone) in blood plasma is well established as a reliable indicator of stress (Donaldson, 1981; Gustaveson, *et al.*, 1991; Pankhurst and Sharples, 1992). Heart rate was used as a stress index for exhaustively angled Atlantic salmon (Family Salmonidae; *Salmo salar*) to test for differences in recovery at different water temperatures (Anderson *et al.*, 1998).

Measurement of physiological stress responses may provide a useful tool in determining the severity of a stress applied after capture. However, caution should be exercised in assuming associations between measurements of stress and levels of PRS, as the relationship between physiological stress and survivorship remains unclear (Davis *et al.*, 2001). Stress responses in field and laboratory conditions have been shown to differ both qualitatively and quantitatively for blue mao mao or sweep (Family Kyphosidae; *Scorpis violaceus*) and it is thus difficult to extrapolate estimates of captive survivorship to wild situations (Lowe & Wells, 1996).

1.6.2 Experiments on captive fish.

Some catch and release studies in Australia have used laboratory tanks to assess PRS of line-caught fish. Laboratory studies have the advantage of being able to precisely monitor fish and manipulate environmental conditions, but results may be confounded by the effects of unnatural confinement over a prolonged period. For example, yellowfin bream (Family Sparidae; *Acanthopagrus australis)* held in tanks were damaged only slightly by hooking, however mortality rates were high from hyperplasia and fusion of gill filaments caused by copepods and protozoan parasites (Broadhurst *et al.*, 1999). Such high concentrations of parasites were considered unlikely to occur in wild populations.

One of the simplest and most cost-effective approaches to estimating short-term PRS (<3 days) is to hold fish caught by standardised line fishing techniques in cages (see Ayvazian *et al.*, 2001; Moran and St John, 2001; Lloyd, 2000). Estimates of PRS could be regarded as "worst case" scenarios, as fewer fish may die in natural situations than in cages. Such experiments are useful for providing an indication of initial levels of PRS and whether further research on a species or fishery is required. For species with low PRS, further manipulative experiments may be required to isolate specific factors contributing to death. Consideration of the environmental conditions in which experiments are conducted and the response of the species to being caged are required so that fish do not die as a direct result of confinement. Diver observations and video techniques can be useful.

Recent studies in WA have used cages to investigate PRS of undersize reef fish subjected to hooking, handling and environmental stressors characteristic of normal fishing practices (Moran & St John, 2001). Dhufish (Family Glaucosomatidae; *Glaucosoma hebracium*) and pink snapper (Family Sparidae; *Pagrus auratus*) caught from three different depths (10-15; 20-30; and 40+m) with different hook types (J v Circle) and subjected to different levels of 'venting' were released into cages anchored at depth. Tag recapture studies carried out in conjunction with this project aim to further test the findings of the cage experiments. A similar study in the NT used video techniques to assess barotrauma in deepwater snappers held in cages (Lloyd, 2000, see section 1.4.6). Video techniques may be useful where observations by divers are not possible and have the benefit of being less invasive.

1.6.3 Mark recapture/Tagging

Tag recovery data were used to determine relative measures of PRS for Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*) by associating condition codes to various types of hook removal injury, release methods and hook styles (Kaimmer & Trumble, 1998). Similarly, research on red groupers (Family Serranidae; *Epinephelus morio*) incorporated data obtained from a large tag and recapture study with a series of onboard observations of fish to estimate potential survival (Wilson & Burns, 1996). Mark recapture information was used to ground truth predictions derived from short-term observations after release.

The amount of information on PRS that tag and recapture programs can provide is generally limited by the low rate of tag returns and the high costs involved. For example, a program designed to mark yellowfin tuna (Family Scombridae; *Thunnus albacares*) in the western Pacific estimated that it would cost US $5000 for every yellowfin tag returned (Hilbourn & Walters, 1992). Additionally, results can be strongly influenced by tag shedding, mortality associated with the tagging of the fish and unreported tag recaptures (Ricker, 1975). Such problems may be overcome through captive experiments to determine tag loss and tag related mortality but results may not represent fishery conditions (McGlennon & Partington, 1997).

The National recreational fishing organisation, ANSA, has recently established national tagging programs (AUSTAG) that provides several potentially useful types of data for obtaining estimates of relative PRS of line-caught fish. The programs have provision for recording the release condition of a fish on a scale of 1-5 (excellent to dead), with the Qld branch 'SUNTAG' having data for approximately 85% of all (267 000) tagged fish. Information is also available on the location of capture (to interpret depth from bathymetric charts), size of fish, hook types, hook injury and condition of the swimbladder.

The Gamefish Tagging Program (GTP) was established in the 1970's to provide gamefishers with opportunities to participate in research. The program operates through the Game-Fishing Association of Australia (GFAA) and ANSA, and includes 177 clubs, most of which are located on the East Coast. Data for approximately 255 000 fish that have been tagged since 1974 are available through the GFAA. Percentages of recaptured fish vary between 0.68 and 8%. Data includes species, capture time, capture location, play length, size and weight as well information on the condition of each fish at the time of release. This information may be useful for determining the relative rates of PRS associated with various fishing and handling procedures.

Recreational fishing competitions provide cost-effective opportunities to obtain data on PRS. For instance, competitors in the 'Rocky Bay Barra Bounty' tag and release fishing event in Rockhampton, Qld, record information on hook type and hooking location for released fish. Similarly, competitors in the "Boyne Tannum Hookup" tag and release fishing competition in Gladstone, Qld have recorded data relating to the handling of fish for the last two years. An advantage of using recreational anglers to tag and release fish is that information can be collected for species that are not considered to be high priorities for research and may not be the subject of dedicated studies.

Recent catch and release studies have used satellite archival tags or ultrasonic tags to assess PRS. In the past, it was a necessity to recapture tagged fish to download information from tags. Low recapture rates combined with the high cost of tags prevented this technique from being used extensively. Pop off satellite archival tags (PSATs) currently being tested on southern bluefin tuna (Family Scombridae; *Thunnus maccoyii*) can be released at a pre-arranged time and float to the surface to download information on parameters such as swimming depth via satellite (J. Gunn, CSIRO, Marine Research, pers. comm.). This technology shows promise in assessing PRS over periods greater than 3 days, yet may have limitations. Tagging procedures are extremely invasive and may only be applicable to larger species. Tag failure and fish mortality may also be hard to separate as non-reporting tags introduce uncertainty into estimates of PRS that cannot be quantified (Graves *et al.*, 2002).

Adult tautog (Family Labridae; *Tautoga onitis*) were tagged with internal transmitters by surgical insertion into the visceral cavity (Arendt and Lucy, 2000). High PRS of fish released in the wild corroborated high short-term survival for fish retained in cages. Similarly Webb (1998) used sonic tags to measure PRS of Atlantic salmon (Family Salmonidae; *Salmo salar*) up to the spawning period.

Ultrasonic tagging techniques have been used to study movement patterns and PRS of black marlin (Family Istiophoridae; *Makaira indica*) and have indicated high PRS after capture by standard sport-fishing techniques (84 to 91%) (Pepperell and Davis, 1999). The GFAA recently funded and implemented a satellite-tagging program. Preliminary results obtained from the PSATs show over 90% survival of marlin species when caught and released under typical game-fishing conditions (G. Williams, GFAA, pers. comm.).

1.6.4 Combining tagging and stress diagnostic measures

Current research in Hawaii has combined the use of a set of diagnostic tools to assess the physiological status of blue sharks (Family Carcharhinidae; *Prionace glauca*) with information provided from PSATs (C. Moyes pers. comm.). The extent of tissue damage arising from systemic oxidation and stress through capture is assessed through comprehensive molecular analyses of ions, metabolites and proteins in blood plasma and of blood cells themselves (see Yang *et al.*, 2000; Lund *et al.*, 2000; Phillips *et al.*, 2000 and Moyes *et al.*, 2001). These results are related to information on survival duration gained from PSATs.

1.6.5 Modelling

Modelling approaches have the advantage of being flexible and relatively cheap compared to at sea sampling programs and complex experiments. While data for modelling approaches inevitably relies on some fieldwork to gain estimates of PRS and gear selectivity, the extent or frequency of such sampling programs may be substantially reduced (Harley *et al.*, 2000). However, it should be stressed that the modelling approach, on its own, is not a substitute for obtaining data on PRS. One of the most useful applications of models may be in assessing the sensitivity of particular fish populations/fisheries to changes in PRS. This approach may reveal trends that can be categorised according to a species' biological characteristics or population dynamics.

Numerous approaches have been taken to modelling the effects of catch and release. Clark *et al.* (1980) and Clark (1983) incorporated catch and release mortality estimates in a model of freshwater species to evaluate the potential effects of changes in the minimum legal size. Similarly long-term hooking mortality of striped bass (Family Moronidae; *Morone saxatalis*) was measured through a logistic regression model that used backwards-stepwise selection to predict probability of death from catch and release (Diodati and Richards, 1996). The model included depth of hook penetration, gear type, and angler experience as predictor variables that were estimated from experimental fishing within impoundments. Mortality estimates derived varied from 3% under the most favourable conditions to 26 % under the least favourable. Lawson and Sampson (1996) developed a model for evaluating gear related mortality in selective fisheries (*i.e*. those where stock composition and gear encounter rates change throughout the course of the fishing period) to explore the potential importance of different sources of mortality (including catch and release). Harley *et al.* (2000) used estimates of gear selectivity in a snapper fishery in New Zealand (Family Sparidae; *Pagrus auratus*) to determine discard and mortality rates. Growth in striped bass (Family Moronidae; *Morone saxatilis*) in Massachusetts was shown to decrease (13-30%) using a bioenergetics model that simulated growth under multiple hooking events (Stockwell *et al.*, 1999). Using a

30% mortality rate of released fish, McGarvey and Jones (2000) modelled the effect of a maximum size limit for snapper (Family Sparidae; *Pagrus auratus*) (>75 cm) on the yield and egg per recruit for this species in the South Australian fishery and found that although egg per recruit increased substantially, the yield to the fishery did not support the implementation of a maximum size limit.

1.7 Harm minimisation procedures: precautionary measures to enhance survival

Harm-minimisation practices can be established on the basis of research into their benefits or by applying a "commonsense" and precautionary approach. While more research into the benefits of some of the practices is required, a precautionary approach to enhancing PRS is increasingly being adopted in recreational fisheries in North America and more recently in Australia. Some of the practices that have been promoted and recommended and their advantages are listed below. The list was partly taken from www.capmel.com/catch_release. Most practices are also listed on the state fisheries websites. The ANSA Code of Practice recommends all of the practices outlined above, except the use of stainless steel hooks.

- In deep-hooked bait-caught fish, cutting lines or leaders is thought to increase the survival rates of released fish (Lucy, 2001).
- Where large numbers of fish are released, the use of barbless/crimped hooks acts to reduce handling times.
- The use of circle hooks reduces the incidence of gut hooking.
- Stainless hooks rust less than other hooks and decrease mortality (Horst, 2000), with fish being able to reject hooks from even the stomach or gullet.
- Where hooks are difficult to remove the use a dehooking tool or long nosed pliers can minimise damage to fish.
- For large fish the use of heavy lines tends to minimise play duration. (It is generally recommended that large fish should be landed or brought alongside within 20 minutes of being hooked.)
- Fish to be released should be kept in the water where possible. Large fish should not be brought onboard. The use of gaffs and abrasive landing nets should be avoided. Nets should be made of knotless cord or neoprene. Fish should not be lifted using the leader or trace as this can increase the damage caused by terminal gear.
- Fish should be handled with wet hands and controlled at all times. Fish should be released gently and (where possible) should not be thrown back into the water.
- Fish should be revived in the shade, as cooler water contains more oxygen.

- Fish should be retrieved slowly from deep waters as this allows them to adjust to changes in pressure.
- For fish with obvious barotrauma effects, the use of devices to return fish to deep water may be valuable. (www.ausfish.com/demonjigs/recfish)
- Deflation of the swimbladder with an appropriate tool (venting) is recommended for species in which this practice has been shown to enhance survival.

1.8 Discussion

PRS of line-caught fish varies among and between species and is affected by characteristics of the fish (*e.g.* life-history phase, behaviour), fishery (*e.g.* methods used, regulations in place, environmental characteristics) and fishers (*e.g.* experience, attitudes to handling). Differences in regulations (*e.g.* different minimum size limits) for the same species in different jurisdictions (Prokop, 1995) add to the complexity of estimating PRS for a species over its entire geographic distribution, and for understanding why fish are released and for developing strategies to maximise PRS.

Few data exist on the population sizes of most Australian line-caught species and more information is required on the total numbers of fish caught, harvested and released. Quantifying the numbers of fish released is essential for determining levels of catch and release mortality. However, patterns of release vary at several temporal and spatial scales in response to different regulations, social attitudes, fish life-history pattern and fishing methods. Hence, extensive monitoring is required to obtain accurate information. Fishery-independent monitoring is important as fishers are thought to underestimate rates of release (G. Henry, NSW Fisheries; pers. comm.).

Data on catch and release in Australian line fisheries is available from recreational surveys, and charter-boat and land-based charter fisheries in Qld, WA, NSW and the NT. Some states now have regional information from recreational surveys (*e.g.* Higgs, 1999, 2001; Sumner *et al.*, 2002; McGlennon & Kinloch, 1997), and additional data on the numbers of fish released will be provided in the final report for the NRIFS. Detailed analyses of these data are needed to identify spatial and temporal patterns of release within each state. In contrast, data on discard levels for commercial line fisheries are only available for Cwlth pelagic and demersal longline and dropline fisheries and the Qld commercial line fishery for reef fish (B. Mapstone, JCU, pers. comm.). To quantify spatial and temporal patterns of release and estimate levels of catch and release mortality, data are required on catch and release rates in commercial line fisheries in each state and the charter boat and land-based charter fisheries in SA, Vic and Tas.

Future research should involve observers to monitor commercial line fisheries and to determine the numbers of each species released and describe fishing, handling and release procedures that may affect PRS. Commercial line fishers should also be required to record the species, numbers and condition of fish released during fishing operations. Charter operators in SA, Tas and Vic should also be required to supply this information. The implementation of voluntary data collection schemes in the recreational, charter boat, and land-based charter fisheries would provide significant amounts of information and may be a useful step towards establishing more rigorous systems.

Experiments that use cages to hold fish caught by typical line-fishing techniques may provide the most cost-effective way of estimating short-term (<3 days) levels of PRS. Cages may be particularly useful for assessing the effects of barotrauma on rates of PRS. The effects of other factors (e.g. hook damage, play length and handling time) on rates of PRS and the value of various harm minimisation strategies (*e.g.* venting, retrieval speed, different hook types) could also be assessed using cages (see Ayvazian *et al.*, 2001). However, careful consideration must be given to potential effects of confinement on results. Pilot studies that incorporate diver or video observations may be necessary to determine the locations, cage designs, and stocking densities that will yield the most meaningful results.

Pens similar to those used in aquaculture operations may provide a cost-effective option for conducting manipulative experiments that measure PRS in response to hook damage and variations in play length and handling time. The value of harm minimisation strategies such as changes in hook size/type/composition could also be tested in this manner. Pens can be large (up to 25 m diameter) and experiments may be less influenced by the effect of confinement than those conducted in cages, and thereby provide estimates of long-term (>3 days) PRS. Pens may provide improved estimates of PRS, however costs of research may be increased by the need to feed fish and maintain pens over longer periods.

Laboratory facilities with tanks may be appropriate for researching short-term PRS of fishes (<3 days) in response to different treatments of applied stress (*e.g.* hook damage, play length handling stress), however results may be confounded by the effects of parasites, fungal infections and confinement and these factors need to be monitored closely, particularly if fish are confined for prolonged periods.

Estimates of PRS (and hence mortality) derived from manipulative experiments can be used to predict relative and total catch and release mortality in wild fisheries. Such an approach has been applied successfully in longline fisheries of Alaska (Kaimmer and Trumble, 1996) and should be the long-term goal of Australian studies.

Tagging programs such as those carried out by ANSA and recreational fishing competitions such as the “Boyne Tannum Hookup” have historical data on different catch and release procedures for many recreationally caught species. Detailed analyses of these data may provide useful estimates of relative PRS for key recreational species. Results could be used to identify species that require dedicated research on PRS, identify gaps in existing information and improve data collection procedures in future tagging programs.

Ultrasonic tags are useful for monitoring short-term PRS for small numbers of billfish and tunas (Pepperell and Davis, 1999). PSATs show promise for measuring longer term (>3days) PRS rates of larger species in response to different levels of hook damage, play length and handling time. Harm minimisation strategies such as changes in hook size/type/composition could also be tested using PSATs. Advances in technology may make ultrasonic tags and PSATs applicable to smaller species in the future.

Future Australian experimental research, fishery monitoring and tagging programs should be developed around a standardised nationally-accepted classification system for measuring and recording stress, condition and injury types (Chopin and Arimoto, 1995). This will ensure that results from different studies can be meaningfully compared. An example of a system for measuring and recording injury types and damage, which draws on information provided by Schaeffer and Hoffman (2002), is presented below (Table 1.3):

Table 1.3. Classification system for measuring and recording levels of damage and injury

DAMAGE/INJURY	LEVEL	DEFINITION
Bleeding	Minimal	No bleeding or bleeding is insignificant
	Moderate	Light bleeding or moderate flow
	Severe	Copious amounts of blood or continuous flow
Hook damage	Minimal	Simple puncture wound in jaw /mouth
	Moderate	Some tearing or laceration of tissue
	Severe	Tearing or laceration severe enough to impair anatomical function/or deep hooked
Handling damage	Minimal	No scale damage
	Moderate	Some scales (<5%) or mucous removed
	Severe	Many scales (>5%) missing. Obvious visible damage
Barotrauma damage	Minimal	No obvious signs of barotrauma-fish observed to swim away strongly.
	Moderate	Signs of decompression damage, either bloated abdomen, protruded eyes or everted stomachs. Fish swim away after some time (< 1 minute) on surface.
	Severe	Many signs of decompression damage. Bloated abdomen, protruded eyes and everted stomachs. Fish do not swim away strongly and spend > 1 minute on surface or fish is dead.

Similar standardised information is required on the stressors applied to fish during catch and release, as these are important determinants of the levels of PRS (Chopin and Arimoto, 1995). Future research on PRS in Australian line fisheries will be enhanced by the establishment of a technical group to oversee research projects and develop an operations manual that documents a standardised nationally-accepted classification system for measuring and recording stress, condition and injury types.

There is also a need for selectivity studies of recreational fishing gears to determine the probability of catching undersize fish and non-target species, and potentially to assist the development of gear restrictions for recreational fisheries (Broadhurst *et al.*, 1999). Methods of measuring gear selectivity are almost always comparative and indirect. Studies that assess PRS of fishes caught and released from different gear types could be incorporated into cage or tank experiments or mark-recapture programs that quantify relative estimates of survival.

Fisheries managers are becoming increasingly aware of the need to address the survival rates of released fish in the management strategies for line fisheries. For example, the minimum size limit for garfish (Family Hemiramphidae; *Hyporhamphus melanochir*) in the Vic recreational fishery was recently replaced by a recreational bag limit (irrespective of size), on the basis of anecdotal reports of low rates of PRS (S. Morison, MAFRI, pers. comm.).

Other management strategies to limit catch and release mortality are non-specific seasonal and area closures. Such closures limit the number of fish released and may be particularly effective in nursery areas where large numbers of undersized fish are often caught.

Vessel or fisher incentive programs have been used with success in the U.S.A to reduce the numbers of fish released and to enhance PRS. Pacific longline fisheries of Alaska that target Pacific cod (Family Gadidae; *Gadus macrocephalus*) catch considerable quantities of Pacific halibut (Family Pleuronectidae; *Hippoglossus stenolepis*) incidentally. Pacific halibut are valued highly by other specific long-line commercial operations and recreational fisheries. Estimates of release mortality are subtracted from annual halibut quotas, and U.S.A authorities developed individual vessel incentive programs to improve target catch while avoiding bycatch of halibut (Smoker, 1996). Current longline management regulations require careful release techniques for halibut bycatch (Kaimmer and Trumble, 1996).

Gear restrictions can also reduce the numbers of fish released and enhance PRS. This approach can be particularly useful for deep-water fisheries where PRS is low. For example, the minimum size limit in the blue cod (Family Pinguipedidae; *Parapercis colias*) fishery in New Zealand was reduced in response to the high numbers of small fish taken. However, small hooks are the main cause of mortality and a gear restriction (setting a minimum hook size) may have been more effective in reducing the mortality rates of undersized fish (Carbines, 1999). The establishment of gear restrictions should be based on comprehensive selectivity studies.

Educational programs are cost effective mechanisms for enhancing PRS. Promotion of the use of appropriate gear types and better release practices can substantially increase PRS in recreational fisheries that have high participation rates. This has been recognised by the Steering Committee for this project and will be a future component of the national strategy to enhance the survival of released line-caught fish.

CHAPTER 2: FUTURE RESEARCH PRIORITIES FOR ASSESSING POST-RELEASE SURVIVAL IN AUSTRALIAN LINE FISHERIES

Objective: **To determine gaps in the current information and prioritise future research options.**

This chapter synthesises data available on released line-caught fish in Australian commercial and recreational line fisheries and identifies species that are potentially susceptible to high levels of catch and release mortality.

To determine whether line-fished populations are vulnerable to catch and release mortality it is necessary to know how many fish are released. Data on the numbers of line-caught fish released by the commercial sector are available only for the Cwlth pelagic long-line fishery and Qld reef-line fishery. Weights of fish caught and harvested by commercial line fishers were used to identify the species that are potentially released in large numbers. Limited data are available on the numbers of fish released by recreational fishers in most states. Data from the NRIFS will improve this situation.

A survey conducted in each state and territory identified the Australian line-caught species potentially susceptible to high levels of catch and release mortality. Meetings with fisheries biologists and managers confirmed that research should focus on species or groups of species with high socio-economic value. Future research should be coordinated nationally, however research conducted in each state should be tailored to fit local needs and issues. Several species were identified as priorities for research in several states (*e.g.* snapper in WA, SA, NSW, Vic and Qld; a suite of coral reef species in Qld, WA and NT; barramundi in WA, NT and Qld; billfishes and mackerels in Qld, WA, NT and NSW; tunas in Qld, WA, NT, NSW, Tas and SA). Several key species occur in similar habitats and projects should be ecologically (cf. taxonomically) based. Research should focus on the effects of barotrauma, hook damage and handling for species in reef and sheltered coastal ecosystems, and play length, handling and hook damage for pelagic fishes.

2.1 Introduction

The vulnerability of line-caught fishes to changes in PRS is largely unknown and is not accounted for in current stock assessments. Australia's line fisheries target a wide variety of species and utilise a wide range of gear types, and the rates of PRS of fishes varies among species and fisheries. Hence, estimating the effects of catch and release practices on Australia's line-caught fishes presents a significant challenge.

The objective of this chapter is to determine gaps in the current information and prioritise future research options on PRS in Australia's line fishers. The aims of the chapter are:

1) To collate information on the species and numbers of fish caught and released in Australia's commercial and recreational line fisheries;
2) To review previous and current research on PRS of key line fishing species in Australia.
3) To identify species that are potentially susceptible to high levels of catch and release mortality and that are priorities for future research;
4) To identify biological and environmental factors that may contribute to low PRS in these species and which should be the focus of future studies.

2.2 Methods

2.2.1 Commercial fisheries

To identify the main species retained and potentially released by commercial line-fishers in State and Cwlth waters, catch data for the main 15 species or species groups were obtained from the relevant government agency (AFMA, NSW Fisheries; QDPI; Fisheries WA; DPIWE Tas; SARDI and MAFRI Victoria). Catches were expressed as weight harvested by line (kg) and the total weight of that species/group taken by all fishing methods. To identify the significance of line-fishing for each species, the amount (kg) taken by line was expressed as a percentage of the amount taken by all methods. Estimates of the percentage of fish released were also obtained from the Cwlth managed fisheries. Data for species groups (sharks, tunas and billfish) were divided into 4 regions of Australia – NE, NW, SE and SW, with the lines of demarcation between regions being 30°S and 130°E.

2.2.2 Recreational fisheries

We initially planned to use data from the NRIFS to estimate numbers of fish caught and released in Australia's recreational, indigenous and charter fisheries. However, at the workshop in Cronulla in May 2002, it was agreed that data on each species caught and released in each state would be expressed as a percentage of the total catch only. The percentages of fish commonly caught and released in each state were subdivided into three categories: temperate marine, tropical/sub-tropical marine and freshwater.

2.2.3 Scientific information

International research on the PRS of line-caught fish species is reviewed in section one of this report. In the present section, we summarise previous and current Australian studies on the PRS of line-caught fishes.

2.2.4 Prioritising species for research

A questionnaire was developed for fisheries biologists, fishery managers and key members of the recreational and commercial fishing industry in each state. This questionnaire included a list of marine and freshwater species caught by line in each state and territory of Australia (Appendix 3). Species were identified from fishery website information, fisheries magazines and information gathered from government fisheries agencies relating to recreational and commercial line fishing. Participants in the survey were required to rate factors that influence the susceptibility of line-caught species to catch and release mortality.

Three groups of factors listed in the questionnaire (Table 2.1) were:

1) Factors affecting the numbers of fish released after capture (6 factors)
2) Factors affecting the survival of released fish (8 factors)
3) Factors affecting the ability of fish populations to sustain anthropogenic impacts (9 factors).

