Department of **Agriculture, Fisheries and Forestry**

Assessing technology changes and risks to the sustainable management of deepwater line fisheries in southern Queensland

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NON TECHNICAL SUMMARY

2010/053	**Assessing technology changes and risks to the sustainable management of deepwater line fisheries in southern Queensland**

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OBJECTIVES:

1 Quantify recent changes in fishing technology in the commercial, recreational and charter line fishing sectors and evaluate the extent to which these changes could impact on the sustainability of deepwater fish species.

2 Collect and analyse biological data on key deep-water line caught fish species in collaboration with the fisheries observer program and collate information identified by the gap analysis currently being undertaken by Fisheries Queensland.

3 Assist Fisheries Queensland in developing an ecological risk assessment for deepwater fin fish species.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE:

The project outputs have contributed to or will lead to the following outcomes:

1. Biological and fisheries information on species targeted by deepwater fishers has been collected, collated and will be incorporated into future risk assessments enabling the improved monitoring and sustainable management of species fished by deep water line fishers.

2. An example for risk assessment matrix has been suggested to be used as part of the risk assessment process that will soon be organised and conducted by Fisheries Business Group.

3. Technology information will be included in catch standardisations in the next snapper stock assessment due in 2014 and will form an important part of catch data standardisations in other offshore line fishery assessments in southern Queensland.

4. Project results will be communicated in collaboration with Fisheries Queensland through meetings with stakeholders as part of the risk assessment process.

From the early 1990s, commercial line fishing increased in deeper waters (>200m) in Queensland, partly in response to management arrangements designed to reduce the pressure on more heavily fished shallow water areas, particularly those of the Great Barrier Reef. The granting of multi-hook endorsements (L8) contributed to this, although there had been some level of fishing for deepwater species for many years. By 1999, forty L8 licenses had been issued but in October 1999 a ‘freeze’ was placed on the granting of further L8 licenses. Subsequently, more stringent entry restrictions have resulted in a reduction of the number of vessels carrying L8 endorsements to 7 (January 2012). Throughout this period, deepwater stocks continued to be accessed by commercial line fishers under normal L1, L2 and L3 entitlements which allow the use of up to 6 hooks per line.

Such gear still enables viable catches to be taken in water greater than 200m, particularly when using electric/hydraulic winches, and logbook information (as well as anecdotal reports) suggests that this type of fishing has recently increased. In addition, some recreational fishers and a limited number of charter operators target deep water species and all sectors are believed to have increased fishing effort in deeper water. Concerns about the sustainability of Queensland's deepwater fisheries have been highlighted for many years and this report was prepared to review the available information on Queensland's deepwater line fisheries and to assess the likely impact of each line fishing sector on these stocks as well as providing information on the impact of improved fishing technology. Information in this report will then be used in stakeholder workshops to produce a risk assessment for the fishery.

Commercial logbook (CFISH) data of deepwater fishery species still suffers from the widespread use of generic categories, despite improvements in the species identifications and logbook enhancements. The continued use of categories such as "mixed cod", "mixed jobfish" and "mixed fish" results in catch assessments of individual species being underestimated. Species identification of many deepwater species (particularly less common species) is still poor even by experienced commercial line fishers and processors. Bar rock cod (*Epinephelus ergastularis*) in particular is much underreported.

Fisheries observer data analysed was limited spatially to southern Queensland and confirmed the importance of bar rock cod as the principal target species, and the relatively limited diversity of the other species caught. Bycatch from this fishery is limited and there are few fish returned to the water because they are unmarketable or undersized. There is evidence that spawning aggregations of bar rock cod may be being targeted. It is also a relatively long-lived species with the bulk of the fish being greater than 10 years old, although few fish were sampled that were over 25 years old. The ageing of this species, like many offshore species from subtropical locations, is relatively inaccurate and imprecise.

Surveys of recreational fishers indicated that plotters and sounders have each contributed a 40% increase to fishing power with fishing gear contributing about a further 25% increase over the last 2 or 3 decades. Braided line as well as various lures and hooks have also been influential in increasing recreational fishers' ability to catch fish. Commercial line fishers were earlier adopters of more advanced plotter and sounder technology but they have not used alternative modern fishing gear (such as braided line) as much as the recreational sector. Hydraulic and power winches have dramatically increased the efficiency of deepwater line fishing among all line endorsed fishers. There is also a small proportion of recreational and charter fishers that also access these deepwater stocks and it is expected that advances in technology will continue to increase the access of all fishing sectors to deepwater stocks. Fisher surveys confirmed a wide range of demographics and motivations to fishing that result in large numbers of surveys being required to have enough power to detect changes and motivations among each of these demographics.

Compliance is an issue in the deeper areas as these are located far from the coast where remoteness makes surveillance more difficult. The use of multi-hook apparatus (or other non-regulated fishing gear) by fishers not endorsed to do so is difficult to detect given that most fishing gear can be rigged and de-rigged very quickly. The use of VMS to monitor line fishing in deepwater may further improve compliance and act as a means of monitoring effort on deepwater stocks should it prove beneficial to restrict fishing in waters greater than 200m. Similar strategies have been employed in Western Australia where line fishing effort deeper than 200m in the south of the state has been restricted to 100 days in total. All operators wishing to access these stocks are required to have VMS.

Strategies also need to be adopted that protect vulnerable deepwater species as effort from existing shallow water line fisheries expands to deeper areas. One way to achieve this may be to control, or at least tightly monitor the catch of vulnerable species, and in particular those that are restricted to these deep water areas. There are several species that are almost exclusively caught in deep water > 200m, including bar rock cod (*Epinephelus ergastularis*), hapuka (*Polyprion oxygeneios*), Bass grouper (*Polyprion americanus*), flame snapper (*Etelis coruscans*), blue-eye trevalla (*Hyperoglyphe antarctica*) and a range of elasmobranchs. Rosy snapper (*Pristipomoides filamentosus*) are also an important deepwater species but these are still caught by shallow water fisheries (including recreational and charter sectors). CFISH data, as well as available biological information suggests that they are also vulnerable to overexploitation.

An example risk assessment framework to determine the deep-water species most vulnerable to overexploitation has been adapted (see Table 10.1) from a similar format used to categorise recreational line-caught species in Western Australia. The quantification of the various factors in the matrix is compromised by the lack of information about many of the species involved. Giving the highest risk ranking to sections of the matrix where nothing is known may over-rate the threat to some of these species as they represent a very minor component of the catch. By highlighting data-poor areas we may be giving too much weight to these species, although this may be warranted if the precautionary principle is to be applied. We have therefore chosen to be more subjective in our assessments, yet the ability is there to weight whatever characteristics stakeholders view as significant to provide a more objective assessment of the species that are to be categorised as vulnerable. Weightings for each line of the matrix are subjective and would obviously change with the views of particular stakeholder groups. Species categorised as being most at risk of overexploitation include bar rock cod (*Epinephelus ergastularis*) and some of the *Pristipomoides* species; Bass grouper (*Polyprion americanus*) and hapuka (*Polyprion oxygeneios*) are also susceptible although they are only a very small component of the catch. A number of risk assessment frameworks were identified, but whatever method is used by Fisheries Queensland the information summarised in this report will be central to the risk assessment.

KEYWORDS: deep water, fishery management, risk assessment, bar rock cod, trevalla, sustainability, fishing technology.

1. ACKNOWLEDGEMENTS

We wish to acknowledge the many commercial, recreational and charter fishers who took the time to complete Questionnaires which provided project staff a wealth of information regarding their fishing activities. A number of processors also assisted with the provision of fish frames and other biological material for which we are grateful. We would like to thank Mooloolah River Seafood, Point Cartwright Seafood and the Fish Kitchen who were particularly helpful. A number of commercial fishers readily allowed fisheries observers to accompany them on their fishing trips and this research would not have been possible without their assistance. Nadia Engstrom also provided summaries of the observer data and assisted with valuable insights into the analysis of those data. We also wish to thank Australian Fisheries Management Authority (AFMA) for the provision of commonwealth commercial logbook data. The photos for the front cover were provided by Jo Rowley (www.deepdropcommercial.com).

2. BACKGROUND

Around the world deepwater fisheries began to expand in the 1960s and 70s, coinciding with declines in shallow-water stocks (Roberts 2002), and the number of boats fishing the deepwater areas have increased substantially since that time. While fishing effort in deeper (>200m) offshore areas of Queensland may be proportionally less than in inshore areas, recent advances in technology, easier access, limited offshore habitat, the schooling habits and biology of many species, and the targeting of spawning populations have resulted in depletion in many deepwater areas (Rocky Reef Fishery Discussion Paper 1998). History has shown that deepwater fisheries often follow the pattern of high rates of exploitation and great rewards initially, followed by the collapse of stocks after a decade or so of exploitation (Roberts 2002).

In the late 1980s Australia's deepwater fisheries were identified as having developmental potential. From the early 1990s operators in Queensland were encouraged to move into deepwater areas, to reduce the pressure on more heavily fished shallow water areas, particularly those of the Great Barrier Reef. Initial entry policy to what was then to be developed as a multi-hook longline and dropline fishery was generous - all holders of L1, L2 or L3 line fishery symbols on a primary commercial fishing boat were entitled to apply for an L8 endorsement that enabled the use of multi-hook gear in water greater than 200m. By 1999, forty such L8 endorsements had been issued but in October 1999 a 'freeze' was placed on the granting of further L8 licenses. Subsequent, more stringent entry restrictions resulted in the reduction of the number of vessels carrying L8 endorsements to 7 today (January 2012). During this period, deepwater stocks continued to be accessed by commercial line fishers who did not have an L8 endorsement and the usual L1, L2 and L3 entitlements allowed the use of up to 6 hooks per line. This limitation in the quantity of gear still enabled viable catches of fish to be taken in water greater than 200m.

Concerns about the sustainability of Queensland's deepwater fishery have arisen amongst fishers, processors, managers and scientists for a number of reasons including:

- Continuing anecdotal reports of reduced catch rates of some species. These reports became more prevalent in the late 1990s and were highlighted by White and Sumpton (2002).
- Processors reporting increased volumes of deepwater demersal species being marketed by both state and federal license holders and the development of overseas markets for some deepwater species.
- Increasing fishing pressure in some deep water areas caused by: (a) displacement of effort due to recent extension of the marine park in the Coral Sea and other commonwealth and state legislative changes. (b) general increases in fishing effort by both recreational and Qld licensed commercial line vessels in deep (>200m) water.

- A lack of knowledge of deepwater fisheries and species composition of the catch. Species caught and locations fished have proven difficult to quantify owing to problems with logbook records. Identification of many species is difficult, and little is known about the biology or stock status of some species, although many are believed to be slow-growing, long-lived species and therefore likely to be susceptible to overexploitation.

- Difficulties associated with enforcing gear restrictions in offshore locations resulting in great potential for illegal fishing activity in these areas.

The objective of this report is to assess the sustainability of the Queensland deepwater fishery and provide information to be used in a risk assessment of key species based on: (1) available biological information on the target species, (2) a review of the CFISH (commercial logbook) data and information from deepwater fishers based on a fisheries observer program and (3) an analysis of the impact of changing technology on the ability of individuals to target deepwater fish stocks.

CURRENT MANAGEMENT CONTROLS ON DEEPWATER FISHERIES

State Regulations Governing the Multi-hook Fishery (L8)

Deepwater stocks off the Queensland coast are accessed by state based fishers under L8 and other line entitlements. In Queensland the multi-hook (L8) fishing area is restricted to all waters deeper than 200m that are east of longitude 142^{o}31’49” (See Appendix 3 for jurisdictional map). Commercial line fishers using other line endorsements (L1, L2, L3) are still able to access these areas using conventional fishing gear as are recreational and licensed charter boat fishers

To use multiple-hook apparatus within the Great Barrier Reef Marine Park requires an additional permit, obtained from the Great Barrier Reef Marine Park Authority (GBRMPA). However, to date the GBRMPA has adopted a policy of not granting permits for multiple hook fishing within the Marine Park. No additional permits are required for operation in the Coral Sea Marine Park.

Providing fishers hold the appropriate endorsement, any finfish (other than those regulated as “No Take” for all fishers) other than barramundi, coral trout, red emperor and snapper may be taken by L8 fishers. Size limits currently exist for most species caught in the deepwater fishery (See Table below).

Finfish may only be taken using bottom set lines (trot-line) or droplines, and the person operating these lines must be within 100m of the lines while they are in use. A maximum of 300 hooks may be used at a time and a trotline and a dropline must not be used at the same time. Droplines are vertically set lines with hooks attached by short weighted branch lines, or snoods, dropped into deepwater areas. A maximum of six droplines, each with not more than 50 hooks attached, can be used at one time. Each of these must be attached to a light-coloured float, of at least 300mm size in any dimension if they are deployed away from the vessel. Trotline (or bottom set line) fishing involves a horizontally set mainline which usually has small floats attached to suspend it off the seabed to avoid snagging. Snoods are attached at intervals along the main-line's length. These are set vertically in the water and act like a series of short droplines. A maximum of three trotlines, with not more than a total of 300 hooks attached, can be used at a time. A light coloured float, at least 300mm in any dimension, must be attached to each end of the bottom set line.

Primary commercial fishing boats must not be greater than 20m in length. A tender commercial fishing boat must be within 800m of its primary commercial fishing boat. If a commercial and an assistant fisher are on separate commercial fishing boats, the permitted distance for the assistant fisher to be away from the commercial fisher is no more than 800m.

In this report we have not concentrated on the multiple hook (L8) fishery as this was described in earlier research (White and Sumpton 2002) but it is important to remember that there are few species that are unique to either of these fisheries. L1 fishers in particular can easily access waters greater than 200m where the L8 fishery is restricted to.

State Regulations Governing the L1, L2 and L3 Fishery

Commercial fishers can access deepwater stocks if they have an L1, L2, or L3 entitlement (See Appendix 3 for fishery areas). L1 fishers are limited to waters south of the Great Barrier Reef Marine Park (GBRMP) while fishers operating under L2 and L3 entitlements are permitted to fish in the GBRMP.

Most of the species targeted by Queensland commercial operators holding L1 endorsements are classified as coral reef species for management purposes and can be line fished using a maximum of six hooks per line.

A range of input and output controls are legislated to manage the harvest of finfish species, including:

- apparatus restrictions with a limit on the number of hooks and lines that can be used by both commercial and recreational fishers: maximum of 3 lines per person with no more than 6 hooks in total.
- limited entry into the commercial sector.
- commercial fishing vessels limited to a maximum of 20 metres in length.
- minimum and maximum size limits for both commercial and recreational fishers (see next section).
- requirement to have an “RQ” fishery symbol and quota to retain any coral reef fin fish that are taken.
- total commercial entitlements under RQ units for species other than coral trout and red throat emperor (OS) are 955 604 kg, however the CRFFF management plan requires a reduction in the value of OS units if specified catch triggers are reached. This ensures that the total allowable commercial catches introduced in 2004 are not exceeded.
- commercial Total Allowable Catch (TACs) allocated through Individual Transferable Quotas (ITQs).
- seven coral reef fin fish are designated as ‘no-take’ species (barramundi cod, potato cod, Queensland groper, chinaman fish, hump-headed Maori wrasse, paddletail and red bass).
- two annual five-day spawning closures in October and November that apply to all fishers operating on the east coast between latitude 10°41’S and 24°50’S to the eastern boundary of the GBRMP. The fishery is also subject to restrictions on areas in which it can operate through zoning declared under GBRMP and Queensland Marine Parks Zoning Plans.
- an interim six week closure was put in place from 15 February to 31 March 2011 in order to reduce the fishing pressure on the snapper stock whilst new management arrangements were considered. This closure prohibited the retention of snapper, pearl perch and teraglin and as such had only a limited impact on fishers fishing water >200m. Following the closure the recreational bag limit for snapper was reduced from 5 to 4 fish and a maximum of 1 fish greater than 700mm in length was introduced for recreational anglers.

State Size and Bag Limit Regulations

A range of minimum legal sizes & recreational bag limits exist for many of the species caught in deepwater line fisheries under Queensland jurisdiction: The most important are summarised in Table 2.1.

Table 2.1 Size limit and bag limits of common fish species caught in deepwater line fisheries in southern Queensland. [1]There are exceptions to the size and bag limits for some species belonging to these families but few of these species are caught in water > 200m.

Species	Minimum size limit (cm) except where stated otherwise	Recreational bag limit
All cods and groupers[1]	38	5 in total
All Emperors[1]	25	5 per species
Tropical snappers and sea perches (see exceptions below)	25	5 per species
Rosy snapper and lavender snapper	38	Combined limit of 8
Saddletail snapper	40	Combined limit of 9 with crimson snapper
Flame snapper	38	5
Goldband snapper	38	5
Red emperor	55	5
Ruby snapper	38	5
Amberjack	75	Combined limit of 2 of amberjack and Samson fish
Pearl perch	35	5 in total
Sharks and rays	150 maximum	1 in total

It is not our intention in this report to describe in detail the commonwealth fisheries that operate in waters outside state jurisdiction. It is however important to note that the two fisheries are accessing the same stocks in many cases and the impacts of management changes in one jurisdiction will impact the other, as can the effects of fishing by operators in each jurisdiction.

Commonwealth Fisheries Regulations

Bycatch limits (for Commonwealth tuna fishing concession holders):

- Amberjack**,** yellowtail kingfish, black kingfish – 2 fish in total per trip
- Emperors, tropical snappers, cods, groupers, blue-eye trevalla, snapper, pearl perch, hapuka & bar cod, Spanish mackerel, Australian spotted mackerel, mackerel tuna, frigate mackerel, shark mackerel, rake gilled mackerel, Australian bonito, Oriental bonito, leaping bonito, rainbow runner, dog toothed tuna, , wrasses, tusk fish, dolphin fish – 10 fish in total per trip

Commonwealth line fisheries are also regulated by quotas for individual operators.

3. NEED

There is a risk that Queensland's deepwater (>200m) fish stocks are being fished at levels that are not sustainable Increased effort by commercial fishers in deep waters under normal line entitlements and the lack of knowledge of many of the targeted deepwater species (many of these species are presumed to be long-lived, schooling species susceptible to overexploitation) are key threats.

There is also anecdotal evidence that recreational fishers are fishing further offshore in deeper water and that recent improved fishing technologies have increased the effective effort on deepwater fish by all sectors. It is imperative that basic information on these deep-water stocks is collected at a time when management arrangements are being updated for rocky reef species (both shallow and deepwater).

The DEEDI Fisheries Observer Program has 100 days allocated to the deepwater fishery providing a unique opportunity to gather additional biological information on deepwater species that would not normally be collected as part of the routine core functions of the program. The provision of resources via a short-term “Tactical Research Fund” project will provide additional information at a time that is critical in the management cycle. It would also enable an assessment of the impact of improvements in vessel and gear technology (braided line, soft plastic lures, GPS etc) that could be used to better standardise catch rates. This is an essential requirement in any future stock assessments.

Fisheries Queensland has recently undertaken a gap analysis to identify information needs for completing an ecological risk assessment of this fishery. The proposed research is critical as it is designed to address the data deficiencies identified by that analysis.

Fisheries Queensland has identified this issue as a priority to be addressed over the next 18 months with a view to internally review risks to fish stocks under the existing management arrangements.

4. OBJECTIVES

1 Quantify recent changes in fishing technology in the commercial, recreational and charter line fishing sectors and evaluate the extent to which these changes could impact on the sustainability of deepwater fish species.

2 Collect and analyse biological data on key deepwater line caught fish species in collaboration with the fisheries observer program and collate information identified by the gap analysis currently being undertaken by Fisheries Queensland.

3 Assist Fisheries Queensland in developing an ecological risk assessment for deepwater fin fish species.

5. METHODS

5.1 LITERATURE REVIEW OF QUEENSLAND'S DEEPWATER FISH SPECIES

In general terms, many of the fish species caught in water greater than about 200m are characterised by slow growth rates, extended longevity, late onset maturity and low rates of natural mortality. In addition, some (particularly some rock cod species) are hermaphroditic, changing sex at some stage of their life cycle. As a consequence of these features they are likely to be particularly vulnerable to overexploitation (Looby 1997; Newman *et al*. 2000a) raising concerns about their long-term sustainability, particularly given recent increases in fishing pressure. Despite these concerns there is a lack of basic biological information and limited information of any kind on fish stocks for many deepwater species. Likewise, the issue of inaccurate catch reporting, species mis-identification and grouping of species groups in catch reports further restrict the information that is available to assess stock status.

The schooling behaviour and presumed large spawning aggregations of many deepwater species also contribute to their vulnerability. It is well established that the exploitation of schooling species can continue with relatively high, stable CPUE long after declines in overall population abundance have occurred (hyperstability) (Newman *et al*. 2000a). Furthermore, the young of many deepwater species are of a similar size to the older fish, meaning that fishing pressure may significantly alter the reproductive capacity of the population without altering its size structure (Williams *et al* 1995).

Our literature review summarises the available biological information for species caught in water greater than 200m in depth. It is an update of a previous summary compiled by White and Sumpton (2002). Much of the literature used to compile this section is from studies conducted outside Australia and in some cases there is considerable variation in the biological parameters estimated among studies. In addition, the published information often conflicts with the anecdotal information provided by fishers. In this section both published and anecdotal information is presented.

Other important information that needs consideration in any risk assessment includes: catchability (predictable location, spawning aggregations, mixed schools), marketability (current & future potential, local & overseas), whether they are actively targeted by fishers or not, quantity being landed, size range being caught and recreational fishing effort.

5.2 LOGBOOK DATA - COMMERCIAL FISHERY (1990 to 2011)

Queensland commercial fishers are required to complete daily catch and effort logs which have been compulsory in Queensland since 1988. Changes in the logbooks and amended management arrangements have impacted on the accuracy and precision of some of this information. The logbook analysis provides a summary of these data without standardising for factors that are likely to impact catch. We chose not to standardise the data due to poor resolution of the usual important factors such as effort in the data. We concentrate on the rock cod species (mainly bar rock cod, *Epinephelus ergastularis* and wreck fishes, *Polyprion americanus* and *Polyprion oxygeneios*) that dominate catches in south-east Queensland, as noted in the recent observer trips. We do not attempt to analyse the tropical snappers and emperors that are widely distributed throughout the more tropical regions of Queensland. It should also be noted that the catch of several individual fishers are highly influential in terms of the overall catch of many of the species taken in deeper waters. However, for confidentiality reasons we do not report at this fine level of detail in any of our analyses. The 2011 catch data is also not complete as it only represents less than half of that years catch at the time of analysis.

Commonwealth licensed fishers also operate outside waters over which Queensland has jurisdiction but still in waters off the Queensland coast and as such interact with state based deepwater fisheries. The catch from these fisheries is only relatively small and a range of gear types including trawls, line and trap are used. We have analysed the commonwealth logbook catches from these fisheries to indicate the potential scale of interaction between state and commonwealth license holders.

5.3 OBSERVER DATA - COMMERCIAL LINE FISHERY (2008 to 2011)

The observer analysis presents summaries and interpretations of data collected by fisheries on-board observers operating on commercial line fishing boats. The analysis is limited to the period of 2008 to 2011 when on-board observers accompanied a number of commercial line fishers, including those who were fishing in water in excess of 200m in southern Queensland. During this period, observer trips in water greater than 200m were limited to the CFISH grids W31, X32, X33, X36, X37 and X38 (See Appendix 4) and, as such, provide information from only a limited part of the deepwater fishery off southern Queensland. Observers recorded all aspects of the commercial fishing activities as well as measuring the length of fish caught, wherever possible. In this section, the species and sizes of fish landed during these surveys are described, with an emphasis on those trips that were conducted in relatively deep water (>200m). The analysis recognises a number of depth ranges but there is little analysis of trips where fishing was in water less than 100m. Depth ranges are clearly presented in all figures and tables but we have not described much of the data from trips in less than 100m.

5.4 INTERVIEW DATA - COMMERCIAL LINE FISHERS (2001 and 2011)

White and Sumpton (2002) contacted all L8 endorsed fishers during 2001 and interviewed them about their fishing activities, their views on the target species and current management arrangements. This section updates this anecdotal information supplied by fishers, and includes more recent comments from L1 fishers that were targeting deepwater species using normal line fishing gear rather than multi-hook apparatus. It reflects more current views on the specific issues described. It is not intended to be an objective discussion encompassing a representative sample of all fishers but we believe that in the absence of independent data it provides information relevant to the management of deep waters stocks and the assessment of risks associated with this fishery. It is further interesting to note that sometimes the views on particular species differ from data published in the scientific literature; however, we feel that the corroboration among the various accounts provided by fishers suggests that the information supplied is generally accurate so we have only included information that was corroborated by more than one source.

5.5 QUESTIONNAIRE ANALYSIS – RECREATIONAL LINE FISHERS (2011 to 2012)

A questionnaire was developed to gather information on changes in fishers' use of technology and their fishing practices over time. We initially sought to representatively sample the recreational, charter and commercial sectors but time and budgetary constraints forced us to under sample the charter and commercial sector. See Appendix 1 for a copy of the questionnaire used to interview the recreational sector. The questionnaires used for the other sectors only differed marginally from this template.

This analysis provides a summary of the results of the survey of the recreational component of the survey. Eighty six interviews were conducted with recreational fishers but only those whose fishing career spanned over 25 years were used in this analysis (n=52). Insufficient data have currently been collected from either the commercial or charter sectors to provide a detailed analysis of trends for these sectors and this aspect of the analysis awaits further development. The information contained in this section will be more useful when it is incorporated in catch standardisations in the framework of fisheries stock assessments.

