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Fishing for More: A student-stakeholder workshop on the biology, ecology, sociology and economics of fisheries.

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CRC Reef Research Centre

and James Cook University

CRC Reef Research Centre is a knowledge-based partnership of coral reef ecosystem managers, researchers and industry. Its mission is to provide research solutions to protect, conserve and restore the world's coral reefs. It is a joint venture between the Association of Marine Park Tourism Operators, Australian Institute of Marine Science, Great Barrier Reef Marine Park Authority, Great Barrier Reef Research Foundation, James Cook University, Queensland Department of Primary Industries and Fisheries, Queensland Seafood industry Association and Sunfish Queensland Inc. The University of Queensland is an associate member.

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The aim of these proceedings was to document our research and the issues raised by stakeholder representatives at the workshop in order to benefit the sustainable management of fisheries on the east coast of Queensland and in the Torres Strait. Clearly, this would not have been possible without the enthusiastic participation of all stakeholder representatives at the workshop, for which we are grateful. We would also like to thank CRC Reef for their financial support, which was essential for funding both the workshop and the production of these proceedings.

We would particularly like to thank Annabel Jones for assistance with the initial organising of the workshop, helping with the production of the invitation brochure and for the successful production of the Fishing and Fisheries newsletter providing a summary of the workshop presentations. Also, thanks to Ashley Williams and Cameron Murchie for presenting their work at relatively short notice to help enrich the workshop for Torres Strait participants, in particular.

We thank Mark Elmer and Mark McCormick who refereed these proceedings. Thanks also to our supervisors and Task Associates whose constructive comments helped improve the quality of this document; and Annabel Jones, Chloe Lucas and Tim Harvey for recording of the discussion minutes. We particularly acknowledge advice and editing/written contributions provided by Gavin Begg.

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FOREWORD AND EXECUTIVE SUMMARY

The CRC Reef Research Centre's second student stakeholder workshop in November 2004, "Fishing for More", demonstrated the continued recognition of the importance and acceptance of stakeholder engagement in scientific research. The CRC Reef has fostered an ethos and commitment to collaborative, applied and integrative stakeholder-driven research of which its postgraduate students are encouraged to develop and embrace. The workshop and subsequent proceedings presented here are testimony to the adoption of this culture.

Postgraduate students of the CRC Reef Fishing and Fisheries Project and James Cook University built upon the first successful student stakeholder workshop in 2001, "Bridging the Gap". This workshop focused upon linking student research with fisheries stakeholders (*i.e.*, effectively "bridging the gap" between the research and end users of that research). In contrast, the second workshop promoted a dialogue between stakeholders and students so as to not only link their research, but to enable stakeholders to inform their research (*i.e.*, effectively "fishing for more" information to better interpret research findings). Outcomes from both these workshops emphasised the genuine commitment of the respective students to ensure their research is relevant and has direct implications to the assessment and sustainable management of Queensland fisheries and its stakeholders.

The overall aim of the second student stakeholder workshop was to facilitate the effective transfer of information to stakeholders about current CRC Reef postgraduate research on Queensland east coast and Torres Strait fisheries. A diverse array of stakeholders with interests across these fisheries contributed to achieving this aim. The workshop consisted of six PhD presentations, in various stages of candidature, encompassing three broad research topics: 1) biology and management of reef fish; 2) incorporating social and economic information into fisheries management; and 3) traditional fisheries and their management in Torres Strait. The diversity of these research topics captures the essence of modern fisheries management and its need to incorporate aspects of biology, ecology, sociology and economics in a holistic manner.

Bergenius, Marriott and Pears provided information on the biology of important target and by-catch species of the Coral Reef Fin Fish Fishery of the Great Barrier Reef, and insights into their effective management. All of these studies are contributions from the CRC Reef Effects of Line Fishing (ELF) Project, where significant value-adding in the form of auxiliary information to the ELF Project has been gained from these, and other, student studies. As with all of the ELF research, the student research is dependent on stakeholder engagement and consultation.

Bergenius compared vital life history characteristics of the main target species, common coral trout (*Plectropomus leopardus*), across broad spatial and temporal scales. Results revealed large variations in growth, mean age and survivorship of common coral trout among regions of the Great Barrier Reef, although the patterns were not consistent among years. Regional variation in life history characteristics can lead to differences in productivity and reproductive output that can be used to infer stock structure. Currently, common coral trout (and all other reef fish), however, are managed as a single stock on the Great Barrier Reef with no consideration of regional differences in vital life history characteristics; albeit that these results suggest several stocks are evident and a precautionary approach to regional management may be warranted.