Respondents were required to assign a value of one to three (1, 2 and 3) to each factor.
A rating of 1 indicated that the stakeholder considered that the factor would result in:

(i) low numbers of the species being released; or
(ii) high PRS for that species; or
(iii) the species/population having a high capacity to sustain anthropogenic impacts.

Conversely, a rating of 3 reflects the assessment that the factor would result in:

(i) high numbers of the species being released; or
(ii) low PRS for that species; or
(iii) the species/population having a low capacity to sustain anthropogenic impacts.

Fishery biologists and managers were asked to complete the questionnaire for all groups of factors. Commercial and recreational fishing representatives were asked to complete the questionnaire for the first two groups of factors only. Where species information was not available for a state, a species was given a rating based on information gathered for the same species in other states, information collected within its family, or a rating of 3.

The mean value of each factor was calculated for each species or group within each state. Means of all factors were then summed and the totals were weighted by the proportion of respondents that supplied information. It was assumed that the number of respondents for a given species related to the socio/economic importance of that species. No weighting was given to totals for species in states where questionnaire information was determined by participant's consensus in meetings (*e.g.* NT). Weighted totals were ranked for each species/group in each state to provide an index of susceptibility (SI). Species with low rankings were those that were considered to be released in low numbers, have high rates of PRS, be able to sustain significant anthropogenic impacts and be of low socio-economic value. Conversely, species with high rankings were those that were considered to be released in high numbers, have low rates of PRS, be vulnerable to anthropogenic impacts and be of high socio-economic value.

Table 2.1. Summary of the factors, descriptions and ratings used in the questionnaire to assess the susceptibility of Australian line-caught fish species to catch and release mortality. (Rating 1 = low susceptibility; 3 = highly susceptible).

SECTION	FACTOR	RATING & DESCRIPTION
Factors affecting the numbers of line-caught fish released	Species targeted for its eating qualities.	1. Not targeted for its eating quality 2. Targeted moderately 3. Targeted primarily
	Species targeted for its game/sport-fishing or trophy qualities.	1.Not targeted for game-fishing/trophy qualities 2. Targeted moderately (*e.g.* on fishing trips primarily targeting other species) 3. Targeted primarily by specific fishing operations
	Potential of catching this species below its minimum size limit	1. No minimum size limit in place and/or sub-adult schools are not primarily targeted. 2. Minimum size limit in place and majority of fishing targets fish of all sizes and/or fish generally occur in schools of mixed sizes 3. Majority of fishing targets fish close to the minimum size limit or sub-adult schools are primarily targeted
	Potential of catching fish above the maximum size limit	1. No maximum size limit in place and /or large adult fish are not primarily targeted 2. Maximum size limit in place and majority of fishing targets all sizes of fish and/or fish generally occur in schools of mixed sizes 3. Maximum size limit is in place and fishing targets large adult fish
	Potential of catching bag limit	1. No bag limit exists for this species or it is greater than 20 fish per person and/or bag limit is rarely obtained 2. 11-20 fish bag limit per person and/or bag limit is occasionally obtained 3. 1-10 fish bag limit and/or bag limit is typically obtained
	Potential of capture as bycatch when fishing for other species	1. Species is very rarely caught when not targeted. Capture is highly selective due to the gear type used 2. Species is occasionally caught when not targeted but only certain size classes 3. All size classes are frequently subject to capture as bycatch

SECTION	FACTOR	RATING & DESCRIPTION
Factors affecting the PRS of line-caught fish	Potential of species being susceptible to barotrauma effects	1.Not an issue. Species is primarily fished from shallow water and/or species suffers minimal effects (*e.g.* sharks, fishes without swimbladders) 2. Occasionally affected. Species is fished from both deep and shallow water 3. Highly likely. Species is primarily fished from deep water and/or is highly susceptible to decompression effects
	Potential of species being susceptible to handling damage	1. No landing equipment or handling necessary prior to release (*e.g.* large gamefish where leader is cut without any fish handling) 2. No landing equipment used (*e.g.* net/gaff) and minimal handling is required for release (*e.g.* small boatable fish) 3. Landing equipment required and/or extensive handling (*e.g.* larger boatable fish) is required for release
	Potential of species being subject to long play duration prior to landing	1. Short capture duration typically < 5 minutes. 2. Medium capture duration typically 5-20 minutes. 3. Long capture duration typically > 20 minutes.
	Potential of species to being subjected to thermal shock through the fishing process	1. No temperature change 2. Moderate temperature change 3. Strong possibility of undergoing temperature change from time of capture to point of release
	Potential of species to undergo osmoregulatory stress due to changes in salinity caused by the fishing process	1. Species experiences no osmotic stress. Species is either strictly marine or strictly freshwater 2. Species undergoes some osmoregulatory stress. After being hooked the fish experiences a moderate change in salinity *e.g.* as a result of salinity changing with depth. 3. Species undergoes a sudden shift from: saltwater to freshwater or freshwater to saltwater (*e.g.* caught at the mouth of an estuary and brought into freshwater)
	Potential of fish being subjected to post-capture "high-grading" in live wells	1. Fish is never kept for high-grading 2. Fish occasionally kept for high grading 3. Fish regularly kept for grading
	Potential of predation after fish is released	1. Potentially low predation. The fish incurs no observable damage by barotrauma or handling and fish are observed to revive rapidly. 2. Moderate predation. Fish may revive soon after release but not immediately. 3. Highly susceptible to predation. Behaviour is observed to be greatly altered after release making fish vulnerable to predation for a lengthy period (greater than 5 minutes)
	Susceptibility of fish to hook damage	1. Low degree of hook damage. (Hook types used are species or size specific and designed for minimum damage, *e.g.* circle hooks used in commercial operations) 2. Variable degree of hook damage. Species is caught on a variety of hook types and sizes 3. High degree of hook damage. Species is caught on smaller than necessary hook sizes, multiple hooks or is regularly deep hooked or gut hooked.

SECTION	FACTOR	RATING & DESCRIPTION
Factors affecting the capacity of fish populations to sustain anthropogenic impacts	Longevity of the species	1. Short lived species (1-10 years) 2. Medium lived species (11-20 years) 3. Long lived species (20 + years)
	Growth rate of the species	1. Fast growth 2. Medium growth 3. Slow growth
	Current exploitation rate of the species (by any method)	1. Low exploitation rate 2. Medium exploitation rate. Sustainable 3. High exploitation rate. Not sustainable
	Reproductive potential (the chance a species has of spawning before being caught)	1. Minimum size limit > Size at maturity 2. Minimum size limit < Size at maturity 3. No minimum size limit in place
	Fecundity of the species (Total fecundity or reproductive output of an individual)	1. High fecundity 2. Medium fecundity 3. Low fecundity (*e.g.* fish have a high degree of parental care and /or small batch sizes)
	Length of spawning season	1. Protracted spawning season (8-12 months) 2. Intermediate length spawning season (4-8 months) 3. Discrete spawning season (0-4 months)
	Spawning aggregations vulnerable to line fishing	1. Spawning aggregations are not targeted by fishing 2. Spawning aggregations are intermediately targeted 3. Spawning aggregations are specifically targeted
	Distribution pattern of the species/ stock	1. Species/stock has a wide distribution: > 5 states of Australia and exists outside Australia 2. Species/stock has an intermediate distribution: found in 2-4 states of Australia 3. Localised distribution: Found < 2 states of Australia
	Biological understanding	1. Biology well understood. No need for research. 2. Some biological parameters understood. More research required 3. Biology very poorly understood. Research is of high priority

2.2.5. Confirming species for research

The results of the questionnaire were presented at the Sydney 2002 workshop. Meetings were subsequently conducted with stakeholders in WA, SA, Vic, Tas and Qld to confirm the lists of species requiring research in each state. Scientists and managers from NSW and the NT were consulted by telephone. In consultation with fishery biologists, fisheries managers and representatives of the FRDC steering committee, the following standardised formula was developed to prioritise fishes requiring catch and release research in temperate and tropical aquatic ecosystems:

(C + R + E) * V = priority score; where:

C = The level of release in the commercial line fishery (1 - low; 2 - medium; 3 - high). As few data were available for this sector, values of C were based on advice from "experts".

R = The percentage of the catch released by recreational fishers. Estimates of R were based on data from the NRIFS, and/or other recreational survey information (1: 0-33% release; 2: 34-66% and 3: 67-100%).

E = The known exploitation status of the species, taking into account all methods of capture (1: under-exploited; 2: fully exploited; 3: over exploited; 4: uncertain status or is a protected species).

V = The value of the species to the state, taking into account both ecological and socio-economic factors.

All species with scores >10 were arbitrarily deemed as being high priorities for future research; species with scores between 5 and 9 were deemed to be medium priorities; and species scoring less than 5 were regarded as low priorities. Using IMCRA classification for marine and coastal environments (ANZECC, 1998), the marine/estuarine species were grouped into either tropical/subtropical regions or warm/cold temperate regions. Species were then subdivided into: oceanic pelagic, offshore reef, coastal sheltered or coastal high-energy ecosystems. Some of the species were assigned to more than one ecosystem, with juveniles or adults occurring in separate habitats. For example, snapper, (*Pagrus auratus*) and mangrove jack (*Lutjanus argentimaculatus*).

Freshwater species were grouped into the regions according to Lake's (1971) classification of regions for freshwater fish in Australia, and were then subdivided as being either "wild" or "stocked". Although some introduced species, such as rainbow and brown trout have high local value in several states, they were not considered as priorities for future research on the PRS of line-caught fish.

2.2.6 Prioritising research on factors affecting post-release survival

To prioritise the most important factors influencing PRS, the three factors that had the highest averaged ratings, as determined from the questionnaire survey for each priority species, were listed in descending order of score. The factor with the highest average rating was scored at 3, the second at 2 and the third at 1. Scores for each factor were summed for species confirmed as high priorities for future research. Results were presented for each ecosystem in tropical/subtropical and temperate regions.

2.3 Results

2.3.1 Commercial line fisheries of Australia

2.3.1a Overview

The top species/groups were ranked by total weight, and larger species such as sharks and rays ranked highly (Tables 2.2-2.9). Total line catches of cartilaginous species (sharks, rays and skates) ranked highly in all states except Qld.

2.3.1b South Australia

Snapper (Family Sparidae; *Pagrus auratus*), King George whiting (Family Sillaginidae; *Sillaginodes punctata*), Australian salmon (Family Arripidae; *Arripis truttacea*), snook (Family Sphyraenidae; *Sphyraena novahollandiae*), trevally (Family Carangidae; *Pseudocaranx dentex*) and parrotfish (Family Labridae; *Pseudolabrus* spp.) dominated commercial line catches of bony fishes, with total catches ranging from 560 766 kg to 20 205 kg (Table 2.2). Line fishing took over 70% of the total catch by all fishing methods for snapper, King George whiting, parrotfish, trevally and red mullet.

Table 2.2. Top 15 (by weight) marine species/groups of fish taken by South Australian commercial line fisheries in the 2000/2001 financial year. (*Excludes ocean leatherjacket trap fishery)

Species/Group	**Catch by line (kg)**	**Total catch by all methods (kg)**	**Amount caught by line as percentage of all methods**
Snapper (*Pagrus auratus*)	560 766	563 271	99.56
King George whiting (*Sillaginodes punctata*)	335 350	455 731	73.59
Gummy shark (*Mustelus antarcticus*)	69 676	166 354	41.88
Australian Salmon (*Arripis truttacea*)	56 956	302 385	18.84
Bronze whaler shark (*Carcharhinus brachyurus, Carcharhinus obscurus*)	55 436	95 230	58.21
Rays & Skates (all species)	48 585	52 665	92.25
Shark -other (all other species)	41 008	62 013	66.13
Snook (*Sphyraena novahollandiae*)	26 721	106 726	25.04
Trevally (*Pseudocaranx dentex*)	21 392	21 883	97.76
Parrotfish (*Pseudolabrus* spp.)	20 205	20 385	99.12
Red mullet (*Upeneichthys lineatus*)	3 771	4 618	81.66
School shark (*Galeorhinus australis*)	4 621	8 591	53.79
Mulloway (*Argyrosomus japonicus*)	3 106	145 140	2.14
Leatherjacket (Family Monocanthidae)*	2 666	37 657	7.08
Yellow eye mullet (*Aldrichetta forsteri*)	2 111	194 348	1.09

2.3.1c *<u>New South Wales</u>*

Bonito (Family Scombridae; *Sarda australis*), yellowtail kingfish (Family Carangidae; *Seriola lalandi*), blue-eye trevalla (Family Centrolophidae; *Hyperoglyphe antarctica),* gemfish (Family Gempylidae; *Rexea solandri*), snapper (Family Sparidae; *Pagrus auratus*), spotted mackerel (Family Scombridae; *Scomberomorus munroi),* mulloway (Family Sciaenidae; *Argyrosomus japonicus*), teraglin (Family Sciaenidae; *Atractoscion aequidens*) comprised the majority of commercially line-caught bony fish between July 1999 and June 2000, with total catches ranging from 188 000kg to 30 214 kg (Table 2.3). Over 50% of the total catch of mulloway and 90% of the total catch of bonito, yellowtail kingfish, blue-eye trevalla, gemfish, mackerel and teraglin was taken by line. While snapper rated fifth by weight, the line catch comprised only 19% of the total harvest for all methods.

Table 2.3. Top 15 (by weight) marine species/groups of fish taken by New South Wales commercial line fisheries in the 1999/2000 financial year.

Species/Group	Catch by line (kg)	Total catch by all methods (kg)	Amount caught by line as percentage of all methods
Bonito (*Sarda australis*)	188 000	198 260	94.83
Kingfish, Yellowtail (*Seriola lalandi*)	130 808	134 690	97.12
Blue-eye Trevalla (*Hyperoglyphe antarctica*)	105 305	106 672	98.72
Gemfish (*Rexea solandri*)	74 759	77 472	96.50
Snapper (*Pagrus auratus*)	54 361	283 480	19.18
Mackerel, Spotted (*Scomberomorus munroi*)	49 513	50 845	97.38
Mulloway (*Argyrosomus japonicus*)	41 374	76 585	54.02
Shark, Carpet (all species)	30 748	49 102	62.62
Teraglin (*Atractoscion aequidens*)	30 214	32 169	93.92
Shark, Gummy (*Mustelus antarcticus*)	23 489	36 449	64.44
Shark, Black Tip (*Carcharhinus brevipinna*)	23 342	35 116	66.47
Shark, School (*Galeorhinus australis*)	14 022	24 637	56.91
Tuna, Skipjack (*Katsuwonus pelamis*)	13 230	13 373	98.93
Trevally, Silver (*Pseudocaranx dentex*)	11 004	306 931	3.59
Tuna, Yellowfin (*Thunnus albacares*)	2 333	2 333	100.00

2.3.1d <u>*Tasmania*</u>

Striped trumpeter (Family Latridae; *Latris lineata*), parrotfish/wrasse (Family Labridae; *Pseudolabrus* spp.) and flathead (Family Platycephalidae; *Platycephalus bassensis, Leviprora laevigatus, Neoplatycephalus richardsoni*) dominated the commercial line catches of bony fish. Total catches were small ranging from 39 416 kg to 8 290 kg. Approximately 70%, 40% and 13% of the total catch for trumpeter, parrotfish and flathead respectively was taken by line (Table 2.4.).

Table 2.4. Top 15 (by weight) marine species/groups of fish taken by Tasmanian commercial line fisheries in the year 2000.

Species/Group	Catch by line (kg)	Total catch by all methods (kg)	Amount caught by line as percentage of all methods (kg)
Shark- Gummy (*Mustelus antarcticus*)	40 661	106 681	38.11
Trumpeter, Striped (*Latris lineata*)	39 416	56 395	69.89
Wrasse, Kelpie, Parrotfish, Bluethroat (*Pseudolabrus species*)	35 060	86 374	40.03
Shark, Seven gilled (*Notorhynchus cepedianus*)	14 532	15 995	90.85
Flathead (mainly *Platycephalus bassensis, Leviprora laevigatus, Neoplatycephalus richardsoni*)	8 290	63 889	12.97
Gurnard-all species (*Chelidonichthys kumu, Lepidotrigla papilio, Pterygotrigla polyommata*)	4 930	7 593	64.92
Morwong, Jackass, (*Nemadactylus macropterus*)	3 788	12 706	29.82
Shark, school (*Galeorhinus australis*)	3 531	4 202	84.05
Cod-all species	2 931	5 565	52.66
Barracouta (*Thyrsites atun*)	1 685	21 650	7.78
Shark, Unspecified	1 337	3 458	38.67
Skipjack Tuna (*Katsuwonis pelamis*), Southern Bluefin Tuna (*Thunnus maccoyii*), Albacore (*Thunnus alalunga*)	1 095	1 880	58.24
Salmon, Australian (*Arripis* spp.)	1 071	378 194	0.28
Skates (mainly *Raja* spp.)	648	2 170	29.86
Eel, Conger (*Conger species*)	450	1 098	41.00

2.3.1e Victoria

Snapper (Family Sparidae, *Pagrus auratus*), wrasse (Family Labridae; mainly *Pseudolabrus tetricus*) and barracouta (Family Gempylidae; *Thyrsites atun*) were the main bony fish species taken in the commercial line fishery in the 2000/2001 financial year. Catches ranged from 38 675 kg for snapper to 14 065 kg for barracouta. The total commercial line catch for all wrasse species was 32 554 kg. Between 48% and 91% of the total catch of these species was taken by line methods (Table 2.5). Only 1% of the total amount of Australian salmon (Family Arripidae; *Arripis trutta & A. truttacea*) caught by all commercial methods was taken by line yet these species were ranked fifth overall for bony teleost fish taken by line.

Table 2.5. Top 14 (by weight) marine species/groups of fish taken by Victorian commercial line fisheries in the 2000/2001 financial year.

Species/Group	Catch by line (kg)	Total catch by all methods (kg)	Amount caught by line as percentage of all methods (kg)
Snapper (*Pagrus auratus*)	38 675	79 928	48.39
Wrasse, unspecified species	22 141	30 824	71.83
Barracouta (*Thyrsites atun*)	14 065	16 072	87.51
Wrasse, bluethroat *Pseudolabrus tetricus*	10 413	11408	91.28
Shark, Gummy (*Mustelus antarcticus*)	7 909	24 750	31.96
Australian Salmon (*Arripis* spp.)	5 254	442 428	1.19
Shark, Seven-gilled (*Notorhynchus cepedianus*)	2 780	2 909	95.57
Wrasse, saddle (*Pseudolabrus fucicola*)	2 746	3 279	83.75
King George whiting (*Sillaginodes punctata*)	2 675	121 559	2.20
Skate, all species	2 380	15 472	15.38
Flathead, Unspecified	2 306	9 940	23.20
Leatherjacket-all species	1 688	43 391	3.89
Skates and Rays, Other	1 398	1 655	84.47
Sweep (*Scorpis* species)	1 036	1 441	71.89

2.3.1f Western Australia

Snapper (Family Sparidae; *Pagrus auratus*), spanish mackerel (Family Scombridae; *Scomberomorus commerson, S. semifasciatus*), dhufish (Family Glaucosomatidae; *Glaucosoma hebracium*), Nor-West snapper (Emperor) (Family Lethrinidae; *Lethrinus nebulosus*), samson fish/kingfish (Family Carangidae; *Seriola* species), jobfish/goldband snapper (Family Lutjanidae; *Pristopomoides multidens*), mackerel (Family Scombridae; Other species besides *Scomberomorus* spp.), trevally (Family Carangidae; unspecified species), sweetlip (Family Haemulidae/Lethrinidae) comprised the majority of species taken in the commercial line fishery with catches ranging from 709 000 kg to 52 647 kg in the 1999/2000 financial year (Table 2.6). Total catches for the other major commercially caught line species were all over 40 000 kg. Line-fishing methods accounted for between 50% and up to 99% of the total catches of bony fish for all species. Line catches of shark species ranked lower in WA than in other states.

Table 2.6. Top 15 (by weight) marine species/groups of fish taken by Western Australian commercial line fisheries in the 1999/2000 financial year.

Species/Group	Catch by line (kg)	Total catch by all methods (kg)	Amount caught by line as percentage of all methods (kg)
Snapper, Pink (*Pagrus auratus*)	709 073	738 660	95.99
Spanish mackerel (*Scomberomorus commerson, S. semifasciatus*)	336 361	337 345	99.71
Dhufish, WA (*Glaucosoma hebracium*)	187 750	210 781	89.07
Snapper, Nor-West (Emperor) (*Lethrinus nebulosus*)	101 308	166 830	60.73
Samson fish, Sea Kingfish (*Seriola* species)	87 496	102 077	85.72
Jobfish, Goldband Snapper (*Pristopomoides multidens*)	70 491	136 530	51.63
Mackerel, Other	67 404	72 682	92.74
Trevally, Unspecified	59 581	221 604	26.89
Sweetlip (Family Haemulidae/Lethrinidae)	52 647	102 791	51.22
Shark, thickskin, sandbar (*Carcharhinus plumbeus*)	52 171	232 458	22.44
Emperors *(Large Lethrinids, mainly L. nebulosus, L. miniatus, L olivaceus)*	50 821	91 749	55.39
Emperor, Sweetlip (Other)	48 875	52 198	93.63
Cod, Unspecified	46 668	106 834	43.68
Bronze whaler shark (*Carcharhinus brachyurus*)	41 802	348 199	12.01
Groper, Baldchin (*Choerodon rubescens*)	40 382	45 953	87.88

2.3.1g <u>*Queensland*</u>

The majority of the line-caught species are associated with coral reefs. Coral trout (Family Serranidae; *Plectropomus* spp.), emperors (Family Lethrinidae, *Lethrinus* spp.), spanish mackerels (Family Scombridae; *Scomberomorus* spp.), tropical snappers (Family Lutjanidae), cods (Family Serranidae), sweetlip (Family Lethrinidae), and jobfish (Family Lutjanidae) had total line catches ranging from 1 528 000 kg to 85 000 kg in 2000 (Table 2.7). The total quantities of these species taken by other fishing methods are believed to be insignificant (L. Solomon, QDPI, pers. comm.). Similar to WA, but in contrast to some of the more southern states, shark species were noticeably absent from the list of top species taken by line.

Table 2.7. Top 10 (by weight) marine species/groups of fish taken by Queensland commercial line fisheries in the year 2000.

Species/Group	Total caught by line (kg)	Total caught by other methods
Coral trout (*Plectropomus species*)	1 528 000	unreported
Emperor, Red throat (*Lethrinus species*)	631 000	unreported
Mackerel, Spanish (*Scomberomorus commerson, S. semifasciatus*)	527 000	unreported
Tropical snappers (Family Lutjanidae)	140 000	unreported
Mixed Reef B, unspecified species	125 000	unreported
Cods –unspecified (Family Serranidae)	112 000	unreported
Sweetlip (Family Lethrinidae)	110 000	unreported
Jobfish (Family Lutjanidae)	85 000	unreported
Snapper, Red (*Pagrus auratus*)	< 80 000	unreported
Mackerel, Shark (*Grammatorcynus bicarinatus*)	55 000	unreported
Mixed Reef A, unspecified species	27 000	unreported

2.3.1h Northern Territory

Few data were available for line catch of commercial species. The major commercial line-caught species taken within 15 nm of the coast during the year 2000 were black jew (Family Sciaenidae; *Protonibea diacanthus*), golden snapper (Family Lutjanidae; *Lutjanus johnii*), tricky snapper (Family Lethrinidae; *Lethrinus* spp.) and a mix of other species of lutjanids, lethrinids and cods (Table 2.8.). Black jewfish comprised over 70% of the total commercial line catch.

Table 2.8. Top line-caught fishes (by weight) taken in Northern Territory commercial line fisheries in the year 2000.

Species/Group	Catch by line (kg)	Total catch by all methods (kg)	Amount caught by line as percentage of all methods (kg)
Black jewfish (*Protonibea diacanthus*)	102 000	Unavailable	Unavailable
Golden snapper (*Lutjanus johnii*)	18 200	Unavailable	Unavailable
Tricky snapper (Family Lethrinidae)	3 000	Unavailable	Unavailable
Various cods, lethrinids, and lutjanids	19 760	Unavailable	Unavailable

2.3.1i Commonwealth managed fisheries

Large quantities of fish were taken by commercial line operations in Cwlth managed fisheries, with over 10 000 tonnes of fish taken in the 2000/2001 financial year. Total weights of all species caught by line exceeded catches of any species caught in state waters. Larger pelagic species dominated the catch. Broad billed swordfish (Family Xiphiidae; *Xiphias gladius*), striped marlin (Family Istiophoridae; *Tetrapturus audax*), tunas (Family Scombridae;

Thunnus albacares and *Thunnus obesus*, *Thunnus alalunga*,) and dolphinfish (Family Coryphaenidae; *Coryphaena hippurus*) comprised the majority of the pelagic line catch (Table 2.9). Over one third (3991 tonnes) of the total annual line catch was broad billed swordfish. Catches of deep-water species such as blue eye trevalla (Family Centrolophidae; *Hyperoglyphe antarctica*) and rudderfish (Family Centrolophidae; *Centrolophus niger*) range from over 300 tonnes to almost 500 tonnes per annum. Between 68% and 100% of the total catch of these species is taken by line methods. Release rates of target species in commonwealth fisheries are generally low (see Knuckey et al, 2001, 2002), however a large percentage (59.9 %) of southern bluefin tuna (*Thunnus maccoyii*) were released perhaps due to quota restrictions in place for this species.

Table 2.9. Top 15 (by weight) marine species/groups of fish landed in Australia by Australian vessels in Commonwealth commercial line fisheries during the 2000/2001 financial year and the percentage released for the calendar year 2001.