The sample frame of this survey was not sufficient to representatively sample for technology change amongst the range of different demographics that were identified during the interviews but we concentrate here on those experienced fishers that have spanned the timing of recent technology improvements in sounders and Global Positioning technologies.

5.6 BIOLOGICAL DATA: BAR ROCK COD AND OTHER TARGET SPECIES

The collection of biological material, particularly otoliths and gonads was attempted for bar rock cod as well as other species landed by deep water fishers. This species is generally sold whole to the Sydney Fish Markets and most fishers were reluctant to allow the removal of otoliths as the process of otolith removal in bar rock cod requires considerable damage to the fish as larger specimens have a heavy bony skull from which it is difficult to remove the otoliths. This damage reduces the market price and, unfortunately, after assessing several different techniques for removing otoliths, both on-board vessels and at processors otolith removal from fish that were to be marketed was abandoned. Techniques trialled included the chiselling of the anterior skull from near the dorsal origin of the gills (a technique used successfully for other species in Western Australia - Corey Wakefield pers comm.), the use of a core drill to remove a plug of the skull (including otoliths). Both of these techniques worked well for some fish (particular those weighing less than 10kg) but the massive nature of the skull of larger bar rockcod was a major impediment. Samples of fish were obtained from processors as well as some commercial fishers who filleted their catch by arrangement with the project team. Smaller bar rock cod were also sourced from fishers who were fishing in shallower waters more frequented by juvenile fish. Otoliths were sectioned and aged as per standard fisheries techniques and the index of average percent error (IAPE) was used to examine ageing error and any biases between readings. Gonads were removed, weighed and macroscopically staged according to standard fisheries protocols wherever possible. Again, the lack of monthly samples precluded a thorough analysis of the reproductive seasonality and size-at-maturity for this species. Most of the fish from which biological material was obtained were from fishing trips that did not have fisheries observers on board.

6. RESULTS/DISCUSSION

6.1 LITERATURE REVIEW OF QUEENSLAND'S DEEPWATER FISH SPECIES

Table 6.1.1 Summaries of the main biological features of fish species taken in deepwater line fisheries in Queensland. A more detailed account of the important fishery species are also summarised in the sections following the table. Refer to White and Sumpton (2002) for descriptions of other minor species not included in this report.

Table 6.1.1 Summary of biological characteristics of deepwater species, caught in southern Queensland (**Fishing methods:** Tr = trawl; H = handline (rod and reel) or other line with < 7 hooks; L = longline (> 6 hooks); Tp = trap; G = gillnet. **Distribution**: W = widespread – occur outside of Australian waters; L = local distribution – only known to occur in Australian waters; N = northerly edge of the species' distribution in Queensland (temperate species); S = southerly edge of the species' distribution (tropical species); P = patchy (discontinuous) distribution. **Habitat:** R = rocky areas; S/M = occur over sand/ mud; CR = coral reef. # species not classified as coral reef species for management purposes.

Species	Fishing methods	Depth range (m)	Distribution	Habitat	Max. length (cm TL)	Max. age (yrs)	Size/age at maturity	Spawning season	Behaviour
Bar rock cod *Epinephelus ergastularis*	H,L	15-130 Juv 110-400 Ad	L,N	R	157	28+		Probably Spring/summer	Forms small schools
Eight-bar grouper *Hyporthodus octofasciatus*	H,L	150-300	W,N (P)	R	130			Summer spawner in Western Australia	
Comet grouper *Epinephelus morrhua*	H	80-370	W,S	CR,R	90				
Speckled grouper *Epinephelus magniscuttis*	H	50-300	W,S(P)	CR,R	150				
Oblique-banded grouper *Epinephelus radiatus*		80-380 Juv.to 20m	W,S(P)		70				
Bass grouper *Polyprion americanus*	H,L, Tr	40-600	W,N	R	210	40+		Summer in temperate waters	Solitary or in small schools
Hapuka *Polyprion oxygeneios*	H,L, Tr	50-600	W,N	R	170	60+	85-88cm, 10-13yrs	Summer in temperate waters	Solitary or in small schools
Flame snapper* *Etelis coruscans*	H, L	90-335	W,S	R	120		55-80cm	Summer peak, intermittently rest of yr*	
Ruby snapper *Etelis carbunculus*	H,L	90-400	W,S	R	80+	?	~30cm	3 months summer (Hawaii)	
Pale snapper *Etelis radiosus*	H	90-200	W,S	R	60				
Goldband snapper *Pristipomoides multidens*	H, L, Tp	40-245	W,S	R	90	14	35-50cm	Summer peak in Vanuatu*	Schools
Lavender jobfish *Pristipomoides sieboldii*	H, L	180-360	W,S	R	60		~29cm		Schools

Species	Fishing methods	Depth range (m)	Distribution	Habitat	Max. length (cm TL)	Max. age (yrs)	Size/age at maturity	Spawning season	Behaviour
Rosy jobfish* *Pristipomoides filamentosus*	H, L,Tp	40-400	W,S	R, CR	90	26+	35-50cm, ~2yrs	Apr-Oct (Hawaii)*	Large schools
Ornate jobfish *Pristipomoides argyrogammicus*	H	70-300	W,S	R	40				
Golden-eye jobfish* *Pristipomoides flavipinnis*	H	90-360	W,S	R	60	?		All yr (peak activity Dec-Feb)(Vanuatu)*	
Rusty jobfish (Ironjaw) *Aphareus rutilans*	H,L	100-330	W,S	R	90			Spring-summer (Vanuatu)	
Mozambique bream *Wattsia mossambica*	H	100-290	W,S		55				
Cocoa snapper *Paracaesio stonei*	H	200-318	W,S(P)		50+				
Blue-eye trevalla # *Hyperoglyphe antarctica*	H, Tr, L	300-800	W,N	R	140	75	Av 72cm 8-12yrs	March-Apr	Schooling species, V-large: solitary
Ocean blue-eye trevalla # *Schedophilus velaini*	H, L	200-600	W,N	R	90+				

* Data are from Lutjanid populations around islands; populations associated with larger landmasses have a more restricted (summer) spawning season (Grimes 1987).

Family Serranidae (Cods and groupers)

Serranids are mostly demersal fishes found predominantly in tropical and subtropical waters living on or near coral and/or rocky reefs. Many species are solitary, except for periods during the spawning season when they may form aggregations. They are generally resident on particular reefs for long periods of time. This site specificity and their relatively slow growth rate and reproductive strategies (many are hermaphrodite) make them particularly vulnerable to overfishing (Heemstra and Randall 1993). Although three deepwater cod species are important target species of the east coast deepwater fishery in southern Queensland (see below), there are many cod species that are also taken along with the main target species. There is currently very little biological data available on the most important species (bar rock cod) and there is much confusion regarding identification and common names for many of these species.

Epinephelus ergastularius (Bar rock cod, bar cod)

Bar rock cod has been the dominant species caught by the NSW deepwater line fishery for many years and is an important species for L1 fishers that extend their fishing activities to water in excess of 200m (in some areas they are also taken in water shallower than 200m). Adults are found at depths of 110-370m and juveniles 15-130m. Their distribution is limited to the south-west Pacific off the eastern coast of Australia between 18°S and 36°S (Heemstra and Randall 1993). The greatest reported size in the available literature is 157cm TL and 66kg but fish closer to 1.8 m and well over 100kg have been reported by some fishers. Very little is currently known about their biology, but they may spawn in the spring and summer.

Epinephelus morrhua (Comet grouper, deepwater cod)

Comet grouper is reported to be relatively abundant in parts of the Great Barrier Reef, being the most abundant Serranid species taken in handline sampling surveys Kramer *et al.* (1994). It is found at depths of 80-370m and has a broad Indo-Pacific distribution (Heemstra and Randall). Nothing is known about its biology. The maximum reported size is 90cm TL (6.7kg).

Hyporthodus octofasciatus (formerly *Epinephelus octofasciatus)* (Eight bar grouper)

This species appears to be less common than bar rock cod in Queensland waters despite it being an important deepwater fishery in Western Australia. Eight bar grouper inhabit rocky reefs (Heemstra and Randall 1993) at depths of 150-300m (adult), although the juveniles occur in shallower waters. It has a broad Indo-Pacific distribution with a maximum reported length of 130cm TL and maximum weight 80kg. Currently Western Australian researchers are investigating the biology of this species but they are believed to have relatively distinct spawning areas that feed recruits to other parts of the fishery.

Family Polyprionidae (Wreckfishes)

There are two species in this group and both are the subject of sustainability concerns in many jurisdictions throughout their distribution to the extent that they have protected status in South Africa.

Polyprion americanus (Bass grouper/ wreckfish)

Bass grouper are caught as a secondary species in line fisheries in temperate and subtropical waters throughout Australia. Juvenile bass grouper inhabit surface waters for the first 2 years of life (Sedberry *et al*. 1997), before moving to deeper waters (40-600m), often around caves or shipwrecks. Adults are usually solitary and reach lengths of up to 210cm TL (100kg), living to at least 45 years. Spawning occurs in summer. They have a global distribution (Sedberry *et al*. 1997) and are heavily exploited in many areas. Experience with bass grouper in areas such as Bermuda (Sedberry *et al.* 1997) and Brazil (Peres and Haimovici 1998) indicates that they can be quickly overfished, as technology and techniques better develop to target the species. This species (along with Hapuka) are currently the subject of research in Western Australia which is examining stock structure as well as fisheries sustainability.

Polyprion oxygeneios (Hapuka)

Hapuka is a secondary catch of line fisheries in depths up to about 400m. Juveniles inhabit surface waters and are rarely caught in the New Zealand fishery (Francis *et al*. 1998) as well as Australia, probably due to this pelagic stage of their life history. In New Zealand they have been recorded as switching from a pelagic to demersal lifestyle at around 50cm (3-4 years), at which time they move to deeper (50 to 600m) waters and become the target of line fisheries. Adults are generally found over rough ground from the central shelf to the shelf edge and upper slope (Francis *et al*. 1998). They have a southern circum-global distribution (Roberts 1986 in Francis *et al*. 1998). Hapuka is a large, long-lived fish, reaching sizes of at least 150cm TL (100kg) and living to at least 60 years old (Francis *et al.* 1998). In New Zealand populations, maturity occurs at between 10 and 13 years (85cm males; 88cm females) (Francis et al. 1998). Both bass grouper and hapuka are believed to be extremely wide ranging in their movement and recruitment patterns.

Family Lutjanidae (Tropical snappers/ jobfish)

Many Lutjanid species are slow growing and long-lived with low rates of natural mortality. They are likely to be vulnerable to overexploitation (Newman *et al* 2000a). This is further exacerbated by the tendency of most species to aggregate in large schools, which are easy to locate and catch in large numbers by vessels using modern sounders and other technologies (Newman *et al* 2000a).

Aphareus rutilans (Rusty jobfish/ ironjaw)

Rusty jobfish is commonly confused with small-toothed jobfish or is recorded as 'jobfish unspecified'. They inhabit reefs and rocky bottom areas and are widely distributed in the tropical Indo-Pacific as well as occurring in the Southeast Atlantic (Allen 1985) in waters up to 350m. There is nothing known about the biology of rusty jobfish in Queensland. It grows to a maximum of 110cm TL. In Vanuatu spawning occurs mainly during spring and summer, with peak activity in November-December (Allen 1985).

Etelis carbunculus (Ruby snapper, short-tailed ruby snapper)

Ruby snapper live over rocky habitats in depths of 90-400m, although juveniles are found in shallower areas (60-90m) (Moffitt and Parrish 1996, in Parrish *et al.* 1997). They are widespread in tropical waters of the Indo-Pacific. Virtually nothing is known about the biology or stock status of ruby snapper in Queensland waters although they are known to grow to at least 80cm TL. In the Hawaiian Islands, females grow to 65cm FL (maximum length), and their length at first maturity is 30cm FL (Grimes 1987). In Hawaii multiple or serial spawning occurs during a 3-month reproductive season over summer (Kikkawa 1984, in Grimes 1987). Everson (1984) found that large females matured earlier in the reproductive season and remained in spawning condition longer than the small fish.

Sex ratios for Vanuatu and Hawaii populations are strongly skewed in favour of females, particularly in the large size classes (Grimes 1987). Growth parameters are available from a number of sources and due to the wide variation there is clearly considerable variation and uncertainty in these parameters. In Western Australia they are believed to be protogynous with most reproductive activity occurring in the northern waters with recruits being fed to more southerly waters.

Linf = 63.9, K = 0.36/yr (Uchida *et al.* 1982 in Carlot 1990) (Hawaii)

Etelis coruscans (Flame snapper, onaga, longtail, flametail, long-tailed ruby snapper)

Flame snapper make up a significant proportion of the catch in the deepwater line fishery in some areas and years. They are found at depths of 90 to 335m over rocky bottoms and are widely distributed throughout the tropical Indo-Pacific, extending as far south as NSW (Everson *et al*. 1989). Flame snapper grow to 120cm TL and in Hawaii they reach sexual maturity at 55-80cm FL, with nearly 100% mature at 85cm Females probably spawn repeatedly through the spawning season which extends throughout the summer months in Hawaii and Vanuatu (Everson *et a*l. 1989). Intermittent spawning activity also occurs throughout the rest of the year in Vanuatu (Everson *et al*. 1989). K = 0.13/yr, M = 0.12 (Vanuatu population, Brooks 2000). Virtually nothing is known about the biology or stock status of this species in Queensland waters.

Pristipomoides filamentosus (Rosy snapper/ king snapper/ rosy jobfish)

Rosy snapper are also caught by the recreational sector, comprising 5% of south east Queensland's offshore recreational catch (Rocky Reef Fishery Discussion Paper 1998). They occur over rocky bottoms at depths of 40-400m and are widespread in the tropical Indo-Pacific. They were the most abundant species in Kramer *et al*'s (1994) handline survey of deeper waters in the Great Barrier Reef. The high catch rates of rosy snapper in particular areas might be due to its tendency to aggregate in large shoals in up-current localities (Mees 1993).

The maximum reported length is 90cm TL with fish maturing between 35-50cm TL) (Polovina and Ralston 1986). Rosy snapper have a rapid initial growth rate that then slows significantly, so a 30cm fish may be anything from 3 to 30 years of age. The potential vulnerability of rosy snapper to overexploitation has been shown in Samoa, where commercial development of the multiple hook fishery began in 1980. By 1989 there were 43 boats fishing at 50-450m. A resource assessment program showed that by 1989 a significant depletion of rosy snapper had occurred over the seamounts and large fish (over 61cm) had disappeared altogether from these areas (Langi and Langi 1989).

Males: Linf = 85.5cm, K = 0.30/yr. Females: Linf = 77.6cm, K = 0.275/yr. M = 0.534 (sexes combined). (Mees 1993) (Seychelles).

Pristipomoides multidens (Goldband snapper)

The species is caught in relatively large numbers in the Swains reef region (Brooks 2000). It is the most common species caught in the deepwater trap and dropline snapper fisheries in both Western Australia and the Northern Territory (Newman *et al.* 2000b). Goldband snapper are a schooling species, found at depths of 40-245m (Brooks 2000) in areas of hard, rocky and uneven sea floor and steep slopes off islands of the Indo-Pacific (Parrish 1987).

Nothing is known about the biology and stock status of goldband snapper in Queensland. However it is known to be a moderately slow-growing, long-lived species (Walters *et al*. 1996), living to at least 14 years and growing to a maximum of 90cm. Females mature at 35-50cm and undergo multiple or serial spawning during the reproductive season (Kikkawa 1984 in Lloyd 1994).

K = 0.219, L inf = 59.1cm (SL)	(Edwards 1985) (Timor Sea)
K = 0.13-0.18/yr	(Walters et al 1996)

Pristipomoides sieboldii (Lavender jobfish)

This species is caught elsewhere throughout its range mainly with bottom longlines and deep handlines. Although *P. sieboldi* (lavender jobfish) and *P. filamentosus* (rosy snapper) differ in biology they are very similar in appearance, and both species are often collectively referred to as 'rosy snapper'. The available literature states that they occur over rocky bottoms at depths of 180 to 360m (Kami 1973) and are caught most abundantly from about 180 to 270 m (Andersen and Allen 1997). Despite this it is known to be caught extensively by the recreational and charter sectors in Queensland waters in depths less than 100m. Lavender jobfish grow to a maximum length of 60cm, with average length at maturity being 29cm FL (De Martini and Lau 1999) in Hawaiian populations.

Pristipomoides typus (Sharptooth jobfish, marketed as goldband snapper)

Sharptooth jobfish are caught in relatively large numbers in the Swains reef region, where they live in schools in areas of hard, rocky, uneven seafloor at depths of 40-120m. They occur in the Eastern Indian Ocean, Andaman Sea and Western Pacific. They are present in Australia from the North West Shelf to Tweed Heads (Kailola *et al*. 1993). Sharptooth jobfish grow to 70cm TL, maturing at 28cm (Allen 1985). It is a serial spawner (Kikkawa 1984, in Lloyd 1994). Nothing is known about the biology and stock status of sharptooth jobfish in Queensland waters.

Family Lethrinidae (Emperors)

There are many members of this family that are caught throughout Queensland but few species are known to penetrate into water greater than about 150m. Most are caught in associated with shallower coral and rocky reefs in tropical and subtropical areas. The main exception to this is the Mozambique bream which is reported in fishers' logs and has also been documented on fisheries observer trips of the L1 fishery.

Wattsia mossambica (Mozambique bream)

This species is caught in relatively small quantities in Queensland. They are only reported from a few scattered localities in the Indo-West Pacific in depths of 100-290m at the outer edge of the continental shelf (Allen and Carpenter 1989). Its maximum length is 55cm, but it is most commonly caught around 35cm elsewhere in its distribution (Allen and Carpenter 1989). Nothing is currently known about its biology.

Family Centrolophidae (Medusa fishes)

Hyperoglyphe antarctica (Blue-eye trevalla)

Deepwater fishers in southern Queensland catch quantities of blue-eye trevalla although more commonly they are taken by Commonwealth-licensed fishers. Blue-eye is much more important in NSW where it is caught mainly using dropline and longlines at depths between 300 and 500m (Baelde 1996) with annual catches of around 200 tonnes sustained for many years. It is also a highly valuable species in southern Australia, New Zealand, South Africa and South America (Horn *et al.* 2010). In Australia they inhabit the outer continental slope and shelf waters and have been reported as far north as offshore from Tin Can Bay in Queensland. Juveniles inhabit surface waters and adults are most common over or near rocky areas, especially at edges of canyons at 100-300m depth, but they are caught at depths of over 800m. Outside Australia they are found in water as deep as 120m (Horn *et al* 2010). They generally remain close to the seabed during the day and move up in the water column at night, following concentrations of food (Kailola *et al*. 1993).

Blue-eye trevalla attain a maximum length of 150cm TL and live to at least 42 years. Fish are larger at depths >600m. In Tasmania fishers initially targeted larger fish in deeper waters. The size of fish and catch rate declined rapidly and the fishery then moved to shallower waters (400-440m) catching smaller fish (Baelde 1995). The smaller fish are caught in relatively high numbers because of their schooling behaviour (the larger fish tend to be more dispersed). As a result catch rates increased from the late 80s to mid-90s. Baelde's (1995) study also showed that boats now catch smaller fish at a given depth than in the past. The average sizes at which sexual maturity is reached is 72cm (11-12 years) for females and 62cm (8-9 years) for males. A brief 2-month spawning period occurs from early March – early May each year. Females spawn between 2 and 11 million eggs yearly depending on their size (Baelde 1995). Immature fish dominated the catches in the Tasmanian commercial fishery in 1994-95 (59% were found to be below the size of sexual maturity). Catches in Victoria and NSW are also likely to be composed largely of immature fish (Baelde 1995). There is believed to be one genetic stock of blue-eye trevalla in southern Australia (Bolch *et al*. 1993, in Baelde 1996). Recent work in New Zealand (Horn et al 2010) has shown that the age of this species may be greater than previously estimated with many fish of less than 90cm in length being over 40 years old.

Schedophilus velaini (Ocean blue-eye trevalla)

Ocean blue-eye is caught mainly using droplines and longlines between NSW and SA. It is very similar in appearance to blue-eye trevalla, and also inhabits similar depth range (200-600m) throughout the southern hemisphere. The maximum reported length of ocean blue-eye is 90cm. This species of trevalla is taken less frequently in Queensland waters but fishers do report catches of these at times off the southern Queensland Coast. Unlike the blue-eye, for which there is considerable information, very little is known about the biology of this species.

6.2 LOGBOOK DATA – COMMERCIAL FISHERY (1990 to 2011)

Queensland logbook data

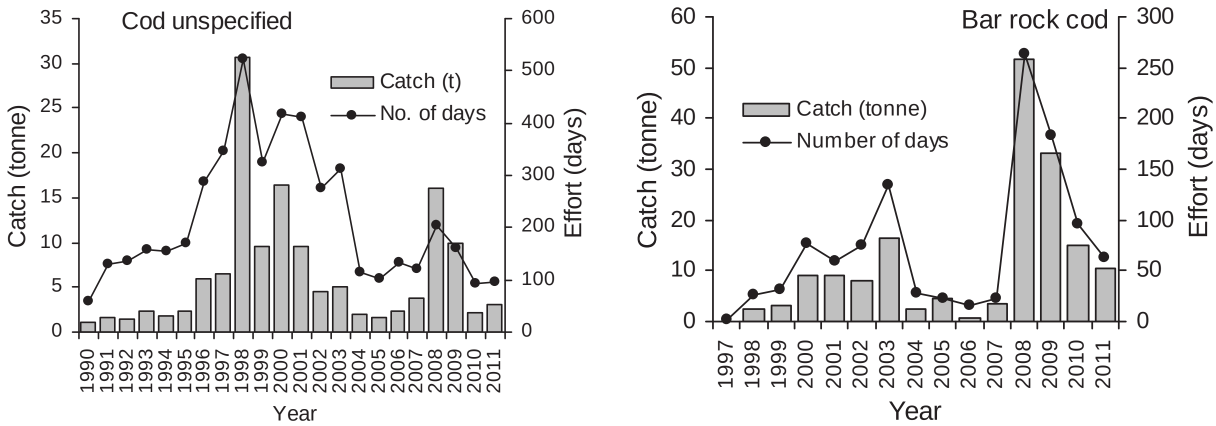

Figure 6.2.1 Commercial catch and effort of unspecified cod and bar rock cod in all Queensland waters (bar rock cod were not specifically identified in logs until about 1997).

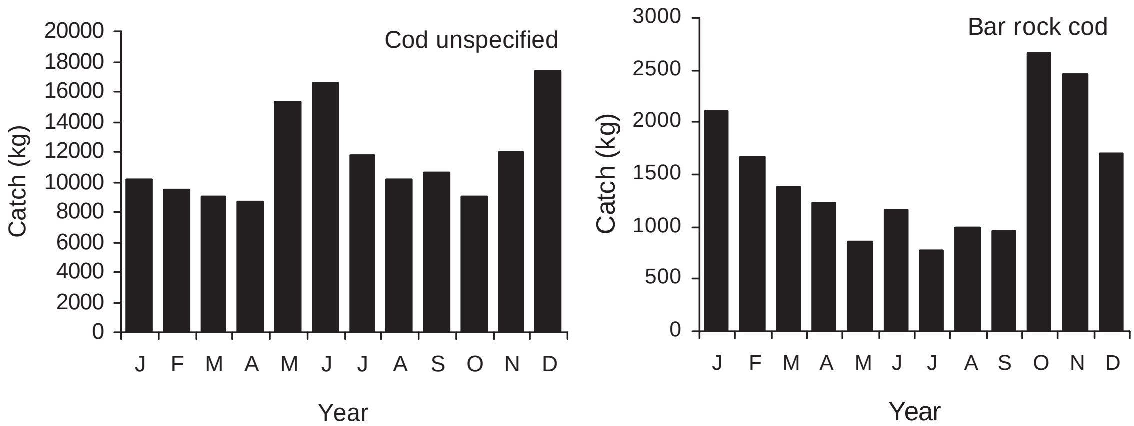

Figure 6.2.2 Average monthly catch of unspecified cod and bar rock cod recorded in CFISH logs from 1997 to 2011.

Unspecified cod were a significant component of the commercial catch records with up to 30 tonne recorded annually, although the yearly average was considerably less than this at around 5 tonnes (Figure 6.2.1). Efforts to improve identification around 2006 would have impacted on the accuracy of species records but the increase in records of bar rock cod which took place in 2008 was also associated with an increase in the unspecified cod records. The similarity in the post-2007 records in both these graphs suggests that there has been a fairly dramatic decline in the catch of bar rock cod since the peak of 2008/2009. Seasonally, bar rock cod are more commonly targeted and caught during spring and summer, but catches are maintained throughout the year. Changes in catch of the cod species is largely reflected in the fishing effort data which shows similar patterns to the catch.

Overall, effective fishing effort is difficult to define in this fishery and is usually analysed as days on which a particular species was recorded. During many fishing trips species will not be reported in fishers' logs even though that species may have been targeted. In addition, some species may be non-target catch caught while fishing for other species. This is particularly relevant to some of the less common species discussed later in this report.