Marriott examined the biology and potential impacts of fishing on populations of red bass (*Lutjanus bohar*); a long lived reef fish that has recently been regulated as a no-take species in the Coral Reef Fin Fish Fishery. Although red bass is no longer harvested for consumption on the Queensland east coast, changing regulations have resulted in it becoming an important by-catch species in the fishery. In addition, red bass is still a target species in other fisheries and regions such as the Torres Strait. The species longevity, late maturation, slow growth and unknown post-release mortality are all characteristics indicative of its high vulnerability to over-fishing that need to be considered in the management of multi-species fisheries of which it is a component.

Pears described demographic and life history characteristics of flowery cod (*Epinephelus fuscoguttatus*), and the closely related, camouflage cod (*E. polyphekadion*). These species are an important component of the Asian live reef food fish trade and the Coral Reef Fin Fish Fishery of the Great Barrier Reef. Similar to red bass, flowery cod and camouflage cod are relatively long lived, slow growing and late maturing species that are vulnerable to over-fishing. Results from this study suggest the effectiveness of recent size limits implemented in the fishery as a measure to protect the species need to be reviewed, particularly for flowery cod, as little protection is afforded to the reproductive component of its population.

The need to incorporate social science in fisheries management has been debated for some time, but is now gaining momentum under legislative requirements for total systems approaches to management. Traditionally, fisheries have been managed using ecological information, but evidence is now showing that incorporating social science into the decision-making process may improve resource protection through increased compliance and decreased conflict (Marshall, these proceedings). Likewise, CRC Reef and its students have recognised the benefits of multi-disciplinary research and demonstrated their progressive thinking and commitment towards social science. Although we have a long way to go in effectively using social science in a pragmatic fisheries management framework, the studies of Marshall and Tobin reported in these proceedings provides some insights to this on-going commitment.

Marshall investigated the resilience of the commercial fishing industry in Queensland to changes in fisheries management policy. Considering the significant management changes that have recently been implemented throughout Queensland (*i.e.*, RAP, Trawl Plan, Reef Line Plan, etc) results from this study are particularly timely. The level of dependency on fisheries resources, the way in which policies are interpreted, and personal and family characteristics were found to be important social factors in determining how resilient a fishing family may be to policy change. Future decision-making processes need to consider social information to ensure management strategies are designed to not only protect fisheries resources, but minimise conflicts and other social impacts.

Tobin discussed the apparent ubiquitous and growing conflict between stakeholders for shared fish stocks, with a focus on recreational anglers and commercial gillnet fishers targeting barramundi (*Lates calcarifer*) in north Queensland estuaries. Results from structured questionnaires indicated that fishers from each sector hold negative opinions of the competing sector, and positive opinions of their own sector, for aspects of fishery health and productivity. Negative opinions, however, appeared to be based on perceptions rather than research, suggesting that the general fishing public is poorly informed. Current conflict between sectors may be eased through increased education and communication, emphasising the importance of social science in understanding and ultimately, improving such situations.

Another relatively new area of research focus for the CRC Reef and its students involves traditional fishing practices and resource dependency of indigenous communities in the Torres Strait. In this research, consultation is perhaps even more important given the social and cultural considerations that need to be addressed. Busilacchi introduced ongoing research designed to characterise the traditional subsistence fishing (*kaikai*) practices in the eastern Torres Strait. Preliminary results suggested that there have been changes over time in the species harvested for consumption in response to changing motivations for fishing. Information on fishing practices of the subsistence sector will be integrated with results from a complementary study examining the commercial sector of the fishery to provide an exhaustive and reliable assessment of reef fish in the Torres Strait.

The student research presented at the workshop and in these proceedings are all CRC Reef funded tasks, demonstrating their applied focus to stakeholder interests. CRC Reef offers many opportunities for students to become involved in stakeholder engagement and develop all aspects of their profession including good communication and collaboration skills, although it is up to them to embrace these opportunities. This workshop was entirely organised by the students of the CRC Reef Fishing and Fisheries Project, who viewed this as a unique opportunity to discuss with stakeholders their research, whilst gaining invaluable feedback on their findings. These actions demonstrate the traits and philosophy to applied fisheries research that is inherent in CRC Reef students. Notably, their research and motivations are driven by a desire to provide stakeholders with relevant outcomes for management; attributes that are not necessarily common place in traditional academia.

The second CRC Reef student stakeholder workshop, "Fishing for More", and the resulting proceedings documented in this report, therefore, continue the genuine commitment of the CRC Reef and its students to stakeholder engagement and consultation. The workshop was intended to involve a wide array of stakeholders, and these proceedings are likewise intended to be accessible to a broad audience with interests in Queensland east coast and Torres Strait fisheries. These proceedings express the views of stakeholders at the workshop, and demonstrate the value of effective stakeholder engagement that is built on reciprocal trust and respect.