Species/Group	**Catch by line (kg)**	**Total catch by all methods (kg)**	**Amount caught by line as percentage of all methods (kg)**	**Percentage of line catch released (%) (2001)**
Broad Billed Swordfish (*Xiphias gladius*)	3 991 607	3 992 974	99.97	4.1
Tuna, Yellowfin (*Thunnus albacares*)	2 531 753	2 533 253	99.94	4.1
Bigeye Tuna (*Thunnus obesus*)	1 350 650	1 350 727	99.99	8.8
Striped Marlin (*Tetrapturus audax*)	718 698	718 698	100.00	4.8
Blue-eye Trevalla (*Hyperoglyphe antarctica*)	498 065	726 814	68.53	0
Albacore Tuna (*Thunnus alalunga*)	463 732	463 732	100.00	3.5
Rudderfish (*Centrolophus niger*)	300 743	310 189	96.95	1.8
Dolphinfish (*Coryphaena hippurus*)	171 903	171 903	100.00	9.4
Southern Bluefin Tuna (*Thunnus maccoyii*)	112 502	5 212 502	2.16	59.9
Ling (*Genypterus tigerinus*)	89 320	1 386 024	6.44	0
Jackass Morwong (*Nemadactylus macropterus*)	66 765	948 962	7.04	0
Hapuku (*Polyprion oxygeneios*)	31 948	74 428	42.92	0
Rosy Jobfish (*Pristipomoides filamentosus*)	30 075	32 667	92.07	0
Black Oilfish (*Ruvettus pretiosus*)	27 888	27 913	99.91	1.5
Northern Cod (unspecified species)	25 376	25 552	99.31	0
TOTAL	**10 401 021**			

Percentages of released finfish (sharks, tunas and billfish) for the four regions of Australia (Table 2.10) show high variability between regions and between species groups. The average release percentages throughout Australia were 55.8% for sharks, 7.1% for billfish and 5.4% for tunas (Table 2.10). The high release percentage of sharks was associated with high release percentages of blue, dusky and bronze whaler sharks from north-west and south-west Australia. Although percentage of released tunas was relatively high in north and southwest

Australia (56.8 and 20.4% respectively), the overall low percentage (5.4%) was due to high retention of yellowfin tuna in north-east and south-east Australia. Of the three groups, billfish showed the least regional variation in terms of percentage released.

Table 2.10. Percentages of three major finfish groups released in Commonwealth line fisheries for 2001 calendar year (T. Skoussen, AFMA, pers. comm.).

Species Group	NE Australia	NW Australia	SE Australia	SW Australia	Average for Australia
Sharks	55.0	95.6	11.6	92.4	55.8
Tunas	2.9	56.8	3.0	20.4	5.4
Billfish	7.9	13.2	2.4	5.9	7.1

2.3.1j Commercial freshwater fisheries

The use of hook and line methods to capture fish commercially in freshwater systems of Australia is limited to a few set-line operations targeting Murray cod (Family Percichthyidae; *Maccullochella peelii peelii*) in SA. No line catches of Murray cod were reported for the 2000/2001 financial year.

2.3.1k Summary of commercial line harvest.

The harvest by commercial line fishers in 1999/2000 was relatively large in Qld, WA, SA NSW and Cwlth waters but smaller in Vic and Tas (Figure 2.1). For all jurisdictions, a small number of species (up to 5) comprised up to 70% of the total harvest.

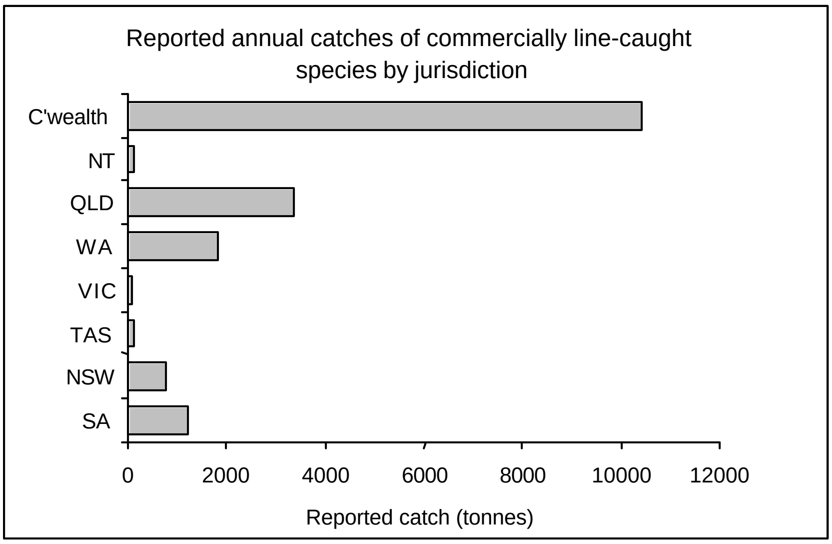

Figure 2.1. Annual harvest of commercial line-caught fish by jurisdiction for 2000/01.

2.3.2 Recreational fisheries

For all states and all regions percentages of released fish were extremely variable, ranging from 2.9% for European carp in SA to 95.6% for marine catfish in the NT (Table 2.11). For a number of marine temperate and tropical species, high percentages of release could be attributed to the species being caught regularly as bycatch when fishing for other species or to unfavourable eating qualities (eg. weedy whiting, *Haletta semifasciata* in SA; toadfish, Family Tetraodontidae and striped perch, *Pelates sexlineatus* in WA). For temperate marine species percentages of fish released were consistently high between states for more edible species such as snapper (*Pagrus auratus*) (45 – 75%). By comparison, consistently low percentages of release occurred for garfish (*Hyporhamphus melanochir*) (4 – 12.5%). For marine tropical species, barramundi (*Lates calcarifer*) and serranid cods (Family Serranidae) were released between 55.5 and 72% of the time. For freshwater species, highest percentages of release occurred for Australian bass (*Macquaria novemaculeata*), spangled perch (*Leiopotherapon unicolor*) and Murray cod (*Maccullochella peelii peelii*). Percentages of callop (golden perch) (*Macquaria ambigua*) released varied between 41 and 57% throughout its geographic range.

Table 2.11. The percentages of the most commonly caught finfish released by recreational line-fishers based on the results of the NRIFS for 2000/01. (NB: two sets of figures for a state denotes more than one species within that species group. Species highlighted in **bold** are those in which the percentage released is > 66.7% of the total catch)

a) Temperate marine species

Species	SA	NSW	Tas	Vic	WA	Qld	NT
Flathead		49	33.4, 40.6	45	58		
Australian salmon	20.7		26.7	48			
Australian herring	25				14.5		
Tailor		41			24.7	37	
Cod – rock, & slimy		**87**	37.4				
Wrasse			**70.1**	**86**			
Bream (black, yellowfin, tarwhine)		**67**	36.8	57	52.4, 64.3		
Mullet – yelloweye	24.6	32	42.6	33			
Trevally - silver			56.7		24.8		
Striped perch (Teraponids)	62.6				**83.6**	46	
Toadfish					**88.3**		
Garfish – all species	8.6	4		10	12.6		
Mackerel – blue, jack	24.1	15		11	36.4		
Snapper – pink, sthn	**75.1**	**74**		45	**69.9**	59	
KG whiting	33.1			17	26.8		
Whiting – sand	29.6	41				43	
Whiting – winter, unspecified	30.4				18.5	25.7	

Species	SA	NSW	Tas	Vic	WA	Qld	NT
Red mullet	37.6						
Gurnard			65.9				
Barracouta			28.3				
Jackass Morwong			14.4				
Luderick		31					
Leatherjacket	63.6	36					
Snook	4						
Sweep	52.4						
Weedy whiting	**82.7**						

b) Tropical/sub-tropical marine species

Species	SA	NSW	Tas	Vic	WA	Qld	NT
Marine catfish					92.1	77.1	95.6
Serranid cods					55.5-68.3	66.8	69
Barramundi					68.3	72.4	69
Lutjanid snappers					68.3	53.3	43-65
Coral trout						39.4	
Dart						60.7	
Lethrinid emperors					39.2 – 48.9	48.7	39
Trevally - golden					47.9	49.7	60
Spanish mackerels					26.7		
Wrasse spp.					77.8	46	
Sparid bream					50.9	62.5	
Shark - unspecified							92
Small baitfish							5
Mullet - unspecified							13
Queenfish							63

c) Freshwater temperate and tropical species

Species	SA	NSW	Tas	Vic	WA	Qld	NT
Callop, Golden Perch	57	41		45		40.8	
Trout - brown			24.2				
Trout - rainbow			30.2				
Redfin Perch		49	51.2	37			
European carp	2.9	12		13			
Murray cod				76			
Silver Perch				80			
Freshwater catfish						63.3	95
Spangled Perch						82.2	
Australian bass						87.4	

2.3.3 Scientific information

There has been very little research focussing on PRS of Australian line-caught fish. Some work has been done on tag loss and tag-induced mortality in Australian species of line-caught fish (see McGlennon and Partington, 1997; Quartararo and Bell, 1992) however for this review we concentrate on research relevant to injury and PRS relating to line-fishing. Previous research has been covered in Chapter 1, however a summary is provided in Table 2.12 to highlight research achievements so far.

Table 2.12. Summary of Australian research relating to post-release survival of line-caught fish.

SPECIES	RESEARCH
Snapper (Family Sparidae; *Pagrus auratus*)	"Maximising survival of released undersize west coast reef fish (FRDC 2000/194)". Research used tagging and caging experiments to investigate survival influenced by catch and handling methods (hook type, hook location, ascent time, deck time), depth, size of fish and venting of the swimbladder in WA. (Moran and St John, 2001).
Snapper (Family Sparidae; *Pagrus auratus*)	"Biology requirements and yield and egg per recruit estimates for management of the South Australian snapper (*Pagrus auratus*) fishery." Research used an assumed level of catch-and-release mortality to model the effect of a maximum size limit on egg and yield per recruit in SA (McGarvey and Jones, 2000).
Snapper (Family Sparidae; *Pagrus auratus*)	"Minimising the cost of future stock monitoring, and assessment of the potential for increased yields from the oceanic snapper, *Pagrus auratus*, stock off Shark Bay. (FRDC 2000/138)." Research in WA assessed risks to snapper stocks at a range of annual commercial and recreational catches taking into account mortality of released fish. (Moran and St John, 2000)
Western Australian Dhufish (Family Glaucosomatidae; *Glaucosoma hebracium*)	"Maximising survival of released undersize west coast reef fish (FRDC 2000/194)." See above
Baldchin groper (Family Labridae; *Choerodon rubescens*)	"Maximising survival of released undersize west coast reef fish (FRDC 2000/194)." See above
Venus tusk fish (Family Labridae; *Choerodon venustus)*	"The Biology of and effects of line fishing on the venus tusk fish *Choerodon venustus*." Research used observations of swimming behaviour on the Great Barrier Reef, Qld, to measure the level of impact of barotrauma on fish after swimbladder venting (Platten, unpublished data).
Breaksea cod (Family Serranidae; *Epinephelus armatus*)	"Maximising survival of released undersize west coast reef fish (FRDC 2000/194)." See above.
Wire netting cod (Family Serranidae; *Epinephelus quoyanus*)	"Hooking mortality of two species of shallow water reef fish caught by recreational angling methods." Research used tagging and tank experiments to measure PRS in response to different hook types, hook location, hook damage, handling time and water temperature on the Great Barrier Reef, Qld (Diggles and Ernst, 1997).
Yellow stripey (Family Lutjanidae; *Lutjanus carponotatus)*	"Hooking mortality of two species of shallow water reef fish caught by recreational angling methods." See above (Diggles and Ernst, 1997).

SPECIES	RESEARCH
Yellowfin bream (Family Sparidae; *Acanthopagrus australis*)	"Scale-loss and survival of juvenile yellowfin bream, *Acanthopagrus australis*, after simulated escape from a Nordmore-grid guiding panel and release from capture by hook and line." Research used captive tank experiments to measure damage and PRS of juvenile fish in response to hooking and variable handling times. (Broadhurst *et al.*, 1999).
Mulloway (Family Sciaenidae; *Argyrosomus japonicus*)	"Effects of capture by hook and line on plasma cortisol, scale loss and survival in juvenile mulloway, *Argyrosomus hololepidotus*." Research involved the use of captive tank experiments to measure stress, handling damage and survival in juvenile fish (Broadhurst and Barker, 2000).
King George whiting (Family Sillaginidae; *Sillaginodes punctata*)	"The impact of commercial hauling nets and recreational line fishing on the survival of undersize King George whiting (*Sillaginodes punctata*)." Research in SA used captive tank experiments to measure stress, hook injury level and PRS for sub-legal length fish (Kumar *et al.*, 1995).
Deep-water dogfish (Family Dalatiidae; *Centroscymnus* spp.)	"Catch analysis and productivity of the deepwater dogfish resource in Southern Australia (FRDC 1998/108)." This research involved estimating mortality of the discarded catch of deep-water dogfish within different geographical areas and depth strata within the Southern shark, Western Australian shark, South East trawl, Great Australian Bight trawl and South Australian dropline fisheries (Stevens, 2000).
Tailor (Family Pomatomidae; *Pomatomus saltatrix*)	"Short-term hooking mortality of tailor (*Pomatomus saltatrix*) in Western Australia and the impact on yield per recruit." Research investigated differences in mortality between different hook types (Ayvazian *et al.*, 2001).
Tropical snappers (Family Lutjanidae; *Lutjanus sebae, Lutjanus malabaricus, Lutjanus erythropterus, Pristipomoides multidens*)	"Assessment of barotrauma in deep-water snappers using video techniques." Research in the NT used video to assess the effects of barotrauma of deepwater snappers held in cages (Lloyd, 2000).
Black marlin (Family Xiphidae; *Maikaira indica*)	"Post-release behaviour of black marlin, *Makaira indica*, caught off the Great Barrier Reef with sportfishing gear." Research used ultrasonic telemetry to track five fish for up to 27 hours (Pepperell and Davis, 1999).
Coral trout (Family Serranidae; *Plectropomus* spp.)	"Investigation of dory tank dynamics on the stress responses of coral trout". Research measured plasma-cortisol levels to assess stress of coral trout held in live holding tanks for live fish export. (Kane *et al.*, in print)
Wrasse (Family Labridae; *Notolabrus tetricus*.)	"The stress response of Wrasse (*Notolabrus tetricus*) to capture, handling and transport: implications for live fish transport". Research measured plasma-cortisol and haemoglobin levels to assess stress of wrasse held in holding facilities for transport (Steffens, 1994).

2.3.4 Prioritising species for research

Results of the rankings obtained from the questionnaire for all species in all states are provided in appendix 4. The top 10 marine species/groups identified as potentially susceptible to high levels of catch-and-release mortality are listed in Table 2.13. Data from WA and Qld include both temperate and tropical/sub-tropical species. Species/groups common to temperate, tropical and subtropical waters are listed twice (depicted in bold type). Rankings obtained from data collated for species in the NT were not weighted as scores for each factor established by consensus during a meeting of scientists, fishing representatives and managers.

For freshwater ecosystems, Australian bass (*Macquaria novemaculeata*) ranked as the species most potentially susceptible to high levels of catch-and-release mortality in NSW and Qld and ranked second in Vic. Murray cod (*Maccullochella peelii peelii*) were identified as being potentially susceptible to high levels of catch-and-release mortality in SA (rank 1), Vic (rank 5) and Qld (rank 3). Callop (*Macquaria ambigua*) also ranked highly in SA (2), NSW (2), and Qld (4). In WA brown trout (*Salmo trutta),* and rainbow trout (*Oncorhynchus mykiss)* were the key species highlighted as were saratoga (*Scleropages* spp.) and catfish (all species) in the NT. It should be noted that barramundi (*Lates calcarifer*) are anadromous and were included in the analysis covering marine species.

Table 2.13. The ranking of Australian marine line-caught species with respect to criteria that reflect their susceptibility to catch-and-release mortality. Species/groups common to temperate, tropical and subtropical waters are listed twice (depicted in bold type).

RANKING	SOUTH AUSTRALIA	NEW SOUTH WALES	TASMANIA	VICTORIA	WESTERN AUSTRALIA	QUEENSLAND	NORTHERN TERRITORY
TEMPERATE WATERS 1	Snapper (*P. auratus*)	Black/Yellowfin bream (*Acanthopagrus* spp.)	Australian salmon (*A. trutta*)	Australian salmon (*A. truttacea*, *A .trutta*)	Breaksea and chinaman cods (*E. armatus*, *E. rivulatus*)	Bream, yellowfin, northwest black (*Acanthopagrus* spp.)	
2	Mulloway (*A. japonicus*)	Luderick (*Girella* spp.)	Flathead (*Platycephalus* spp.)	Flathead (*Platycephalus* spp.)	Western Australian dhufish (*G. hebracium*)	Snappers/seaperches and hussar (*Lutjanus* spp.)	
3	King George whiting (*S. punctata*)	Flathead (*Platycephalus* spp.)	Gummy shark (*M. antarcticus*)	Estuary perch (*M.colonorum*)	Australian salmon (*A. truttacea*)	Emperors (*Lethrinus* spp.)	
4	Australian salmon (*A .truttacea*)	Sand whiting (*S. ciliata*)	Bluethroat/purple wrasse (*Pseudolabrus* spp.)	Bream (*A. butcheri*)	Pink snapper (*P. auratus*)	Cods (Family Serranidae)	
5	Bluefin tuna (*T. maccoyii*)	Tailor (*P. saltatrix*)	Jackass morwong (*N. macropterus*)	Snapper (*P. auratus*)	Groper and tuskfish (*Choerodon* spp.)	Mackerels (*Scomberomorus* spp.)	
6	Black bream (*A. butcheri*)	Yellowtail kingfish (*S .lalandi*)	Southern bluefin tuna (*T .maccoyii*)	King George whiting (*S .punctata*)	Bream –black, yellowfin, northwest black (*Acanthopagrus* spp.)	Whiting-sand, gold-lined, northern (*Sillago* spp.)	

RANKING	SOUTH AUSTRALIA	NEW SOUTH WALES	TASMANIA	VICTORIA	WESTERN AUSTRALIA	QUEENSLAND	NORTHERN TERRITORY
7	Garfish (*H. melanochir*)	Mulloway (*A. japonicus*)	School shark (*G. australis*)	Gummy shark (*M. antarcticus*)	King George whiting (*S. punctata*)	Flathead (*Platcephalus* spp.)	
8	Flathead (*Platycephalus* spp.)	Groper (*A. viridis*)	Leatherjackets (Family Monacanthidae)	Elephant fish (*C. milii*)	Tailor (*P. saltatrix*)	Pearl perch (*G. scapulare)*	
9	Yellowtail kingfish (*S. lalandi*)	Billfish (Families Istiophoridae & Xiphidae; Marlins and Sailfish)	Bastard trumpeter (*L .forsteri*)	Garfish (*H. melanochir*)	Whiting-western sand, school and yellowfin (*Sillago* spp.)	Tailor (*P. saltatrix*)	
10	Blue groper (*A. gouldii*)	Australian salmon (*A. trutta)*	Black bream (*A. butcheri*)	Mullet (*A. forsteri*)	Australian herring (*A. georgianus*)	Queenfish (*S.commersonnianus*)	
TROPICAL & SUBTROPICAL WATERS 1					Tropical snappers (*Lutjanus* spp. *Pristipomoides* spp.)	Snappers/seaperches and hussar (*Lutjanus* spp.)	Golden snapper (*L. johnii*)
2					Breaksea and chinaman cods (*E. armatus*, *E. rivulatus*)	Barramundi (*L. calcarifer*)	Emperors (*L. laticaudis*, *Lethrinus* spp.)
3					Emperors (*L. nebulosus*, *Lethrinus* spp.)	Emperors (*Lethrinus* spp.)	Black jewfish (*P .diacanthus*)

RANKING	SOUTH AUSTRALIA	NEW SOUTH WALES	TASMANIA	VICTORIA	WESTERN AUSTRALIA	QUEENSLAND	NORTHERN TERRITORY
4					Coral trout (*Plectropomus* spp.)	Coral trout (*Plectropomus* spp.)	Mackerels (*Scomberomorus* spp.)
5					Mackerels (*Scomberomorus* spp.)	Cods (Family Serranidae)	Coral trout (*Plectropomus* spp.)
6					Baldchin groper and tuskfish (*Choerodon* spp.)	Mackerels (*Scomberomorus* spp.)	Fingermark bream (*L. russelli*)
7					Barramundi (*L. calcarifer*)	Giant threadfin salmon (*P. sheridani*)	Barramundi (*L. calcarifer*)
8					Mangrove jack (*L. argentimaculatus*)	Threadfin salmon- (*E .tetradactylum, Polydactylus* spp.)	Tropical snapper (*L. carponotatus*)
9					Threadfin salmon- (*Polydactylus* spp., *E. tetradactylum*)	Mangrove jack (*L .argentimaculatus*)	Sharks (all species)
10					Sharks (all species except whale sharks).	Queenfish (*S.commersonnianus*) .	Bream (*Acanthopagrus* spp.)

2.3.5. Confirming species for research

Meetings with fisheries scientists and managers in each state confirmed species requiring priority catch-and-release research. Rankings obtained in meetings closely resembled those resulting from the questionnaire and are fully listed in Appendix 5. Figures 2.2 (a & b) depict the groups of fishes that were highlighted in meetings as priorities for catch-and-release research. Fishes are split into temperate, subtropical and tropical aquatic ecosystems.

Similar groups of species were identified as being priorities for future research in several of the tropical/subtropical ecosystems. For example, in the pelagic offshore ecosystem, billfish (Families Istiophoridae and Xiphidae) and mackerels (*Scomberomorus* spp.) were identified as being important in WA, NSW, and Qld. Similarly, barramundi (*Lates calcarifer)* was ranked as the highest priority for catch-and-release research in sheltered coastal ecosystems in WA, NT and Qld. For the tropical reef ecosystem, large tropical snappers (Family Lutjanidae) ranked highly in WA, NT and Qld; however, large emperors (Family Lethrinidae) and cods (Family Serranidae) were identified as priorities for research in WA and Qld only; maori wrasse (*Cheilinus undulatus*) was regarded as a high priority for research on reefs of Qld, but not in WA (where it is protected). Similarly, in high energy coastal ecosystems black jewfish (*Protonibea diacanthus*) was a high research priority in WA and NT, but not in Qld. Mangrove jack (*Lutjanus argentimaculatus*) and golden trevally (*Gnathanodon speciosus*) were recognised as priorities for research in Qld and WA respectively. No freshwater species were regarded as high priorities for research in the tropics; however, it should be remembered that barramundi (*Lates calcarifer*) was listed as a marine species for this review.

Similar suites of species were identified as being priorities for future research in the each of the ecosystems in states with temperate waters (Figure 2.2.b). For example, snapper (*Pagrus auratus*) was identified as a priority for future research in reef and coastal sheltered ecosystems in WA, SA, Vic, NSW and Qld; flathead (several species) was considered a priority for research in sheltered coastal ecosystems of Qld, NSW and Tas; breams (*Acanthopagrus* spp.*)* were identified as being important in Vic, Tas, NSW and WA; and mulloway (*Argyrosomus japonicus*) was considered to be significant in NSW, SA and WA.

Meetings with fisheries scientists and managers concluded that native species and sport fished species (*e.g.* trout) were likely to benefit more from research on stock enhancement and the effects of habitat degradation than research on PRS.

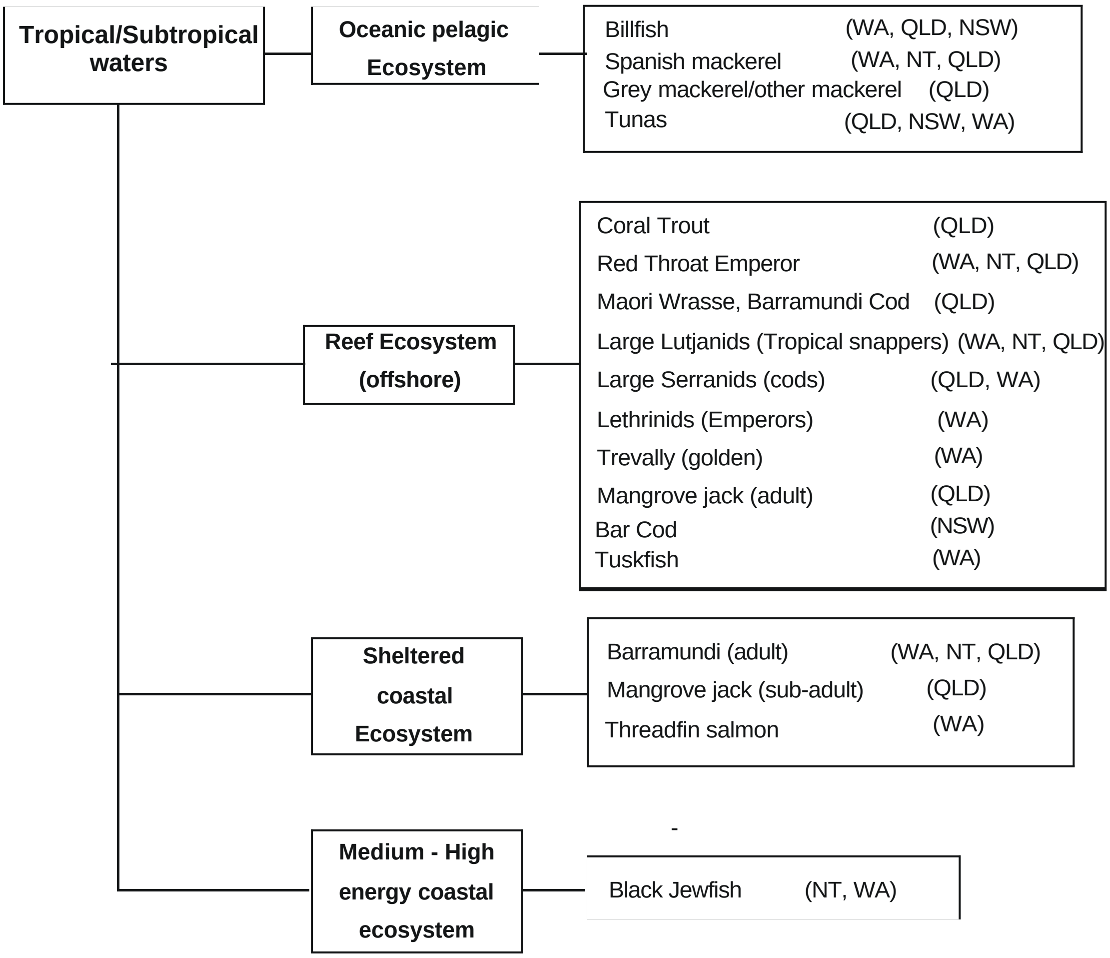

Figure 2.2a. Tropical/subtropical species priorities for catch and release research in Australia.