Reporting practises of individual fishers was also important in determining species composition as some fishers clearly discerned individual species in their logs more than others and this resulted in elevated catches of some species in the years that those particular fishers were more active in the fishery. Therefore, effort will not be considered further for the other species because of these targeting and identification issues.

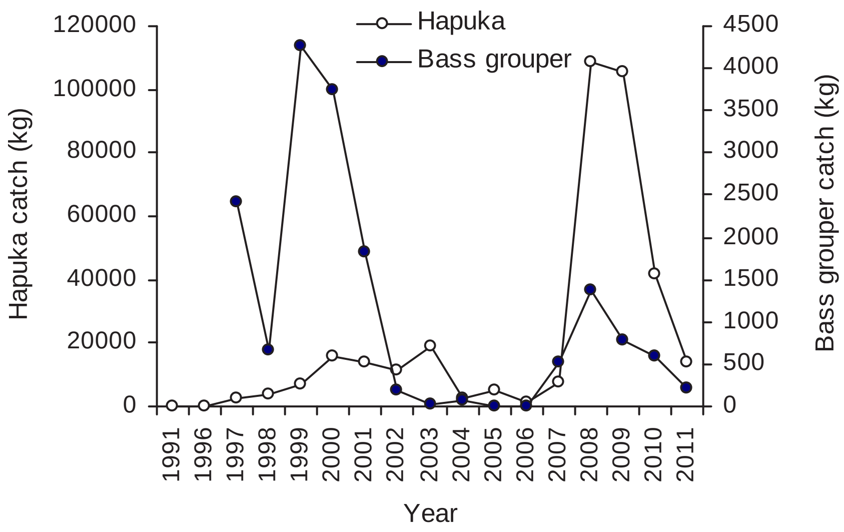

Figure 6.2.3 Total annual catch of hapuka and bass grouper in commercial logs of line fishers from 1991 to 2011.

Both hapuka and bass grouper are also recorded in the unspecified cod categories, but hapuka is currently reported more frequently than bass grouper with annual catches sometimes exceeding 5 tonne. Bass grouper were not even reported in some years (2005 and 2006) but it is clear that both of these species showed a similar recent trend in terms of overall catch (Figure 6.2.3) which peaked during 2008/2009. Both species have recently declined rather dramatically to the relatively low level of catch reported prior to 2008.

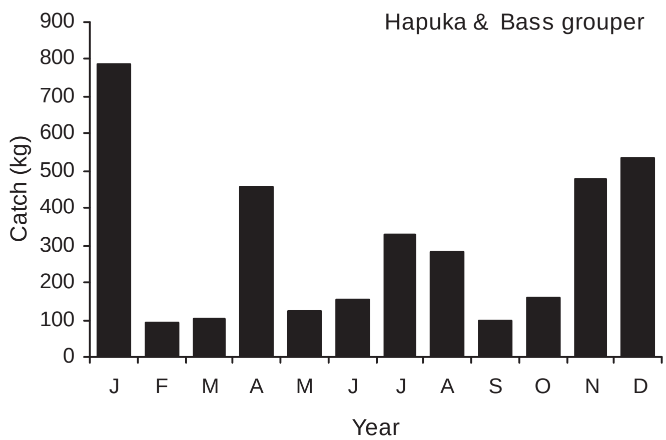

Figure 6.2.4 Average monthly catch of bass grouper and hapuka from commercial line fishers logs from 1991 to 2011.

The seasonal catch pattern of the wreckfish group (Hapuka and Bass grouper) was similar to bar rock cod in that most fish were landed during the summer months (Figure 6.2.4).

The eight bar cod was not commonly reported in commercial logs records with catches being limited to 2000, and the period 2008 to 2010. To date less than 5 tonnes have been reported in total with more than half of this reported in 2009 (2779 kg).

The flame snapper catch was restricted to grids in the southern part of Queensland and showed dramatic annual fluctuations (Figure 6.2.5), although the catch peak in 2008 and 2009 (which was seen for many deepwater species) was also evident for this species as well. The seasonal trends also varied widely from month to month, largely reflecting the activities of individual fishers rather than any real seasonal availability of the species.

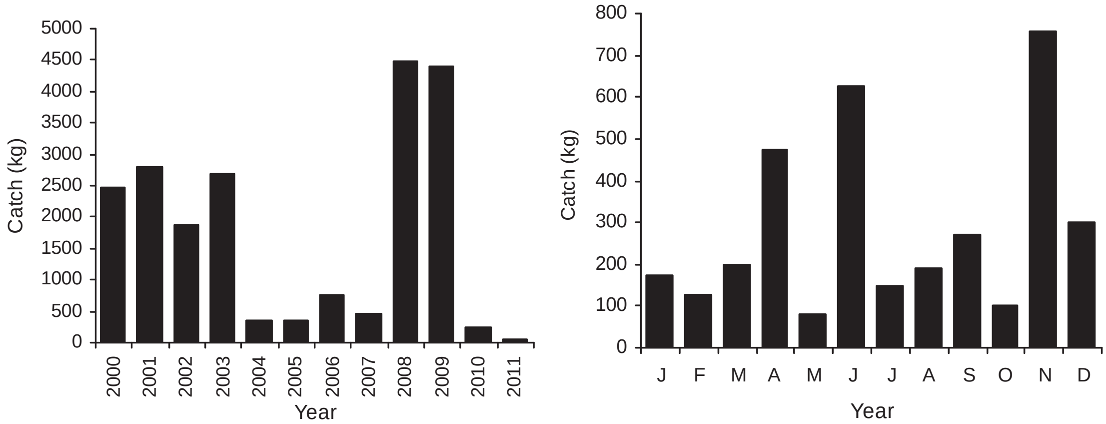

Figure 6.2.5 Annual and average monthly catch of flame snapper reported in commercial fishers' logs from 2000 to 2011.

The two species of blue-eye trevalla caught in Queensland waters were not differentiated in fishers' logs although the blue-eye trevalla is believed to make up the vast majority of the catch in these waters with the other species more commonly caught further south.

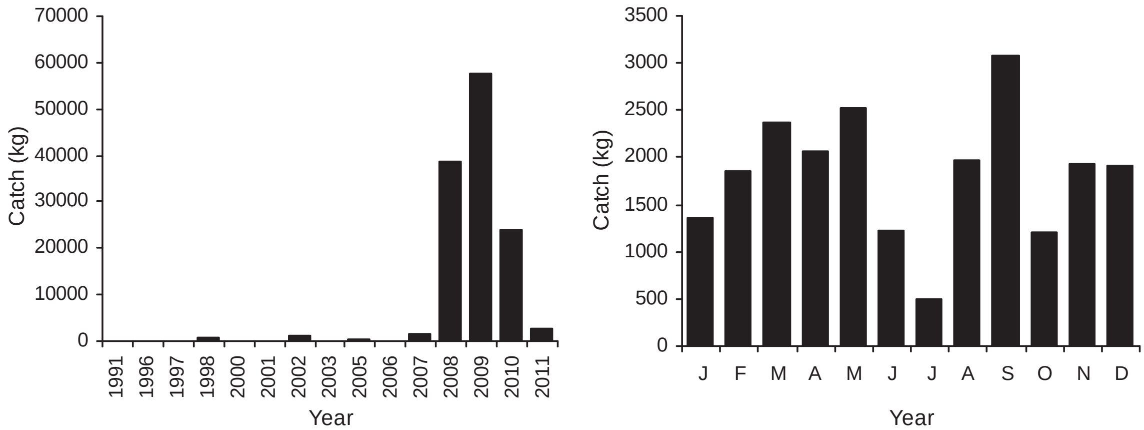

Figure 6.2.6 Annual and average monthly catch of blue-eye trevalla reported in commercial fishers' logs from 1991 to 2011.

Blue-eye trevalla have only been a relatively recently reported species in Queensland fishers' logs (Figure 6.2.6) and showed similar patterns to the cod species where the period 2008 to 2009 represented a period of elevated catches. Seasonally, blue-eye trevalla were caught throughout the year and did not display the strong spring autumn peak found for the cod species.

Commonwealth logbook data

The following results provide an indication of the importance of some of the deepwater species to commonwealth license holders.

Eight bar cod and bass grouper were not reported in commonwealth logs, however bar rock cod, hapuka, blue-eye trevalla, flame snapper and rosy snapper are important components of the catch in a number of these fisheries (Figure 6.2.7). The commonwealth data also highlights the contribution of individual fishers to both temporal and seasonal trends and again for confidentiality reasons we do not present a detailed analysis of individual species. Figure 6.2.7 however, does highlight the considerable overlap in species importance across jurisdictions (See Chapter 7 as well). Spatial trends are particularly important in determining the importance of individual species.

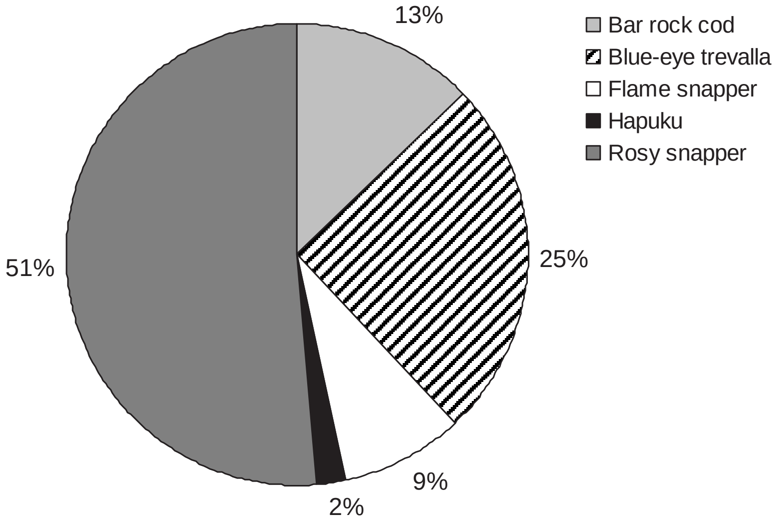

Figure 6.2.7 Percentage contribution of 6 common species targeted by commonwealth licensed fishers off Queensland (when other species have been excluded from the analysis).

Analysis of the commercial logbook data from both Queensland and the Commonwealth highlights a number of issues, the most important being the effect of recording catch in generic categories rather than individual species and also probable identification problems, particularly in the state logs. Both these issues have been highlighted previously (White and Sumpton 2002) and are also covered in other parts of this report, yet they are still the most serious impediments to addressing ongoing sustainability concerns for just about all species of interest. The lack of precision and accuracy of reporting however cannot hide the fact that 2008 and 2009 represented two very good catch years for a range of species with the subsequent decline in catch in 2010. The activities of individual fishers are influential in these patterns but there has been a real decline in catch of some of these species but at this stage it is uncertain whether this is a reflection of heavy fishing pressure on these stocks (see later General Discussion, Chapter 7).

The degree of overlap and varying influence of the activities of state-based and commonwealth licensed fishers on each other is also a significant issue, and one which is difficult to address without considerable management collaboration across the multiple jurisdictions that manage these stocks. The fact that the NSW dropline fishery also catches significant quantities of bar rock cod and blue-eye trevalla is a further complication. Given that Queensland is at the northern extreme of the range for most of these species and only contributes a small proportion to the overall east coast catch of species such as bar rock cod, hapuka and blue-eye trevalla, the management arrangements in other jurisdictions are more likely to influence the Queensland fishery than vice versa. The exception to this could be if species such as bar rock cod were moving to Queensland waters to spawn. The available literature suggests that this is not the case for blue-eye trevalla, hapuka and bass grouper as they are known to spawn predominantly in cooler temperate waters but the reproductive biology of bar rock cod is still poorly understood. It is interesting to note that spawning of rosy snapper in the northern part of its range in Western Australia drives the recruitment and subsequent fishery for this species further south (Corey Wakefield pers. comm..). If bar rock cod behaved in a similar manner then the Queensland based fishery for this species could have significant effects on the fisheries of other jurisdictions.

6.3 OBSERVER DATA – COMMERCIAL LINE FISHERY (2008 to 2011)

Ten fishers who fished in water greater than 100m participated in the on-board observer program and this number declined to 7 when depth of fishing increased to 200m. Effort in terms of the number of sites fished with depth is presented in Figure 6.3.1 which shows most effort in the 200m to 300m depth range corresponding to known rocky reef patches off northern Fraser Island and the Sunshine Coast. The shallower reefs (<100m) are more closely associated with the inshore areas which are more easily accessible to all fishing sectors and there is little fishing activity in the intermediate depths (150 – 200m) largely due to the relative lack of reef structure and complex habitat in these areas.

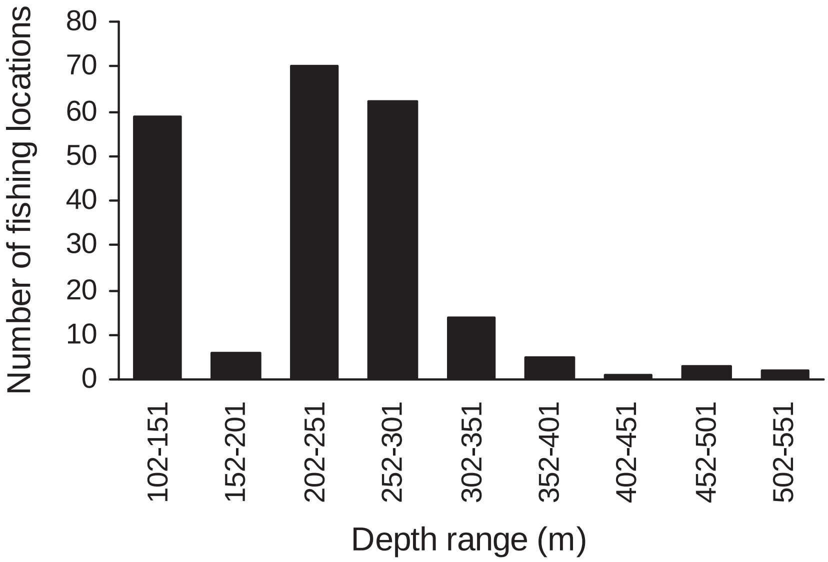

Figure 6.3.1 Number of fishing sessions recorded in various depth ranges by on-board observers accompanying commercial line fishers in southern Queensland.

The number of individual fishing locations on any given day of fishing by these fishers ranged from 1 to 17 with the an average of five locations fished per day, although these numbers varied dramatically among fishers and even on different fishing days. Fewer locations were fished if catch rates were satisfactory at the first locations fished.

When the depth range of observer trips was restricted to greater than 200m only 11 species were recognised in the catch, the most common species being the bar rock cod which represented over 85% of the catch (Figure 6.3.2). It needs to be recognised that this is by no means representative of the species' relative abundance in these waters. Rather, it is an indication of the importance of this species to a select group of fishers that were both willing to accommodate an observer and who fished in deeper waters (predominantly >200m in southern Queensland), targeting this species. With more extensive spatial coverage, we expect significant regional differences in the species composition of the catch as has been shown previously (White and Sumpton 2002). The data however do clearly show that bar rock cod can be targeted to the extent that little else is caught and fishers clearly are capable of fishing this species efficiently with limited by-catch or even by-product given modern fishing technology.

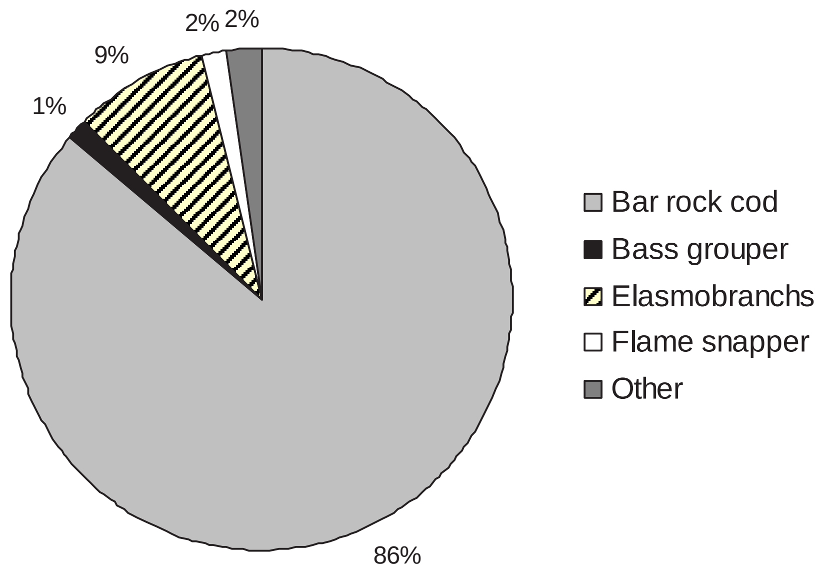

Figure 6.3.2 Catch composition of observer trips with L1 fishers in water greater than 200m

Surprisingly, there were no teleost fish released (either alive or dead) on observer trips when fishers targeted demersal species in water > 200m. However, a number of elasmobranchs including gummy sharks, spurdogs and dogfish were returned to the water after capture (Table 6.3.1).

Table 6.3.1 Fate of fish and sharks taken by commercial line fishers when fishing in water > 200m deep in southern Queensland. Table based on fisheries observer data of L1 fishers from 2008 to 2011. *represents species that are not described in the literature summaries presented in Chapter 6.1.

Common name	Kept dead	Released alive	Released dead	Used for bait
Bar rock cod	416			
Comet grouper	1			
Eightbar grouper	1			
Bass grouper	6			
Hapuku	2			
Flame snapper	8			
Brilliant pomfret*	3			
Rosy snapper	1			
Ruby snapper	1			
Smalltooth jobfish	1			
Pearl perch	1			
Eastern highfin spurdog*	3	12	2	2
Eastern longnose spurdog*	1	1		
Other Squalidae (dogfishes)*	10		3	6
Eastern spotted gummy shark*		1		
Gummy shark*	1			
Total	456	14	5	8

Species identifications of many of these elasmobranchs were difficult, and many of the dogfishes (Family Squalidae) were categorised into a common category. Most elasmobranchs were released alive, but their ultimate fate was undetermined, while some were also used as bait. The elasmobranchs were restricted to a relatively narrow depth range of 200 to 300m (See Table 6.3.1), apart from a single gummy shark landed from a depth of over 400m. This shark was not identified to species level. While elasmobranchs are an important ecological group they are considered outside the scope of this report, and will not be discussed in detail.

Table 6.3.2 Numbers of line caught finfish (including elasmobranchs #) at various depths (>101m) from onboard observer surveys of commercial line fishing vessels in southern Queensland. Single individual catches from each of 15 additional species are not presented. Some uncertainty also exists about the identification of some of the elasmobranch species.

	Depth range (m)									
Common name	102-151	152-201	202-251	252-301	302-351	352-401	402-451	452-501	502-551	Total
Bar rock cod			134	105	177					416
Pearl perch	209	88	1							298
Snapper	113	3	1							117
Rosy snapper	65		1							66
Yellowtail kingfish	34		15	2						51
Comet grouper	12	2			1					15
Redfish			8	6						14
Amberjack	12									12
Blue-eye trevalla						4		5	2	11
Radiant rock cod		1	9							10
Flame snapper			6	2						8
Eightbar grouper	4	2	1							7
Bass grouper				1	2	2		1		6
Toadfishes			1	2						3
Scorpionfish	1		1	1						3
Pale ruby snapper	3									3
Hussar	3									3
Goldband snapper	3									3
Brilliant pomfret						2	1			3
Venus tuskfish	2									2
Highfin amberjack	2									2
Hapuku					2					2
Dogfishes#			16	2				1		19
Spurdogs#			7	14						21
Whalers#			2	3						5
Gummy sharks#				2						2

Fifteen additional species (not presented in Table 6.3.2) including teraglin, red emperor and cobia were represented in the catch by only one individual.

The only species where more than 20 fish were caught in water greater than 100m were bar rockcod, pearl perch, snapper, rosy snapper and yellowtail kingfish. The following sections highlight these species and provide a more detailed assessment of the characteristics of their fishery based on observer records.

Bar rock cod

Bar rock cod were the dominant species caught on observer trips in waters greater than 200m in depth in southern Queensland. The recorded catch of this species was restricted to the depth range of 220 to 350m. Despite this, samples of juvenile bar rock cod (n = 8) were obtained (independent of the observer program) from line fishers operating in water as shallow as 100m off the Sunshine Coast (M Campbell, personal observation) but we had no reports of adult bar rock cod in waters < 200m.

The size range recorded by observers was 450mm to 1250mm which differed to the size range of this species recorded off Fraser Island during 2001 (White and Sumpton, 2002 and Figure 6.4.1). During this earlier survey bar rock cod were generally smaller than those fish landed during the present survey. The earlier catch samples were limited to catches from only two fishers and are unlikely representative of the entire fishery. In addition, bar rock cod over 1500mm in length were reported and photographed by some fishers on non-observer trips.

There was considerable variation in the average size of species in the catch among trips reflecting the possible fishing of size specific “aggregations”. The catch overall was dominated by fish in the 750 to 1200mm size range (Figure 6.3.3) and there was no strong declining trend in the number of larger fish (declining numbers of larger and older fish is typical of fisheries with a high exploitation rate). There was no significant relationship between depth and average size of fish landed although smaller individuals were caught in shallower water (Figure 6.3.4).

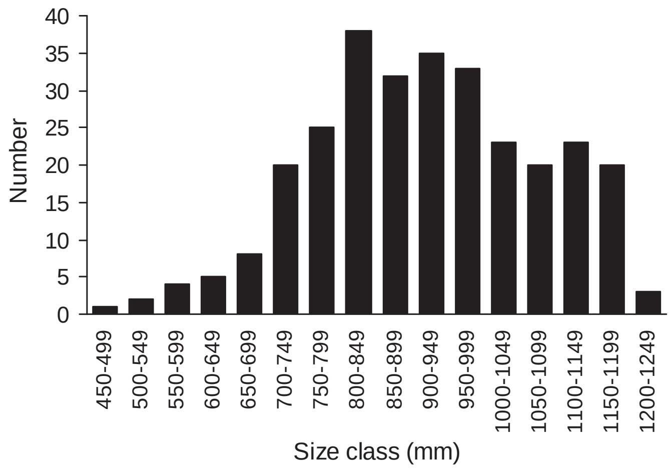

Figure 6.3.3 Size frequency (total length) of bar rock cod retained during observer trips with commercial line fishers in offshore waters of southern Queensland.

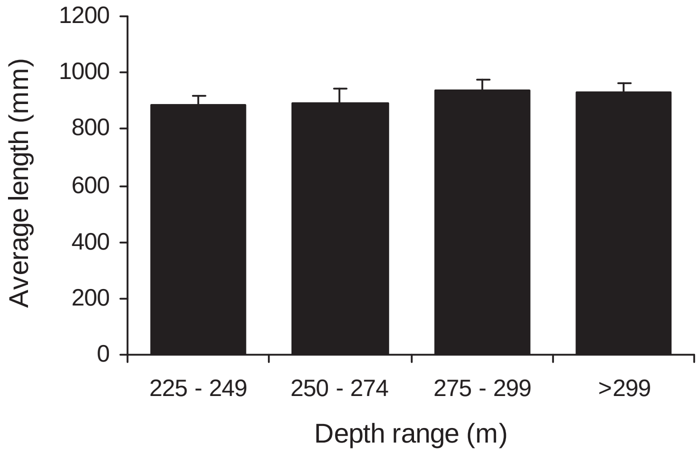

Figure 6.3.4 Average size of bar rock cod caught at various depths by commercial line fishers. Vertical bars are 95% confidence intervals.

Pearl Perch

Pearl perch were not taken in water less than 50m depth; the majority of the catch was taken in 100-200m. A small proportion of pearl perch caught on observer trips were undersized (Figure 6.3.5) and subsequently released. Released fish exhibited good survival as evidenced by individuals immediately swimming down from the surface once they were released. This size structure from the observer trips has a higher proportion of larger fish than samples collected from the overall fishery by the Queensland Fisheries Long Term Monitoring Program where the 350 to 450 mm size classes dominated the catch.

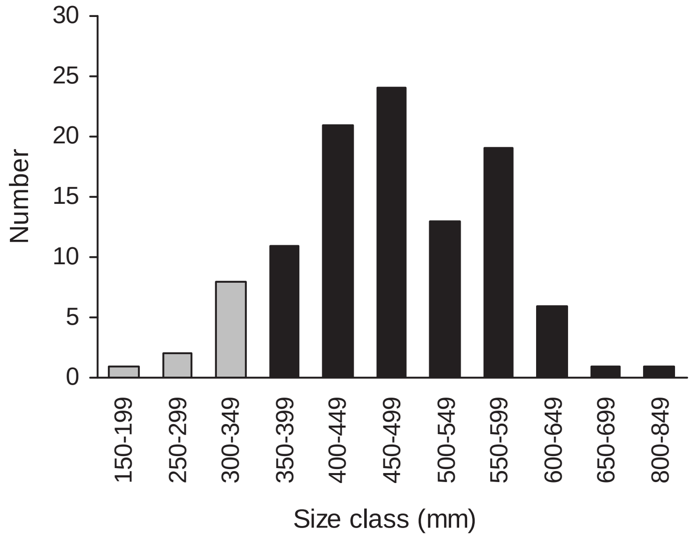

Figure 6.3.5 Size frequency of pearl perch caught during observer trips with commercial line fishers in offshore waters of southern Queensland. Grey bars are fish that were undersized and subsequently released.