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INTRODUCTION AND OBJECTIVES

This report presents the papers and discussion minutes from the "Fishing for More" workshop of November 2004. This workshop was set up by the postgraduate students of CRC Reef's Fishing and Fisheries Program to collectively present their findings to both inform, and reward the assistance and participation of, a broad range of stakeholders. Research topics covered a broad range of fishing and fisheries issues on the East Coast of Queensland and Torres Strait. The program consisted of three sessions:

Session 1: Biology and management of reef fish

Session 2: Incorporating social and economic information into fisheries management

Session 3: Traditional fisheries and their management in Torres Strait.

This workshop builds on the "Bridging the Gap" workshop held by students of CRC Reef's Effects of Line Fishing (ELF) project in 2001. A similar workshop structure was used, which provided an open forum discussion of each research project. Each student gave a 15-minute presentation during which his or her findings were presented so as to be relevant to invited stakeholders. Each presentation was followed by a moderated discussion of that research during which participants exchanged views and ideas on the implications of the research findings for users, managers and other stakeholders.

Therefore, the overall objective of the workshop was to:

Facilitate the effective transfer of information on current research on fishing and fisheries issues on the East Coast of Queensland and Torres Strait, to all stakeholders, in an environment conducive to a meaningful exchange of ideas.

A NOTE ON SCIENTIFIC AND TECHNICAL ASPECTS OF PROCEEDINGS

The CRC Reef student stakeholder workshop was intended to involve a wide array of people, and these proceedings are likewise intended to be accessible to a broad audience. Therefore, the content and structure of the following papers does not follow the format of most scientific publications. We aim to avoid burdening or even discouraging non-scientist readers with excessive technical detail, so most of the papers simply describe and discuss research results without explanation of methodology.

Still, we recognise that many readers are likely to be interested in the process by which these research results were attained. We encourage those readers to pursue sources cited throughout these proceedings for the information of interest. PhD or MSc theses and papers in peer-reviewed journals will provide background on sampling design and methodology, validation of age determination methods, and other technical and analytical aspects. Moreover, we encourage readers to contact authors directly for further information. The team that organised the workshop and authored this volume includes researchers at different stages in their studies. While some have reached a stage where their research is appearing in scientific journals, others have only reached the stage of thesis production. Still others have not yet reached the dedicated writing stage, and for these individuals the only source of additional information will be direct contact with the researcher. However, we encourage readers to contact any researcher directly, regardless of the stage of their studies. Our objective in running the workshop was to open a dialogue between early career researchers and a wide array of stakeholders. We did not intend for that dialogue to end when the workshop ended, nor to be limited only to workshop attendees.

Finally, although we have strived to make these papers accessible to a broad readership, some use of specialist terminology was inevitable. We encourage readers to refer to introductory texts on ichthyology, ecology, conservation biology, fisheries management, social science, and economics to clarify any terms or concepts discussed in this volume.

SESSION 1: BIOLOGY AND MANAGEMENT OF REEF FISH

Implications of spatial and temporal patterns in life history characteristics for the management of common coral trout on the Great Barrier Reef.

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Abstract

Common coral trout (*Plectropomus leopardus*) is currently managed as a single stock on the Great Barrier Reef (GBR), by regulations which do not consider potential difference in biology of these fish between areas. Fish stocks with different biological characteristics may respond differently to fishing pressure and failure to consider such variations may result in overfishing of less productive stocks. This study compared the patterns of growth, age and survivorship of common coral trout between four widely separated regions of the GBR between 1995 and 1999. Results revealed large variations in growth and mean age among regions, although the patterns were not consistent over the study period. Similarly, survivorship was different between year classes (fish born in the same year) and the patterns were not consistent among the regions. These results indicated that there may be several stocks of coral trout on the GBR. However, the stock structure was variable with time. While region-specific management strategies may be difficult to implement for common coral trout at this time, it is recommended that a precautionary approach to management be implemented. This should account for variable biological characteristics, combined with long-term monitoring of the population.

Introduction

Common coral trout, (*Plectropomus leopardus)* is the main target species of the Queensland coral reef fin fish fishery (known as the Great Barrier Reef (GBR) line fishery). Currently all species taken in this fishery are managed uniformly across the GBR (through catch and effort restrictions, area and temporal fishing closures) with no consideration for variability between different regions in biological characteristics such as growth, age and reproduction. This study compared biological characteristics of common coral trout in four regions (Lizard Island, Townsville, Mackay and Storm Cay) of the GBR to determine whether there may be different stocks of common coral trout.