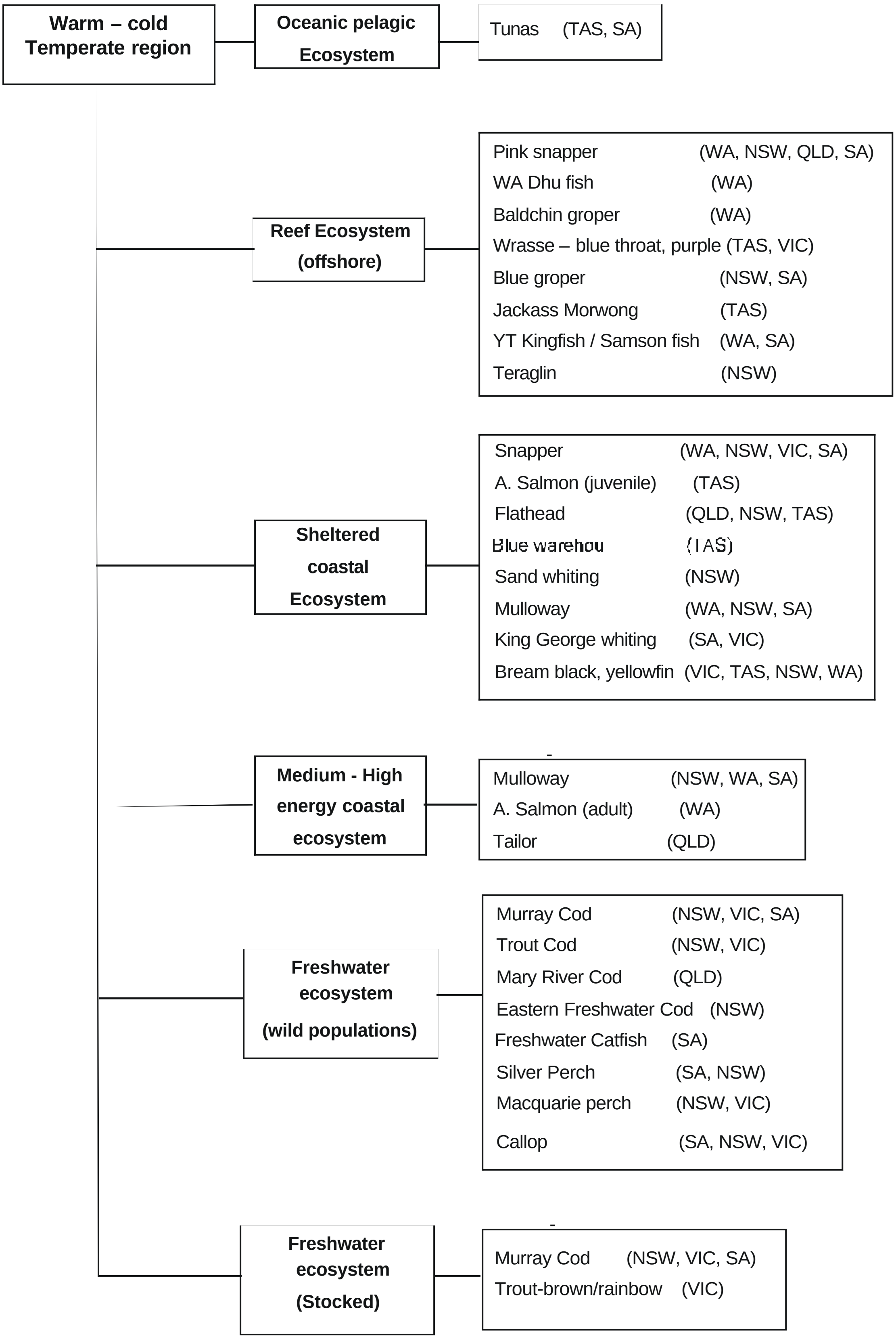

Figure 2.2.b. Temperate water species priorities for catch and release research in Australia.

2.3.6. Prioritising research on factors affecting post-release survival

Of the eight factors listed as influencing fishes' PRS, a small number were consistent identified within ecosystems in subtropical/tropical and temperate regions (Figures 2.3 a & b). For tropical and temperate pelagic ecosystems, play length and handling were the two most important factors affecting PRS. For species inhabiting reef ecosystems barotrauma, hook damage and handling were highlighted as the three most important factors. For sheltered coastal ecosystems handling and hook damage were highlighted as having the greatest influence on PRS. For medium energy coastal ecosystems handling was deemed the most important factor and secondary factors were play length and hook damage. The most important factors that influence PRS of line-caught fishes are listed in Appendix 5.

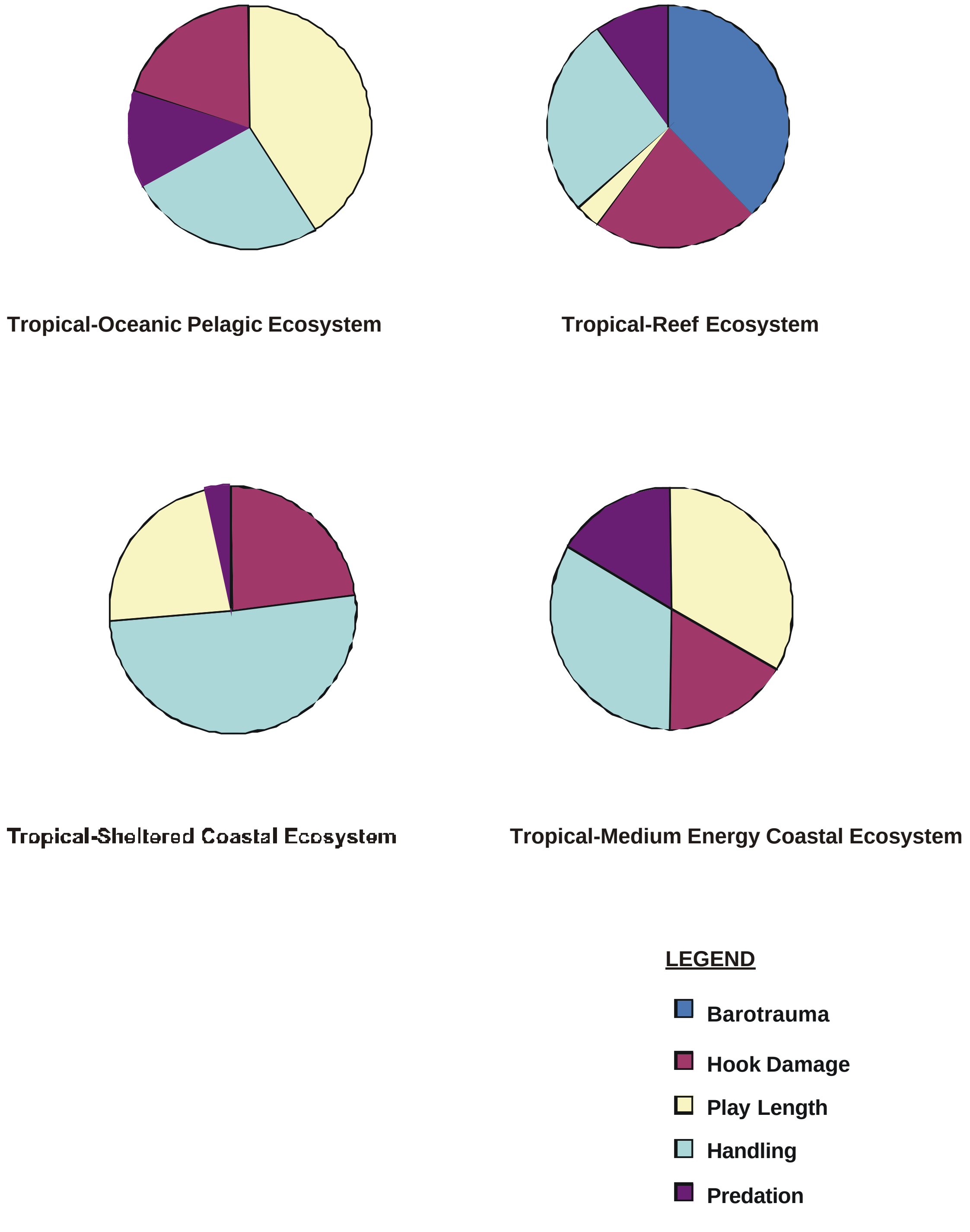

Figure 2.3.a. Factors potentially affecting levels of post-release survival among four different ecosystems in tropical/subtropical waters.

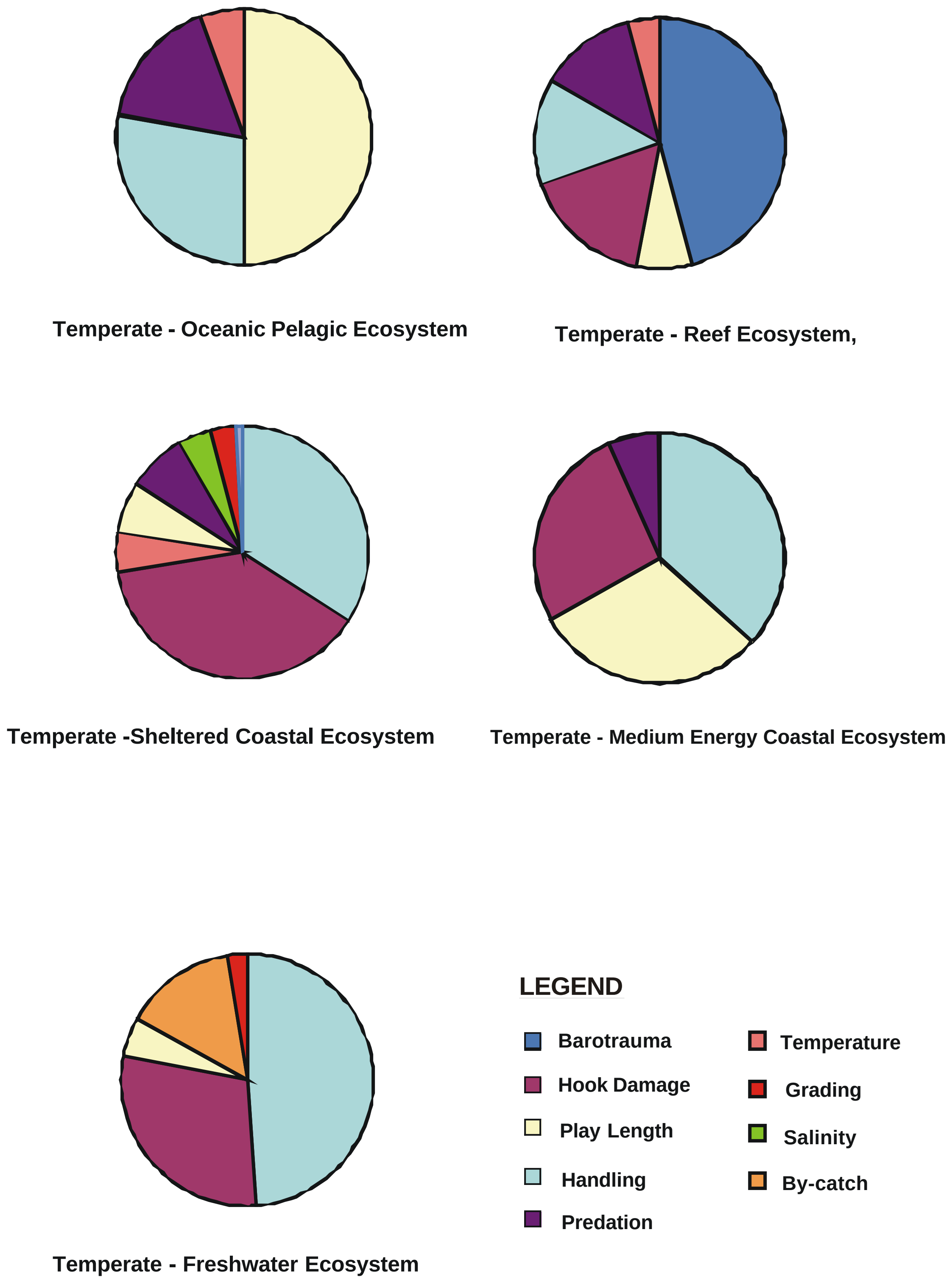

Figure 2.3.b. Factors potentially affecting post-release survival among five different ecosystems in warm/cold-temperate waters..

2.4. Discussion

The influence of catch-and-release fishing on a line-fished population is dependent on the level of fishing pressure and the extent to which fish populations can sustain harvest and non-harvest mortality. Low levels of catch-and-release mortality may still have a large effect on a fished population if the number of fish released is high. This review has identified sources of information on the numbers of fish released by line fishers. It has also identified parts of the line-fishing sector where monitoring systems need to be improved if the effects of non-harvest mortality are to be better understood. The fishes potentially susceptible to high levels of catch-and-release mortality were identified by combining information on the numbers of fish caught and released in Australian recreational and commercial line fisheries with information obtained from fishery scientists, managers and industry representatives. Priorities for research on the PRS of Australian line-caught species were then identified in light of previous and current Australian and international studies.

Few data are available for the numbers and weight of fish discarded by commercial line operators. Commercial fishers are likely to release smaller proportions of fish than recreational fishers as they are unlikely to target undersize fish and likely to stop fishing when quotas are taken. Using catch weight to identify species that are potentially released in high numbers is problematic, as larger species, such as sharks, tend to rank more highly than smaller species. Despite this bias, catch data provides a preliminary indication of commercial species that may be released in large numbers and potentially susceptible to high rates of catch-and-release mortality.

Data on the total numbers of fish released in recreational line fisheries are essential for confirming the species potentially vulnerable to catch-and-release mortality, and were collected in the NRIFS but not made available in their entirety to the present project. Data provided by the NRIFS on the percentages of fish released by recreational fishers were consistent between states. For example, high percentages of snapper (*Pagrus auratus*) were released in all the states. Regulations such as minimum size limits and bag limits are not the only factors contributing to high rates of release. Fisher attitudes and the strength of the year classes below the minimum size limit can also be significant. For example, species of emperor (Family Lethrinidae) and snapper (Family Lutjanidae) have no minimum size limit in the NT yet percentages released were comparable to those in Qld and WA where minimum size limits are in place. Closer monitoring is needed to determine the main factors that affect the rates of release in different fisheries.

Results obtained from the questionnaire closely resemble the priority species lists developed during meetings with scientists and managers in each state. However, a number of marine species originally ranked as high priorities for research were given lower priority at the meetings due to their relatively low ecological and socio-economic importance in some states or if rankings were considered to be artefacts of respondent error (*e.g.* luderick (*Girella* spp.) in NSW; leatherjackets (Family Monacanthidae) and bastard trumpeter (*Latridopsis forsteri*) in Tas). Furthermore, some species that ranked as low priorities for research in the questionnaire were ranked more highly after meetings with scientists and managers (*e.g.* billfish (Family Xiphidae) in WA, Qld and NSW; saddletail snapper (*Lutjanus malabaricus*) in the NT; bluethroat wrasse (*Pseudolabrus* spp.) in Vic). Data obtained from the NRIFS confirmed that large percentages of highly ranked species (*e.g.* snapper) were released and that those species were potentially susceptible to high levels of catch-and-release mortality.

Few studies have been conducted on PRS in Australian line fisheries. Recent studies of reef species such as snapper (*Pagrus auratus*), dhufish (*Glaucosoma hebracium*) and baldchin groper (*Choerodon rubescens*) in WA have highlighted the cost-effectiveness of conducting research on species that co-exist within an ecosystem (*e.g.* temperate reefs). Suites of species inhabiting similar environments require investigation in several states and a nationally coordinated approach to future PRS research is needed. However, because fishing operations and fisheries regulations differ between states, research in each state should be tailored to fit local needs and issues.

Snapper (*Pagrus auratus*) was identified as a high priority for research on reef ecosystems in WA, Vic, SA, NSW and Qld and should be the focus of a nationally coordinated research program on PRS. Significant benefit could also be gained by broadening the study to include other species that occur on reefs. The research program on snapper recently undertaken in WA used this approach to obtain information on dhufish (*Glaucosoma hebracium*), baldchin groper (*Choerodon rubescens*) and breaksea cod (*Epinephelus armatus*) as well as snapper (FRDC 2000/194). A research project that focussed on snapper on temperate reefs could also provide information on bluethroat wrasse (*Pseudolabrus* spp.) in Vic, blue groper (*Achoerodus* spp.), kingfish (*Seriola lalandi*) and adult King George whiting (*Sillaginodes punctata*) in SA, and teraglin (*Atractoscion aequidens*) in NSW. Research programs on fish inhabiting reef ecosystems should focus on barotrauma, handling and hook damage, as these factors are most likely to influence PRS.

Snapper (*Pagrus auratus*) was also identified as a high priority for research in temperate sheltered coastal ecosystems in WA, Vic, SA and NSW. Similarly, flathead (*Platycephalus* spp.*)* was identified as a priority for future research in these ecosystems in Qld, NSW and Tas. A nationally coordinated research project that focussed on snapper and flathead in sheltered coastal ecosystems could provide additional data on juvenile mulloway (*Argyrosomus japonicus*) in WA, NSW and SA, juvenile Australian salmon (*Arripis* spp.) in Tas, bream (*Acanthopagrus* spp.) in Vic, Tas, NSW and WA and whiting (*Sillaginodes punctata*, *Sillago* spp.) in SA, Vic and NSW. Research programs on fish inhabiting sheltered coastal ecosystems should focus on handling stress, hook damage and play length.

Similar benefits could be gained by a nationally coordinated research program on mulloway (*Argyrosomus japonicus*) in medium-high energy ecosystems of SA, NSW, and WA. Species such as Australian salmon (*Arripis truttacea*) and tailor (*Pomatomus saltatrix*) coexist with mulloway in some of these areas and could be included in research projects as state (cf. national) priorities. Research programs on fish inhabiting medium-high energy ecosystems should focus on handling stress and hook damage.

For pelagic ecosystems, nationally coordinated research should focus on species targeted by gamefishers in tropical and subtropical waters. Marlins (*Makaira indica*, *Makaira mazara*) and sailfish (*Istiophorus* spp.) support important tourism industries in WA, NT, Qld, and NSW. Gamefishing operations release a high percentage of billfish based on the assumption that there is a high survival rate. The Game Fishing Association of Australia has already implemented the use of pop off satellite archival tags (PSATs) to estimate PRS of marlins on the East Coast. Additional benefit would be gained through the national coordination of such research programs. In oceanic pelagic waters of WA, Qld, NSW, Tas and SA there is also a need to implement research programs for tunas (*Thunnus* spp.). Mackerels (*Scomberomorus* spp.) also require research in WA, NT and Qld. Play length, handling and hook damage are the key factors affecting PRS of these species. High release rates of southern bluefin tuna (*Thunnus maccoyii*) and shark (*Charcharinus* spp., *Prionace glauca*) by commonwealth pelagic and demersal longline fishers respectively, suggest some research may be needed to better understand how different rates of PRS contribute to overall catch mortality (ie. retained + non retained harvest components) in these fisheries. Soak time is likely to be a major factor affecting PRS in set-line fisheries.

Large tropical snappers (Family Lutjanidae), emperors (Family Lethrinidae), and cods (Family Serranidae) have significant tourist and commercial value in tropical reef ecosystems of WA, NT and Qld. Coral trout (*Plectropomus* spp.*)* and red-throat emperor (*Lethrinus miniatus*) should be a primary research focus in Qld with other co-habiting species such as maori wrasse (*Cheilinus undulatus)* studied opportunistically. Similarly golden snapper

(*Lutjanus johnii*), and red emperor (*Lutjanus sebae*) should be the focus of research in the NT. Spangled emperor (*Lethrinus nebulosus*), red-throat emperor (*Lethrinus miniatus*), red emperor (*Lutjanus sebae*), red snapper (*Lutjanus erythropterus*) and saddle-tail snapper (*Lutjanus malabaricus*) are priorities for research in WA. Although the priorities for research vary between states, there is considerable overlap in the species occurring within these coral reef ecosystems and research should be coordinated nationally. As in the temperate reef ecosystems, barotrauma, hook damage and handling are the key factors influencing PRS of tropical reef species.

For tropical coastal sheltered ecosystems, barramundi (*Lates calcarifer*) was highlighted as the priority for research in the NT, Qld and WA. A research project on the effects of handling, playlength and hook damage on PRS of barramundi is underway in the NT (FRDC Project 2002/039). Future research on the PRS of barramundi should build on knowledge gained in the NT study and could also provide information on other species encountered when fishing for barramundi, such as mangrove jack (*Lutjanus argentimaculatus*) and threadfin salmon (*Polydactylus* spp.).

DIRECT BENEFITS AND BENEFICIARIES

This project is part of a national strategy to enhance the PRS of Australian line-caught fish and will provide a basis for planning and coordinating future research.

The steering committee for the national strategy will benefit from this project by having access to:

(i) a review of data sources and previous research on PRS of line-caught fish;
(ii) an assessment of methods for investigating PRS;
(iii) a prioritised list of species with potentially low levels of PRS;
(iv) an analysis of approaches and methods for future research.

This information will also benefit fisheries managers in each state. Research projects established as a result of this project will provide information required to incorporate non-harvest mortality into stock assessment models and identify management strategies to increase rates of PRS of line-caught fish.

Fishers will benefit from increases in the size of fish populations resulting from improved stock assessment procedures, refined management arrangements and increases in PRS resulting from nationally coordinated research established on the basis of information presented in the report.

The review of previous research and the analysis of suitable approaches and methods for future research will benefit fisheries scientists in each state.

Information provided in this review will also enhance the communication and extension strategy that is proposed for 2002.

The assessment of approaches and methods for future research presented in this review will benefit FRDC by providing a sound basis for developing future research strategies.

FURTHER DEVELOPMENT

This project will aid the development of future research projects on the PRS of line-caught fish and aid managers by addressing research and management issues relating to PRS at a national level. The document provides advice to the FRDC Steering Committee for the National Strategy for the Survival of Released Line-caught Fish for use in prioritising future Australian research in this field. It also provides up to date information to the communications and extension strategy (FRDC Project 2002/099) on existing research on PRS of line-caught fish and current strategies to minimise harm of fish released from line.

PLANNED OUTCOMES

This project is the first step in assessing the importance of PRS of line-caught fish to the sustainability of line fisheries of Australia. Literature and data sources relating to PRS and release rates of line-caught species in International and Australian fisheries are identified. It has highlighted the species requiring future research in Australia, the types of information required in future monitoring systems that measure PRS and the strategies best applied to researching PRS of line-caught fish. This information will aid researchers and managers in addressing issues relating to PRS at a national and state level..

CONCLUSIONS

Apart from the Cwlth pelagic and demersal long-line and dropline operations of the South East Non-trawl fishery and Qld reef-line fishery, few data are available on the numbers of line-caught fish released by the commercial sector. Monitoring programs are needed to collect these data for other commercial line fisheries. Systems for collecting these data are also needed for the charter-boat fisheries in SA, Vic and Tas. There are some data on the numbers of fish released by recreational fishers in some states. Results of the NRIFS will be important for identifying the number of fishes released by anglers. Fine-scale analyses of spatial and temporal trends in catch-and-release activities are also required. Future data collection systems should detail not only the numbers and size of fish caught and released but the condition of released fish and the characteristics of the fishing operation.

Information obtained from fishers, fishery managers and fishery biologists in each state highlighted the need for research on socio-economically important species. Several species and groups of species were identified as priorities for research in several states. Future research should be coordinated nationally and would benefit from the development of a standardised system for classifying stress, condition and injury and the stressors applied during catch-and-release procedures. An advisory group should be established to coordinate technical aspects of future research projects.

Future studies should involve refined fishery monitoring systems, manipulative experiments using cages, tanks and pens as well as tagging studies. Cages that hold fish may be particularly useful for assessing how barotrauma affects short-term (<3days) rates of PRS. Cages, laboratory facilities with tanks or ultrasonic tags may be appropriate for measuring short-term (<3days) PRS of fish affected by different levels of hook damage, handling stress and play length. Experiments that use pens may be better for assessing long-term (>3days) responses to different levels of hook damage, handling stress and play length. Tagging programs can provide estimates of relative rates of PRS associated with different catch and release procedures. PSATs are more suitable for measuring absolute PRS rates of larger species in response to different levels of hook damage and changes in play length and handling time. Future studies should include assessments of the benefits of various harm minimisation strategies.