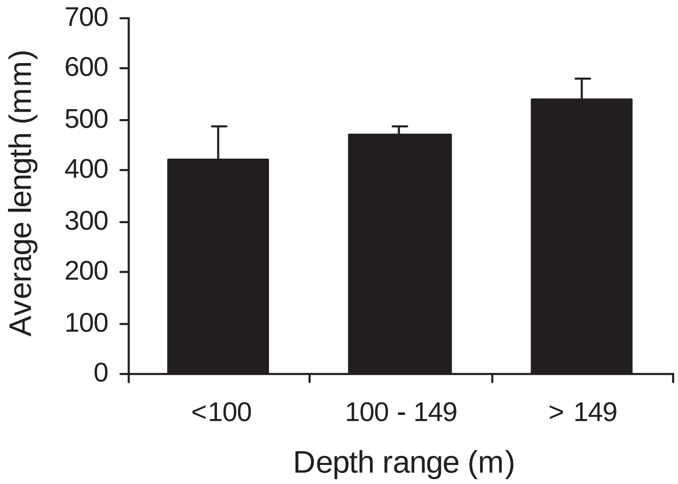

Figure 6.3.6 Average size of pearl perch caught at various depths by commercial line fishers. Vertical bars are 95% confidence intervals.

The average size of pearl perch also increased significantly ($P<0.05$) with depth (Figure 6.3.6).The extent to which the relationship between pearl perch size and depth reflects the effects of fishing is uncertain although this size/depth relationship is also observable in the charter boat fishery in southern Queensland.

Snapper

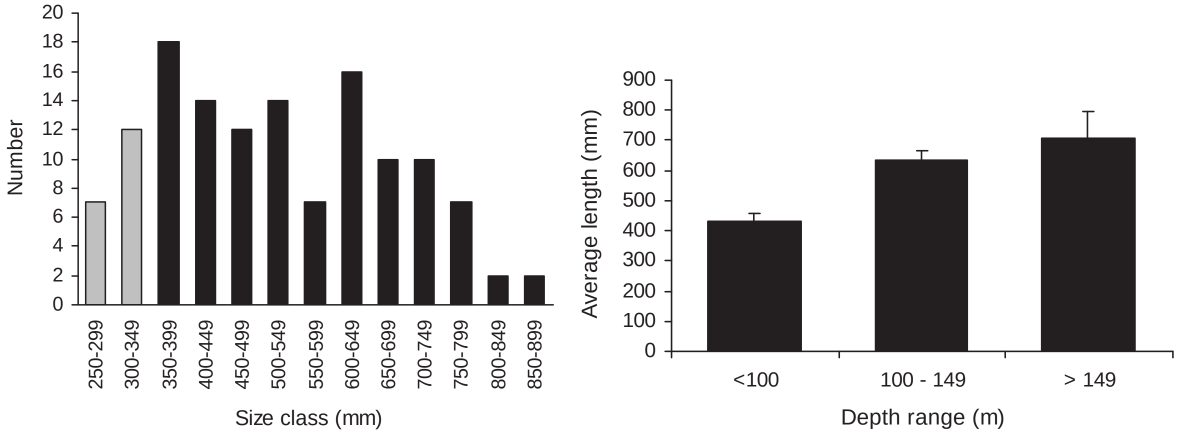

Figure 6.3.7 Total size frequency of snapper and average length of snapper caught in various depth ranges on observer trips with commercial line fishers from 2008 to 2011. Grey bars are fish that were undersized and subsequently released. Vertical bars are 95% confidence intervals.

The size structure of snapper sampled in 100m+, like pearl perch, was more dominated by larger size classes than samples collected from the overall commercial line fishery for this species. Snapper release rates due to undersized catch were also relatively low (Figure 6.3.7). Snapper caught in water greater than 100m were mainly restricted to the 100-150m depth range (Table 6.3.2) and like most other species there was an increase in average size of fish in the catch with increasing depth.

Rosy snapper

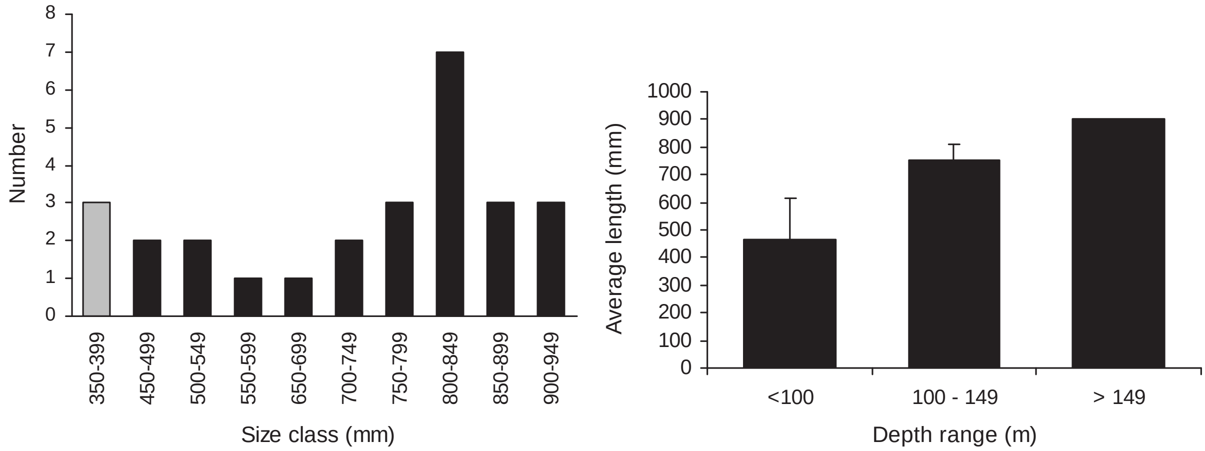

Figure 6.3.8 Total size frequency of rosy snapper and average length of rosy snapper caught in various depth ranges on observer trips with commercial line fishers from 2008 to 2011. Grey bars are fish that were subsequently released. Vertical bars are 95% confidence intervals.

There were relatively few rosy snapper caught during observer trips but as is the case for most fish targeted in deepwater, few were undersized (Figure 6.3.8). This species was also not caught in abundance in water > 150m but there were still significantly larger fish caught at the deeper extremes of their depth range.

Yellow-tail kingfish

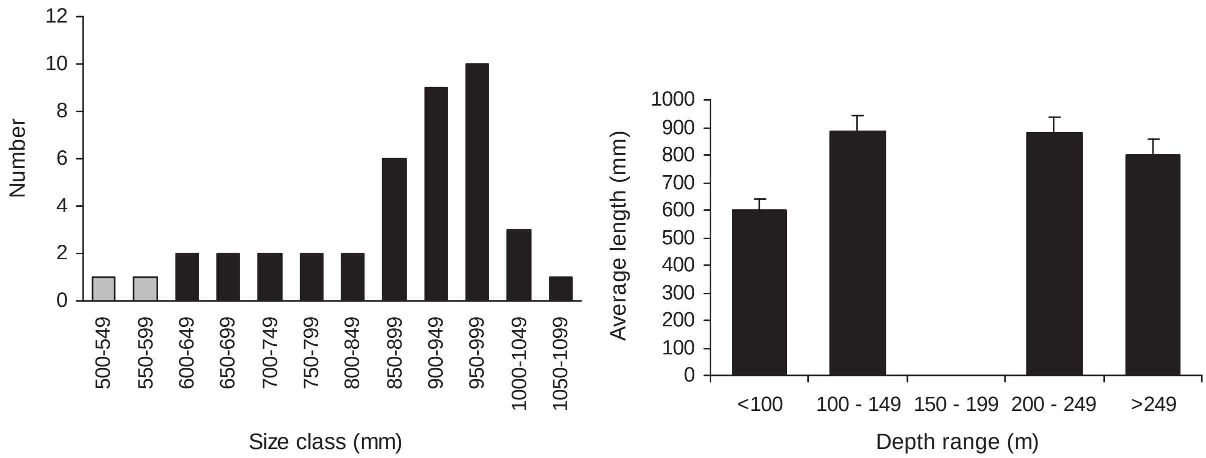

Figure 6.3.9 Total size frequency of yellow-tail kingfish and average length of yellow-tail kingfish caught in various depth ranges on observer trips with commercial line fishers from 2008 to 2011. Grey bars are fish that were undersized and subsequently released. Vertical bars are 95% confidence intervals.

Few yellow-tail kingfish were undersized with catch dominated by fish > 850mm in length (Figure 6.3.9); however numbers caught were really too low to draw too many conclusions.

6.4 INTERVIEW DATA - COMMERCIAL LINE FISHERS (2001 and 2011)

Target species & fishing activity

Target species for deepwater fishers vary depending on time of year and broad geographic region and there is considerable variation among fishers as to what constitutes a target species. Some fishers target just one or two species (as appears to be the case for bar rock cod in southern Queensland), others target a range of species, moving up and down the coast depending on the weather and where the fish are seasonally abundant. Such behaviour is common amongst most line fishers who work in shallower waters. Many fishers are adept at targeting different species and there is a great diversity in terms of fishing operations among fishes at all ports.

Primary target species (those that fetch the best market price and are relatively easy to catch in large quantities) include bar rock cod, flame snapper, goldband snapper, rosy snapper, ruby snapper, and sometimes large-mouthed nannygai. However, relatively large quantities of other species are caught along with the primary target species, particularly ironjaw / small-toothed jobfish and amberjack / samson fish. These latter fish are not discarded, although their market value is not as good as that of the primary target species.

Because of the large hook size used by deepwater fishers, most fishers state that their catches of small, undersized fish are limited and discard rates are low. This is a view supported by fisheries observer data collected during 2008 – 2011 (See Chapter 7). Most fishers, however, indicated that mortality rates were high for fish removed from deep water, due to barotrauma (over-inflation or bursting of the air bladder). Most species do not survive being brought to the surface from depths over 100m apart from the few exceptions (according to the fishers), which are mentioned in later sections.

Cods / groupers

Deepwater cods (especially bar rock cod) are regarded by many fishers in the southern part of the state as the main deepwater target species (and this is borne out by fisheries observer records). Deepwater fishers working outside the Swain's Reef area report small catches of the occasional isolated cod but larger catches are rare in the central part of the state. Bar rock cod appear to be restricted to southern waters outside the GBRMP. Larger bar rock cod are more solitary but they do occur in small schools when large quantities can be taken relatively quickly once the fish "go on the bite". Some fishers believe that they aggregate to spawn during the late spring and early summer when catches can be quite high (confirmed by logbook records). Large quantities are caught offshore from the northern end of Fraser Island and further south in waters 200-400m deep over rocky reef areas.

There is still much confusion regarding cod identification and several common names are used. Some fishers and processors are unable to reliably identify the species they are catching. Some suggest that the species sometimes recorded as 'hapuka' in logbooks is actually eight-bar grouper and bass grouper. Several fishers use the name 'lightship cod' to describe a cod (apparently similar in appearance to bar rock cod), caught in deep water. This species is probably hapuka or eight-bar grouper (or even bar rock cod in some logs). Many fishers also acknowledge that much of the cod is recorded as mixed cod in the fisheries logbooks, a practise that severely limits the value of the logbook data as an assessment tool for these species. This practise of using more generic categories was even more prevalent prior to the updating of the line fishing logs but is still a significant obstacle to the sustainable management of this group in particular.

Bass grouper and hapuka

Most fishers say that they catch only small numbers of these two species, predominantly as large fish (50kg+) with only a few taken on even the best fishing trips. Fishers believe that these two species are probably hooked quite frequently, but being so large, many are able to break the line or bend weaker hooks, particularly when relatively "light gear" is used. Like the bar rock cod, they are restricted to southern waters. Observers only saw two hapuka on trips conducted in 2011.

Ironjaw / small-toothed jobfish

Ironjaw still has a relatively low market value and are primarily a by-catch species particularly in the Swain's Reef area. This species is not often specifically recorded in fishers' logs tending to be grouped in the mixed species categories. It was not recorded on fisheries observer trips but some fishers still acknowledge it as an important species, most likely in areas north of observer coverage. It is also possible that there is some confusion of this species with other similar looking Lutjanids taken in relatively deep water.

Flame snapper / Ruby snapper

These *Etelis* species are important target species for some fishers, particularly in tropical waters. They are a highly schooling species, commonly caught at 100-400m, sometimes forming mixed schools. During the 1990s fishers reported that the average size caught was between 5 and 7kg. These two species also suffer from misidentification, and it is likely that they are misreported or recorded as 'mixed jobfish' particularly in earlier logbook records. Few of these were recorded on recent observer trips largely because there was little observer coverage in tropical areas.

Saddletail snapper

While not strictly a deepwater species, some fishers report catches from >200m deep, particularly in north Queensland. Although it was previously not a target species for many fishers due to its relatively poor market value some years ago, its popularity has increased over time as its marketability has improved. It forms large single species schools (or as a mixed school with crimson snapper), but is also found with goldband snapper in some areas. Some fishers comment that schools can be fished over several trips reducing the school to a fraction of its size over a week or so of fishing. Records of 500kg or more taken within a few days are present in the logs from North Queensland. Fishers report that these are often relatively large (4-12kg) fish.

Red emperor

Red emperor is an important line caught species for all fishing sectors, and being an aggressive species it is quite easy to catch large numbers. Unlike most species, red emperor often survives being brought from relatively deep water but few are taken in water greater than 150m.

Goldband snapper

This species is found in abundance inside the edge of the 200m zone, in large schools in some areas outside the Swains Reefs. Fishers report that when they catch goldband snapper in the Swains Reef area, very few other species are caught. Serial, localised depletion is common in these areas with catches declining over a series of fishing trips, resulting in fishers resting these areas for months or years before they become productive again.

Rosy snapper

Rosy snapper is an aggressive, schooling species of high catchability, fished mostly between 100-300m depth particularly between the Swains and Fraser Island. Fishers have reported a decline in the numbers of rosy snapper in the Fraser Island-North Reef area since the 1970s. The most common size of individual fish in some schools targeted last century was between 5 and 7 kg. Large schools of juvenile rosy snapper occur in areas around the “Hardline”. In this area there are very few mature rosy snapper, however fishers note that the few isolated mature fish that occur in this area are always very large. Some have suggested this to be a spawning and nursery area. Some fishers believe that they sometimes target spawning populations, getting particularly large catches fishing at night. Owing to the large size of hooks generally used by commercial operators few small-sized rosy snapper are landed. However, recreational and charter fishers fish in areas known to hold small fish and little is known about their catches.

Blue-eye trevalla

Relatively small quantities of blue-eye trevalla are reported by state based fishers although it is highly prized because of its high market value. Some fishers believe that it was not reported in logs prior to about 2005 despite some catches being taken by Queensland licensed fishers. In waters over which Queensland has jurisdiction, blue-eye is only caught south of Tin Can Bay in waters greater than 350m deep. In recent years large quantities have appeared on the local market, particularly on the Sunshine Coast, although much of this probably comes from Commonwealth licensed fisheries.

Amberjack / Samson fish

In the past, amberjack and Samson fish were not a heavily targeted species because of their poor market value. In the past, fishers reported driving away from schools of these species, but this does not appear to be the case in recent years according to logbooks submitted by rocky reef fishers. These fish are often found in the same area as target demersal deepwater species but are often in the water column above the target fish. Nowadays these species are certainly targeted when schools are located by commercial fishers operating in all depths.

Fishing methods

For deepwater fishers, fishing effort is limited by the size of the boat (and how much fuel it can carry), the fishing area’s distance from the shore, weather and current conditions. Some fishers with smaller vessels are restricted to single-day trips. Fishers who venture further offshore usually have to allow two days travelling time for 3-4 days fishing. Strong currents and rough weather (especially during the summer months) can make fishing difficult. Some multiple hook (L8) operators concentrate their fishing in the winter months and do very little (if any) deepwater fishing in January/February due to adverse weather and current conditions. However, this seasonality is not universal as bar rock cod are targeted particularly during these warmer months. Fishing locations are found using GPS and schools are located by sounder with some L8 fishers initially using a single line with a winch or handline, to determine what fish are present and whether they’re biting. They then either fish using lines from winches on the boat or set droplines attached to buoys at some distance from the boat (if they have an L8 endorsement). Nowadays most fishing is done using hydraulic or electric winches from the vessel. There has apparently been little use of longline technology even when large numbers of L8 endorsements were “active” in the fishery. (NB activity of fishers using multiple hook demersal longline technology was probably never high in deeper water).

The use of lines attached to winches (either mechanical or power assisted) on the boat is the preferred method for fishing. Some boats have five winches (one at the stern and two at either side). When there are many schools or a single school covering a large area, some L8 fishers still set droplines attached to buoys in order to cover a larger area. These are usually retrieved after a soak time of 20 minutes to an hour.

The number of lines and hooks used varies widely between operators in the deepwater fishery. L8 fishers may set between two and 20 lines at a time, with 9 to 40 hooks per line. If too many lines are set the fisher doesn’t have time to get to the last lines before fish start to escape or sharks destroy the gear. Rigs of up to 500 hooks have been used in the past but generally far fewer are used (between 20 and 90 hooks at a time is common). Size 13/0-16/0 tuna circle hooks are usually used, with larger hooks used for more aggressive fish. Too many hooks on a line will result in too much weight or problems with hooks snagging on the bottom.

L1 licensed fishers are limited to 6 hooks per line and many have either hydraulic or power assisted deck winches to increase their fishing efficiency.

Fisher views on management

Changes to management of other fisheries have had dramatic effects on effort exerted on deepwater fish stocks. Changes to the trawl management plan and coral reef finfish management have been particularly influential in this regard. Furthermore, the spanner crab fishery licensing system allows transferable quotas. A fisher with both spanner crab and line endorsements can split their licences, so one person can be using the spanner crab licence at the same time as another is deepwater fishing. Some deepwater fishers believe this is placing extra pressure on deepwater fish stocks.

Some fishers suggest that only boats currently holding an L8 licence should be able to fish in deepwater or that line fishers should be given a choice between fishing the deep or shallow waters (and licensed accordingly) but should not be permitted to do both.

Almost all fishers have highlighted localised declining catches in particular areas and many have commented on general declines. There is a diversity of views regarding the sustainability of deeper water fish stocks. Some report that stocks of many species have already been greatly depleted in the more easily accessible areas closer to shore. Others report catches of rosy snapper and bar rock cod have declined dramatically in some areas and these species in particular are subject to localised depletion. Others have even suggested closures of the heavily exploited areas (Fraser-North Reef) to allow the recovery of some stocks. Some longer term fishers have noted that bar rock cod have been fished periodically for decades.

The use of traps has been suggested as an alternative method to catch deepwater species. Traps would allow small fish and non-target species to escape alive and some have argued that they would result in a better quality product (no hook damage). This method has been trialled recently under permit but to date has not been successful in deeper areas largely due to strong currents and other logistic issues. There is also some doubt as to the quality of trap caught fish because it is well recognised that the price obtained for many trap caught species such as snapper is often inferior to line caught fish.

There is limited historic size-structure information of most species targeted by deepwater line fishers. However, information collected by White and Sumpton (2002) showed considerable variation between individual catches and the size of fish caught. These data are re-presented (Figure 6.4.1) for comparison with current catch information. On some occasions the smallest *P. multidens* measured was 65 cm while this was the largest size recorded in the catches of some fishers. A diverse range of other species was encountered but they never made up a significant proportion of the catch and not enough were measured to provide an indication of size range. Only 5 catches of bar cod were measured with the average size being 80 cm. There were few bar cod greater than 1m in length landed despite the fact that the species reaches a length of over 1.5m.

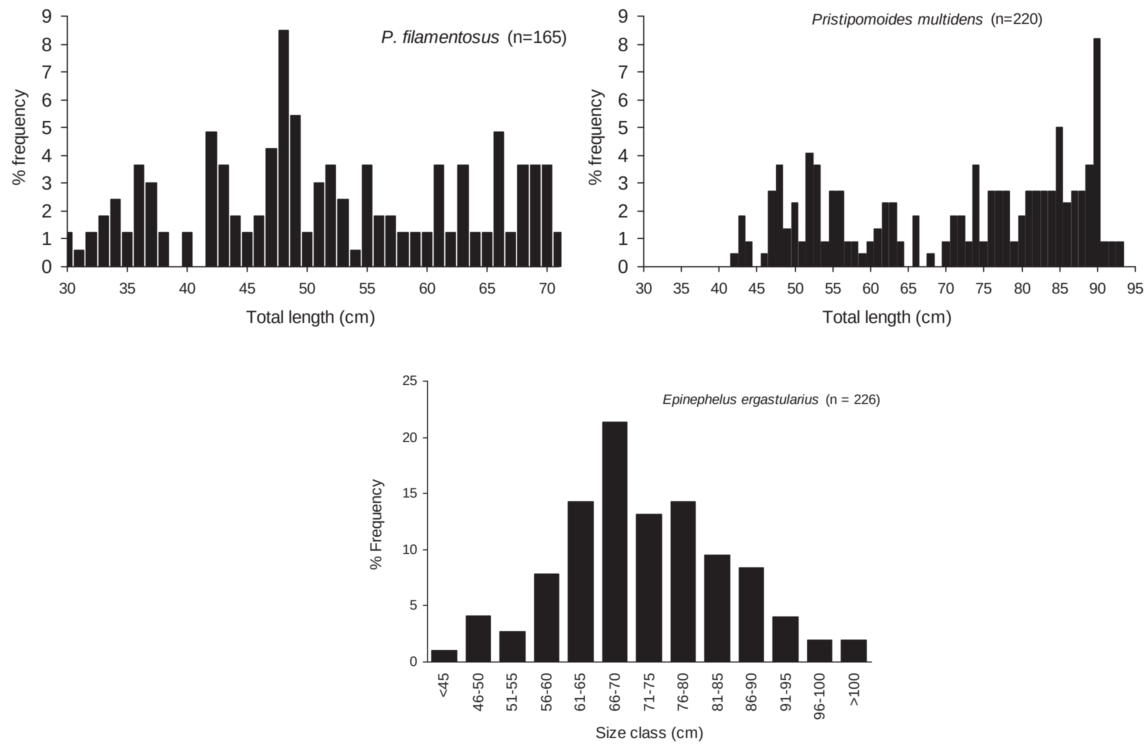

Figure 6.4.1 Length frequencies of 3 species of fish targeted by deepwater fishers in southern Queensland in 2000.

6.5 QUESTIONNAIRE ANALYSIS – RECREATIONAL FISHERS (2011 to 2012)

General demographics

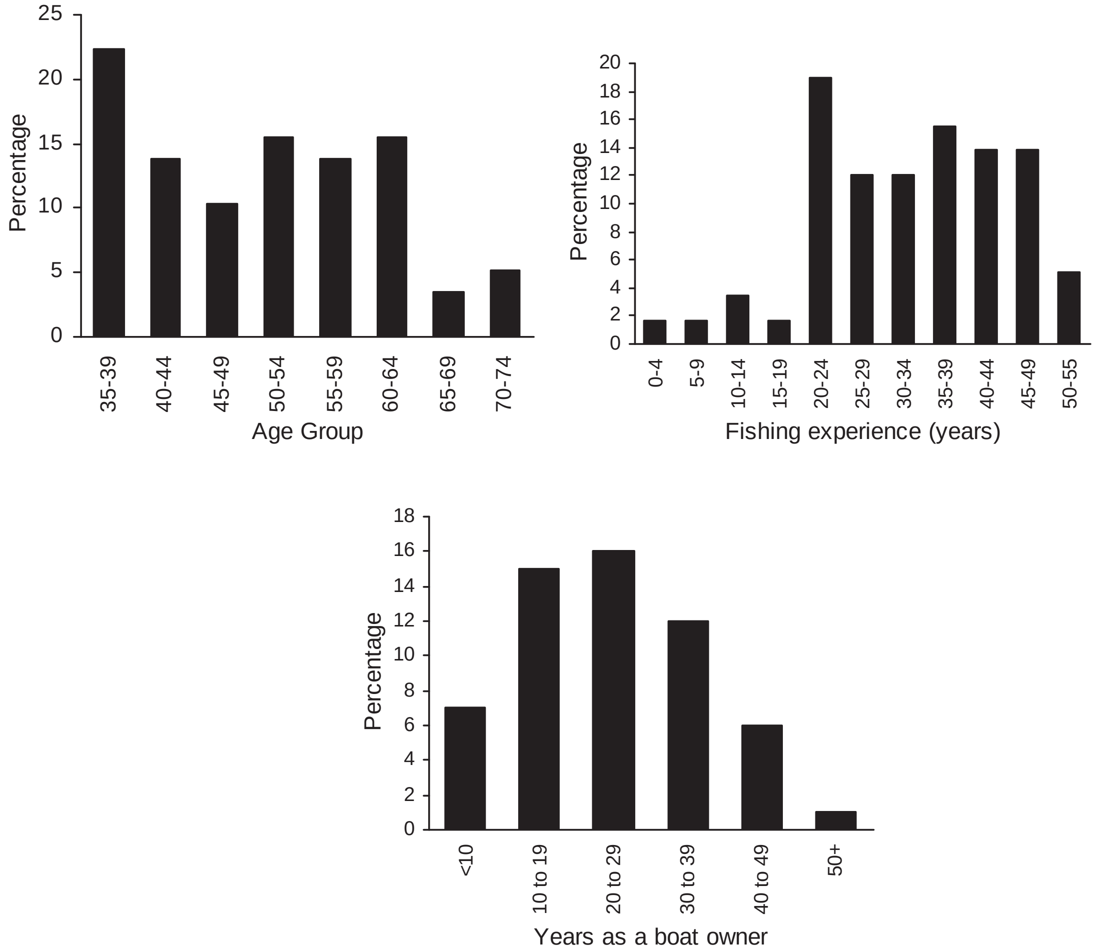

Figure 6.5.1 Demographics of recreational fishers surveyed in terms of age, fishing experience and years of boat ownership.

The sample of recreational fishers from which we obtained interviews was dominated by older more experienced fishers (Figure 6.5.1). Likewise most were long-term boat owners and highly experienced anglers. This is not unusual as most fishers who fish offshore are more experienced and often more affluent, allowing for the purchase of larger, offshore-capable vessels compared to the smaller craft used inshore. Initially we conducted interviews at boat ramps and marinas in order to obtain a more representative sample of fishers but a significant proportion of the boat owners interviewed were not offshore fishers and so considerable time was consumed waiting to get interviews with offshore anglers. We therefore adopted a strategy of gaining interviews from offshore fishing club members to supplement those conducted at boat ramps. We also had a significant rate of refusals (10%) at boat ramps and as the questionnaire took approximately one hour to complete there were also issues of completing the surveys.

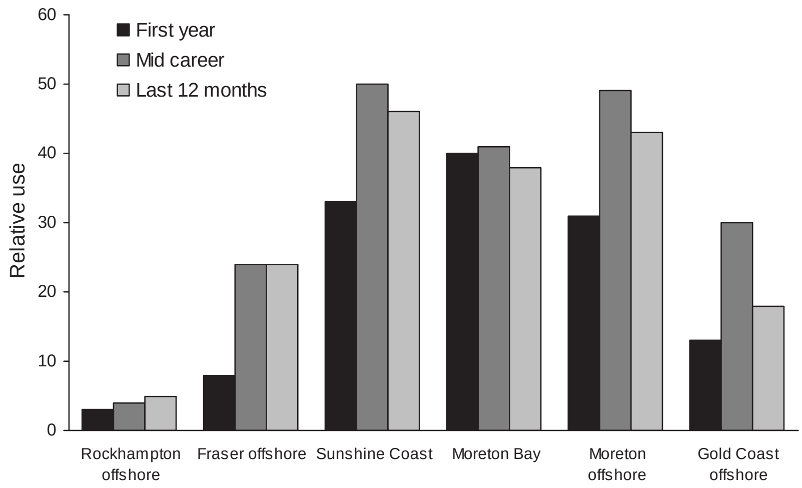

Figure 6.5.2 Relative use of various fishing areas by recreational anglers surveyed, at the beginning, middle and current stages of their fishing career.

Figure 6.5.2 is not meant to indicate the importance of various fishing areas but to show how the areas fished has changed during an individuals fishing career. This figure was constructed by summing the number of times areas were mentioned by fishers as being fished in the three time periods. This confirms the expectation that fishers explore more widely as they gain experience. It is interesting to note that the areas south of Fraser Island have seen a recent decline in fishing activity, particularly the Gold Coast.

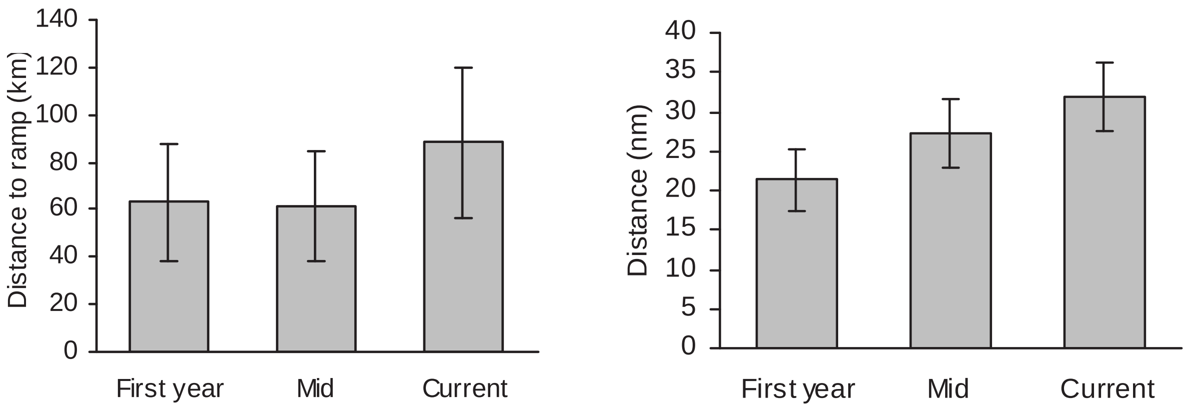

Figure 6.5.3 Distance recreational fishers had to travel from their residence to the boat ramp to go fishing as well as the distance they had to travel to their fishing locations during their first year of fishing, midway through their fishing life and during 2011. 95% confidence intervals are shown as vertical bars.

Fishing trips of our surveyed anglers had also changed over time with fishers having to travel further to the ramps that they were currently using compared to when they started fishing, although this was not statistically significant (Figure 6.5.3). The wide confidence intervals surrounding these means is a reflection of the wide variety of factors influencing this result as many fishers had moved house while others were travelling much further from their home to fish regions that they had not previously fished. Once on the water, the average distance travelled to fishing spots had also increased significantly ($P<0.05$) from when they first started fishing, although there was no difference to mid way through their fishing careers.

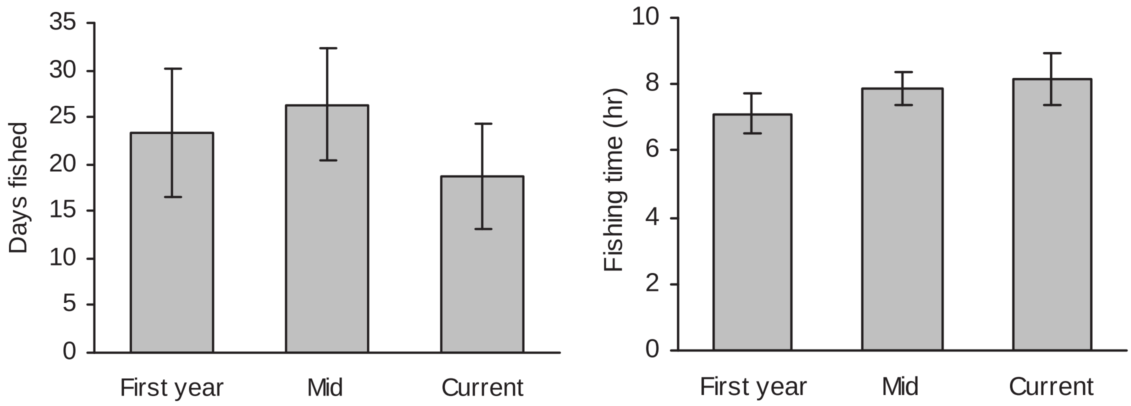

Figure 6.5.4 The number of day's recreational fishers go fishing as well as the distance they had to travel to their fishing locations during their first year of fishing, midway through their fishing life and during 2011. 95% confidence intervals are shown as vertical bars.

There was evidence that recreational fishers had reduced the number of days that they fished each year (Figure 6.5.4) from an average of over 25 days per year to under 20 nowadays and this reduction was statistically significant ($P<0.05$). Whether this is a reflection of a tougher recent economic climate or adverse weather conditions is uncertain but fishers did offer both as reasons for the decline. Fishing time per trip had not changed significantly over time.

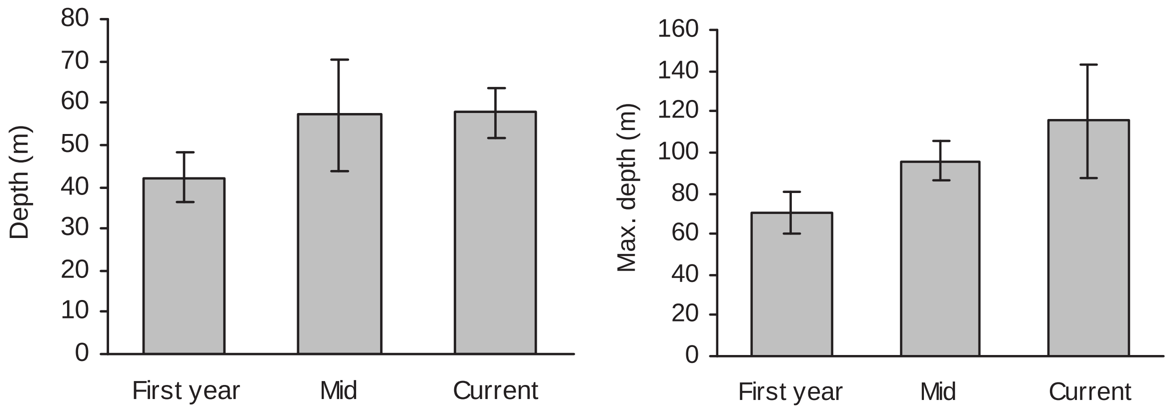

Figure 6.5.5 The average depth fished and the maximum depth fished by recreational fishers during their first year of fishing, midway through their fishing life and during 2011. 95% confidence intervals are shown as vertical bars.

The surveyed line fishers were also fishing significantly deeper water than when they first started fishing offshore (Figure 6.5.5), although there was no significant difference between fishing depths mid way through their experience and more recently. Maximum depth fished has also increased dramatically as well recently with a small subset of fishers fishing at vey large depths (a reflection of the wide confidence intervals in the current mean maximum depth fished). Some fishers had reported fishing as deep as 500m but there many fishers that had reported fishing a maximum depth well in excess of their mean depth in recent times, compared with earlier.

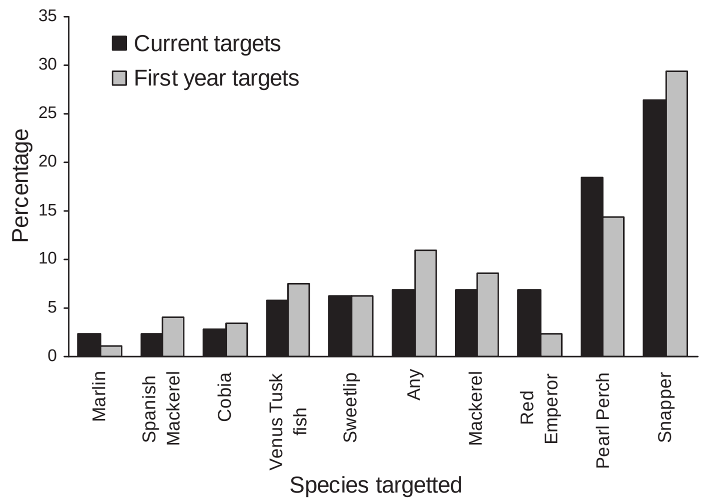

Figure 6.5.6 The percentage of recreational anglers that targeted various species of fish in southern Queensland during their first year of offshore fishing and during 2011.

A wide range of species were targeted by our surveyed anglers and it was clearly difficult for them to rank species in terms of importance, so we chose to analyse the three species mentioned rather than using any ranking of the importance of one over another. Figure 6.5.6 shows the percentage of times the main ten target species were mentioned by anglers both currently and when they began fishing offshore. What was clearly apparent was the importance of both snapper and pearl perch with pearl perch increasing and snapper decreasing in importance over time. Similarly red emperor had also increased in importance over time.

Fishing gear changes

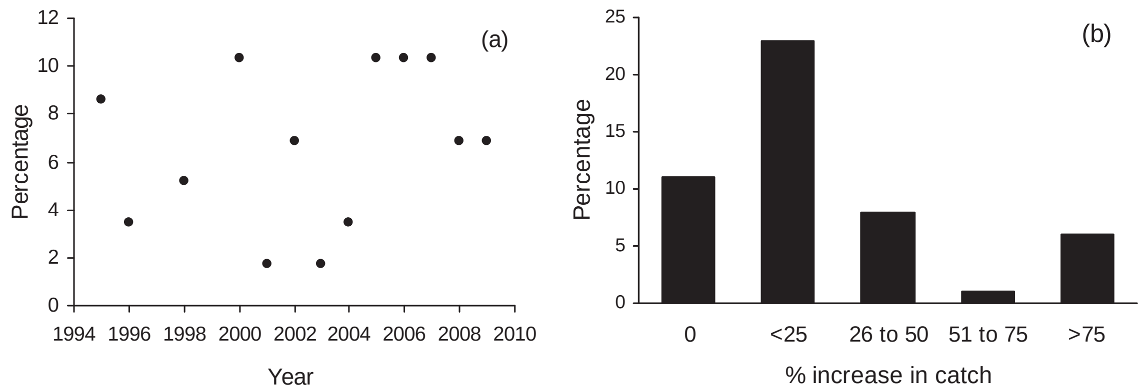

Figure 6.5.7 (a) The percentage of recreational anglers surveyed who had used braided line and the year that they first used braid. (b) Recreational fishers' views on the impact of braid in terms of % increase in catch resulting from its use compared with monofilament line.

Eighty six percent of the offshore recreational fishers surveyed had used braided fishing line, some as early as 1995 (Figure 6.5.7(a)). Of those anglers that had used braid, most believed that it made a significant improvement to their ability to increase their catch, some by over 75% (Figure 6.5.7(b).

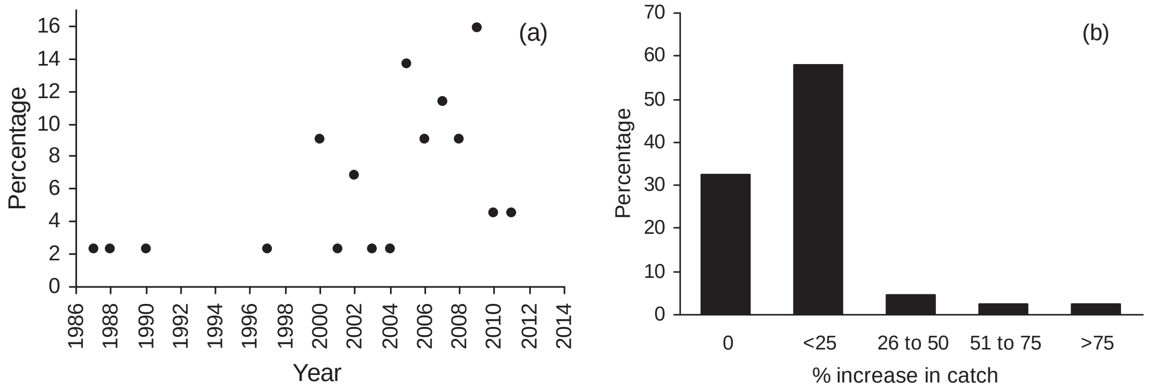

Figure 6.5.8 (a) The percentage of recreational anglers surveyed who had used soft bodied lures and the year that these lures were used. (b) Recreational fishers' views on the impact of soft bodied lures in terms of % increase in catch resulting from their use compared to traditional baits.

Seventy five percent of anglers had also used soft bodied lures at some stage to fish in offshore waters. The earliest reported use was in 1987 but adoption had not become widespread until around 2000 (Figure 6.5.8(a)). Recreational anglers believed that soft plastic lures were not as influential on catch as braided line with most believing that they had less than a 25% positive effect on catch. Anglers often mentioned that these lures were efficient at catching larger individuals of some species (particularly snapper).

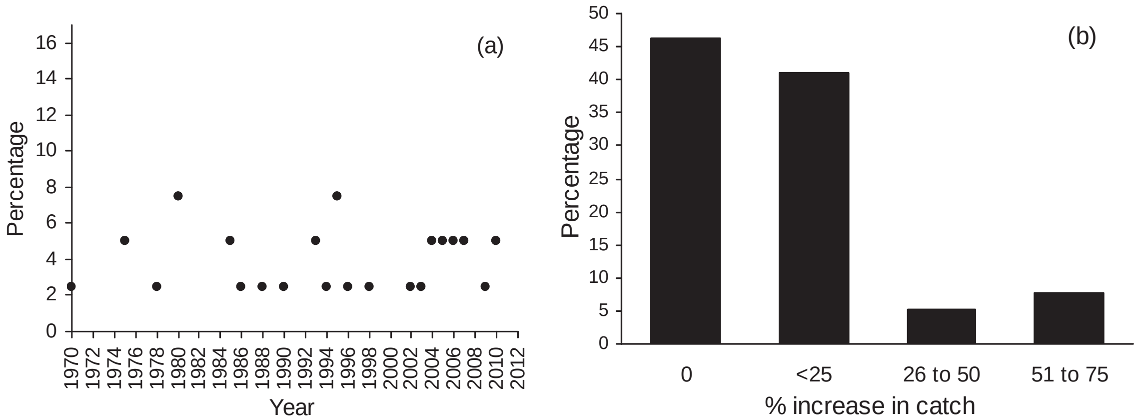

Figure 6.5.9 (a) The percentage of recreational anglers surveyed who had used hard bodied lures/jigs and the year that these lures were first used. (b) Recreational fishers' views on the impact of hard bodied lures/jigs in terms of % increase in catch resulting from their use compared traditional baits.

Hard body jigs and lures had been used at some stage by 71% of the anglers interviewed and as early as 1970 (Figure 6.5.9(a)). These lures were not believed to be as effective as soft plastic lures with almost half the angler interviewed believing that they had no effect in terms of increasing catch. Again they were a technique used by a select group of anglers to target particular species and opinions of their value were quite polarised reflecting experience (or the lack thereof) with this type of lure.

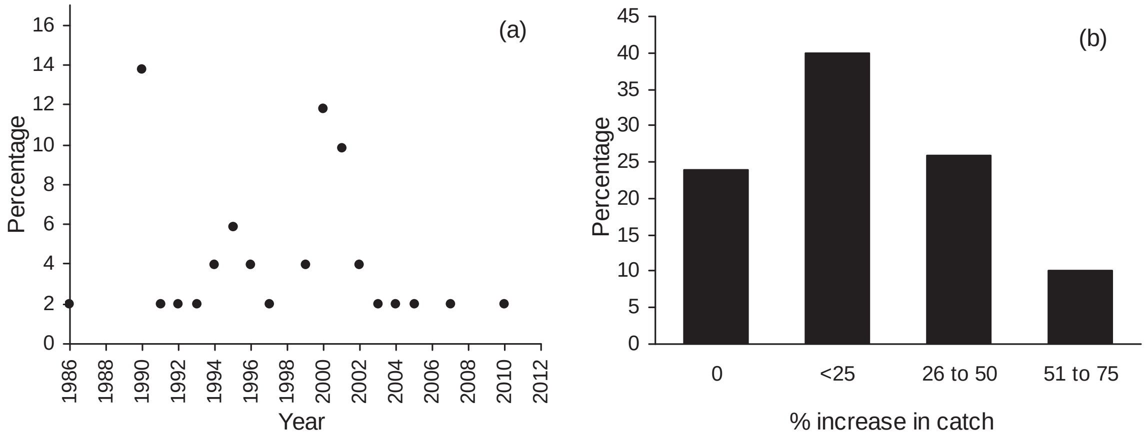

Figure 6.5.10 (a) The percentage of recreational anglers surveyed who had used floater rigs and the year that these rigs were first used. (b) Recreational fishers' views on the impact of floater rigs in terms of % increase in catch resulting from their use compared traditional baits.

Over 90% of anglers had used floater rigs to target demersal fish and 24% of these fishers felt that this type of fishing did not increase their catch. Upon further questioning some anglers noted that these types of rigs allowed the capture of larger fish rather than actually increasing the number of fish caught. This question caused some confusion among anglers but most users noted that the rigs enhanced their fishing in some way (Figure 6.5.10).

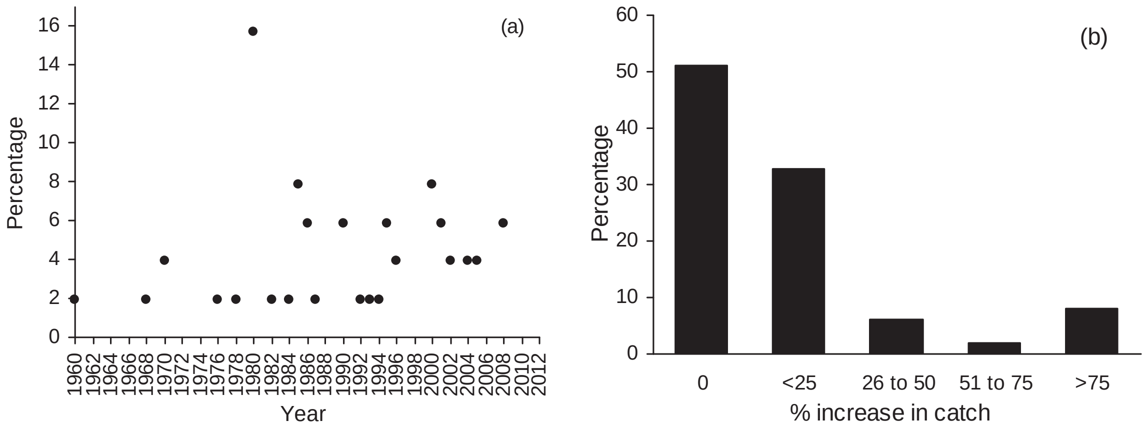

Figure 6.5.11 (a) The percentage of recreational anglers surveyed who had used paternoster rigs and the year that these rigs were first used. (b) Recreational fishers' views on the impact of floater rigs in terms of % increase in catch resulting from their use compared with earlier rigs.

Ninety-three percent of the fishers interviewed had used paternoster rigs. For many this was the first type of rig that they used and as such there were no comparisons in terms of how the use of this rig had increased catches. Often the year that they started to use these rigs was the year they started fishing offshore (Figure 6.5.11(a)). Some fishers however, still felt that the use of multiple hooks and a bottom set weight (paternoster) had increased catches over what they had previously used (Figure 6.5.11(b)).

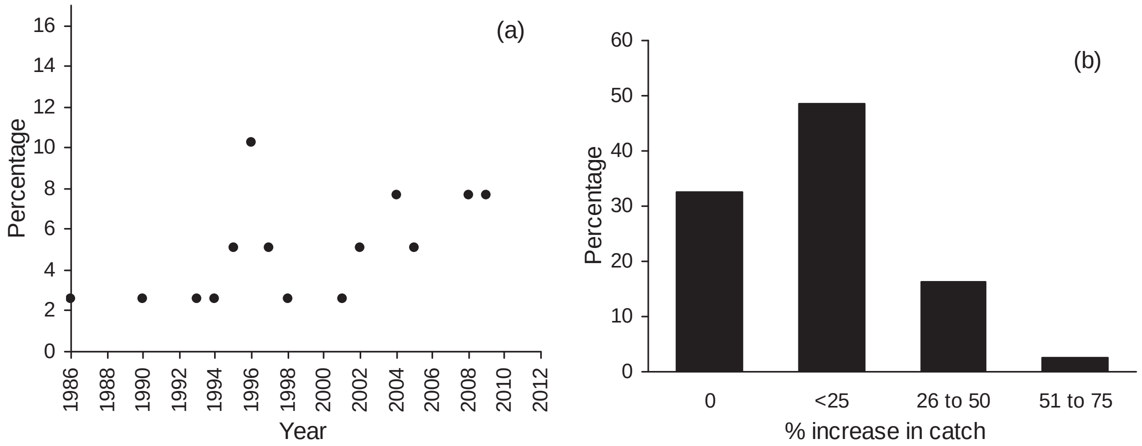

Figure 6.5.12 (a) The percentage of recreational anglers surveyed who had used chemically sharpened hooks and the year that these hooks were first used. (b) Recreational fishers' views on the impact of chemically sharpened hooks in terms of % increase in catch resulting from their use compared with standard hooks.

Chemically sharpened hooks were first used in 1986 and these had been used by 71% of the surveyed anglers (Figure 6.5.12(a)). Overall fishers also believed that these hooks increased the catch over traditional hooks that they had used previously (Figure 6.5.12(b))

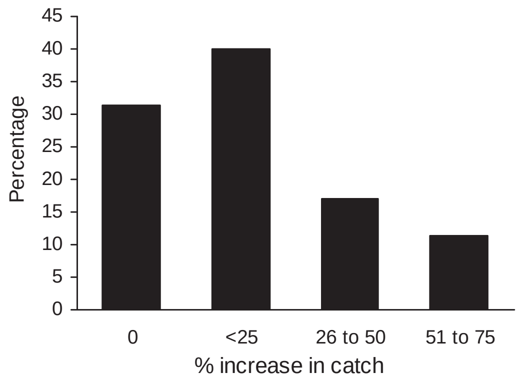

Figure 6.5.13 Recreational fishers' views on the impact of circle hooks in terms of % increase in catch resulting from their use compared with traditional hooks.

Sixty-four percent of anglers had used circle hooks, and many though that they had a positive impact on fishing ability as well as reducing gut hooking of fish (Figure 6.5.13). Only three recreational anglers interviewed had use power assisted reels or hydraulic winches to fish in deeper water.

Fishers also brought up several other advances in fishing technology that were not specifically addressed by the questions, the most important of these were graphite rods and "glow" beads.

Navigation

Using landmarks to find fishing locations was obviously the first method used by fishers prior to the development of modern electronics. Although landmarks are still used extensively today, GPS and plotters have largely taken their place. Only two of the anglers interviewed had not used landmarks to find fishing locations and only one fisher did not have either a plotter or GPS unit in their boat.