Future nationally coordinated research projects should be ecologically (cf. taxonomically) based. Studies conducted within an ecosystem (*e.g.* temperate reefs) should focus on one or several species (*e.g.* snapper) but could also provide information on coexisting species that are state (cf. national) research priorities.

For temperate and subtropical reef ecosystems in WA, SA, Vic, NSW and Qld, the national priority for research is snapper (*Pagrus auratus*). The project on snapper should consult closely with researchers in WA who are already conducting PRS research and focus on the effects of barotrauma, handling and hook damage. The project could also provide additional data on PRS of blue throat wrasse (*Pseudolabrus* spp.) in Vic, blue groper (*Achoerodus* spp.), kingfish (*Seriola lalandi*) and adult King George whiting (*Sillaginodes punctata*) in SA and teraglin (*Atractoscion aequidens*) in NSW.

The national priorities for research in temperate sheltered coastal ecosystems are snapper in WA, SA, Vic, and NSW and flathead (*Platycephalus* spp.) in Qld, NSW and Tas. The project on these species should focus on the effects of handling, hook damage and play length. Additional data could be obtained on juvenile mulloway (*Argyrosomus japonicus*) in WA, NSW and SA, juvenile Australian salmon (*Arripis* spp.) in Vic and Tas, bream (*Acanthopagrus* spp.) in Tas, NSW and Vic and King George whiting (*Sillaginodes punctata*) in SA and Vic.

For coral reef ecosystems, research is needed on many species and the relative importance of these species varies between states. However, there will be considerable benefits in coordinating the research nationally. The project should focus on coral trout (*Plectropomus* spp.) and red-throat emperor (*Lethrinus miniatus*) in Qld; golden snapper (*Lutjanus johnii*) and red emperor (*Lutjanus sebae*) in the NT; spangled emperor (*Lethrinus nebulosus*), red-throat emperor (*Lethrinus miniatus*), red emperor (*Lutjanus sebae*), red snapper (*Lutjanus erythropterus*) and saddle-tail snapper (*Lutjanus malabaricus*) in WA. As in the temperate reef ecosystems, the project should focus on the effects of barotrauma, handling and hook damage.

For tropical sheltered coastal ecosystems, barramundi (*Lates calcarifer*) is the national priority for research. A project on the effects of handling, play length and hook damage on PRS of barramundi is underway in the NT (FRDC Project 2002/039) and results from that project are likely to benefit researchers and managers in Qld and WA.

For oceanic pelagic ecosystems in WA, NT, Qld, and NSW, marlins (*Makaira indica, M. mazara*), sailfish (*Istiophorus* spp.), tunas (*Thunnus* spp.) and mackerels (*Scomberomorus* spp.) are the priorities for research. Tunas (*Thunnus* spp.) are also priorities for research in Tas and SA. PSATs may be useful for measuring the effects of play length, hook and handling damage on the PRS rates of these species. Diagnostic measurements of stress taken during tagging could also be used to determine the effect of physiological status on rates of PRS.

Detailed analysis of historical data held by ANSA on the catch-and-release procedures used on recaptured fish may provide estimates of the relative rates of PRS associated with handling procedures commonly used on key recreational species.

Information on the effects of different gear types on rates of PRS in Australia's line fisheries is needed and has the potential to increase PRS. Studies that assess relative and total PRS in response to different gear types could be incorporated into manipulative experiments of key recreational species and/or examined in future mark-recapture programs.

Estimates of catch-and-release mortality obtained from experiments or tagging programs should be incorporated into stock assessment models for line-fished populations. Models should explicitly assess the effects of PRS on population sizes and the potential and actual benefits resulting from various harm minimisation procedures.

A communication and extension program has been proposed for September 2002. This program will assess current practices and attitudes towards catching, handling and releasing fish and promote better practices through multimedia outlets. Significant benefit will accrue from a close liaison between this program and future national research projects that investigate and develop methods for enhancing PRS in Australia's line fisheries.

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APPENDICES

APPENDIX 1. INTELLECTUAL PROPERTY.

This is not applicable in this project.

APPENDIX 2. STAFF

Dr Keith Jones SARDI (Aquatic Sciences) (part FRDC funded)

Mr Lachlan McLeay SARDI (Aquatic Sciences) (FRDC funded)

Dr Tim Ward SARDI (Aquatic Sciences)

APPENDIX 3. EXAMPLE OF QUESTIONNAIRE FORM SENT TO FISHERY SCIENTISTS, MANAGERS AND INDUSTRY REPRESENTATIVES

VICTORIA-SCORE SHEET	FACTORS AFFECTING THE NUMBER OF FISH RELEASED						FACTORS AFFECTING POST-RELEASE SURVIVAL								FACTORS AFFECTING THE CAPACITY OF FISH POPULATIONS TO SUSTAIN ANTHROPOGENIC IMPACTS								
Marine species	**Species is targeted for eating**	**Species is targeted for gamefishing/trophy qualities**	**Likelihood of capture below the MinSL**	**Likelihood of capture above the MaxSL.**	**Likelihood of catching bag limit**	**Likelihood of capture as bycatch when line fishing for other species.**	**Likelihood of barotrauma**	**Likelihood of handling damage**	**Likelihood of long capture duration/play length**	**Likelihood of thermal shock**	**Likelihood of osmoregulatory stress**	**Likelihood of grading (live-well retention)**	**Likelihood of post-capture and release predation**	**Likelihood of significant hook damage**	**Longevity**	**Growth rate**	**Current exploitation rate**	**Reproductive potential (chance to spawn before capture)**	**Fecundity**	**Length of spawning season**	**Vulnerability of spawning aggregations**	**Distribution patterns of stock**	**Biological understanding. Need for research**
Australian Salmon (*Arripis truttaceus*)																							
Australian Bass (*Macquaria novemaculeata*)																							
Boarfish (*Parastiopterus spp*)																							
Bream (*Acanthopagrus spp*)																							
Elephant fish (*Callorhinchus milii*)																							
Estuary Perch (*Maquaria colonorum*)																							
Flathead (*Platycephalus spp*)																							
Garfish (*Hyporhamphus melanochir*)																							
King George Whiting (*Sillaginodes punctata*)																							
Shark- Gummy (*Mustelus antarcticus*)																							
Shark-School (*Galeorhinus australis*)																							
Ling (*Genypterus blacodes*)																							
Luderick/Rock Blackfish (*Girella spp*)																							
Mullet, yellow eye/sand (*Aldrichetta forsteri*)																							
Mulloway (*Argyrosomus hololepidotus*)																							
Snook (*Sphyraena novahollandiae*)																							
Trevalley-Silver (*Pseudocaranx dentex*)																							
Snapper (*Pagrus auratus*)																							
Sweep (*Scorpis spp*.)																							
Tailor (*Pomatomus saltatrix*)																							
Tommy Ruff (*Arripis georgianus*)																							
Warehou (*Seriolella brama*)																							
Wrasse, Bluethroat (*Pseudolabris spp*)																							
Kingfish- Yellowtail (*Seriola lalandi*)																							
Other spp																							
Freshwater species																							
Australian Bass (*Macquaria novemaculeata*)																							
Australian grayling (*Prototroctes maraena*)																							
Blackfish (*Gadopsis marmoratus*)																							
Eels-shortfinned/longfinned (*Anguilla spp*.)																							
Silver Perch (*Bidyanus bidyanus*)																							
Murray Cod (*Maccullochella peelii*)																							
Macquarie Perch																							
Trout cod (*Maccullochella macquariensis*)																							
Trout -Brown/Rainbow (*Salmo trutta, Oncorhyncus mykiss*)																							
Golden Perch (*Macquaria ambigua*)																							
Other spp??																							

APPENDIX 4: SPECIES PRIORITY LIST RESULTS (FROM QUESTIONNAIRE)

The ranking of South Australian line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line-fishing operations.

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted Total**
Snapper (*Pagrus auratus*)	2.7	2.6	2.3	2.1	2.0	2.1	2.5	2.3	2.0	2.0	1.0	2.1	1.9	2.3	3.0	2.0	1.0	1.0	1.0	3.0	3.0	1.0	2.0	46.8	11	1.96	**91.83**
Mulloway (*Argyrosomus hololepidotus*)	2.4	2.9	2.3	1.0	2.2	1.1	1.3	2.5	2.5	1.4	1.9	1.8	1.7	2.3	3.0	2.0	3.0	2.0	1.0	2.0	3.0	2.0	3.0	48.4	10	1.78	**86.28**
King George Whiting (*Sillaginodes punctata*)	3.0	1.6	2.4	1.0	2.1	1.6	1.5	2.1	1.1	1.6	1.0	1.8	1.5	2.0	2.0	2.0	1.5	2.0	2.0	3.0	3.0	2.0	1.0	42.8	10	1.78	**76.26**
Australian Salmon (*Arripis truttacea*)	2.2	2.5	1.6	1.0	2.1	1.9	1.0	1.8	2.0	1.1	1.0	1.4	1.7	1.8	2.0	2.0	2.0	2.0	2.0	2.5	1.5	2.0	2.0	41.1	10	1.78	**73.31**
Bluefin Tuna (*Thunnus maccoyii*)	2.1	2.8	1.1	1.1	2.1	1.0	1.3	2.4	2.8	1.3	1.0	1.3	1.6	1.5	3.0	1.0	3.0	3.0	2.0	3.0	1.0	1.0	1.0	41.3	8	1.43	**58.91**
Black Bream (*Acanthopagrus butcheri*)	2.3	1.6	2.7	1.0	1.7	1.4	1.0	1.7	1.3	1.5	1.3	1.6	1.0	2.1	2.0	1.5	1.0	1.0	2.0	2.0	2.0	1.5	1.5	36.7	7	1.25	**45.82**
Garfish (*Hyporhamphus melanochir*)	2.8	1.2	2.0	1.0	1.4	1.5	1.0	2.7	1.0	1.4	1.0	2.0	2.7	2.0	2.0	1.0	3.0	1.0	2.0	2.0	2.0	2.0	2.0	40.6	6	1.07	**43.46**
Flathead (*Platycephalus* spp.)	2.4	1.3	2.1	1.0	1.5	2.2	1.0	1.8	1.3	1.2	1.0	1.0	1.2	1.7	1.5	1.5	1.0	1.0	2.0	2.0	2.0	1.5	1.5	34.7	7	1.25	**43.33**
Yellowtail Kingfish (*Seriola lalandi*)	1.5	3.0	1.5	1.0	1.8	1.0	1.0	2.2	2.8	1.2	1.0	1.5	1.2	1.8	2.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	38.5	6	1.07	**41.19**
Blue groper (*Achoerodus gouldii*)	1.4	1.6	1.4	2.0	2.0	2.0	2.4	2.2	2.2	1.6	1.0	1.0	2.0	2.0	3.0	2.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0	45.8	5	0.89	**40.83**
Yellowfin whiting (*Sillago schomburgkii*)	3.0	1.0	2.0	1.0	2.0	1.8	1.2	1.7	1.2	1.0	1.0	1.2	1.5	1.8	2.0	1.0	2.0	2.0	1.0	2.0	1.0	3.0	2.0	37.3	6	1.07	**39.93**
Sweep (*Scorpis* spp.)	2.2	1.3	2.0	1.0	1.2	1.8	1.7	1.5	1.3	1.4	1.0	1.5	1.2	1.2	2.0	2.0	1.0	1.0	2.0	2.0	2.0	1.0	2.0	35.3	6	1.07	**37.73**
Trevally, Silver (*Pseudocaranx dentex*)	2.0	2.0	1.8	1.0	1.5	1.8	1.8	1.8	1.4	1.0	1.0	1.2	1.4	1.6	2.5	2.0	2.0	3.0	1.5	2.5	2.0	1.5	3.0	41.3	5	0.89	**36.82**
Tommy ruff (*Arripis georgianus*)	2.6	1.0	1.6	1.0	2.3	2.4	1.0	1.8	1.0	1.0	1.0	1.4	2.2	1.6	2.0	2.0	2.0	3.0	1.0	3.0	2.0	2.0	1.0	39.9	5	0.89	**35.53**
Snook (*Sphyraena novahollandiae*)	2.4	1.4	2.0	1.0	2.0	1.2	1.0	1.8	1.2	1.0	1.0	1.0	1.2	1.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	37.8	5	0.89	**33.70**
Nannygai (*Centroberyx* spp.)	2.3	1.5	2.3	1.0	2.3	2.5	2.3	2.0	1.0	1.8	1.3	1.3	2.0	1.8	2.5	2.5	1.0	2.0	1.5	2.5	3.0	2.0	2.0	44.1	4	0.71	**31.44**
Mullet-yelloweye (*Aldrichetta forsteri*)	2.0	1.0	1.5	1.0	2.3	2.0	1.0	1.8	1.0	1.7	1.5	1.8	1.8	1.3	1.0	1.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	37.5	4	0.71	**26.74**
Blue Morwong (*Nemadactylus valenciennesi*)	1.7	1.3	2.0	1.0	1.0	2.0	2.3	1.7	1.7	1.3	1.0	1.0	1.7	2.0	3.0	2.0	1.0	2.0	3.0	3.0	3.0	2.0	3.0	43.7	3	0.53	**23.36**
Leatherjacket (Family Monacanthidae)	1.8	1.0	1.0	1.0	1.0	3.0	1.5	1.8	1.0	1.0	1.0	1.0	1.3	1.5	2.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	2.0	32.8	4	0.71	**23.36**
Samson fish (*Seriola hippos*)	2.0	3.0	1.5	1.0	2.0	1.0	1.0	3.0	3.0	1.5	1.5	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	42.5	2	0.36	**15.16**
Shark, School (*Galeorhinus australis*)	2.5	1.0	3.0	1.0	1.0	1.5	1.5	1.5	2.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	40.0	2	0.36	**14.26**
Shark, gummy (*Mustelus antarcticus*)	2.5	1.0	3.0	1.0	1.0	1.5	1.5	1.5	2.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	39.0	2	0.36	**13.91**
Great white shark (*Carchaodon carcharias*)	1.0	3.0	1.0	1.0	3.0	2.0	1.0	1.0	3.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0	1.0	2.0	3.0	3.0	1.0	1.0	2.0	41.0	1	0.18	**7.31**

APPENDIX 4 (cont.)

The ranking of New South Wales line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line-fishing operations.

SPECIES/ GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted total**
Bream, black, yellowfin (*Acanthopagrus* spp.)	2.4	2.0	2.4	1.0	1.6	2.4	1.0	1.4	1.3	1.3	1.0	1.3	1.1	1.9	2.0	1.5	2.5	1.0	2.0	2.0	2.0	1.5	1.5	38.0	8	2.08	**78.89**
Luderick/Rock Blackfish (*Girella* spp.)	2.5	2.2	2.1	1.0	1.5	1.4	1.0	1.4	1.0	1.3	1.0	1.1	1.1	1.4	2.0	1.5	2.5	2.0	2.0	2.0	2.0	1.5	1.5	37.0	8	2.08	**76.85**
Flathead (*Platycephalus* spp.)	2.6	1.8	2.1	1.0	1.9	2.3	1.4	1.3	1.1	1.2	1.0	1.0	1.2	1.5	1.5	1.5	2.5	1.0	2.0	2.0	2.0	1.5	1.5	36.9	7	1.82	**67.17**
Whiting-Sand (*Sillago ciliata*)	2.5	1.2	2.3	1.0	1.8	2.0	1.0	1.5	1.0	1.2	1.0	1.2	1.3	2.2	2.0	1.5	2.5	1.0	2.0	2.0	2.0	2.0	2.0	38.2	6	1.56	**59.60**
Tailor (*Pomatomus saltatrix)*	2.0	1.4	2.0	1.0	2.0	2.5	1.0	1.5	1.2	1.4	1.0	1.0	1.7	2.2	2.0	1.0	1.8	1.0	2.0	1.0	2.0	1.0	2.0	35.6	6	1.56	**55.55**
Yellowtail kingfish (*Seriola lalandi)*	2.0	2.2	2.4	1.0	2.2	2.0	1.2	1.6	2.0	1.3	1.0	1.2	1.4	2.0	2.0	1.0	3.0	2.0	2.0	2.0	2.0	1.5	2.0	41.0	5	1.30	**53.20**
Mulloway (*Argyrosomus japonicus)*	2.2	1.8	2.4	2.3	1.8	2.0	1.8	2.4	1.6	1.3	1.0	1.0	1.2	2.2	2.0	1.5	2.5	1.5	1.0	2.0	2.0	1.5	1.5	40.4	5	1.30	**52.49**
Groper, Blue , Red/Brown *(Achoerodus viridis)*	1.6	1.8	1.4	1.0	1.8	2.0	1.4	1.4	1.2	1.3	1.0	1.0	1.2	1.6	2.0	1.5	2.0	3.0	3.0	2.0	2.0	2.5	2.0	39.7	5	1.30	**51.51**
Billfish - Marlins (striped, black, blue)/ Sailfish/ Swordfish/Spearfish	1.0	3.0	1.0	1.0	1.8	1.8	1.0	1.4	2.8	1.2	1.0	1.0	2.2	2.0	3.0	1.0	2.0	3.0	1.0	2.0	2.0	1.0	2.0	39.2	5	1.30	**50.93**
Australian Salmon (*Arripis trutta*)	1.6	1.6	1.0	1.0	2.4	2.4	1.0	1.8	1.4	1.3	1.0	1.0	1.4	2.0	1.0	1.0	3.0	3.0	2.0	2.0	2.0	1.5	2.0	38.4	5	1.30	**49.93**
Trevally-Silver (*Pseudocaranx dentex*)	2.0	1.4	1.5	1.0	2.2	2.6	1.2	1.2	1.4	1.0	1.0	1.0	1.4	1.8	1.0	1.5	2.5	2.0	2.0	2.0	2.0	1.5	2.0	37.2	5	1.30	**48.33**
Hairtail (*Trichiurus lepturus)*	2.4	1.0	1.2	1.0	1.8	1.6	1.0	2.0	1.2	1.3	1.0	1.0	1.2	2.0	1.0	1.5	2.0	3.0	2.0	2.0	2.0	1.5	2.5	37.2	5	1.30	**48.27**
Tunas -Albacore, Big-eye, Longtail, Southern bluefin, Yellowfin (*Thunnus* spp.)	2.3	2.5	1.5	1.0	2.5	2.0	1.0	2.0	2.8	1.5	1.0	1.3	2.3	2.0	2.5	1.0	2.5	3.0	1.0	2.0	2.0	1.0	1.5	42.0	4	1.04	**43.65**
Snapper (*Pagrus auratus*)	2.3	1.5	2.3	1.0	2.3	2.5	2.3	1.5	1.3	1.7	1.0	1.3	1.8	2.0	3.0	1.5	3.0	1.5	2.0	2.0	2.0	1.0	1.5	41.9	4	1.04	**43.57**
Mackerels -Spanish, Spotted (*Scomberomorus* spp.)	2.0	2.5	1.5	1.0	2.0	2.3	1.0	1.8	2.0	1.3	1.0	1.0	2.0	1.8	2.0	1.0	2.5	3.0	1.0	2.0	2.0	1.5	2.0	40.0	4	1.04	**41.57**
Blue-eye trevalla (*Hyperoglyphe antarctica*)	2.3	1.7	1.0	1.0	2.5	1.7	3.0	1.7	2.3	2.3	1.0	1.0	2.3	2.0	2.0	1.5	2.5	3.0	3.0	2.0	2.0	1.5	2.0	45.3	3	0.78	**35.34**
Hapuka (*Polyprion oxygeneios*)	2.0	1.0	1.0	1.0	1.7	2.0	3.0	1.7	1.7	2.3	1.0	1.3	1.7	1.7	2.0	1.5	2.5	3.0	3.0	2.0	2.0	1.5	2.5	43.0	3	0.78	**33.52**
Bass groper (*Polyprion americanus*)	3.0	1.0	1.0	1.0	2.0	1.7	2.3	2.3	1.7	2.0	1.0	1.0	1.7	2.0	2.0	1.5	2.5	3.0	2.0	2.0	2.0	1.5	2.5	42.7	3	0.78	**33.26**
Gemfish (*Rexea solandri*)	2.5	1.0	1.0	1.0	2.0	2.0	3.0	1.3	1.7	2.3	1.0	1.0	1.7	2.0	2.0	1.5	3.0	3.0	2.0	2.0	2.0	1.5	1.5	42.0	3	0.78	**32.74**
Barcod (*Epinephelus ergastularius*)	3.0	1.0	1.0	1.0	2.3	1.7	2.0	2.3	1.3	1.7	1.0	1.0	1.3	2.0	2.0	1.5	2.5	3.0	2.0	2.0	2.0	1.5	2.5	41.7	3	0.78	**32.48**
Teraglin (*Atractoscion aequidens)*	2.0	1.0	1.7	1.0	2.3	2.3	2.3	1.3	1.7	1.3	1.0	1.0	1.7	2.0	2.0	1.5	3.0	1.0	3.0	2.0	2.0	1.3	2.0	40.5	3	0.78	**31.57**
Jackass morwong (*Nemadactylus macropterus)*	2.7	1.0	1.7	1.0	1.0	2.7	2.3	1.3	1.3	2.0	1.0	1.0	1.7	1.3	3.0	1.0	3.0	3.0	1.0	2.0	2.0	1.0	2.0	40.0	3	0.78	**31.18**
Shark-School (*Galeorhinus australis*)	2.5	1.0	1.3	1.0	2.3	2.3	1.0	1.3	1.0	1.0	1.0	1.0	1.3	1.3	3.0	1.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	37.5	3	0.78	**29.23**
Tarwhine (*Rhabdosargus sarba)*	2.0	1.0	1.7	1.0	2.0	2.3	1.0	1.3	1.3	1.3	1.0	1.0	1.7	2.0	2.0	1.5	2.5	1.0	2.0	2.0	2.0	1.5	2.0	37.2	3	0.78	**28.98**
John Dory (*Zeus faber*)	2.3	1.0	1.0	1.0	1.0	2.3	1.7	1.3	1.0	1.7	1.0	1.0	1.3	1.3	1.0	1.5	2.5	2.0	2.0	2.0	2.0	1.5	2.0	35.5	3	0.78	**27.67**
Mangrove Jack (*Lutjanus argentimaculatus*)	1.7	2.7	1.7	1.0	2.0	2.3	1.0	1.3	1.0	1.3	1.0	1.0	1.3	1.7	3.0	1.0	1.0	3.0	1.0	1.0	1.0	1.3	2.0	35.3	3	0.78	**27.54**
Moses perch *(Lutjanus russellii)*	2.0	2.0	1.0	1.0	2.5	2.5	2.0	1.5	1.0	2.0	1.0	1.0	1.5	1.5	2.3	1.0	1.0	3.0	1.7	2.7	2.3	1.0	2.0	39.5	2	0.52	**20.53**
Red morwong (*Cheilodactylus fuscus)*	1.5	1.0	2.0	2.5	2.0	1.5	2.0	1.5	1.0	1.5	1.0	1.0	1.5	2.0	3.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0	38.0	2	0.52	**19.75**
Sawtail (*Prionurus microlepidotus)*	1.5	1.0	1.0	1.0	2.5	2.5	1.0	1.5	1.0	1.0	1.0	1.0	1.5	1.5	2.0	1.5	1.5	3.0	2.0	2.0	2.0	2.0	2.0	37.0	2	0.52	**19.23**
Morwong, banded (*Cheilodactylus spectabilis)*	2.0	1.0	2.0	1.0	2.0	1.5	2.0	1.5	1.0	2.0	1.0	1.0	1.5	1.5	3.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0	37.0	2	0.52	**19.23**
Mullet (sea/bully) (*Mugil cephalus*)	1.5	1.0	1.5	1.0	2.0	2.5	1.0	1.5	1.0	1.5	1.0	1.0	2.0	1.5	2.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	2.0	34.0	2	0.52	**17.67**
Sharks-other (Mako, Tiger, hammerhead)	1.0	3.0	1.0	1.0	1.0	2.0	1.0	1.0	3.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	2.0	3.0	2.0	2.0	2.0	1.0	2.0	38.0	1	0.26	**9.87**
Mahi-Mahi (*Coryphaena hippurus*)	3.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	1.0	3.0	1.0	2.0	3.0	36.0	1	0.26	**9.35**

APPENDIX 4 (cont.)

The ranking of Tasmanian line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing operations.