While the sample of fishers interviewed was probably not representative of all those recreational anglers that fished offshore, the fact that most were very experienced meant that they had seen a wider range of technologies than fishers who had just entered the fishery. This meant that their adoption of technologies related more closely to the times that those technologies became widely available to fishers. For this analysis we only used those fishers that had used paper depth sounders as these were the earliest forms of modern navigational and fish finding equipment that could have influenced catches. The cumulative adoption curves presented are designed to provide an indication of the timing as well as the speed of uptake of the technology. The figures are produced by examining the first year that the various technologies were used by fishers.

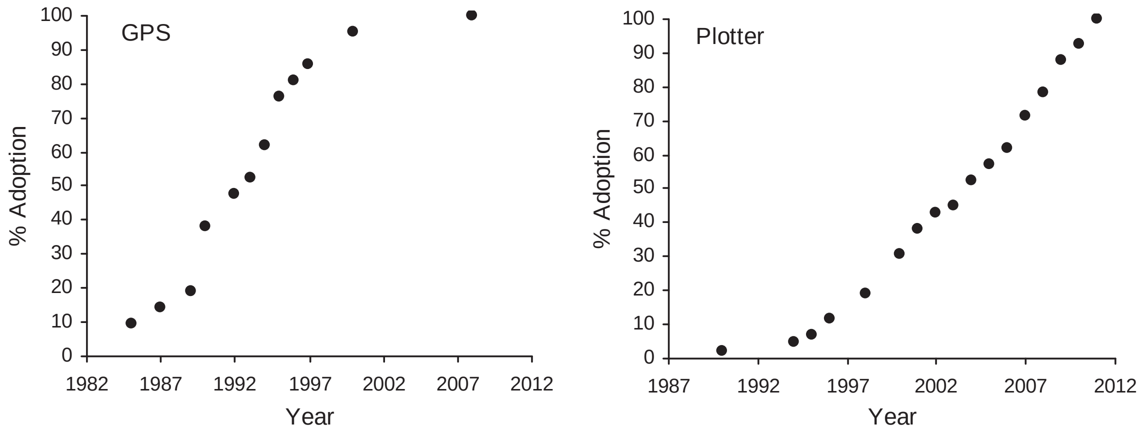

Figure 6.5.14 Cumulative uptake of GPS and Plotter technology by offshore recreational fishers surveyed in southern Queensland.

Commercial line fishers began using GPS technology during the early as 1980s but the cost of this technology was prohibitive to most recreational fishers. However, their use became widespread in the mid 1990s before plotters began to replace the less sophisticated GPS units (Figure 6.5.14). While plotters were used by some recreational fishers as early as 1990 it was not until the early 2000s that their use became more widespread.

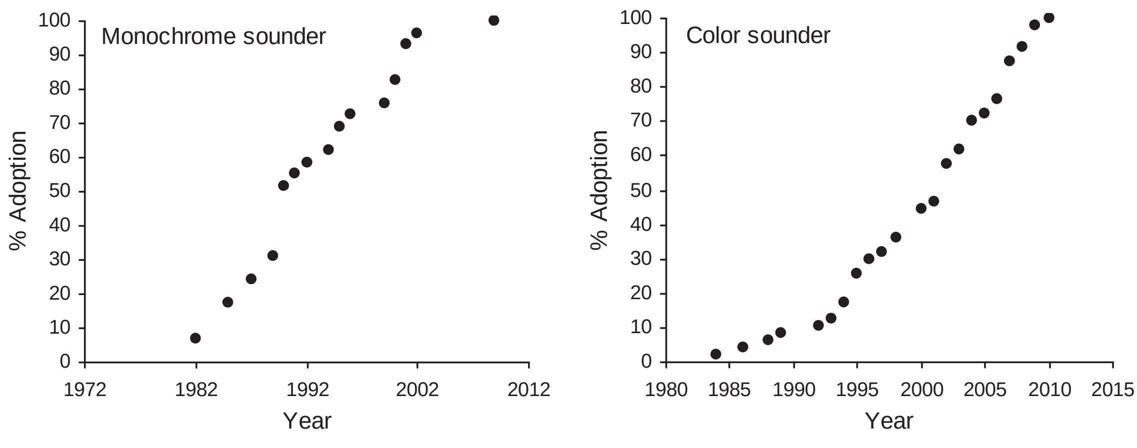

Figure 6.5.15 Cumulative uptake of GPS and Plotter technology by offshore recreational fishers surveyed in southern Queensland.

Paper sounders were phase out in the 1980s as more sophisticated electronic sounders began appearing on the market. Only 7.4 % of fishers did not currently have a colour depth sounder but all currently had some form of sounder. The early 1980s saw the introduction of monochrome sounders and their use became widespread during that period (Figure 6.5.15). The introduction of affordable colour sounders in the last 15 years saw their widespread uptake by offshore fishers and the virtual total replacement of the older monochrome equipment. Bottom discriminating colour sounders were an additional advance in sonar technology that are now universally used by recreational anglers. Three dimensional bottom discrimination displays are also now being used by recreational anglers but only two recreational fishers interviewed currently had these sounders.

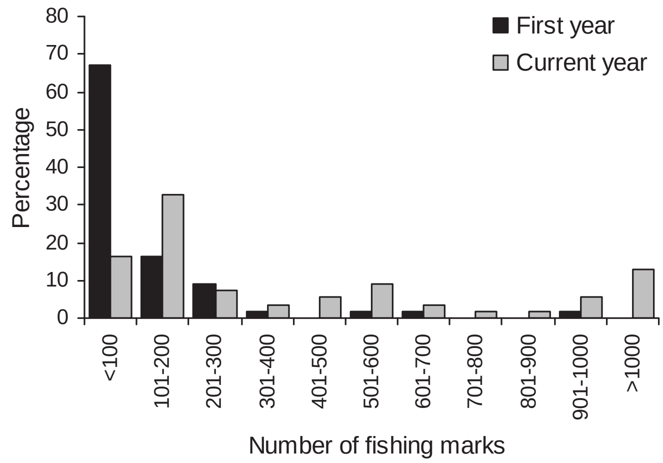

Figure 6.5.16 The distribution of number of fishing marks in the GPS units of recreational anglers during their first year of GPS ownership and their current number of points.

There has been an average of a 5 fold increase in the number of GPS points in the GPS units used by recreational fishers interviewed. The average was 103 for the first year of ownership compared with an average of 470 today. The distributions of these fishing marks are shown in Figure 6.5.16 which shows significant increases in average number of fishing marks over time.

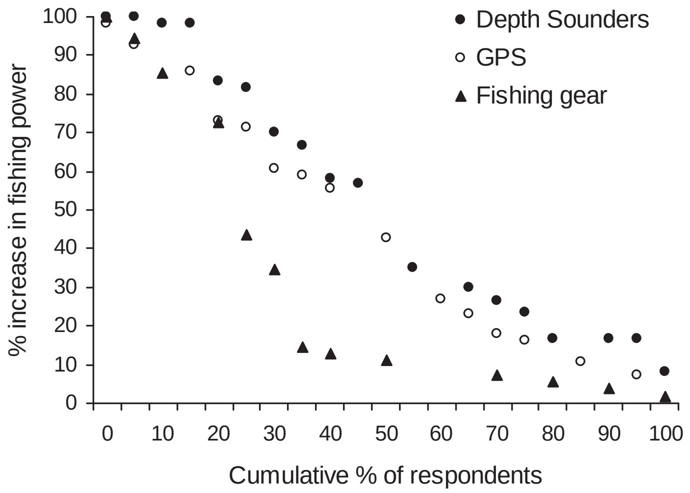

Figure 6.5.17 Cumulative percentage of respondents who rated the effects of various fishing technologies on their fishing power.

The effect of depth sounders and GPS on fishing power were basically equally weighted by our respondents with over 50% of surveyed anglers believing that these two technologies were each at least responsible for a 40% increase in fishing power (Figure 6.5.17). The general question on the power of fishing gear also provided a similar response to the more detailed questions posed to anglers earlier in the interviews where an approximate 25% increase in fishing power related to fishing gear was the common response for the main categories of braid, lures, chemically sharpened hooks etc.

Fisheries management

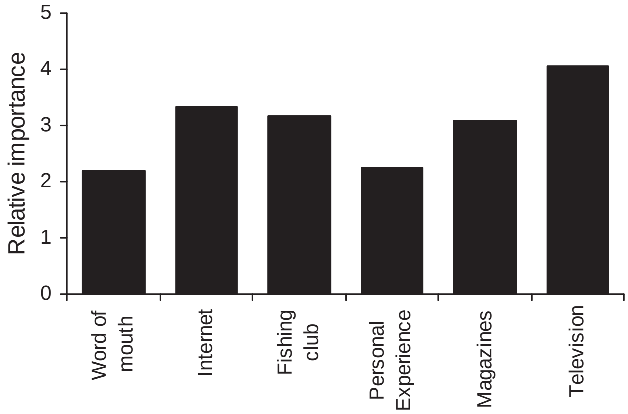

Figure 6.5.18 Relative importance of various fishing and boating information sources weighted by recreational anglers.

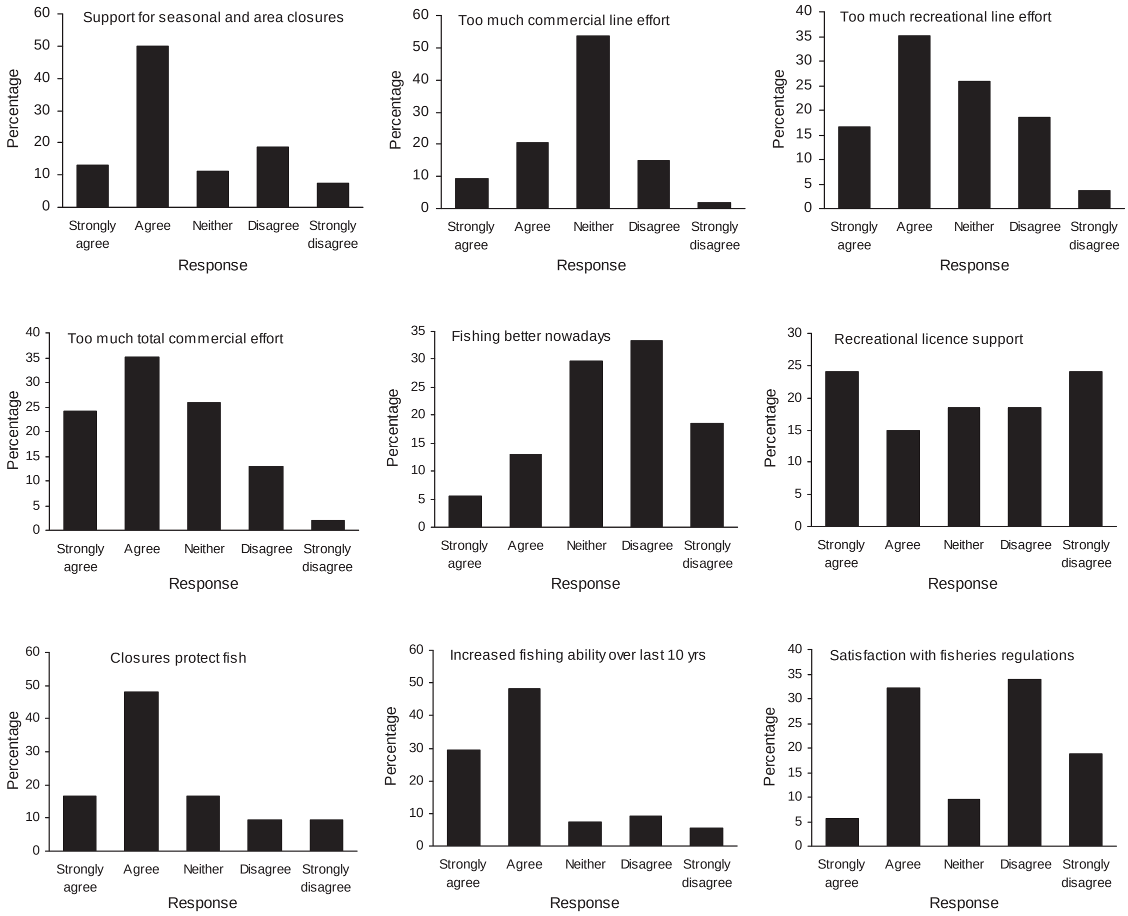

Figure 6.5.19 Response of recreational fishers to management related questions. Refer to Appendix 6 for exact questions posed to respondents.

There was a great diversity in the areas from which anglers sourced fishing information but overall television was the main source of fishing information for the recreational anglers we surveyed (Figure 6.5.18). Magazines, the internet and fishing clubs were similarly weighted. We did not conduct enough interviews to fully determine the demographic effects on information sources but there were clearly age related and other demographic issues involved here. Obviously club members viewed this source of information more highly than did non-members.

Recreational fishers had a wide variety of views to the questions posed in the survey (Figure 6.5.19). There was general support for fishing closures with most believing that these measures helped protect fish stocks. While recreational fishers generally thought that there was too much commercial fishing effort, including trawling and netting, the response was less emphatic when only commercial line fishing effort was considered. This response probably reflects the generally low commercial line fishing activity in southern Queensland and the dislike recreational fishers have for what they perceive as a destructive form of fishing in trawling.

It was somewhat surprising that the subset of anglers interviewed believed that there was too much recreational line fishing effort rather than too much commercial line fishing effort. Most believed that fishing had deteriorated in the last 10 years but that their ability to catch fish had increased during that time.

The question relating to recreational fishing licences was the one that provided the widest spread of opinions with almost 25% of anglers either strongly agreeing or strongly disagreeing that recreational licences would improve the line fishery in southern Queensland. Likewise, opinions were divided in terms of satisfaction with the current regulations.

The variation in the response of recreational fishers to questions posed in the survey was huge reflecting the wide variation in motivations, fishing practises, fishing abilities and general economic and social demographics. As noted previously the sample of recreational fishers was biased towards more experienced older anglers. To some extent this is a desirable characteristic as these people would be in the best position to comment on the impact of various technological changes having experienced a wider range of those changes. Offshore fishers also tend to be older and more experienced than estuarine fishers because the vessels normally required to fish these areas are much larger and more expensive than inshore vessels. From an economic perspective younger people are less often in a financial position to afford such vessels and are thus underrepresented in any sampling program. Nonetheless it is important to stress that the sampled fishers were not necessarily representative of the entire sampling frame of offshore anglers.

What was clear from all interviews was the belief that technology had dramatically increased the ability of fishers to catch fish although there were some people who had changed their activities little over the years. The perceived level of increase in fishing power associated with the widespread use of sounders and GPS equipment was a significant finding from this survey. The fact that fishers attributed such a high level of impact of these technologies on their fishing capacity compared with fishing gear has important implications for catch standardisations used in stock assessments. If the perceptions of this group of anglers are correct then catch rate trends that do not account for the impact of these technologies will present overly optimistic views of stock status.

6.6 BIOLOGICAL DATA ON BAR ROCKCOD AND OTHER TARGET SPECIES

Bar rock cod

Figure 6.6.1 Photos of juvenile bar rock cod caught in 100m showing swimbladder damage, gut eversion and exophthalmia.

All bar rockcod caught by the commercial sector in water greater than 200m in depth were retained and no small fish were released. As expected, this species suffers from barotrauma and even fish caught in relatively shallow water (<100m) had severe barotrauma symptoms of gut eversion and exophthalmia (Figure 6.6.1) from which they probably would not have survived had they been released. The damage caused to the swimbladders of the three smaller fish caught in <100m was interesting in that while the membrane of the swimbladder had ruptured the swimbladder gases had been retained within the thinner distended mesenteric membranes.

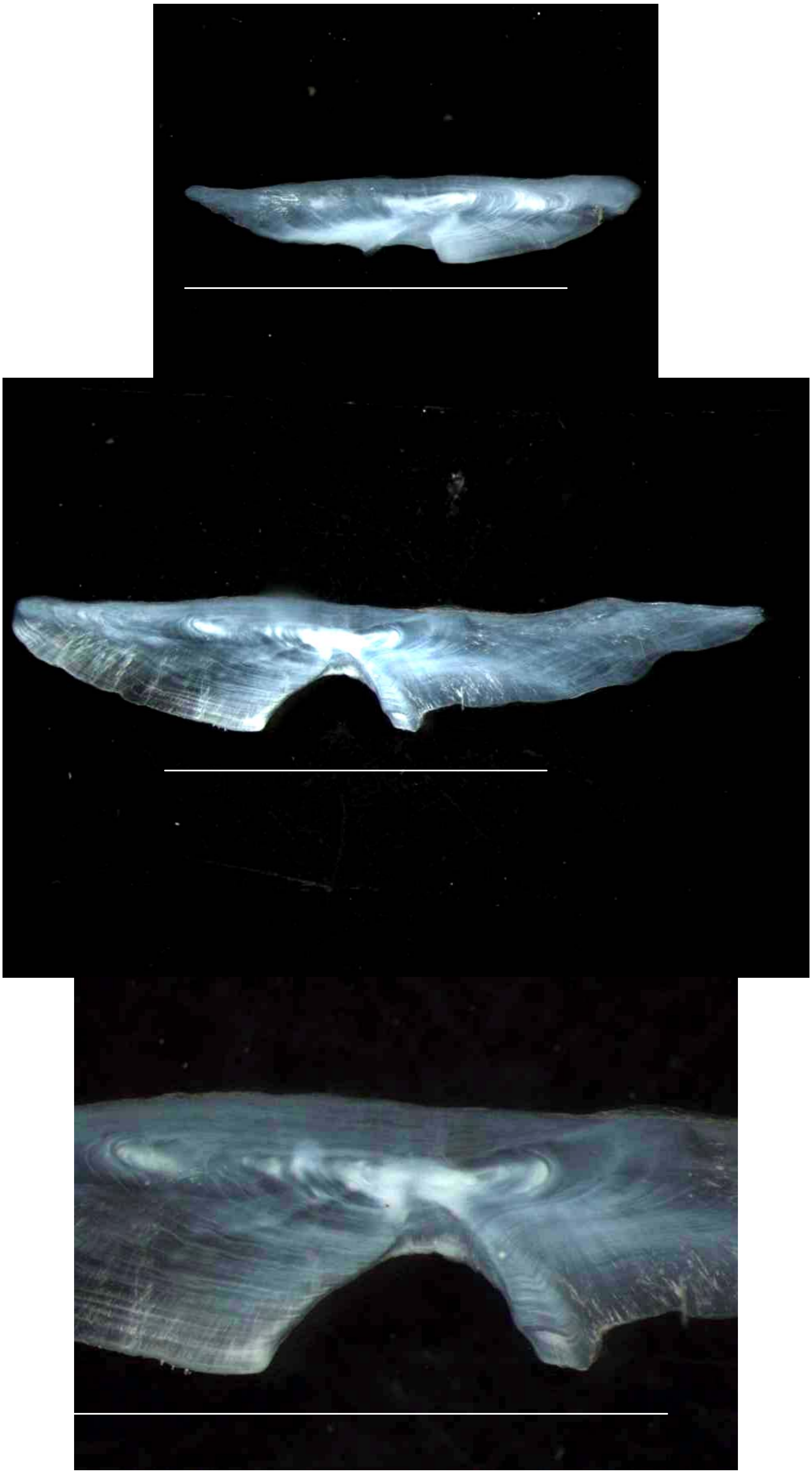

Figure 6.6.2 (from top to bottom) Sectioned otoliths from a 350mm 2 year old, 950mm 10 year old and close up of the same 950mm bar rock cod. A 5 mm scale bar is shown in each photo.

This response to capture-at-depth is similar to other species in this family where the gases from a ruptured swimbladder are often partially retained in these tissues. Fishers also report that most of the bar rock cod landed had obvious barotrauma signs.

Ageing of all deepwater species was difficult despite the fact that there have been extensive age and growth studies of all but bar rock cod from other areas of their distribution. Photos of sectioned bar rock cod otoliths (Figure 6.6.2) show that double banding and indistinct regions of the otoliths were features of all sections. This species is like many other subtropical species that live in offshore waters where currents and temperatures may vary on very small spatial and temporal scales and are less consistent than in more relatively stable temperate regions. The difficulty in interpreting otolith banding is reflected in poor agreement between readings with an IAPE of 28%. The distribution of differences in ageing and IAPE also indicated that there were biases in ageing of this species. These problems suggest that a more thorough investigation of ageing protocols would be necessary to increase the accuracy and precision of age estimates. Such a study was outside the scope of this project but would be necessary to validate any future ageing of this species.

The length-at-age information for the sample of bar rock cod from which otoliths and gonads were obtained is shown in Figure 6.6.4. Fish sampled from trips that had on-board observers have also been excluded from this figure. Observers were unable to remove the otoliths from any of the fish on their trips due to logistic reasons and the difficulty in removing otoliths from animals without damaging them to the extent of diminishing their market value.

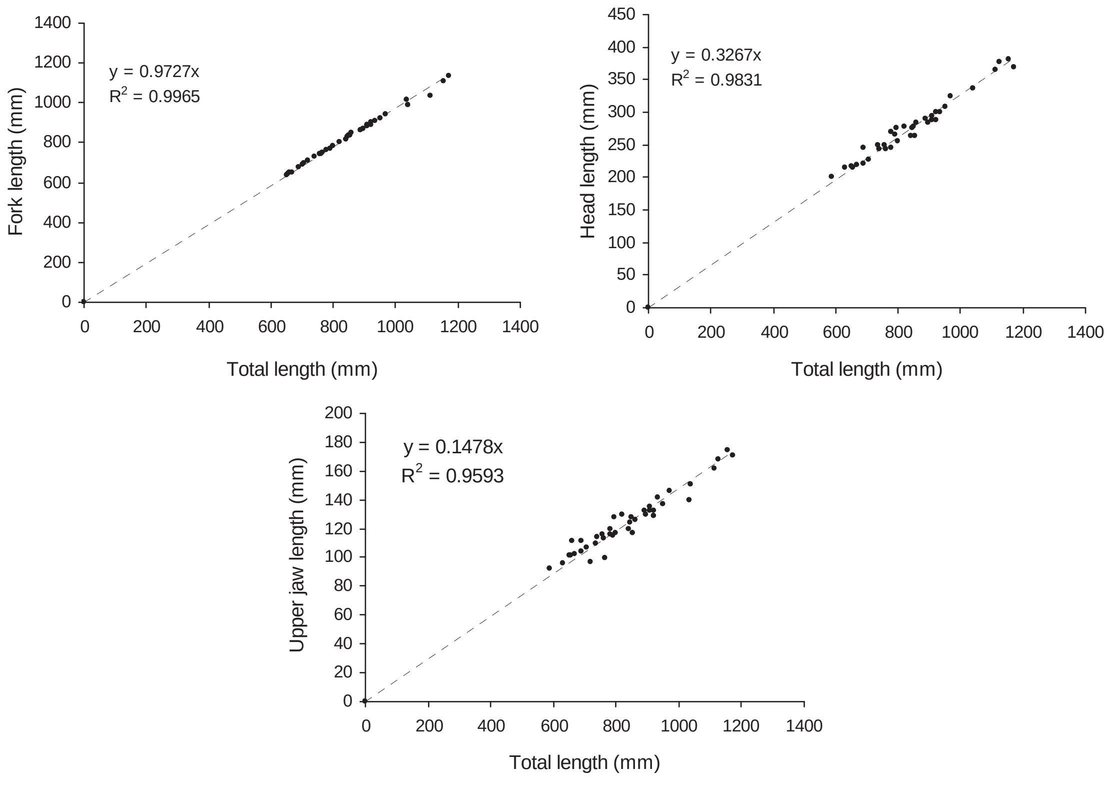

Figure 6.6.3 Relationships between total length and other morphometric measures of bar rock cod. Linear equations of trend lines and R-squared statistics are also shown.

Due to the difficulty in obtaining complete samples of bar rock cod for measurement and dissection, a series of morphometrics were recorded for whole fish so that samples of heads could be used to estimate fish length when only heads were available from fishers, processors and retailers. There was obviously very good relationships between fork and total length (Figure 6.6.3) but head length and upper jaw length still provided good estimators of total length (R^2 = 0.98 and 0.96 respectively). Head length was the preferred estimator given its tighter relationship with total length.

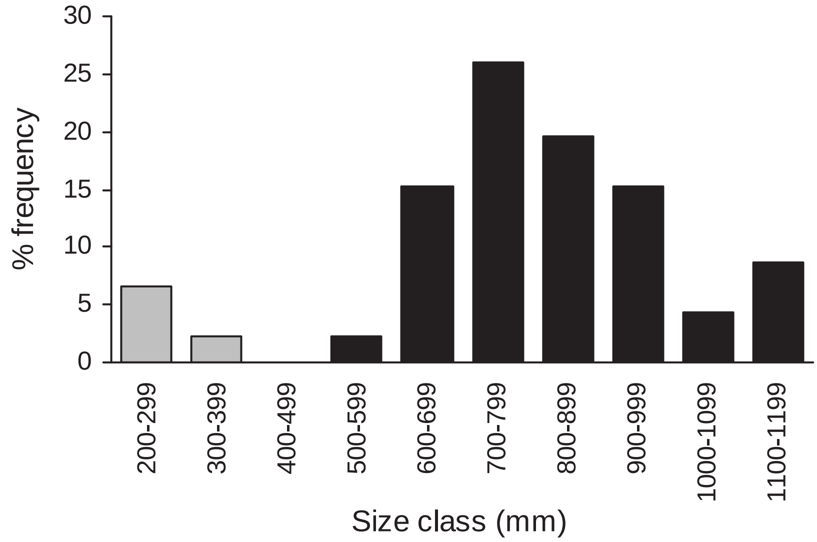

Figure 6.6.4 Length frequency of bar rock cod commercial samples used to generate age structures. Grey bars were not retained by fishers.

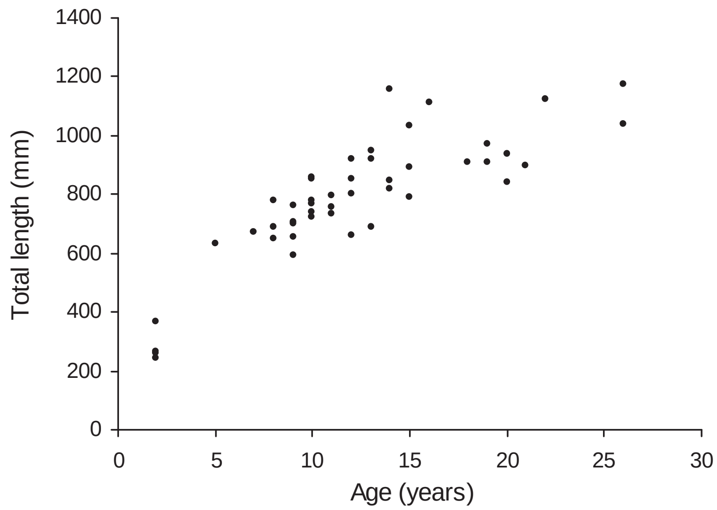

Figure 6.6.5 Length at age relationship for bar rock cod samples in southern Queensland during 2011.

There were no fish less than 200mm sampled and none greater than 1.2m in length (Figure 6.6.4). This size structure was similar to the distribution obtained on observer trips (See Figure 6.3.4) although there were larger and smaller fish seen on observer trips than were sampled independently of the program. At this stage we have not fitted a growth curve to the length-at-age data as we believe that there is currently insufficient data to generate an accurate and precise relationship. Younger age classes were poorly represented in our samples, which would severely bias estimates of *k* in any derived von Bertalanffy relationship (Figure 6.6.5). Commercial line-caught samples contained few young fish (<7 year old) and fish of this age would need to be sourced independently of the deepwater commercial fishery as juveniles are found in shallower inshore waters.

Age frequency data is similarly compromised by the small sample size and we have thus not calculated any estimates of fishing mortality as we are not confident that the sample of fish gathered was representative of the entire catch (Figure 6.6.6). Likewise, we did not collect sufficient samples to generate a reasonable age/length key. Regardless of these limitations, bar rock cod were shown to be a relatively long-lived species but not to the same extent as species such as blue-eye trevalla, hapuka and bass grouper where individuals greater than 40 years old are commonly taken.

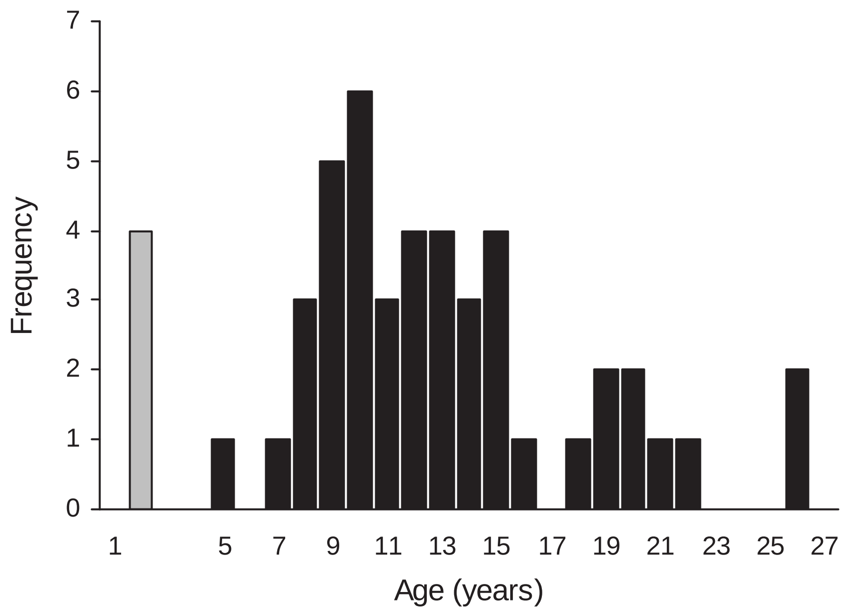

Figure 6.6.6 Age frequency of bar rock cod sampled from commercial fishers in southern Queensland. Grey hatched bar was a sample of fish caught by trawl (sampled under permit by fisheries observers) while others were retained line catch.

Insufficient reproductive data was collected to determine size of maturity or timing of spawning however, catches sampled during November, December and January contained spent females and a high proportion of maturing gonads suggesting that those months formed part of the spawning season. In addition, one sample of 20 fish observed in January was exclusively females suggesting aggregating behaviour. However, a high proportion of these females had only stage 3 (maturing) gonads that were some days off ripening to fully mature gonads capable of spawning. This suggests either that the sexual aggregations may not necessarily form for spawning or that they may be maintained for large proportions of the spawning season.

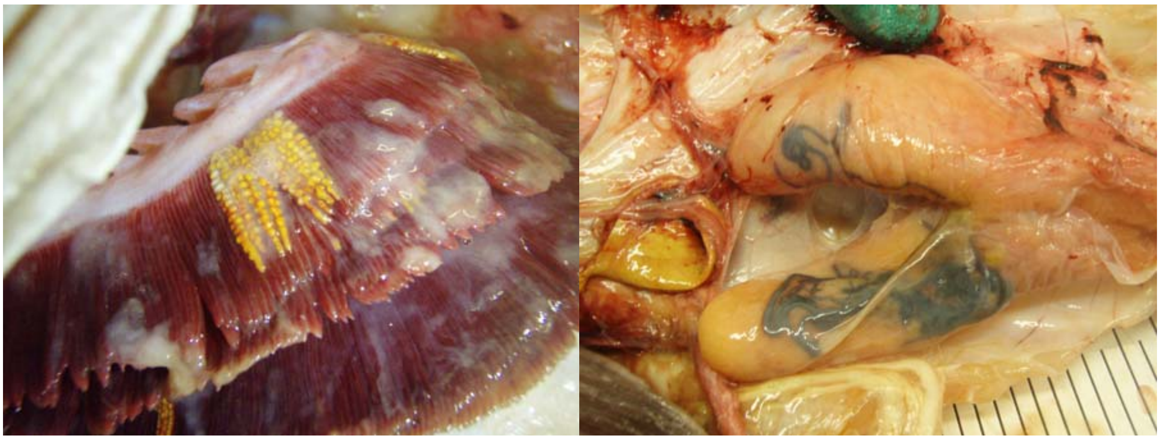

Figure 6.6.7 Common parasites found in the gills and gonads of bar rock cod.

We did not conduct a detailed analysis of the parasites and diseases of the fish that we sampled however, there were a few obvious examples of macroscopic parasites. Parasitic nematodes had a relatively high prevalence (observed in 64% of fish examined) in the gonads of female bar rock cod (Figure 6.6.7). The prevalence of these parasites is known to increase with size for other species of fish and may be useful in discriminating regional differences among management units (“stocks”), although it is doubtful whether regional management is an option even though these species are fished across three jurisdictions (Queensland, Commonwealth and NSW).

Other species

Insufficient data were collected from either of the other important target species (hapuka, bass grouper or blue-eye trevalla) to enable documentation of their subtropical biology. The only bass grouper sampled was a 1.5m fish which was estimated to be 35 years old. The details of the three hapuka sampled are presented in Table 6.6.1 which show fish were all greater than 15 years old. It was interesting to note the considerable variation in length at age with the oldest fish (28 years) sampled being 500mm smaller than a slightly younger fish.

Table 6.6.1 Length measurements and estimated age of hapuka sampled from commercial line catches during 2011 by fisheries observers.

Total length (mm)	Fork length (mm)	Head length (mm)	Jaw length (mm)	Age (years)
960	940	241	146	28
895	865	222	127	18
1450			192	27

Otoliths of these three species were also difficult to interpret (Figure 6.6.9) with double banding present, along with indistinct banding, particularly in earlier years. Blue-eye trevalla was the only species (other than bar rock cod) where sufficient numbers were obtained to investigate the age and growth, although no reproductive information was collected. The biology of this species is fairly well described from more temperate areas of its distribution where otoliths are easier to interpret. Horn *et al* (2010) has validated the ages of this species from New Zealand waters where the maximum age has been estimated at 76 years which is considerably more than earlier estimates (Anon 2007) which placed a maximum age of about 25 on New Zealand fish. The blue-eye trevalla that we collected independent of the observer program were between 650mm and 1000mm in length (Figure 6.6.8) but as only 11 fish of this species were sampled on observer trips there is little that can be gained by a comparison of these data, although two of these fish exceed 1m in length. What was obvious was that the greater depth range of this species resulted in them being less frequently targeted by the state based fishers sampled by this research.

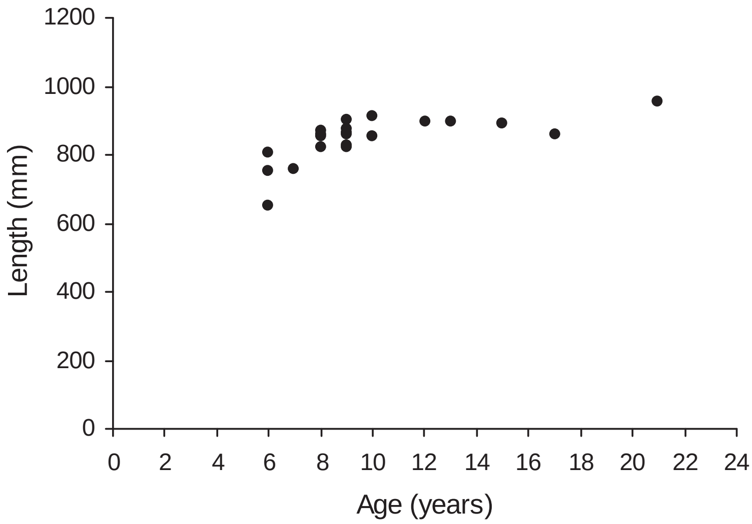

Figure 6.6.8 Length at age of blue-eye trevalla sampled independently of the fisheries observer program.

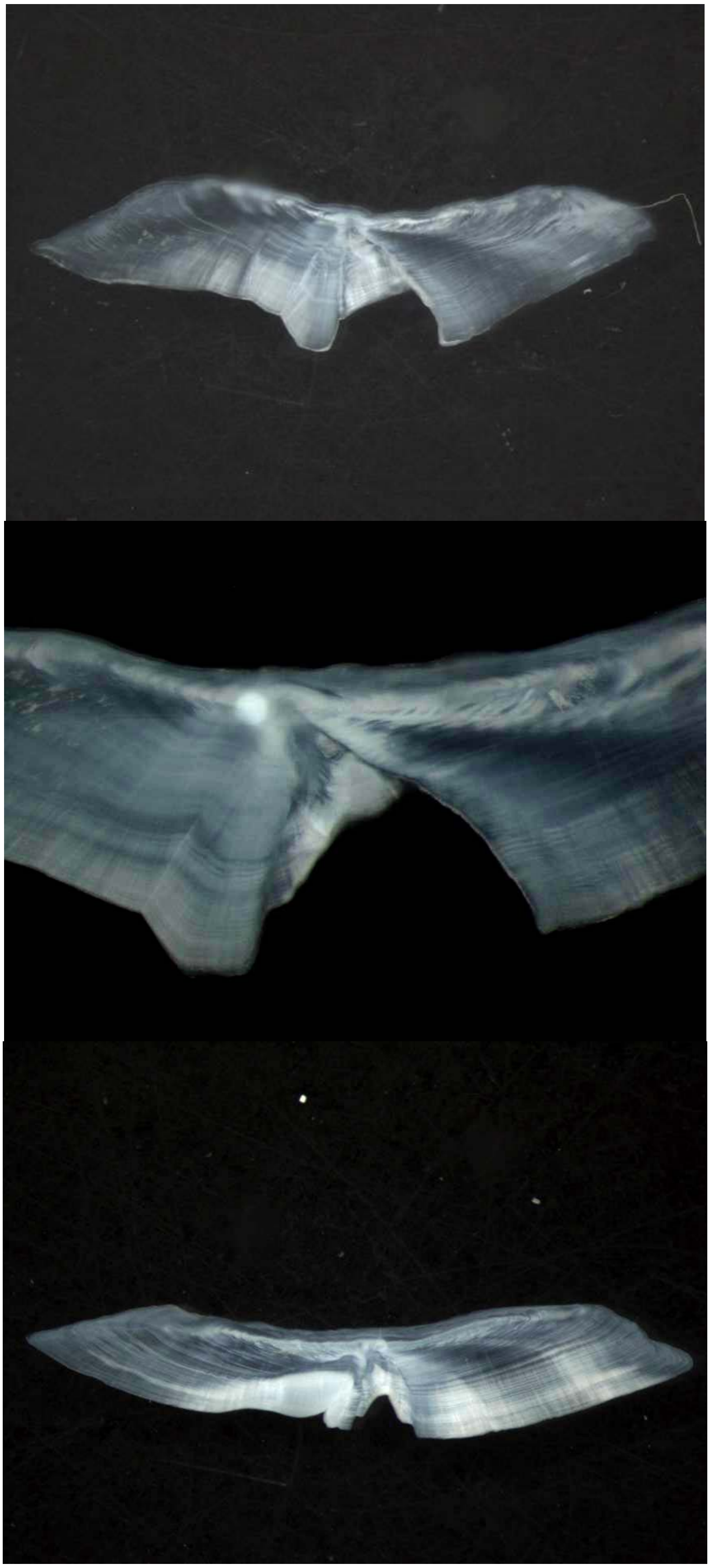

Figure 6.6.9 Photos of sectioned otoliths (from top to bottom) from a 1250mm Bass grouper, 1180mm hapuka, and an 880mm blue-eye trevalla.

7. GENERAL DISCUSSION

Queensland's deepwater finfish stocks have been accessed sporadically by commercial line fishers for many decades. However, these fisheries developed significantly during the early 1990s when L8 multi-hook fishers began fishing in water >200m. Initially, catches increased in the deepwater fishery before declining, partly due to a reduction in the number of operators, which have steadily decreased over the last 15 years. At the same time, many line fishers using existing L1 endorsements increased their activities in deeper water, particularly off southern Queensland, as did L2- and L3-endorsed fishers operating within the GBRMP. Initially, deepwater trips took place during winter when weather and current conditions allowed fishers to access offshore areas but, in the last 10 years, fishing effort occurs in all months, depending on the species being fished. Although L8-endorsed fishers have moved in and out of the multiple-hook fishery, a significant proportion of L1-endorsed fishers now target deep water stocks throughout the year.

Deepwater species can be divided into two groups:

(1) *Species that are caught over a broad depth range from shallow to deep (20m to >200m).* These are generally species found over a wide depth range and in shallow water where fishing effort is less constrained by weather and current conditions. As such they are caught by all fishing sectors and by commercial fishers targeting coral reef finfish and other inshore species. This group includes comet grouper, eight bar grouper, Maori cod, goldband snapper, rosy snapper, samson fish / amberjack and large-mouthed nannygai. Other species including pearl perch and red emperor are also caught in relatively deep water but it is doubtful whether significant catches of snapper are taken in water >200m.

(2) *Species that are predominantly caught in water greater than 200m.* These species are sometimes highly seasonal and their catches are weather-dependent, but significant catches can occur throughout the year. These species include bar rock cod, hapuka, bass grouper, flame snapper, and blue-eye trevalla. Other species that fall into this category (but comprise only a very small part of the annual catch) include Mozambique bream, and other species of rock cod. A suite of elasmobranchs, particularly gummy sharks and spurdogs also fall into this category.

Logbook records show that the reduction in the number of L8 endorsements has had the biggest impact on annual catch for many species in both categories described above.

Generally, species categorised in group 2 have high risk biological characteristics (slower growth and longer life-spans), and distribution (more restricted in terms of habitat, and often have a narrow or patchy distribution). Some of the species caught are apparently quite rare (although this may be an artefact of their deepwater habitat). For this reason it is important to closely monitor the amount of fishing effort in deep waters. However, due to greater fishing pressure on the group 1 species (which in terms of biology, habitat and distribution are in general less vulnerable to over-exploitation), some species in this group are also particularly important to monitor as fishing effort tends to be higher in shallower water due to closer proximity to fishing ports and population centres.

Species that are likely to be vulnerable to over-exploitation include bar rock cod, rosy snapper and a number of other deepwater cod species. Like many other deepwater species, rosy snapper is long-lived and slow growing. It is a highly marketable species and has been caught in large quantities by both L1- and L8-endorsed fishers. It has a high catchability owing to its tendency to aggregate in large schools in predictable locations and its aggressive feeding behaviour. Spawning populations are probably targeted in some areas and there is anecdotal evidence to suggest that stocks are declining, particularly in areas attracting high levels of fishing effort at the western boundary of the species' distribution.

Bar rock cod are likely to have always been caught in reasonable quantities by both L8 and L1-endorsed fishers who fished water >200m, without being reported accurately in logbooks. It is a species that is likely to be vulnerable due to its relatively restricted distribution and high market value.

Other sought-after deepwater cod, and wreckfish species with good market value are potentially vulnerable to overexploitation due to their restricted habitat and distribution and biological characteristics such as slow growth rates. However, catch rates for these species are currently impossible to accurately quantify because they are similar in appearance, difficult to identify, and often recorded in generic categories in logbooks. Similarly, common names, and the species they describe vary regionally and amongst fishers and processors. Hapuka, bass grouper, bar rock cod, eight bar grouper and other cod species are all likely to be placed in these mixed groups in fisher logs.

If it is unfeasible for fishers to record catch weights of all species individually, future studies investigating the species composition of these mixed groups would be beneficial. Discussions with fishers suggested that fishing effort in terms of numbers of hooks used is variable, particularly in the L8 fishery. Such discrepancies in effort recording will result in even less precise measures of CPUE than are now currently reported.

As fisheries develop and near-shore stocks come under increasing pressure from all sectors, commercial fishers often move to deeper areas in order to increase catches. These areas often contain species about which we have little information in regards to biology or stock structure. Currently the species inhabiting a wide depth range in Queensland waters are experiencing greater fishing pressure than those restricted to deep waters, but due to their restricted distribution and biological characteristics, those confined to deeper areas are still highly vulnerable to over-exploitation. In addition, there is the latent ability of participants from inshore line fisheries to target deepwater species (using non L8 apparatus) when management changes or poor catch rates of inshore species necessitate their diversification into other fisheries. Any change in management of line fisheries (and other fisheries) may see additional stress placed on deepwater species even without fishers having the ability to use multiple hook gear. The recent widespread use of power assisted line fishing winches and reels is further evidence of increased effort in deep-water areas. In addition, due to the remoteness of the deepwater fisheries there is a risk of unlicensed fishers using multi hook dropline apparatus. The extent of this practice is currently impossible to determine.

Species identification and recording in commercial logs, particularly the large cod and wreckfish species, is still a major concern. This is despite the comprehensive identification guide compiled by Brooks (2000) and provided to fishers. Much of the problem with species identification in the logbooks relates more to the composition of individual catches. At times, when a few species are caught in large numbers, data will be recorded accurately for each species by many fishers but when a more diverse and mixed range of species are caught more generic groupings are used. While there have been improvements in this regard with the development of updated logbooks and greater education of fishers, it is still an intractable problem.

Some fishers believe that deepwater fish stocks are somewhat protected by the adverse weather and current conditions encountered in the deeper offshore areas. The prevailing current and wind conditions, as well as seasonal activity in other fisheries tend to restrict the deepwater fishery to the months of May to December. The use of traps to target deepwater species has also been raised by fishers but is unlikely to be supported by the community and other stakeholders in this fishery.

In recent years, anecdotal information and data collected by this project has shown that many recreational and commercial fishers have increasingly moved into deeper waters. This practice is certainly not universal as charter fishers in some locations are fishing in shallower water in order to minimize the impact of rising fuel prices and other cost pressures on their businesses. While the analysis of catches from these sectors has not shown widespread capture of truly deep water species (such as bar rock cod and blue-eye trevalla) there are large catches of some of the tropical snappers (particularly rosy snapper) reported. Anecdotal evidence, as well as length frequency information collected from the charter boat fleet in southern Queensland, shows that large numbers of the smaller species of jobfish are taken (Ray Joyce personal observation). There is evidence from a number of sources suggesting that juveniles (or at least smaller size classes) of many of these species are more common in the shallow areas targeted by the charter and recreational sectors. The literature suggests that juveniles of some of the larger cod species are also more abundant in relatively shallow water. Although there is no specific evidence suggesting that either the charter or recreational sectors extensively catch these smaller cod the potential exists for this to occur. Despite the movement of both these sectors into deeper areas than previously fished there is apparently still little recreational and charter effort in areas deeper than 200m. It is still highly likely that an evergrowing subset of recreational anglers will continue to venture into these areas in the future.

The catch from Commonwealth-managed non-trawl fisheries as well as tuna fishery bycatch also remains a significant unknown to the sustainable exploitation of deepwater fish stocks.

We have highlighted that the Queensland-based deepwater line fishery is not likely to be a significant risk to the overall sustainability of species such as blue-eye trevalla, hapuka, and bass grouper. This is because the Queensland catch is only a minor component of the overall catch and most of the spawning biomass is predominantly in waters outside of Queensland’s jurisdiction. There is more risk that the Queensland bar rock cod fishery could be impacting other jurisdictions, although available information is not unequivocal in this regard as we do not have sufficient information of the spawning behavior of this species. The seasonal distribution of catches, however, does suggest the targeting of spawning fish. It will be important to establish the spatial and temporal extent of spawning of this species on the east coast.

Given experiences overseas it is likely that effort on deep-water stocks will increase. There are numerous reports of this from other areas around the world and the discussion of Roberts (2002) is highly relevant to the management of deepwater fisheries. Whilst harsher sea conditions and relative remoteness may offer some protection to deepwater fisheries resources, past experience from elsewhere indicates that overexploitation of many stocks is a potential risk. In Australia this has been recognized in both state and commonwealth fisheries. In Western Australia, management only allows 100 days of line fishing in deep water (>200m) for the similar suite of species that are targeted in Queensland. All boats participating in the fishery must have Vessel Monitoring Systems (VMS) that can verify their position and ensure that the allocated days are not exceeded.

Climate change predictions on temperature and currents, and their impact on these species from a Queensland perspective should see a contraction of the range further south. However, the deepwater nature of their habitat may provide some degree of resilience to climate change. Nevertheless, the reliance of early life history stages of these species to shallower waters is still a significant risk to their sustainable fishing in Queensland waters.

In terms of overall risk, the fact that many of the species belong to unit stocks that are managed under the separate legislations of three jurisdictions is a challenge to management. Bar rock cod, blue-eye trevalla, hapuka, Bass grouper are at the northern end of their range in Queensland with the fishery here only contributing a fraction to the overall catch of these species suggests that Queensland would be unwise to implement management strategies that were more restrictive than those of other jurisdictions.

8. BENEFITS AND ADOPTION

This project was designed to be of assistance to fisheries managers and stock assessment scientists involved in ensuring the sustainability of Queensland's deepwater line fisheries, which should ultimately benefit all stakeholders.

The lack of knowledge about many of the species fished has been partially addressed by literature summaries of key species and by the collection of new biological information on one of the key target species (bar rock cod).

The results of this project will benefit the commercial, recreational and charter line fishing industry in particular by providing information that will assist in the production of a risk assessment for species that are targeted by deep water line fisheries. At this stage the results have yet to be adopted since deepwater fishery risk assessment workshops have yet to be conducted, but there is a commitment by managers and other stakeholder to use information in this report to assist in developing these assessments.

Discussions with fisheries managers have indicated that workshops and the risk assessment process will now begin some time in the 2012/13 financial year and information presented in this report will be central to that process.

The database generated from the technology questionnaire will be used by our stock assessment scientists to improve the standardisation of species catch rate data in stock assessments, not only for deepwater species but also for other offshore demersal species that may have been impacted by recent technological advances. While this research mainly focussed on deepwater species much of the information collected from participants in the fishery will be relevant to the line-based rocky reef and coral reef fin fish fisheries.

9. FURTHER DEVELOPMENT

Further development of this research could assist management of deepwater finfish stocks in the following areas:

The technology surveys provided valuable data on the perceived impact of various fishing technologies on fishing ability, but they also highlighted the diversity in motivators and fishing practices among various demographic groups in each sector. Insufficient surveys were conducted to provide a representative picture of the detailed activities of fishers in these various demographics. This could only be achieved by increasing the sample size of the surveyed anglers and devoting more resources to this task.

The fisheries biology of some of the deepwater species (particularly bar rock cod) is still not fully understood. While research conducted in Western Australia and elsewhere for many of the other deepwater species will provide information that can be used to improve the management of these stocks there is no information being collected on bar rock cod and this is still an area for further development, particular validation of ageing and spawning habits.