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Bag-limit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted totals**
Australian Salmon (*Arripis trutta*)	2.0	1.6	1.7	1.0	1.9	2.4	1.0	1.7	1.6	1.3	1.3	1.1	1.9	1.7	1.0	2.0	3.0	1.0	2.0	2.0	3.0	1.0	2.0	39.2	7.0	1.48	**57.96**
Flathead (*Platycephalus* spp.)	2.9	1.0	2.3	1.0	2.1	2.6	1.4	2.0	1.1	1.5	1.0	1.0	1.4	1.4	1.0	2.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	38.8	7.0	1.48	**57.29**
Shark- Gummy (*Mustelus antarcticus*)	2.5	1.8	1.8	1.0	1.5	2.2	1.7	1.7	1.7	1.8	1.0	1.0	1.5	1.8	2.0	3.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	42.0	6.0	1.27	**53.15**
Wrasse, Bluethroat, Purple (*Pseudolabrus* spp.)	1.7	1.3	2.0	2.3	1.7	2.8	1.8	1.7	1.3	1.2	1.0	1.2	1.5	1.8	1.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	38.4	6.0	1.27	**48.61**
Morwong, Jackass (*Nemadactylus macropterus)*	1.8	1.2	1.8	1.0	1.0	2.2	1.8	1.5	1.0	1.8	1.0	1.2	1.7	1.5	1.0	3.0	3.0	1.0	1.0	2.0	2.0	1.0	2.0	36.5	6.0	1.27	**46.18**
Tuna, Southern Bluefin (*Thunnus maccoyii*)	2.8	2.8	1.4	1.0	2.4	1.0	1.4	2.4	2.6	2.2	1.0	1.0	1.6	2.0	3.0	2.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	43.6	5.0	1.06	**46.02**
Shark-School (*Galeorhinus australis*)	2.6	1.6	1.8	1.0	1.8	2.2	1.6	1.8	1.4	1.7	1.0	1.0	1.4	2.0	3.0	3.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	42.9	5.0	1.06	**45.32**
Leatherjacket (Family Monacanthidae)	1.8	1.2	1.7	1.0	1.0	2.2	1.3	1.3	1.0	1.4	1.0	1.0	1.5	1.5	2.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	34.9	6.0	1.27	**44.23**
Trumpeter, bastard (*Latridopsis forsteri*)	2.8	2.0	2.0	1.0	1.8	1.6	2.6	2.2	1.4	1.9	1.0	1.2	1.8	1.8	1.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	40.1	5.0	1.06	**42.33**
Bream (*Acanthopagrus* spp.)	2.8	2.0	2.0	1.0	2.8	1.8	1.0	1.8	1.2	1.2	1.3	1.2	1.4	1.8	1.0	1.0	3.0	1.0	1.0	2.0	2.0	1.0	2.0	37.3	5.0	1.06	**39.39**
Garfish (*Hyporhamphus melanochir*)	2.4	1.0	2.0	1.0	1.4	1.0	1.0	2.6	1.0	1.0	1.0	1.0	2.2	1.6	1.0	2.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	36.2	5.0	1.06	**38.21**
Mullet, yellow eye/sand (*Aldrichetta forsteri*)	2.0	1.0	2.2	1.0	1.0	2.2	1.2	1.4	1.2	1.2	1.0	1.0	2.0	1.4	2.0	1.0	3.0	1.0	1.0	2.0	2.0	1.0	2.0	34.8	5.0	1.06	**36.73**
Flounders (*Ammotretis, Pseudorhombus* spp.)	2.8	1.0	2.2	1.0	1.4	1.0	1.0	1.4	1.0	1.5	1.0	1.0	1.2	1.4	1.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	33.9	5.0	1.06	**35.74**
Trevalla, blue eye (*Hyperoglyphe antarctica*)	3.0	2.3	1.3	1.0	2.8	1.8	2.8	2.5	1.8	2.6	1.0	1.0	2.0	2.0	1.0	1.0	3.0	1.0	1.0	2.0	2.0	1.0	2.0	41.6	4.0	0.84	**35.15**
Morwong, Banded *(Cheilodactylus spectabilis)*	2.3	1.3	2.3	2.5	1.3	1.8	1.8	1.5	1.0	1.6	1.0	1.3	1.5	1.5	2.0	3.0	3.0	1.0	1.0	2.0	2.0	1.0	2.0	39.4	4.0	0.84	**33.25**
Trevally, all species (mainly *Pseudocaranx dentex*)	2.7	1.7	2.0	1.0	1.7	2.3	1.7	2.0	1.7	1.4	1.0	1.0	1.3	1.3	1.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	37.8	3.0	0.63	**23.93**
Boarfish (*Paristiopterus* spp.)	1.3	1.0	1.7	1.0	1.0	2.3	1.7	1.7	1.0	1.7	1.0	1.0	1.3	1.7	1.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	2.0	32.3	3.0	0.63	**20.48**
Warehou (*Seriolella brama*)	3.0	2.0	2.5	1.0	1.5	1.0	2.0	2.5	1.0	2.0	1.0	1.0	2.5	2.0	2.0	2.0	3.0	3.0	2.0	3.0	1.0	2.0	3.0	46.0	2.0	0.42	**19.42**
Cods, vari ous species (Family Gadidae)	2.0	2.0	1.0	1.0	1.0	3.0	3.0	1.0	1.0	3.0	1.0	1.0	2.0	2.0	3.0	2.0	2.7	2.0	1.3	2.7	2.3	1.8	2.5	44.1	1.0	0.21	**9.31**

APPENDIX 4 (cont.)

The ranking of Victorian line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing.

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Bag-limit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted totals**
Australian Salmon (*Arripis truttacea, A.trutta*)	2.3	2.0	1.8	1.0	1.7	1.8	1.0	1.5	1.3	1.3	1.5	1.0	1.3	1.5	2.0	1.0	1.5	1.5	2.0	3.0	1.5	2.0	2.0	37.7	8	2.67	**100.45**
Flathead (*Platycephalus bassensis*)	2.8	1.4	2.0	1.0	1.2	2.6	1.6	1.8	1.0	1.6	1.0	1.2	1.4	1.6	2.0	3.0	2.0	1.8	2.0	2.0	1.0	2.0	2.0	40.0	7	2.33	**93.33**
Estuary Perc h (*Macquaria colonorum*)	2.8	2.5	1.5	1.0	2.0	1.5	1.0	1.3	1.0	1.3	1.3	1.5	1.0	1.5	3.0	3.0	1.5	1.0	2.0	3.0	1.5	2.0	1.7	39.7	6	2.00	**79.34**
Black Bream (*Acanthopagrus butcheri*)	3.0	2.3	2.0	1.0	1.7	1.7	1.0	1.3	1.0	1.3	1.7	1.3	1.0	2.0	3.0	3.0	3.0	1.0	1.7	2.3	2.0	2.0	2.0	42.3	5	1.67	**70.55**
Snapper (*Pagrus auratus*)	3.0	2.5	2.5	1.0	2.0	2.0	1.5	2.0	2.0	2.0	1.0	1.5	1.5	2.5	3.0	3.0	3.0	2.0	1.5	3.0	2.5	1.0	2.0	48.0	4	1.33	**64.00**
King George whiting (*Sillaginodes punctata*)	3.0	1.0	2.3	1.0	2.0	2.0	1.0	1.7	1.0	1.3	1.0	1.7	1.7	2.0	1.0	1.0	2.5	2.0	2.0	2.0	1.0	2.0	2.0	38.2	5	1.67	**63.62**
Shark- Gummy (*Mustelus antarcticus*)	3.0	2.5	2.5	1.0	1.5	1.5	2.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0	3.0	3.0	1.0	3.0	3.0	1.0	1.0	2.0	43.0	4	1.33	**57.33**
Elephant fish (*Callorhynchus milii*)	2.5	1.0	1.0	1.0	3.0	2.0	1.0	1.5	1.0	1.5	1.0	1.0	1.5	2.0	3.0	2.0	2.0	3.0	3.0	1.0	1.5	2.0	3.0	41.5	4	1.33	**55.33**
Garfish (*Hyporhamphus melanochir*)	3.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	1.0	1.5	1.0	1.5	2.0	2.5	1.5	2.0	1.5	3.0	2.0	3.0	1.5	2.0	2.0	39.5	4	1.33	**52.67**
Mullet, yellow eye/sand (*Aldrichetta forsteri*)	2.0	1.0	1.0	1.0	1.0	2.0	1.0	1.5	1.0	1.5	1.5	1.0	1.5	2.0	2.0	2.0	1.5	3.0	2.0	2.0	1.0	1.0	2.5	36.0	4	1.33	**48.00**
Tailor (*Pomatomus saltatrix*)	2.3	2.3	2.7	1.0	1.0	2.7	1.0	1.3	1.0	1.0	2.0	1.0	1.3	1.3	2.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	36.0	3	1.00	**36.00**
Luderick/Rock Blackfish (*Girella* spp.)	3.0	3.0	2.0	1.0	2.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	2.0	3.0	3.0	2.0	2.0	38.5	2	0.67	**25.67**
Warehou (*Seriolella brama*)	2.0	1.0	3.0	1.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	2.0	3.0	3.0	2.0	2.0	3.0	3.0	2.0	3.0	1.0	2.0	3.0	46.0	1	0.33	**15.33**
Mulloway (*Argyrosomus japonicus*)	2.0	3.0	3.0	1.0	2.0	1.0	1.0	3.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	1.0	2.0	2.0	45.0	1	0.33	**15.00**
Chinook salmon (*Oncorhynchus tshawytscha*)	2.0	2.0	1.0	1.0	3.0	3.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	2.0	3.0	2.0	3.0	1.0	40.0	1	0.33	**13.33**
Sweep (*Scorpis* spp.)	2.7	2.3	2.3	1.0	1.0	1.5	1.5	1.8	1.8	1.7	1.2	1.3	1.5	2.2	2.0	2.0	1.0	1.0	2.0	2.0	2.0	1.0	2.0	38.8	1	0.33	**12.94**
Kingfish- Yellowtai l (*Seriola lalandi*)	2.0	3.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	3.0	2.0	2.0	2.0	2.0	1.5	2.0	38.5	1	0.33	**12.83**
Shark-School (*Galeorhinus australis*)	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	3.0	3.0	3.0	1.0	3.0	2.0	2.0	1.0	2.0	38.0	1	0.33	**12.67**
Wrasse, Bluethroat (*Pseudolabrus* spp.)	1.0	1.7	1.0	1.0	3.0	2.4	2.0	1.4	1.1	1.0	1.5	1.2	1.6	1.8	1.8	1.9	1.8	2.3	1.8	1.8	1.3	1.4	2.0	37.9	1	0.33	**12.63**
Trevally-Silver (*Pseudocaranx dentex*)	2.0	1.4	1.5	1.0	2.0	2.6	1.2	1.2	1.4	1.0	1.0	1.0	1.4	1.8	1.0	1.5	2.5	2.0	2.0	2.0	2.0	1.5	2.0	37.0	1	0.33	**12.33**
Tommy Ruff (*Arripis georgianus*)	2.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	3.0	1.0	3.0	2.0	2.0	1.0	36.0	1	0.33	**12.00**
Boarfish (*Paristiopterus* spp.)	3.0	2.0	3.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	2.0	33.0	1	0.33	**11.00**

APPENDIX 4 (cont.)

The ranking of Western Australian line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing operations

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted Total**
Snapper Tropical (*Lutjanus* spp., *Pristipomoides* spp.)	2.9	1.6	1.8	1.0	2.1	2.8	2.1	1.9	1.8	1.4	1.0	1.0	1.6	1.9	2.4	2.3	2.8	2.4	1.4	2.8	2.1	1.5	2.0	44.3	8.0	2.37	**104.98**
Cods, breaksea, chinaman (*Epinephelus armatus, E.rivulatus*)	2.8	1.2	1.6	1.8	2.2	2.6	2.6	2.2	1.6	1.2	1.0	1.4	2.2	2.2	3.0	2.4	2.4	3.0	1.6	2.0	1.2	1.4	2.2	45.8	5.0	1.48	**67.91**
Australian Salmon (*Arripis truttacea*)	1.4	2.8	1.4	1.0	3.0	1.8	1.2	2.4	2.0	1.2	1.0	1.0	1.4	2.0	2.0	1.5	3.0	2.0	1.5	3.0	3.0	2.0	1.0	42.6	5.0	1.48	**63.17**
Dhufish, WA (*Glaucosoma hebracium*)	3.0	2.0	2.3	1.0	2.3	1.8	3.0	2.5	1.8	1.3	1.0	1.3	2.0	2.0	3.0	2.5	3.0	1.5	1.5	2.5	2.0	2.0	2.0	47.0	4.0	1.19	**55.75**
Emperors (*Lethrinus nebulosus, Lethrinus* spp.)	3.0	2.3	2.0	1.0	2.3	2.5	2.8	2.0	1.8	1.3	1.0	1.3	2.0	2.3	3.0	2.5	3.0	1.5	1.5	3.0	2.0	1.5	1.5	46.8	4.0	1.19	**55.46**
Coral Trout (*Plectropomus* spp.)	3.0	2.0	2.3	1.0	2.5	2.3	2.0	2.5	1.8	1.3	1.0	1.0	1.8	2.5	3.0	2.0	3.0	3.0	2.0	3.0	1.0	1.0	2.0	46.8	4.0	1.19	**55.46**
Mackerels, shark *(Grammatorcynus bicarinatus*), spanish (*Scomberomorus commerson, S. fasciatus*), spotted (*S.munroi*) queensland school (*S.queenslandicus*)	3.0	3.0	1.5	1.0	2.5	2.0	1.0	2.5	2.4	1.3	1.0	1.0	2.3	2.3	2.5	1.5	3.0	1.0	1.5	2.5	2.5	2.0	2.0	45.1	4.0	1.19	**53.53**
Snapper, pink (*Pagrus auratus*)	3.0	2.0	2.0	1.0	2.8	2.0	2.3	1.5	1.8	1.0	1.0	1.0	1.8	2.0	3.0	2.8	3.0	1.0	1.0	2.2	3.0	1.8	2.0	44.8	4.0	1.19	**53.08**
Baldchin groper & tuskfish (*Choerodon* spp.)	2.8	1.8	1.8	1.0	2.5	2.3	2.8	2.0	1.8	1.3	1.0	1.0	2.0	1.8	2.5	2.0	2.5	2.0	1.5	3.0	1.0	2.0	2.5	44.5	4.0	1.19	**52.79**
Barramundi (*Lates calcarifer*)	2.5	2.8	2.5	1.0	2.5	2.3	1.0	2.3	2.0	1.5	1.0	1.3	1.3	2.0	2.0	1.5	2.0	1.5	1.0	3.0	2.0	2.0	2.0	42.8	4.0	1.19	**50.71**
Mangrove jack (*Lutjanus argentimaculatus*)	2.5	3.0	1.5	1.0	2.3	2.3	1.3	1.5	1.3	1.0	1.0	1.0	1.3	1.8	2.5	2.0	1.5	3.0	1.5	3.0	1.0	1.5	3.0	41.5	4.0	1.19	**49.23**
Bream-black, yellowfin, Northwest black, (*Acanthopagrus.* spp.)	2.8	1.5	2.5	1.0	2.3	2.3	1.0	2.0	1.3	1.0	1.0	1.3	1.0	2.0	3.0	3.0	2.5	1.0	1.5	2.5	1.5	1.5	2.0	41.3	4.0	1.19	**48.93**
Whiting, king george (*Sillaginodes punctata*)	3.0	1.5	2.3	1.0	2.0	2.3	1.0	1.8	1.3	1.0	1.0	1.0	1.0	1.8	1.5	2.0	3.0	2.0	1.0	3.0	2.0	2.0	2.0	40.3	4.0	1.19	**47.74**
Tailor (*Pomatomus saltatrix*)	2.5	2.3	2.0	1.0	2.8	2.3	1.0	1.8	1.8	1.0	1.0	1.0	1.5	1.8	1.5	2.0	2.5	2.0	1.5	2.5	1.5	1.0	2.0	40.0	4.0	1.19	**47.45**
Whiting, western sand, school & yellowfin (*Sillago* spp.)	3.0	1.0	1.8	1.0	1.3	2.5	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.8	1.3	2.0	3.0	3.0	1.0	3.0	1.3	2.0	2.0	38.8	4.0	1.19	**45.97**
Herring, Australian (*Arripis georgianus*)	2.5	1.0	1.0	1.0	1.5	2.8	1.0	1.8	1.0	1.0	1.0	1.0	1.3	2.3	1.5	1.5	3.0	3.0	1.0	3.0	2.5	2.0	1.0	38.5	4.0	1.19	**45.67**
Threadfin salmon, bluenose, northern, gunther's and black-finned (*Polydactylus* spp., *Eleutheronema tetradactylum*)	1.8	2.5	1.0	1.0	1.8	2.3	1.0	1.8	1.5	1.0	1.0	1.0	1.3	1.8	1.0	1.5	2.5	3.0	1.0	3.0	1.0	1.5	3.0	38.0	4.0	1.19	**45.08**
Groper, western blue (*Achoerodus gouldii*)	2.3	2.3	1.7	1.0	1.7	1.7	2.3	2.0	2.3	1.0	1.0	1.0	1.3	2.0	3.0	3.0	3.0	2.0	2.0	3.0	2.0	3.0	3.0	47.7	3.0	0.89	**42.41**
Sharks (all species except whale sharks)	1.7	1.7	1.0	1.0	1.7	2.7	1.0	1.7	2.7	1.0	1.0	1.0	1.7	1.3	3.0	3.0	3.0	3.0	3.0	2.0	1.0	2.0	2.0	43.0	3.0	0.89	**38.26**
Samson fish (*Seriola hippos*)	1.0	3.0	1.3	1.0	2.0	2.0	1.7	1.3	2.7	1.3	1.0	1.0	1.7	1.7	2.0	2.0	2.0	3.0	2.0	3.0	1.0	2.0	3.0	42.7	3.0	0.89	**37.96**
Mulloway (*Argyrosomus hololepidotus*) & northern mulloway (*P. diacanthus*)	3.0	2.7	2.0	1.0	2.0	2.0	1.7	1.7	2.7	1.0	1.0	1.0	1.3	1.7	1.0	1.0	3.0	2.0	2.0	3.0	3.0	1.0	2.0	42.7	3.0	0.89	**37.96**
Yellowtail kingfish (*Seriola lalandi)*	2.0	3.0	1.0	1.0	1.7	2.0	1.3	1.7	2.3	1.3	1.0	1.0	1.7	1.0	2.0	2.0	3.0	3.0	2.0	3.0	1.0	1.0	3.0	42.0	3.0	0.89	**37.37**
Giant threadfin salmon *(Polynemus sheridani)*	2.3	2.7	1.0	1.0	2.3	2.7	1.0	2.0	1.7	1.3	1.0	1.0	1.7	1.7	1.5	1.5	2.5	3.0	1.5	2.0	1.0	1.5	3.0	40.8	3.0	0.89	**36.32**
Tuna, Southern bluefin (*Thunnus maccoyii*)	2.7	3.0	1.0	1.0	2.0	2.0	1.0	1.7	3.0	1.3	1.0	1.0	1.7	1.3	3.0	1.0	3.0	3.0	1.0	3.0	1.0	1.0	1.0	40.7	3.0	0.89	**36.18**
Cobia (*Rachycentron canadus*)	2.0	2.7	1.3	1.0	1.7	2.0	1.3	1.7	2.7	1.3	1.0	1.0	1.3	1.7	2.0	2.0	2.0	3.0	2.0	3.0	1.0	1.0	1.0	39.7	3.0	0.89	**35.29**
Billfish - marlin, sailfish and swordfish (*Xiphidae and Istiophoridae* spp.)	1.3	3.0	1.0	1.0	1.7	1.0	1.3	1.7	3.0	1.3	1.0	1.0	2.0	1.3	2.0	2.0	2.0	3.0	2.0	3.0	1.0	1.0	2.0	39.7	3.0	0.89	**35.29**
Queenfish (*Scomberoides* spp.)	2.0	3.0	1.3	1.0	2.0	2.0	1.0	1.7	2.0	1.0	1.0	1.0	1.0	1.3	1.0	2.0	1.0	3.0	2.0	3.0	1.0	2.0	3.0	39.3	3.0	0.89	**34.99**
Mahi-mahi, dolphinfish - (*Coryphaena hippurus*)	3.0	3.0	1.0	1.0	2.0	1.7	1.0	2.0	2.7	1.0	1.0	1.0	1.7	1.3	1.0	1.0	1.0	3.0	1.0	3.0	1.0	2.0	3.0	39.3	3.0	0.89	**34.99**
Mullet-sea/yelloweye (*Mugil cephalus, Aldrichetta forsteri*)	2.7	1.0	2.3	1.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.7	1.7	2.0	2.0	2.0	1.0	2.0	2.0	3.0	1.0	2.0	38.3	3.0	0.89	**34.10**
Fingermark bream/ Moses perch *(Lutjanus russelli*)	2.0	1.7	1.3	1.0	1.7	2.3	1.3	1.7	1.3	1.3	1.0	1.0	1.3	1.7	2.0	1.5	1.0	3.0	2.0	3.0	1.0	1.5	2.5	38.2	3.0	0.89	**33.96**
Tarwhine (*Rhabdosargus sarba*)	2.0	1.0	2.3	1.0	2.0	2.7	1.0	1.7	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	3.0	2.0	1.0	3.0	1.0	1.0	3.0	37.7	3.0	0.89	**33.51**
Snook (*Sphyraena novahollandiae*)	2.0	1.3	1.7	1.0	2.0	1.7	1.0	2.0	1.3	1.0	1.0	1.0	1.3	2.0	1.0	1.0	3.0	2.0	1.0	3.0	1.0	2.0	3.0	37.3	3.0	0.89	**33.21**
Flathead (*Platycephalus* spp.)	3.0	1.0	2.3	1.0	1.7	2.3	1.3	1.7	1.0	1.0	1.0	1.0	1.0	1.7	1.0	1.0	2.0	1.0	2.0	3.0	1.0	2.0	3.0	37.0	3.0	0.89	**32.92**
Garfish (*Hyporhamphus melanochir*)	2.3	1.0	1.0	1.0	2.0	2.0	1.0	2.3	1.0	1.0	1.0	1.0	1.3	1.7	1.0	1.0	1.0	3.0	1.0	3.0	1.0	2.0	2.5	35.2	3.0	0.89	**31.29**
Bonitos, oriental (*Sarda orientalis*), leaping (*Cybiosarda elegans*)	1.7	2.3	1.0	1.0	2.0	2.0	1.0	2.0	1.7	1.0	1.0	1.0	1.3	2.0	1.0	1.0	1.0	3.0	2.0	2.0	1.0	1.0	2.0	35.0	3.0	0.89	**31.14**

Mackerel, blue (*Scomber australasicus*)	1.0	1.3	1.0	1.0	1.0	2.3	1.0	2.0	1.0	1.0	1.0	1.0	1.7	1.7	1.0	1.0	1.0	3.0	1.0	2.0	1.0	1.0	2.0	31.0	3.0	0.89	**27.58**
Cobbler (*Cnidoglanis macrocephalus*)	3.0	1.0	2.0	1.5	2.0	2.0	1.0	3.0	1.0	1.0	1.0	1.0	1.0	2.5	2.0	2.0	3.0	1.0	3.0	3.0	2.0	1.0	3.0	43.0	2.0	0.59	**25.50**
Morwong ,blue (*Nemadactylus valenciennesi*)	2.5	1.0	1.5	1.0	2.0	2.5	2.0	2.0	1.5	1.5	1.0	1.0	2.0	1.5	2.0	2.0	2.0	3.0	2.0	3.0	1.0	2.0	3.0	43.0	2.0	0.59	**25.50**
Snapper, red (*Centroberyx* spp.)	3.0	1.0	1.5	1.0	2.0	2.5	2.5	1.5	1.0	1.5	1.0	1.0	1.5	1.5	2.0	2.0	2.0	3.0	1.0	3.0	2.0	2.0	3.0	42.5	2.0	0.59	**25.21**
Skipjack trevally (*Pseudocaranx* spp.)	3.0	1.5	2.0	1.0	2.0	3.0	1.0	1.5	1.5	1.0	1.0	1.0	1.5	2.0	1.0	1.0	3.0	2.0	2.0	3.0	2.0	1.0	2.0	40.0	2.0	0.59	**23.72**
Leatherjackets (*Monacanthidae* family)	2.5	1.0	1.0	1.0	1.0	3.0	1.5	1.5	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	3.0	2.0	3.0	2.0	2.0	3.0	39.5	2.0	0.59	**23.43**
Flounder (*Pseudorhombus* spp.)	3.0	1.0	2.5	1.0	1.5	2.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	38.5	2.0	0.59	**22.83**
Pike (*Dinolestes lewini*)	2.0	1.0	1.5	1.0	1.5	3.0	1.0	2.5	1.0	1.0	1.0	1.0	1.5	2.0	1.0	1.0	2.0	1.0	2.0	3.0	2.0	2.0	3.0	38.0	2.0	0.59	**22.54**

APPENDIX 4 (cont.)