Deepwater observer coverage in the last 12 months has been largely limited to waters off southern Queensland and there is little available information on the extent of fishing activities and catch composition in tropical deepwater fisheries under Queensland jurisdiction. At this stage, preliminary examination of the CFISH logbooks are inconclusive in determining the likely quantities of fish taken in these areas due to poor spatial resolution of the data which does not allow for accurate positioning of fishing activities relative to depth.

10. PLANNED OUTCOMES

The main planned outcome of the research (identified as Objective (3)) was to assist Fisheries Queensland with the production of a risk assessment for deepwater line caught species. This project has delivered on this immediate fisheries management need but implementation of the finding has been delayed due to recent operational and restructuring events in Fisheries Queensland. The project has provided the scientific information fisheries managers need in order to revise the existing management arrangements that apply to deepwater and associated offshore line fisheries. Data generated by this project will feed directly into the ecological risk assessment for deepwater fisheries to be developed in collaboration with fisheries Queensland and other stakeholders. Without this research the ERA would have limited data on which to proceed. Ultimately each of the fishing sectors will secure significant economic and social benefit from management arrangements based on this information. The technological adoption information will be used to standardise catches in a range of other offshore line fisheries and specifically will be used in the upcoming assessment of the snapper fishery, due to take place in 2014. Stock assessment scientists have already flagged the importance of these data in improving the accuracy and precision of the current snapper fisher stock assessment model.

The project results will be communicated in association with Fisheries Queensland primarily through the ERA process currently being formulated by fisheries managers. The research team will work closely with Fisheries Queensland and their communication unit to ensure that stakeholders are fully informed throughout the ERA process. An example of the how the information in this report could be used in an ERA process is shown in Table 10.1

	Species	Bar rock cod *(Epinephelus ergastularius)*	Eight-bar grouper *Hyporthodus octofasciatus*	Bass grouper / Hapuka *(Poyprion spp)*	Goldband snapper *(Pristipomoides multidens)*	Rosy snapper *(Pristipomoides filamentosus)*	Flame snapper (*Etelis coruscans*)
Biology / Behaviour	Distribution	Australia only **$^{1/2}$	Broad Indo-Pacific *	Widespread *	Widespread *	Widespread, patchy **	Broad Indo-Pacific *
	Depth range	15-130m (juv.) 150-400m (adult) **	150-300m (adult), juveniles shallower **	50-600m. Juv. pelagic, rarely caught **	40-250m ***	40-400m ***	90-500m **
	Max age/size	30yrs+ 157cm TL	Unknown	40 yrs+, 150cm+	14yrs / 90cm TL	18yrs / 90cm TL	120cm
	Reproduction	Possible spring summer spawners		Hapuka mature 10-13yrs	All yr, peak Dec-Jan (Vanuatu)	7mnths Apr-Oct (Hawaii)	Mature 55-80cm FL Spawn through summer (Hawaii)
	Behavioural traits	Solitary / small schools **	Solitary / small schools *$^{1/2}$	Solitary / small groups *$^{1/2}$	Large, often single-species schools ***	Large schools, predictable location ***	Schooling species ***
Biological risk		**HIGH**	**MODERATE**	**HIGH**	**MODERATE**	**HIGH**	**MODERATE**
Fishing pressure	Primary target species	Y ***	Y (but currently caught in relatively low volumes) **	Y (not currently caught in large quantities) **	Y ***	Y ***	Y ***
	Other fisheries	Important in NSW dropline fishery. **	.Possibly some Rec/Charter *	V. Minor Rec & Charter *	Reef line and recreational**	Reef line, Recreational **	Minor Rec and Charter *
	Seasonality	Most in Spring and summer*	*Unknown	Most in summer *	No strong seasonality*	No strong seasonality*	Sporadic catches *
	Catchability	Mod-High **	Moderate **	Low-Mod **	High ***	High ***	High ***
	Marketability	High (local and overseas market). ***	High (local & overseas) ***	High ***	High (local & Overseas) ***	High ***	High ***
	Other			Can be overfished (e.g. Bermuda, South Africa).	Fishers can get almost 100% goldband in a trip	May be declining in shallow areas	Usually caught at 5-7kg
Overexploitation		**HIGH**	**MODERATE**	**MODERATE/HIGH**	**HIGH**	**HIGH**	**HIGH**
Current management controls		Limit on amount taken as tuna bycatch Bag limits	Limit on amount taken as tuna bycatch. Bag limits	Size & bag limits for rec. fishers	Size & bag limits for rec. fishers	Size & bag limits for rec. fishers	

Table 10.1 Example risk assessment matrix for species targeted by the deep water line fishery in southern Queensland.

11. CONCLUSION

The projects three objectives relating to (1) impacts of technology change (2) addressing knowledge gaps and (3) providing information for risk assessments have been addressed as follows:

(1) Cumulative curves showing the impact of plotters, sounders and fishing gear on catch of offshore species are presented in the report. These can be used to better standardise catch rate trends and other fisheries parameters in future stock assessments. The considerable variation in the response among the various participants in the survey in all sectors indicates that a very large sample size would be needed to get a thorough understanding of these trends across all demographic groups. Further development is needed to assess the impact of these changes on the commercial and charter sectors.

Recreational anglers attributed an average 40% increase in fishing power to sounders and GPS but less than 25% to fishing technologies such as braided line, lures and other fishing gear.

There is a great diversity in the fishing practises of recreational and commercial fishers and each will have different motivations for the temporal, spatial and other demographic patterns of their fishing activities. It goes without saying that there is no “typical” fisher in either fishing sector. This creates difficulties in attempting to describe average effects in each of these fisheries.

(2) Biological data has been collected predominantly on the main target species of the southern deepwater fishery – bar rock cod which has shown it to be a long lived species with the bulk of the catch greater than 10 years of age. There is a high likelihood that spawning aggregations are targeted by deepwater fishers. The high market value and logistic difficulties in obtaining otoliths and gonad material from this species is a significant hurdle to collecting information to ensure future sustainability. It may be beneficial to link continued access to species such as bar rock cod to the provision of information that will better assist in the management of the fishery. Based on reports of fishery observers, the by-catch from the southern deepwater line fishery is very low with few reports of fish having to be released due to size limits or other factors suggesting that risks of cryptic mortality are minimal.

Poor identification and recording practises of commercial fishers targeting deepwater fish stocks is still a significant obstacle to the sustainable management of deepwater stocks. This is an area that has improved in recent years but generic categories still mask the quantity of individual species that are caught and limit the value of catch and effort data for determining stock status parameters.

(3) The ecological risk assessment has yet to be undertaken but the information contained in this report will be used in the assessment which will be conducted some time in 2012-13.

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13. APPENDIX 1. INTELLECTUAL PROPERTY

The research was for the public domain. The report and any resulting manuscripts are intended for wide dissemination and promotion.

14. APPENDIX 2. STAFF

Dr Wayne Sumpton (Principal Investigator)

Mr Mark McLennan (Senior Fisheries Technician)

Mr Gavin Leese (Fisheries Observer)

Mr Nathan Roswell (Fisheries Observer)

Mr Matthew Campbell (Fisheries Biologist)

Mr Sam McCulloch (Fisheries Observer)

Dr Julia Davies (Fisheries Observer Co-Ordinator)

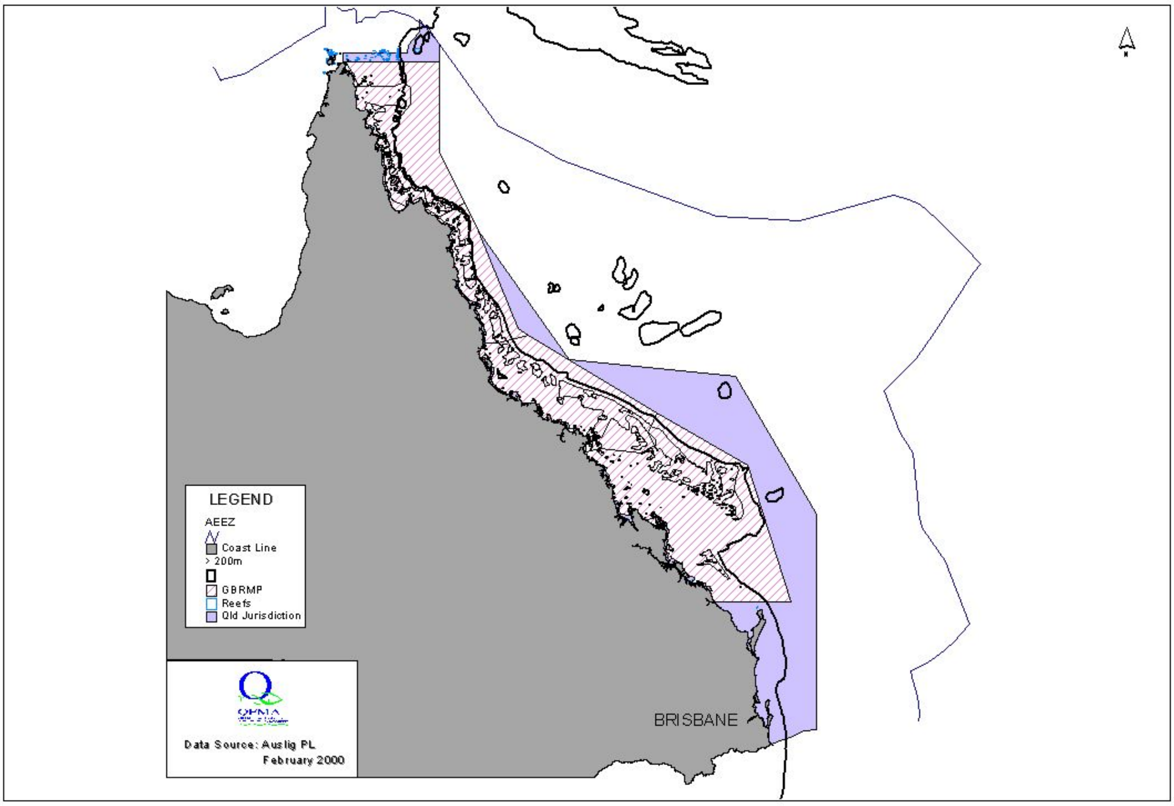
Dr Brigid Kerrigan (Fisheries Manager)

Ms Lisa Shepherd (Fisheries Resource Officer)

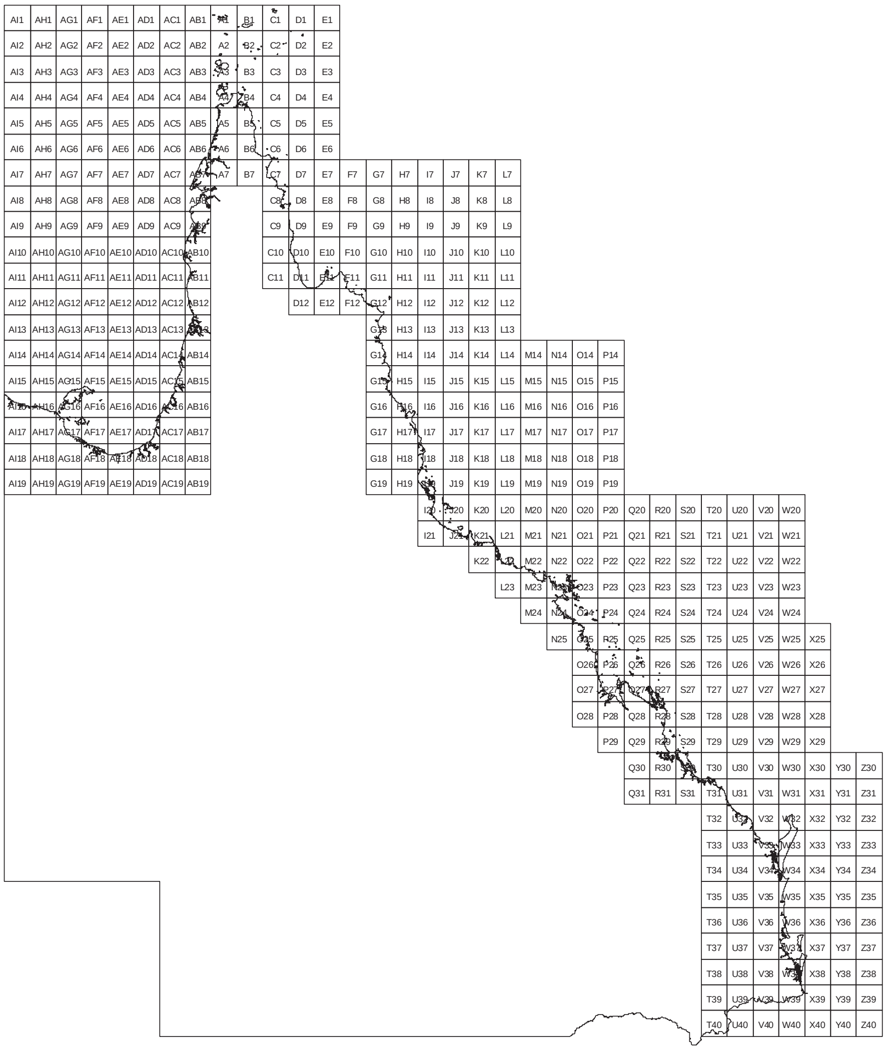
Dr John Kung (Senior Fisheries Resource Officer)

Dr David Mayer (Consulting Biometrician)

15. APPENDIX 3. QUEENSLAND LINE FISHERY AREAS AND ADJACENT JURISDICTIONS



16. APPENDIX 4. POSITION GRIDS (30nm x 30nm) USED IN COMMERCIAL LOGBOOKS



17. APPENDIX 5. LIST OF FISH COMMON NAMES USED SYNONYMOUSLY BY FISHERS & PROCESSORS

Bar rockcod – seven bar grouper, banded rockcod, lightship cod
Eight bar grouper – probably often recorded as ‘hapuka’ or bar cod
Bass grouper – grouper bass
Rosy snapper – king snapper
Goldband snapper – king snapper
Ironjaw – rusty jobfish
Saddletail snapper - large-mouthed nannygai- red jew, scarlet sea perch, saddletail seaperch
Flame snapper – flametail jobfish, longtail, longtail ruby snapper, onaga, scarlet jobfish
Ruby snapper – short-tail ruby snapper.
Mozambique bream – Mozambique perch

18. APPENDIX 6. RECREATIONAL QUESTIONNAIRE

Fishing Power and Technology Survey SE Queensland Line fishing Vessels 2011/2012

Location of Interview (if not self completed) ……………………………

(Eg Boat ramp, on board boat etc)

Tick nature of interview **In person Interview** ☐
Phone Interview ☐

Interviewee………………………………………………

Date…………………………………………………..

Answering the Survey –
The survey is designed to record the historical change in fishing gear and general fishing characteristics for offshore fishing in South East Queensland waters. This will provide more accurate information on the effects of these changes on our fisheries.

Please provide dates on all changes where possible. This information is very important for us to understand the changes that occurred in your fishery over time. If a question does not accommodate your vessel/fishing set up, please specify in your own words. If exact figures are not available please provide careful estimates. If you don't know some details please write "DON'T KNOW" for the question.

All individual information will be treated as strictly confidential. No individual will be identified from the results in any reports. Your individual information will be entered onto an electronic database that has restricted access.

Personal/Family Details

Age of Skipper	……………. Years	Family Fishing History (number of generations of fishermen)	………………..…
Total years fishing commercially (from age 15 to present)	……………. Years	Years as a vessel owner	…………. Years

Vessel Specifications

Please provide information on changes to your current fishing vessel for the period from **purchase date to present**. If you have changed vessels more than twice, please record the year you purchased your first vessel at the end of this question.

Current Vessel Details	
Date you purchased this vessel	………………………
Purchase price of vessel	$………………………
Year vessel was built	………………………
Current Engine Rated Power (hp) and type – (Codes below) 2 stroke carburettor (2C) , 2 stroke injected (2I) , 4 stroke (4S) or diesel (D)	…………(hp)……………(Type)
How often did you upgrade engines for this boat	
Vessel Length (m)	
Construction (plate centre console, fibreglass etc)	
Fuel Capacity (litres)	

Previous Vessel Details	
Date you purchased this vessel	………………………
Purchase price of vessel	$………………………
Year vessel was built	………………………
Engine Rated Power (hp) and type – (Codes below) 2 stroke carburettor (2C) , 2 stroke injected (2I) , 4 stroke (4S) or diesel (D)	…………(hp)……………(Type)
How often did you upgrade engines for this boat	
Vessel Length (m)	
Construction (plate centre console, fibreglass etc)	
Fuel Capacity (litres)	

Earlier Vessel Details	
Date you purchased this vessel	………………………
Purchase price of vessel	$………………………
Year vessel was built	………………………
Engine Rated Power and type (hp) –(Codes below) 2 stroke carburettor (2C) , 2 stroke injected (2I) , 4 stroke (4S) or diesel (D)	…………(hp)……………(Type)
How often did you upgrade engines for this boat	
Vessel Length (m)	
Construction (plate centre console, fibreglass etc)	
Fuel Capacity (litres)	

How many vessels have you owned including those specified above?…………………………………….

In what year did you first purchase a vessel for fishing offshore? ………………………………………….

What areas of Southern Queensland have you fished in **your vessels**? (REFER TO MAP AND TICK AREAS)

When fishing from your boat.	Swains?	Fraser Offshore	Sunshine Coast Offshore	Moreton Bay	Moreton Offshore	Gold Coast Offshore
First Year of Fishing						
Mid – fishing career						
This current fishing year						

Please provide the following information in relation to your offshore boat based fishing activities over your lifetime. Average distance you travelled in your boat in offshore waters i.e. Not Moreton Bay

Offshore only	Avg distance travelled to boat ramp (Km)	Avg distance travelled each fish day (nM)	Average depth (m) of water fished	Max depth (m) fished	Days fished per year	Average hours fished per day
First year of Fishing						
Mid – fishing career						
This current fishing year						

Fishing Gear Changes

The use of different fishing equipment and techniques can change your catch. Please provide the following information. If exact dates/figures are not available please provide careful estimates.

Demersal or Bottom Fishing	
List your top three offshore target species when you began fishing offshore	
List your top three offshore target species now	
Please tick each of the following fishing gears you have used and estimate when you started using them. Estimate the % increase in your catch you would attribute to this change:	
Braided line……………………………….…….	….☐ Start date …..…….. % …………….
Soft plastic lures……………………………......	….☐ Start date …..…….. % …………….
Hard body Lures/Jigs……………………………..	….☐ Start date …..…….. % …………….
Floater rigs………………………………………	….☐ Start date …..…….. % …………….
Paternoster rigs……………………………….…...	….☐ Start date …..…….. % …………….
Circle hooks……….………………………………	….☐ Start date …..…….. % …………….
Chemically sharpened Hooks……………………..	….☐ Start date …..…….. % …………….
Electric or hydraulic winch/reel.……….………...	….☐ Start date …..…….. % …………….
Others ……………………………………………. (please specify eg. Glow sticks)	….☐ Start date …..…….. % …………….

Navigation Capabilities

One of the most important aspects to fishing is the ability to find and fish the most productive areas. Specialised navigation equipment plays an important role in identifying productive fishing grounds and enables fishers to return to these locations with ease and accuracy.

Navigational Equipment	**Have you ever used the following fishing/navigational aids on any vessel you have used?** (Tick one box for each question.)	**Has the equipment been updated or retired since first use?** (please provide date of change)
1. Fishing marks found by reference landmarks	☐ No ☐ Yes, Year first used …………………	
2. Global Positioning System (GPS)	☐ No ☐ Yes, Year first used …………………	☐ 1st update .... ☐ 2nd update ….................... ☐ retired …..…......................
3. GPS Chart Plotter	☐ No ☐ Yes, Year first used …………………	☐ 1st update .... ☐ 2nd update ….................... ☐ retired …..…......................
4. Paper Depth Sounder	☐ No ☐ Yes, Year first used …………………	☐ 1st update .... ☐ 2nd update ….................... ☐ retired …..…......................
5. Monochrome Depth Sounder	☐ No ☐ Yes, Year first used …………………	☐ 1st update .... ☐ 2nd update ….................... ☐ retired …..…......................
6. Colour Depth sounder Indicate if bottom discriminating with a (B) or 3D bottom display (3D)	☐ No ☐ Yes, Year first used …………………	☐ 1st update .... ☐ 2nd update ….................... ☐ retired …..…......................

Searching and fishing spot finding capabilities

Please provide the following details if you use or have used a GPS on any of your vessels.

1. No of waypoints (fishing marks) at end of first year of GPS ownership	
2. No. of fishing marks in GPS today	
Estimate the % increase in your fishing ability that you would attribute to the following:_	
Sounders	
GPS	
Fishing gear	

Rank in order of importance (by putting number from 1 to 6 with 1 being most important) where you get your information on fishing techniques and gear.

Word of mouth … Web … Fishing Club ... Personal Experience … Magazines … TV ….

Fishery Management Questions

Please rate how you feel about the following statements. For each statement tick one box.

1) I support management measures such as seasonal and area closures.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

2) There is too much commercial line fishing effort.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

3) There is too much recreational line fishing effort.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

4) There is generally too much commercial fishing effort (netting, trawling etc).

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

5) Fishing is better nowadays than when I first started fishing.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

6) The line fishery in SE Queensland could be improved by a recreational fishing licence.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

7) Seasonal or area closures help protect fish stocks for the future.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

8) My ability to catch fish has increased over the last 10 years.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

9) I am satisfied with current regulations of recreational line fisheries in Queensland.

Strongly disagree	Disagree	Neither disagree or agree	Agree	Strongly agree

What changes could be implemented to improve the offshore demersal line fishery?……………………………………………………………………………………………..
……

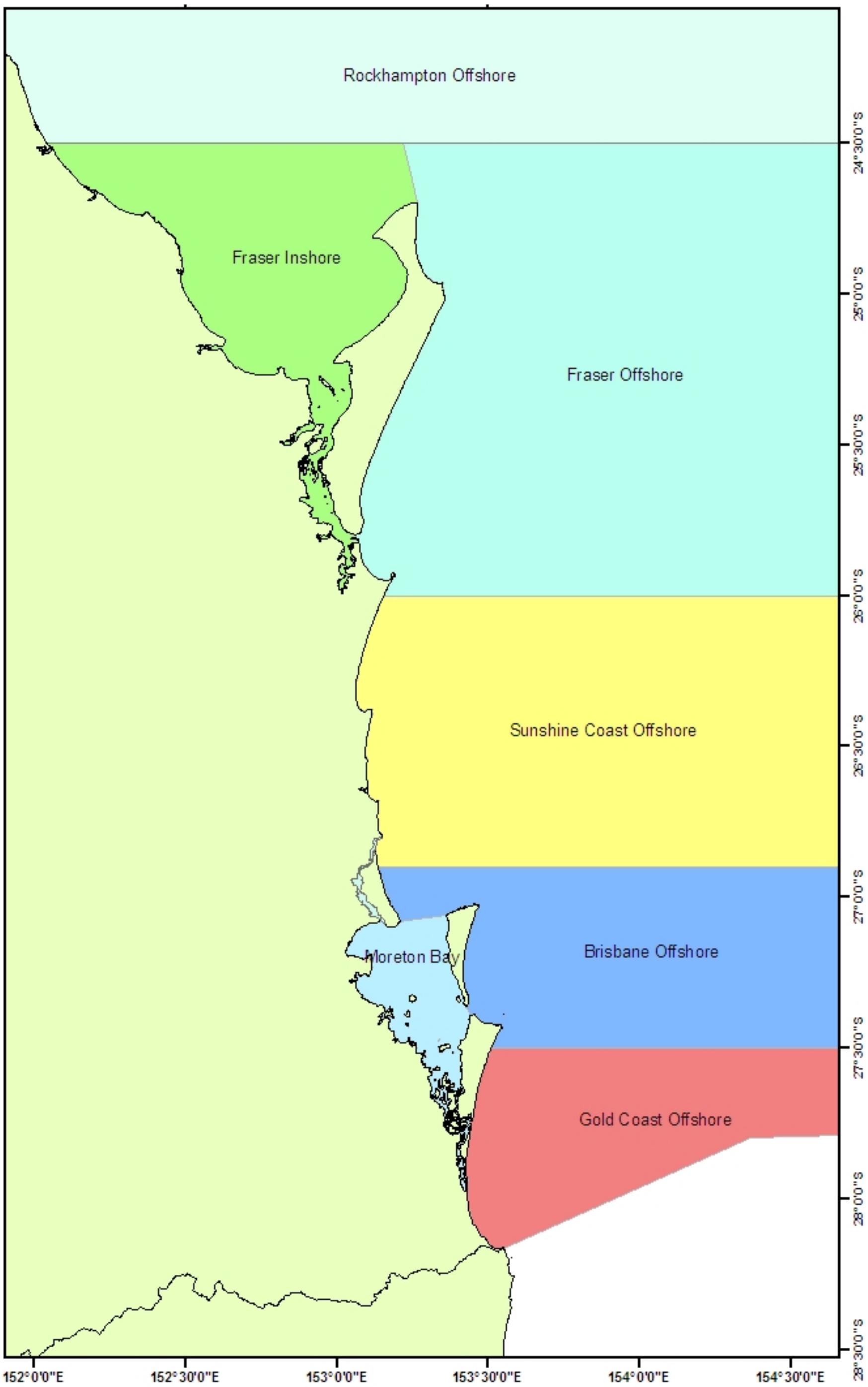


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Figure 1. Rocky reef fish sampling regions

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