The ranking of Queensland line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing operations

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted Totals**
Bream-black, yellowfin, northwest black, (*Acanthopagrus* spp)	2.9	1.3	2.3	1.3	1.1	2.6	1.1	2.1	1.1	1.4	1.0	1.3	1.5	2.3	1.9	2.1	2.6	1.1	1.6	2.9	2.3	1.9	2.0	41.4	14.0	2.6	**106.79**
Snappers, Seaperches, Hussar (*Lutjanus* spp.)	2.9	1.7	2.4	1.0	1.5	2.4	2.8	2.0	1.3	1.5	1.0	1.2	2.6	2.4	2.4	2.4	2.5	1.9	2.1	2.3	2.4	2.0	2.1	46.7	12.0	2.2	**103.38**
Barramundi (*Lates calcarifer*)	3.0	2.9	2.5	1.8	2.0	1.9	1.2	2.6	2.0	1.4	1.0	1.6	1.6	1.9	2.1	1.4	2.9	2.0	1.0	2.9	1.6	1.9	1.7	44.7	11.0	2.0	**90.66**
Emperors -sweetlip, spangled, grass (*Lethrinus* spp.)	3.0	1.1	1.9	1.2	1.5	2.4	2.4	1.7	1.0	1.4	1.0	1.2	1.7	1.8	2.6	1.8	3.0	1.3	1.4	2.6	2.0	1.8	2.5	42.4	10.0	1.8	**78.16**
Coral Trout (*Plectropomus* spp.)	3.0	1.4	2.2	1.4	1.5	2.3	2.3	2.0	1.1	1.3	1.0	1.7	1.8	2.0	2.0	1.3	3.0	1.2	1.2	3.0	2.2	1.8	1.6	42.2	10.0	1.8	**77.79**
Cods (Serranidae family)	2.5	1.3	1.9	1.7	1.3	2.7	2.5	1.9	1.4	1.3	1.0	1.4	1.9	1.9	3.0	2.0	2.7	2.0	1.3	2.7	2.3	1.8	2.5	44.7	9.0	1.7	**74.19**
Mackerels -Spanish (*S.commerson*), Spotted and Qld school (*Scomberomorus* spp.)	3.0	2.6	2.1	1.0	1.7	1.6	1.2	2.7	2.3	1.1	1.0	1.1	1.9	2.3	1.8	1.0	3.0	1.5	1.5	3.0	2.7	2.0	2.3	44.3	9.0	1.7	**73.56**
Fingermark bream/Moses Perch (*Lutjanus russelli, Lutjanus johni*)	2.8	1.9	2.2	1.3	1.3	2.1	1.8	2.1	1.6	1.3	1.0	1.1	1.6	2.1	2.3	2.3	3.1	1.7	1.7	2.7	2.3	1.7	2.3	44.2	9.0	1.7	**73.36**
Whiting, northern, gold-lined, sand, (*Sillago* spp.)	3.0	1.3	2.4	1.0	1.4	2.0	1.1	2.2	1.2	1.2	1.0	1.4	2.1	2.6	1.4	2.0	3.0	1.4	1.6	1.8	2.0	2.0	2.3	41.5	9.0	1.7	**68.80**
Flathead (*Platycephalus fuscus*)	3.0	1.8	2.1	1.7	1.1	2.6	1.0	2.0	1.0	1.3	1.0	1.1	1.0	2.2	1.4	1.8	2.6	1.8	1.2	2.4	2.2	1.6	2.0	39.8	9.0	1.7	**66.04**
Pearl Perch (*Glaucosoma scapulare*)	3.0	1.3	2.1	1.0	1.7	2.9	2.9	1.9	1.1	1.6	1.0	1.4	2.3	2.0	2.0	2.3	2.8	1.2	2.0	3.0	2.0	2.8	2.2	46.3	7.0	1.3	**59.72**
Giant threadfin salmon (*Polynemus sheridani*)	2.5	2.5	1.8	1.0	1.3	2.0	1.1	2.4	2.0	1.3	1.0	1.0	1.6	2.0	1.7	1.8	1.8	1.5	1.3	2.0	1.5	2.0	2.3	39.0	8.0	1.5	**57.60**
Tailor (*Pomatomus saltatrix*)	2.3	2.8	2.6	1.0	1.3	1.6	1.0	2.4	1.4	1.3	1.0	1.4	2.1	2.7	1.3	1.3	3.0	1.0	1.0	3.0	3.0	1.8	2.3	42.5	7.0	1.3	**54.89**
Threadfin salmon- bluenose, northern, Gunther's and black-finned (*Eleutheronema tetradactylum, Polydactylus* spp.)	2.2	2.1	2.0	1.0	1.9	2.1	1.6	2.4	1.7	1.0	1.0	1.1	2.0	2.3	2.5	1.5	2.0	2.0	1.0	2.5	1.0	2.0	2.7	41.6	7.0	1.3	**53.70**
Mangrove jack (*Lutjanus argentimaculatus*)	2.4	2.7	2.4	1.0	1.1	1.7	1.9	2.1	1.1	1.0	1.0	1.1	1.4	1.9	2.4	2.2	2.2	2.0	1.3	2.0	1.6	1.6	2.0	40.3	7.0	1.3	**51.96**
Queenfish (*Scomberoides commersonnianus*)	1.3	2.7	1.7	1.0	1.3	2.3	1.0	2.7	2.2	1.3	1.0	1.0	2.2	2.3	2.0	1.5	1.5	3.0	1.5	2.5	2.0	2.0	2.7	42.7	6.0	1.1	**47.25**
Tunas-bigeye, yellowfin etc (*Thunnus* spp.)	1.8	3.0	1.2	1.0	1.4	1.2	1.2	2.7	3.0	1.8	1.0	1.3	2.7	2.2	2.5	1.0	2.5	2.0	1.0	2.5	2.0	1.0	2.0	41.9	6.0	1.1	**46.33**
Teraglin (*Atractoscion aequidens*)	2.5	1.0	2.2	1.0	1.5	2.5	3.0	2.0	1.0	1.2	1.0	1.3	2.8	2.0	1.6	1.2	2.5	1.2	1.2	2.0	2.3	2.4	2.4	41.7	6.0	1.1	**46.13**
Maori wrasse (*Cheilinus undulatus.*)	2.8	1.0	1.8	1.0	1.9	2.3	2.0	2.2	1.3	1.3	1.0	1.0	1.7	2.0	2.8	2.0	1.7	1.3	1.8	2.7	2.0	1.3	2.2	41.0	6.0	1.1	**45.36**
Dart (*Trachinotus* spp.)	2.2	2.0	1.3	1.2	1.0	2.5	1.2	2.0	1.5	1.2	1.0	1.0	1.2	2.3	1.0	1.7	2.0	3.0	2.0	2.0	1.3	2.0	2.3	38.8	6.0	1.1	**42.97**
Mulloway (*A. japonicus*) & Northern mulloway (*P. diacanthus*)	2.8	2.4	2.2	1.8	2.0	1.8	2.8	2.6	2.4	1.4	1.0	1.0	1.6	1.6	2.5	1.5	2.5	2.0	1.0	2.5	3.0	1.5	2.5	46.4	5.0	0.9	**42.79**
Snapper (*Pagrus auratus*),	3.0	1.4	2.2	1.0	1.8	2.8	2.6	2.0	1.2	1.4	1.0	1.4	2.4	2.0	2.5	2.3	3.0	1.4	1.5	3.0	2.4	1.0	1.4	44.7	5.0	0.9	**41.17**
Trevallys (*Caranx & Carangoides* spp.)	2.0	2.4	1.2	1.0	1.6	2.6	1.4	2.0	2.2	1.4	1.0	1.2	1.8	1.8	2.5	2.0	2.0	3.0	1.5	2.5	2.0	1.5	3.0	43.6	5.0	0.9	**40.20**
Gropers & tuskfish (*Choerodon* spp.) -	2.8	1.0	1.6	1.4	1.6	2.6	2.4	2.4	1.2	1.6	1.0	1.2	2.2	2.0	2.7	1.7	2.5	2.0	1.3	2.5	1.5	1.5	2.7	43.4	5.0	0.9	**39.99**
Cobia (*Rachycentron canadus*)	2.4	2.4	2.0	1.4	1.2	2.0	1.6	2.6	2.6	1.2	1.0	1.0	1.6	1.8	1.5	1.5	2.0	2.0	1.0	2.0	2.0	1.0	2.5	40.3	5.0	0.9	**37.16**
Grunters (Family Terapontidae)	3.0	1.4	2.4	1.0	1.4	2.2	1.6	1.8	1.2	1.0	1.0	1.0	1.4	2.0	2.0	2.3	1.5	1.6	1.5	2.5	2.0	2.0	2.3	40.1	5.0	0.9	**37.01**
Bonitos, oriental (*Sarda orientalis*), leaping (*Cybiosarda elegans*)	1.0	2.3	1.2	1.4	1.0	1.5	1.2	2.6	2.2	1.8	1.0	1.2	2.4	2.4	1.5	1.5	2.0	3.0	1.0	2.5	1.5	1.0	2.5	39.7	5.0	0.9	**36.56**
Sharks (all species except whale sharks)	1.3	2.7	1.5	1.0	1.7	2.5	1.0	2.0	2.3	1.5	1.0	1.0	1.0	1.5	3.0	3.0	2.0	3.0	2.5	2.5	1.5	2.0	3.0	44.4	4.0	0.7	**32.77**
Billfish - marlin, sailfish and swordfish (Families *Xiphidae and Istiophoridae*)	1.0	3.0	1.3	2.0	1.0	1.0	1.5	1.8	3.0	1.8	1.0	1.0	2.3	2.3	3.0	1.5	2.0	3.0	1.0	2.5	2.0	1.0	2.5	42.3	4.0	0.7	**31.17**
Sweetlips (Family Haemulidae)	2.5	1.3	2.3	1.0	1.3	3.0	2.0	2.0	1.0	1.5	1.0	1.3	1.8	2.3	2.0	2.0	2.7	1.3	1.3	2.5	2.0	2.0	2.3	42.2	4.0	0.7	**31.11**
Tarwhine (*Rhabdosargus sarba*)	1.8	1.0	2.3	1.0	1.5	2.3	1.5	1.5	1.0	1.0	1.0	1.0	1.8	2.0	1.5	2.0	2.0	1.5	1.5	2.0	1.5	2.5	2.0	37.0	4.0	0.7	**27.30**
Kingfish/Amberjack (*Seriola lalandi*, *S.dumerili*)	2.3	2.7	2.3	1.3	1.7	2.3	1.7	2.7	2.0	1.7	1.0	1.0	2.0	2.0	2.0	1.5	3.0	2.0	1.0	2.0	2.0	1.0	2.0	43.2	3.0	0.6	**23.89**
Cobbler (*C. macrocephalus*)	2.0	1.0	1.7	1.0	2.0	2.0	1.0	1.3	1.0	1.3	1.0	1.0	1.3	1.3	2.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	42.0	3.0	0.6	**23.24**
Mullet-sea/yelloweye (*Mugil cephalus, Aldrichetta forsteri*)	2.0	1.0	2.0	1.0	1.0	1.3	1.3	2.0	1.0	1.0	1.0	1.3	1.3	1.7	1.0	1.0	2.3	1.3	1.0	3.0	2.3	1.3	1.7	34.0	3.0	0.6	**18.81**
Samson fish (*Seriola hippos*)	2.5	2.0	2.5	1.0	1.5	2.5	2.0	2.5	2.0	1.5	1.0	1.0	2.0	2.0	3.0	1.5	2.0	2.5	1.0	2.5	2.0	1.5	2.5	44.5	2.0	0.4	**16.41**
Luderick (*Girella* spp.)	3.0	1.5	2.0	1.5	2.0	1.0	1.0	1.5	1.0	1.5	1.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	2.0	3.0	3.0	2.0	2.0	40.0	2.0	0.4	**14.75**

Garfish (*Hemirhamphidae* spp.)	3.0	1.0	1.5	1.0	1.0	1.0	1.0	3.0	1.0	1.0	1.0	1.0	2.5	2.5	1.0	1.0	2.0	3.0	2.0	2.0	3.0	1.0	2.0	38.5	2.0	0.4	**14.20**
Mahi-mahi, dolphinfish (*Coryphaena hippurus*)	3.0	2.0	2.0	1.5	1.0	2.0	1.5	2.0	2.0	2.0	1.0	1.0	2.0	2.0	1.8	1.0	1.8	1.0	1.0	1.8	1.3	1.0	2.8	38.3	2.0	0.4	**14.11**
Pike (*D. lewini*)	1.5	1.0	1.5	1.0	1.5	2.5	1.0	1.5	1.0	1.0	1.0	1.5	1.5	2.0	1.0	1.5	1.5	3.0	2.0	2.5	1.5	1.5	2.5	36.5	2.0	0.4	**13.46**
Jobfish (*Aprion virescens, Pristipomoides filamentosus, P.sieboldi, P.multidens, P.typus, Aphareus vutilans*)	3.0	1.0	2.0	1.0	1.0	3.0	3.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	3.0	2.0	3.0	3.0	1.0	3.0	2.0	2.0	3.0	48.0	1.0	0.2	**8.85**
Morwong ,blue (*Nemadactylus valenciennesi*)	2.0	1.0	3.0	1.0	2.0	2.0	3.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	3.0	2.0	1.0	2.0	3.0	3.0	3.0	2.0	3.0	46.0	1.0	0.2	**8.48**
Wahoo (*Acanthocybium solandri*)	1.0	3.0	2.0	1.0	1.0	1.0	1.0	3.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	1.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	44.0	1.0	0.2	**8.11**
Catfish *(P.lineatus, P. albilabrus)*	2.0	1.0	1.0	1.0	1.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	1.0	2.0	2.0	39.0	1.0	0.2	**7.19**
Trevally, silver (*Pseudocaranx dentex*)	2.0	2.4	1.0	1.0	1.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	2.0	2.0	3.0	1.5	2.5	2.0	1.5	3.0	37.0	1.0	0.2	**6.82**
Flounder *(Pseudorhombus* spp.)	3.0	1.0	3.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	1.0	2.0	1.0	2.0	36.0	1.0	0.2	**6.64**

APPENDIX 4 (cont.)

The ranking of Northern Territory line-caught species with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing operations.

SPECIES/GROUP	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Play length	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	**Total**
Snapper Golden (*Lutjanus johnii*)	3.0	3.0	3.0	1.0	3.0	3.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.0	2.0	**54.00**
Emperors (*Lethrinus laticaudis, Lethri nus* spp.)	3.0	1.0	3.0	1.0	2.0	3.0	2.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	3.0	2.0	2.0	2.0	**45.00**
Black Jewfish (*Protonibea diacanthus*)	3.0	3.0	1.0	1.0	3.0	1.0	1.0	3.0	2.0	1.0	1.0	1.0	3.0	2.0	2.0	1.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0	**45.00**
Mackerels, spanish (*Scomberomorus* spp.)	3.0	3.0	1.0	1.0	3.0	1.0	1.0	3.0	2.0	1.0	1.0	1.0	3.0	2.0	2.0	1.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0	**45.00**
Coral Trout (*Plectropomus* spp.)	3.0	1.0	3.0	1.0	3.0	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0	1.3	3.0	1.2	1.0	3.0	2.2	1.8	1.6	**44.00**
Fingermark bream (*L. russelli*)	2.0	3.0	3.0	1.0	2.0	2.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.3	2.3	3.3	1.7	1.7	2.7	2.3	1.7	2.3	**43.25**
Barramundi (*Lates calcarifer*)	3.0	3.0	2.0	2.0	1.0	1.0	1.0	3.0	2.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	3.0	1.0	2.0	2.0	2.0	2.0	**43.00**
Snapper (*Lutjanus carponatatus*)	2.0	1.0	1.0	1.0	2.0	3.0	2.0	2.0	1.0	1.0	1.0	3.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	3.0	1.0	2.0	2.0	**43.00**
Sharks (all species)	1.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	1.5	1.5	3.0	1.5	2.5	2.0	2.0	2.7	**42.67**
Bream (*Acanthopagrus.* spp.)	3.0	1.0	2.0	1.0	3.0	2.0	1.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	1.9	2.1	2.6	1.1	1.6	2.9	2.3	1.9	2.0	**42.29**
Cods (*Serranidae family*)	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	3.0	2.0	2.7	2.0	1.3	2.7	2.3	1.8	2.5	**42.09**
Trevallys (all species)	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0	2.5	2.0	2.0	3.0	1.5	2.5	2.0	1.5	3.0	**42.00**
Yellowtail kingfish (*Seriola lalandi)*	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	1.0	1.0	3.0	**41.00**
Mangrove jack (*Lutjanus argentimaculatus)*	2.0	3.0	3.0	2.0	2.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.4	2.2	2.2	2.0	1.3	2.0	1.6	1.6	2.0	**40.25**
Threadfin salmon (*Polydactylus sheridani*)	2.0	2.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	3.0	2.0	3.0	1.0	2.0	3.0	**40.00**
Queenfish (*Scomberoides commersonnianus*)	1.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	2.0	2.0	2.0	1.5	1.5	3.0	1.5	2.5	2.0	2.0	2.7	**39.67**
Giant threadfin salmon *(Polynemus sheridani)*	2.5	2.5	1.8	1.0	1.3	2.0	1.1	2.4	2.0	1.3	1.0	1.0	1.6	2.0	1.7	1.8	1.8	1.5	1.3	2.0	1.5	2.0	2.3	**39.06**
Whiting, gold-line, northern (*Sillago* spp.)	2.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	1.4	2.0	3.0	1.4	1.6	1.8	2.0	2.0	2.4	**38.60**
Tunas (*Thunnus* spp.)	3.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	1.0	1.0	1.0	2.0	2.0	2.5	1.0	2.5	2.0	1.0	2.5	2.0	1.0	2.0	**38.50**
Pike (*D. lewini)*	1.0	1.0	2.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	1.0	1.0	3.0	3.0	3.0	2.0	1.0	3.0	**38.00**
Bonitos, oriental (*Sarda orientalis*), leaping (*Cybiosarda elegans*)	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	1.5	1.5	2.0	3.0	1.0	2.5	1.5	1.0	2.5	**37.50**
Billfish - marlin, sailfish and swordfish (*Xiphidae and Istiophoridae* spp.)	1.0	3.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	1.0	1.0	1.0	1.0	1.0	3.0	1.5	2.0	3.0	1.0	2.5	2.0	1.0	2.5	**37.50**
Flathead (*Platycephalus* spp.)	3.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.4	1.8	2.6	1.8	1.2	2.4	2.2	1.6	2.0	**36.00**
Cobia (*Rachycentron canadus*)	1.0	3.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	1.0	1.0	1.0	1.0	2.0	1.5	1.5	2.0	2.0	1.0	2.0	2.0	1.0	2.5	**35.50**
Mahi-mahi, dolphinfish (*Coryphaena hippurus*)	2.0	2.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	1.8	1.0	1.8	1.0	1.0	1.8	1.3	1.0	2.8	**33.25**
Mullet-sea (*Mugil cephalus*)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	**33.00**
Flounder *(Pseudorhombus* spp.)	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	3.0	1.0	2.0	2.0	2.0	1.0	2.0	**33.00**

APPENDIX 4 (cont.)

The ranking of the main freshwater line-caught species in Australia with respect to criteria that reflect their susceptibility to catch and release mortality by line fishing operations.

STATE	SPECIES	Eating	Sport	Minimum Size limit	Maximum size limit	Baglimit	Bycatch	Barotrauma	Handling	Playlength	Temperature	Salinity	Grading	Predation	Hook damage	Longevity	Growth	Exploitation rate	Reproductive potential	Fecundity	Length of spawning season	Vulnerability of spawning aggregations	Distribution pattern	Need for research	Total	Survey participation	Weighting	**Weighted total**
SOUTH AUSTRALIA	Murray Cod (*Maccullochella peelii peelii*)	2.2	2.4	2.2	2.2	2.0	1.6	1.6	2.6	2.6	1.5	1.0	1.0	1.2	2.0	3.0	2.0	2.0	1.0	2.0	2.0	3.0	1.0	2.0	44.1	5.0	1.58	**69.63**
	Callop (*Macquaria ambigua)*	2.6	1.6	2.4	1.0	2.0	1.4	1.6	1.8	1.4	1.8	1.0	1.8	1.4	2.0	3.0	2.0	3.0	1.0	2.0	1.0	2.0	2.0	2.0	41.8	5.0	1.58	**65.92**
	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	2.8	3.0	1.8	1.0	1.0	1.3	1.0	1.5	1.8	1.3	1.0	1.0	1.3	1.5	3.0	2.0	3.0	1.0	1.0	3.0	2.0	3.0	3.0	42.1	4.0	1.26	**53.15**
	Catfish (*Tandanus tandanus*)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	3.0	2.0	2.0	2.0	3.0	33.0	2.0	0.63	**20.84**
	Trout cod (*Maccullochella macquariensis*)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	1.0	3.0	2.0	3.0	1.0	2.0	1.0	32.0	2.0	0.63	**20.21**
	Redfin (*Perca fluviatilis*)	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	2.0	1.0	2.0	3.0	3.0	1.0	3.0	2.0	1.0	1.0	34.0	1.0	0.32	**10.74**
NEW SOUTH WALES	Australian Bass (*Macquaria novemaculeata)*	1.6	2.8	2.1	2.2	2.2	1.5	1.2	1.6	1.2	1.5	1.0	1.8	1.2	1.8	2.0	1.5	1.5	3.0	2.0	2.0	2.0	2.0	2.0	41.8	10.0	2.00	**83.54**
	Callop (*Macquaria ambigua)*	2.3	2.0	2.1	1.0	2.4	2.1	1.2	1.7	1.1	2.2	1.0	1.0	1.4	1.9	2.0	1.5	2.0	1.5	2.0	2.0	2.0	2.0	2.0	40.2	8.0	1.60	**64.24**
	Catfish (*Tandanus tandanus*)	1.6	1.7	1.8	1.0	2.0	2.3	1.3	1.8	1.3	1.5	1.0	1.0	1.3	1.3	2.0	1.5	1.5	1.0	3.0	2.0	2.0	2.0	2.5	38.2	5.0	1.00	**38.15**
	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	2.0	3.0	1.6	1.0	2.0	1.0	1.0	1.8	1.2	2.6	1.0	1.0	1.2	2.4	2.0	1.5	1.5	1.0	2.0	2.0	1.0	1.5	1.5	36.8	5.0	1.00	**36.80**
	Silver Perch (*Bidyanus bidyanus*)	1.8	3.0	3.0	1.0	3.0	1.7	1.3	1.3	1.0	2.0	1.0	1.0	1.3	1.8	2.0	1.5	1.5	1.0	2.0	2.0	2.0	2.0	2.0	40.0	4.0	0.80	**32.00**
	Macquarie perch (*Macquaria australasica*)	1.0	1.0	1.5	1.0	1.0	2.0	1.0	1.5	1.0	2.0	1.0	1.0	1.5	2.0	2.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	1.0	35.5	4.0	0.80	**28.40**
	Murray Cod (*Maccullochella peelii peelii*)	2.3	2.0	2.3	2.0	2.5	1.5	1.3	2.0	1.3	2.3	1.0	1.3	1.3	1.7	2.0	1.5	3.0	1.0	2.0	2.0	1.0	2.0	1.5	41.0	3.0	0.60	**24.60**
	Eels-shortfinned/longfinned (*Anguilla* spp.)	1.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	3.0	3.0	1.0	1.0	2.0	3.0	1.0	2.0	41.0	1.0	0.20	**8.20**
TASMANIA	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	2.1	2.9	2.1	1.1	2.0	1.0	1.0	2.4	2.3	2.1	1.3	1.3	1.4	2.4	1.6	1.6	2.5	1.0	1.5	2.4	1.0	1.5	1.5	40.0	8.0	1.90	**76.13**
	Atlantic Salmon (*Salmo salar*)	3.0	2.4	1.6	1.0	2.0	1.4	1.0	1.9	1.4	1.3	1.5	1.6	1.4	2.0	2.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	2.0	37.5	7.0	1.67	**62.45**
	Eels-shortfinned/longfinned (*Anguilla* spp.)	2.3	1.3	1.3	1.3	1.3	1.5	1.0	1.8	1.0	1.5	1.5	1.0	1.0	1.8	2.5	3.0	2.5	1.5	1.5	2.0	2.0	1.0	2.0	37.3	4.0	0.95	**35.48**
VICTORIA	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	1.8	2.8	2.0	1.0	2.3	1.2	1.3	2.5	2.0	2.3	1.0	1.2	1.3	2.3	1.0	1.0	3.0	3.0	2.0	3.0	1.0	1.0	1.0	41.2	6.0	4.11	**169.01**
	Australian bass (*Macquaria novemaculeata)*	2.0	2.0	2.0	1.0	2.5	1.0	1.0	1.5	1.0	1.5	1.0	1.0	1.0	1.5	2.5	3.0	1.0	1.0	1.0	3.0	1.5	2.0	1.5	36.5	2.0	1.37	**49.95**
	Redfin (*Perca fluviatilis*)	3.0	3.0	1.0	1.0	3.0	3.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	3.0	1.0	3.0	2.0	1.0	1.0	41.0	1.0	0.68	**28.05**
	Eels-shortfinned/longfinned (*Anguilla* spp.)	3.0	3.0	2.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	1.0	2.0	3.0	3.0	1.0	2.0	1.0	41.0	1.0	0.68	**28.05**
	Murray Cod (*Maccullochella peelii peelii*)	2.0	3.0	2.0	1.0	3.0	2.0	1.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	2.0	1.0	2.0	3.0	1.0	2.0	1.0	40.0	1.0	0.68	**27.37**
	Atlantic Salmon (*Salmo salar*)	2.0	2.0	1.0	1.0	3.0	3.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	2.0	3.0	2.0	2.0	1.0	39.0	1.0	0.68	**26.68**
	Blackfish (*Gadopsis marmoratus*)	3.0	3.0	2.0	1.0	3.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	3.0	1.0	1.0	3.0	2.0	1.0	2.0	1.0	39.0	1.0	0.68	**26.68**
	Macquarie perch (*Macquaria australasica*)	2.0	3.0	2.0	1.0	3.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	1.0	38.0	1.0	0.68	**26.00**
	Silver perch (*Bidyanus bidyanus*)	2.0	2.0	2.0	1.0	3.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	3.0	3.0	1.0	2.0	1.0	37.0	1.0	0.68	**25.32**
	Callop (*Macquaria ambigua)*	2.0	2.0	2.0	1.0	3.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	2.0	1.0	37.0	1.0	0.68	**25.32**
	Trout cod (*Maccullochella macquariensis*)	1.0	1.0	1.0	1.0	1.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	1.0	3.0	2.0	3.0	1.0	2.0	1.0	35.0	1.0	0.68	**23.95**
	Australian grayling (*Prototroctes maraena*)	1.0	1.0	2.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	3.0	2.0	2.0	1.0	34.0	1.0	0.68	**23.26**
	Carp (*Cyprinus carpio carpio*)	1.0	2.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	1.0	3.0	1.0	2.0	2.0	1.0	1.0	33.0	1.0	0.68	**22.58**
WESTERN AUSTRALIA	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	2.3	2.8	2.5	1.0	2.0	1.5	1.0	1.8	1.5	1.8	1.0	1.0	1.3	1.5	2.0	1.5	3.0	1.0	1.5	3.0	1.5	2.0	2.0	40.3	4.0	1.14	**46.00**

	Freshwater cobbler (*Tandanus bostocki*)	2.7	1.0	1.0	1.0	1.0	1.3	1.0	2.3	1.0	1.3	1.0	1.0	1.0	2.0	1.0	2.5	2.5	3.0	2.5	3.0	1.0	3.0	3.0	40.2	3.0	0.86	**34.43**
QUEENSLAND	Australian Bass (*Macquaria novemaculeata)*	1.8	2.8	2.3	1.0	3.0	2.3	1.4	2.0	1.6	2.0	1.0	2.2	1.4	1.8	2.0	2.5	2.5	1.0	1.5	3.0	1.5	2.0	2.0	44.7	6.0	2.40	**107.21**
	Catfish (all species)	2.7	1.0	1.5	1.0	1.8	2.5	1.0	2.0	1.3	1.0	1.0	1.0	1.3	2.1	1.5	1.5	1.5	1.0	2.5	3.0	1.5	1.5	1.5	36.5	4.0	1.60	**58.46**
	Murray Cod (*Maccullochella peelii peelii*)	2.7	2.7	2.3	2.7	2.3	1.7	1.3	2.7	2.3	1.7	1.0	1.0	1.0	2.0	3.0	2.0	2.5	1.0	1.5	3.0	2.0	2.5	2.0	46.8	3.0	1.20	**56.20**
	Callop (*Macquaria ambigua)*	2.3	2.0	2.3	1.0	2.7	2.0	1.3	2.0	1.0	1.7	1.0	1.7	1.3	2.0	3.0	2.0	3.0	1.0	1.0	3.0	2.0	2.0	2.0	43.3	3.0	1.20	**52.00**
	Jungle perch (*Kuhlia rupestris*)	1.7	3.0	1.7	2.0	2.3	1.7	1.0	2.0	1.0	1.3	1.0	1.0	1.5	2.0	2.0	2.0	1.5	2.0	1.5	3.0	1.0	2.5	2.0	40.7	3.0	1.20	**48.80**
	Saratoga (*Scleropages* spp.)	1.0	3.0	2.0	1.0	2.3	1.3	1.0	2.0	1.7	1.3	1.0	1.0	1.0	1.7	2.0	2.0	1.0	1.0	3.0	3.0	1.0	2.5	2.0	38.8	3.0	1.20	**46.60**
	Sooty grunter (*Hephaestus fuliginosus*)	2.0	2.0	1.7	1.0	1.7	2.3	1.0	2.0	1.0	1.3	1.0	1.3	1.0	2.0	1.5	1.5	2.0	1.0	1.5	3.0	1.5	2.0	2.0	37.0	3.0	1.20	**44.40**
	Trout cod (*Maccullochella macquariensis*)	2.0	2.0	3.0	1.0	3.0	1.0	2.0	3.0	2.0	2.0	1.0	1.0	1.0	2.0	3.0	2.0	3.0	1.0	2.0	3.0	3.0	3.0	2.0	48.0	1.0	0.40	**19.20**
	Silver perch (*Bidyanus bidyanus*)	2.0	1.0	3.0	1.0	3.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	3.0	3.0	1.0	2.5	2.0	42.5	1.0	0.40	**17.00**
	Macquarie perch (*Macquaria australasica*)	2.0	1.0	3.0	1.0	3.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	3.0	1.0	1.0	3.0	3.0	1.0	2.0	1.0	42.0	1.0	0.40	**16.80**
	Eels-shortfinned/longfinned (*Anguilla* spp.)	1.0	1.0	2.0	1.0	1.0	3.0	1.0	3.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	2.0	2.0	2.0	1.0	3.0	1.0	1.0	2.0	37.0	1.0	0.40	**14.80**
	Trout -Brown/Rainbow (*Salmo trutta, Oncorhynchus mykiss*)	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	32.0	1.0	0.40	**12.80**
NORTHERN TERRITORY	Saratoga (*Scleropages* spp.)	2.0	3.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	1.0	3.0	3.0	3.0	1.0	3.0	3.0	42.0	1.0	1.00	**42.00**
	Catfish (all species)	1.0	2.0	1.0	1.0	3.0	3.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	3.0	3.0	2.0	1.0	2.0	2.0	39.0	1.0	1.00	**39.00**

APPENDIX 5. SPECIES PRIORITY LIST RESULTS (FROM MEETINGS WITH SCIENTISTS/MANAGERS)

Priority level (P) = % release rate in commercial line fishery (C) + % release rate in recreational line fishery (R) + Exploitation status (E) * Ecological and Socio-economic value (V).

Species	Region	% Com R.R	% Rec R.R.	Expl. Status	Value to the state	Priority Index	Final priority	Top 3 factors influencing PRS		
WESTERN AUSTRALIA										
Snapper - pink	Temperate	1.5	3	2.5	3	21	**High**	Barotrauma	Hook damage	Play length
Baldchin groper	Temperate	1	1	4	2	12	**High**	Barotrauma	Predation	Handling
Dhufish	Temperate	1	1.5	2	2.5	11.25	**High**	Barotrauma	Handling	Hook damage
Australian salmon	Temperate	1	2	2	2	10	**High**	Handling	Play length	Hook damage
Samson/kingfish	Temperate	1	2	4	1.5	10.5	**High**	Play length	Hook damage	Barotrauma
sharks (gw,gn,dw)	Temperate	3	3	2.5	1	8.5	Medium			
Blue Morwong	Temperate	1	1	4	1	6	Medium			
Flathead	Temperate	1	2	4	1	7	Medium			
Western Blue groper	Temperate	1.5	1	4	1	6.5	Medium			
Mulloway - sthn & nthn	Temperate/Tropical	1	1.5 (2)	4	2	11 (14)	**High**	Play length	Hook damage	Handling
Pelagics (tunas, bonitos, dolphin fish)	Temperate/Tropical	1	2	4	1.5	10.5	**High**	Play length	Handling	Hook damage
Bream - sthn, nthn, yfin	Temperate/Tropical	1	2	2	2	10	**High**	Hook damage	Handling	Grading
Trevally, golden, skipjack	Temperate/Tropical	1	2	4	1.5	10.5	**High**	Hook damage	Play length	Handling
Serranid cods (6 species)	Temperate/Tropical	1	1	2	3	12	**High**	Barotrauma	Play length	Hook damage
Barramundi	Tropical	1	3	2	3	18	**High**	Handling	Play length	Hook damage
Lethrinid snappers (4 species)	Tropical	1.5	2	2	2	11	**High**	Barotrauma	Hook damage	Handling
Lutjanid snappers(4 species)	Tropical	2	2.5	2.5	2	14	**High**	Hook damage	Handling	Barotrauma
Spanish Mackerel	Tropical	1	1	2.5	2.5	11.25	**High**	Handling	Play length	Hook damage
Billfish (Marlin, broadbill, sailfish)	Tropical	1(3)	2.5	4	2	14(19)	**High**	Play Length	Predation	Play length
Bluenose Tuskfish	Tropical	1.5	2	4	1.5	11.25	**High**	Barotrauma	Predation	Handling
Salmon - bluenose (Threadfin salmon)	Tropical	1	2	4	1.5	10.5	**High**	Handling	Hook damage	Play length
Pearl perch	Tropical	1	1	4	1	6	Medium			
Grey mackerel/other mackerels	Tropical	1	1	4	1.5	9	Medium			
VICTORIA										
Snapper	Temperate	1	2	2	3	15	**High**	Hook damage	Handling	Play length
Black Bream	Temperate	1	2	2	3	15	**High**	Hook damage	Salinity	Grading
Wrasse - blue-throat, saddleback	Temperate	3	3	1	2	14	**High**	Barotrauma	Hook damage	Predation
Whiting - King George	Temperate	1	1.5	1.5	3	12	**High**	Hook damage	Handling	Grading
Flathead - sand	Temperate	1	2	1.5	2	9	Medium			
Australian salmon (juveniles mainly)	Temperate	1	2	1	2	8	Medium			
Gummy shark	Temperate	1	1	2	2	8	Medium			
Blue warehou	Temperate	1	1	3	1	5	Medium			
School shark	Temperate	1	1	3	1	5	Medium			
	Temperate									
Estuary Perch	Temperate	1	2	1	1	4	Low			
Elephant shark	Temperate	1	1	1	1	3	Low			
All other species listed (see Appendix 4)	Temperate						Low			
Trout - brown, rainbow	Freshwater	1	2	1 (stocked)	3	12	**High**	Handling	Hook damage	Play length
Murray Cod	Freshwater	1	2	3 (1 stocked)	2.5	15 (10)	**High**	Handling	all other factors equal	
Callop	Freshwater	1	2	2	2	10	**High**	Handling	all other factors equal	
Trout Cod	Freshwater	1	3	4	1.5	12	**High**	Handling	all other factors equal	
Silver perch	Freshwater	1	3	4	1	8	Medium			
Aust. Grayling	Freshwater	1	3	4	1	8	Medium			
River blackfish	Freshwater	1	1	2	1.5	6	Medium			

APPENDIX 5. SPECIES PRIORITY LIST RESULTS (FROM MEETINGS WITH SCIENTISTS/MANAGERS)(cont.)

Priority level (P) = % release rate in commercial line fishery (C) + % release rate in recreational line fishery (R) + Exploitation status (E) * Ecological and Socio-economic value (V).

QUEENSLAND	Region	% Com R.R	% Rec R.R.	Expl. Status	Value to the state	Priority Index	Final priority	Top 3 factors influencing PRS		
Barramundi	Tropical	1	3	2	3	18	**High**	Handling	Hook Damage	Barotrauma
Coral trout	Tropical	2	2	2	3	18	**High**	Barotrauma	Handling	Predation
Red-throat emperor	Tropical	1	2	2	3	15	**High**	Barotrauma	Hook Damage	Predation
Maori wrasse, barramundi cod	Tropical	2.5	3	4	1.5	14.25	**High**	Handling	Barotrauma	Predation
Two other large Lutjanid species	Tropical	1	2	4	2	14	**High**	Barotrauma	Predation	hook damage
Serranid Cods (> 50 cm)	Tropical	2	2	1.5	2	11	**High**	Barotrauma	Predation/ hook damage/ handling equal	
Mangrove Jack	Tropical	1	2	2	2	10	**High**	Handling	Barotrauma	Hook damage
Billfish (sail, black & blue marlin, broadbills)	Tropical, sub-tropical	1 (3*)	3	2	1.5	9 (12*)	**High**	Play length	Predation	hook damage
Spanish mackerel	Tropical, sub-tropical	1	1	3	3	15	**High**	Handling	Predation	Play length
Other mackerels	Tropical, sub-tropical	1	1	2	3	12	**High**	Handling	Predation	Hook damage
Tunas (yellowfin)	Tropical, sub-tropical	1	2	2	2	10	**High**	Play length	handling	hook damage
Tusk fish (2 species)	Tropical	1	2	2	1.5	7.5	Medium			
Serranid cods (< 50 cm)	Tropical	3	2	1	1	6	Medium			
Tunas (longtail, mackerel)	Tropical	1	3	1	1	5	Medium			
Grunts, Sweetlips (F. Haemulidae)	Tropical	1	2	2	1	5	Medium			
Sharks (whalers, river whalers, black tip)	Tropical, sub-tropical	2	2	2	1	6	Medium			
Trevally, queenfish	Tropical, sub-tropical	3	2	1	1	6	Medium			
Small Lutjanids (b) cross-shelf species	Tropical	1	3	1	1	5	Low			
Bream - pikey	Tropical	1	3	1	1	5	Low			
Slatey Bream **	Tropical	1	3	1	1	5	Low			
Fingermark seaperch - *Lutjanus johnii*	Tropical	1	1	2	1	4	Low			
Small Lutjanids (a) shallow reef species	Tropical	1	2	1	1	4	Low			
Jobfish	Tropical	1	1	2	1	4	Low			
Spangled Emperor (*Lethrinus nebulosus*)	Tropical	1	2	1	1	4	Low			
Threadfin salmon	Tropical	1	2	1	1	4	Low			
Whiting - *Sillago analis*	Tropical, sub-tropical	1	2	1	1	4	Low			
Other lethrinids (incl. grassy)	Tropical, sub-tropical	1	3	1	1	5	Low			
Snapper (*Pagrus auratus*)	Temperate	2	3	3	2	16	**High**	Barotrauma	Handling	Hook damage
Tailor	Temperate	1	2.5	2.5	2	12	**High**	Hook damage	Handling	Predation
Flathead (*Platycephalus fuscus*)	Temperate	1	2	2	2	10	**High**	Hook damage	Handling	Temperature
Pearl Perch (*Glaucosoma scapularae*)	Temperate	1(2)	2	2	1.5	7.5 (9)	Medium			
Bream - yellowfin, tarwhine	Temperate	1	2.5	1	2	9	Medium			
Whiting - summer (*S, ciliata, S. analis*)	Temperate	1	2	1.5	2	9	Medium			
Whiting - winter (*S. maculata*)	Temperate	1	1	1	2.5	7.5	Medium			
Large Serranid cods (bass cod, bar cod)	Temperate	1	1	4	1	6	Medium			
	Temperate									
Kingfish/amberjacks	Temperate	1	1	2	1	4	Low			
Mulloway (*A. japonicus*)	Temperate	1	1	1	1	3	Low			
Wahoo	Temperate	1	1	1.5	1	3.5	Low			
Teraglin	Temperate	1	1.5	2.5	1	5	Low			
Luderick	Temperate	1	1	1	1	3	Low			
Dart	Temperate	1	2	1	1.5	6	Low			
Dolphin fish	Temperate	1	1	1	1.25	4	Low			
Catfish (Neosilurus sp)	Temperate	1	3	1	1	5	Low			
Garfish (estuary)	Temperate	1	1	1	1	3	Low			
Mary River Cod (*Maccullochella* sp)	Freshwater - wild	1	3	3	2	14	**High**	Handling	Hook damage	
Yellowbelly (callop)	Freshwater - wild	1	2	2	1	5	Medium			
Australian Bass	Freshwater - wild	1	3	3	1	7	Medium			
Silver perch	Freshwater - wild	1	1	3	1	5	Medium			
Spangled Perch	Freshwater - wild	1	3	1	1	4	Medium			
Murray Cod (*Maccullochella peelii*)	Freshwater - wild	1	2	3	1	6	Medium			
Saratoga sp (2 species)	Freshwater - wild	1	3	1	1	5	Medium			
Freshwater eels	Freshwater - wild	1	3	1	1	5	Medium			
Yellowbelly (callop)	Freshwater - stocked	1	2	1	2	8	Medium			
Australian Bass	Freshwater - stocked	1	2	1	2	8	Medium			
Silver perch	Freshwater - stocked	1	2	1	1	4	Medium			
Mary River Cod	Freshwater - stocked	1	2	1	2	8	Medium			

APPENDIX 5. SPECIES PRIORITY LIST RESULTS (FROM MEETINGS WITH SCIENTISTS/MANAGERS)(cont.)

Priority level (P) = % release rate in commercial line fishery (C) + % release rate in recreational line fishery (R) + Exploitation status (E) * Ecological and Socio-economic value (V).

NORTHERN TERRITORY	**Region**	**% Com R.R**	**% Rec R.R.**	**Expl. Status**	**Value to the state**	**Priority Index**	**Final priority**	**Top 3 factors influencing PRS**		
Barramundi	Tropical Marine	1	3	2	3	18	**High**	Handling	Play length	Hook damage
Golden snapper/fingermark seaperch	Tropical Marine	2	2	1	2.5	12.5	**High**	Hook damage	handling	Barotrauma
Red Emperor (*Lutjanus sebae*)	Tropical Marine	2	2	1	2.5	12.5	**High**	Hook damage	Barotrauma	Predation
Black jewfish	Tropical Marine	2	2	1	2	10	**High**	Handling	Predation	Play length
Spanish mackerel	Tropical Marine	1	2	2	2	10	**High**	Handling	Predation	Play length
Stripey seaperch, saddletail snapper	Tropical Marine	2	2	1	2	10	**High**	Grading	Barotrauma	Handling
Coral trout	Tropical Marine	1	2	1	2	8	Medium			
Serranid cods	Tropical Marine	1	3	2	1.5	9	Medium			
Threadfin salmon	Tropical Marine	1	3	1	1.5	7.5	Medium			
Sharks - unspecified	Tropical Marine	1	3	3	1	7	Medium			
Tuna - longtail (nthn Bluefin)	Tropical Marine	1	3	1.5	1.5	7.75	Medium			
Billfish	Tropical Marine	1(3)	3	1.5	1.5	7.75 (11.25)	Medium			
Trevally - golden, & Queenfish	Tropical Marine	1	2	1	1.5	6	Medium			
Bream - pikey	Tropical Marine	1	2	1	1.5	6	Medium			
Flathead	Tropical Marine	1	1	1	1	3	Low			
Mahi-mahi	Tropical Marine	1	1	1	1	3	Low			
Whiting - unspecified	Tropical Marine	1	1	1	1	3	Low			
Saratoga sp.	Freshwater	1	3	1	1.5	7.5	Low			
NEW SOUTH WALES & ADJACENT C/WEALTH WATERS										
Billfish (Commonwealth fisheries)	Sub-tropical marine	1(3)	3	1.5	2.5	13.8 (18.8)	**High**	Play length	Predation	Hook damage
Bar cod (*Epinephelus ergastularius*.)	Sub-tropical marine	1	3	4	1.5	12	**High**	Handling	Barotrauma	Hook damage
Tunas (yellowfin, albacore)	Sub-tropical marine	1.5	2	1.5	2	10	**High**	Play length	Predation	Handling
Spanish mackerel	Sub-tropical marine	1	1	2	1.5	6	Medium			
Moses perch (*Lutjanus russelli*)	Sub-tropical marine	1					Medium			
Mangrove jack (*Lutjanus argentimaculatus*)	Sub-tropical marine	1	2	2	1	5	Low			
Mahi mahi	Sub-tropical marine	1	1	1	1.5	4.5	Low			
Snapper (*Pagrus auratus*)	Temperate marine	2	3	3	2.5	20	**High**	Barotrauma	Hook damage	Predation
Blue groper (Labrid wrasse)	Temperate marine	1.5	3	4	2	17	**High**	Hook damage	Barotrauma	handling
Mulloway (*Argyrosomus japonicus*)	Temperate marine	1	3	4	1.5	12	**High**	Handling	Hook damage	Barotrauma
Teraglin	Temperate marine	1	3	4	1.5	12	**High**	Barotrauma	Hook damage	Play length
Whiting - sand	Temperate marine	1	2	1	2.5	10	**High**	Hook damage	Handling	Predation
Flathead - unspecified	Temperate marine	1	2	1	2.5	10	**High**	Hook damage	Barotrauma	Handling
Sparid bream - black, yellowfin	Temperate marine	1	2	1	2.5	10	**High**	Hook damage	Handling	Grading
Blue-eye trevalla	Temperate marine	1	1	4	1.5	9	Medium			
Yellowtail kingfish	Temperate marine	1	2	1.5	2	9	Medium			
Tailor / Australian salmon	Temperate marine	1	2	1.5	1.5	6.8	Medium			
Serranid cods (Bass groper)	Temperate marine	1	1	4	1	6	Medium			
Hapuka	Temperate marine	1	1	4	1	6	Medium			
Gemfish	Temperate marine	1.5	1	3	1	5.5	Medium			
School shark	Temperate marine	1.5	1	3	1	5.5	Medium			
Jackass morwong	Temperate marine	1	1	2	1.5	6	Medium			
Luderick	Temperate marine	1	1	1	1.5	4.5	Low			
Mullet (sea)	Temperate marine	1	1	1	1	3	Low			
Murray Cod	Freshwater - MDB	1	2	2	2	10	**High**	Temp	Handling	Hook damage
Callop	Freshwater - MDB	1	2	2	2	10	**High**	Temp	Hook damage	Handling
Silver Perch	Freshwater - MDB	1	2	2	2	10	**High**	Temp	Hook damage	
Macquarie Perch	Freshwater - MDB	1	3	4	1.5	12	**High**	Temp/Hook damage		Handling/predation
Trout cod	Freshwater - MDB	1	3	4	1.5	12	**High**	n/a		
Catfish	Freshwater - MDB	1	2	2	1.5	7.5	Medium			
Eastern Freshwater Cod	Freshwater - eastern	1	3	4	1.5	12	**High**	n/a		
Australian Bass	Freshwater - eastern	1	2	1	2	8	Medium			
Eels	Freshwater - eastern	1	2	4	1	7	Medium			

APPENDIX 5. SPECIES PRIORITY LIST RESULTS (FROM MEETINGS WITH SCIENTISTS/MANAGERS)(cont.)

Priority level (P) = % release rate in commercial line fishery (C) + % release rate in recreational line fishery (R) + Exploitation status (E) * Ecological and Socio-economic value (V).

SOUTH AUSTRALIA & ADJACENT C/WEALTH WATERS	Region	% Com R.R	% Rec R.R.	Expl. Status	Value to the state	Priority Index	Final priority	Top 3 factors influencing PRS		
Snapper	Marine Temperate	2.5	3	2	2.5	18.75	**High**	Barotrauma	Hook damage	Handling
Southern bluefin tuna	Marine Temperate	1	2	3	3	18	**High**	Play length	Handling	Predation
Whiting - KG	Marine Temperate	1	1	2.5	3	13.5	**High**	Handling	Hook damage	Grading
Mulloway	Marine Temperate	1	3	4	1.5	12	**High**	Handling	Play length	Hook damage
Blue groper	Marine Temperate	2	1.5	4	1.5	11.25	**High**	barotrauma	Handling	Play length
YT kingfish/samson fish	Marine Temperate	1	2	4	1.5	10.5	**High**	Play length	Handling	Hook damage
Great white shark	Marine Temperate	1	1	4	1.5	9	Medium			
Sharks - school, gummy, bwhaler	Marine Temperate	1	2	3	1.5	9	Medium			
Bream - black	Marine Temperate	1	3	2	1.5	9	Medium			
Australian salmon	Marine Temperate	1	1	1.5	2	7	Medium			
Australian herring	Marine Temperate	1	1	1.5	2	7	Medium			
Garfish	Marine Temperate	1	1	1.5	2	7	Medium			
Flathead	Marine Temperate	1	2	4	1	7	Medium			
Nannygai	Marine Temperate	1	1	4	1	6	Medium			
Blue morwong	Marine Temperate	1	1	4	1	6	Medium			
Trevally - silver	Marine Temperate	1	1	4	1	6	Medium			
Sweep	Marine Temperate	1	2	1.5	1	4.5	Low			
Snook	Marine Temperate	1	1	1.5	1	3.5	Low			
All other species listed - mullet, yellowfin whiting, leatherjacket	Marine Temperate									
Murray Cod	Freshwater - MDB	2	2	2	2	12	**High**	Handling	Play length	Hook damage
Freshwater catfish	Freshwater - MDB	1	3	4	1.5	12	**High**	Handling	Bycatch	Hook damage
Silver perch	Freshwater - MDB	1	3	4	1.5	12	**High**	Handling	Bycatch	Hook damage
Callop, golden perch	Freshwater - MDB	1	2	2	2	10	**High**	Hook damage	Handling	Grading
All other species listed (see Table 2.14)							Medium, low			
TASMANIA & ADJACENT C/WEALTH FISHERIES										
Flathead - sand and tiger	Temperate	2	3	2	3	21	**High**	Handling	Hook damage	Temperature
Australian salmon - juveniles mainly	Temperate	1	3	2	2.5	15	**High**	Hook damage	Handling	Predation
Wrasse - blue throat, purple (sb)	Temperate	2.5	3	2	2	15	**High**	Barotrauma	Hook damage	Handling
Bream - black	Temperate	1	3	1.5	2	11	**High**	Handling	Hook damage	salinity
Blue warehou	Temperate	1	3	3	2	14	**High**	Handling	Predation	Hook damage
Tuna - SBT, Albacore, YF, Sjack)	Temperate	1	3	2.5	2	13	**High**	Play length	Handling	Hook damage
Morwong - jackass	Temperate	1.5	2	3	2	13	**High**	Barotrauma	Temperature	Predation
Shark - gum, sch (Commonwealth Fisheries)	Temperate	1	1	3	2	10	**High**	Hook damage	Handling	Play length
Shark - gummy * nursery areas	Temperate	3	3	3	1	9	Medium			
Shark - school * nursery areas	Temperate	3	3	3	1	9	Medium			
Trevalla - blue-eye (Commonwealth Fisheries)	Temperate	1	1	2	2	8	Medium			
All other species listed (see Table 2.16)	Temperate						Low			
Trout - brown, rainbow	Freshwater	1	1	1	3	9	Medium			
River blackfish	Freshwater	1	1	2	1	4	Low			
Eels	Freshwater	1	1	1	1.5	4.5	Low			