I will start this report with a clarification of the term stock, outline why different stocks may form, and why it is important to consider different stocks when managing a species. Secondly, I will briefly review what is currently known about the biology of common coral trout. Thirdly, the methods and results of my study will be presented and finally, I will discuss some issues to address in the future and recommendations for the management of this species

Definition of a stock and the importance of identifying stock structure

The biological characteristics of a species, such as growth, mortality and reproduction, are the result of its genetic makeup and the environment in which it lives (Begon et al. 1990). Biological characteristics will change in response to environmental conditions and may influence the number of young a species produces from one generation to the next. The environment is highly variable from area to area, and different groups of individuals within a population are likely to be exposed to different conditions, such as habitat and number of predators or competitors. As a result, individuals in one area, for example, may grow more slowly and reproduce later than individuals in another area. Groups of individuals with different biological characteristics may form and such groups may be referred to as different stocks (Ihssen et al. 1981, Lowe et al. 1998).

The stock structure of fish populations have been researched in the temperate environment for several decades (i.e., Ihssen et al. 1981, Begg et al. 1999) but has rarely been examined for tropical reef fishes. Many different techniques other than biological characteristics such as chemical composition of bones, body shapes and forms, mark-release-recaptures and genetics have been used to identify stocks of both temperate and tropical species (e.g. Ihssen et al 1981, Pawson & Jennings 1996, Begg et al. 1998). However, different techniques can identify different kinds of stocks, such as groups with different biological characteristics or groups that differ genetically. The technique used to identify stocks should primarily be selected with consideration of the reasons to identify stocks in the population (Begg & Waldman 1999). For example, if the purpose is to protect the genetic diversity of a species, genetic information should be sought, while if the reason is to protect a part of the life history, then information about biological characteristics may be more informative. In this study, I researched the stock structure of common coral trout using biological characteristics to determine whether stocks in different regions of the GBR may be more productive or, alternatively, more vulnerable to over-fishing than stocks in other regions.

Consideration of stock structure is important for the appropriate management of fished populations (Iles & Sinclair 1982). Research suggests that the biological characteristics of a species will influence how it is affected by fishing (Jennings et al. 1998). A species that matures later, grows slower and attains a larger size may take longer to recover and be more susceptible to over-fishing and extinction than a species that is fast growing, smaller in size and matures earlier (Adams 1980, Beddington & Cooke 1983, Trippel 1995). Different responses to fishing are also likely to occur between different stocks of the same species. Failure to take such information into account when determining fisheries management strategies may result in over fishing and localised depletion of less productive stocks (Ricker 1958).

Current knowledge of common coral trout

Common coral trout belong to the subfamily Epinephelinae and family *Serranidae* (tropical cods and groupers). Unlike many other epinephelids, which grow slowly and live for a long time (up to 50 years), common coral trout are relatively fast growing and have a relatively shorter life span (less than 20 years) (Ferreira & Russ 1994). Common coral trout form many, small spawning aggregations on individual reefs during late spring to early summer (Samoilys 1997) and there is little movement of adults between reefs (Davies 1995, Zeller 1998, Zeller & Russ 1998).

Although the stock structure of common coral trout on the GBR has not been determined, several studies suggest that there may be different stocks present. For example, a recent study comparing reproductive characteristics of coral trout among four regions of the GBR showed that female coral trout were larger in the central Townsville region and smaller in the northernmost Lizard Island region when compared to the two southern Mackay and Storm Cay (located north of the Swains reefs) regions (Adams 2002). The study also revealed that there were more females than males present in the Townsville region, compared to a dominance of males in the other three regions. Mapstone et al. (2004) showed a difference in both the size and age of legal common coral trout (>38 cm) among regions, with fish being older and smaller in Mackay and Storm Cay than Townsville and Lizard Island. Other studies have shown that densities of common coral trout are much greater in the southern regions than in the northern regions (Ayling et al. 2000). Some studies have also found differences in the size, age (Russ et al. 1995) and mortality for this species (Russ et al. 1998) between neighbouring reefs on the GBR, highlighting the potential for considerable variability in biology also between smaller spatial scales.

Commercial fishing logbook data on catches of common coral trout have also shown distinct regional variation in catch per unit of effort (CPUE) (Mapstone et al. 1996b, 2004, Samoilys et al. 2002) further emphasising the possibility of variable productivities between regions. Although all of the mentioned studies show variations in biological characteristics between years that were not always consistent within regions, these results highlight the possible presence of several stocks of common coral trout on the GBR.

Methods

Common coral trout (from now on abbreviated to coral trout) samples were collected during research surveys by commercial fishers as part of the CRC Reef (Cooperative Research Centre for the Great Barrier Reef World Heritage Area) Effects of Line Fishing Experiment (ELF, Mapstone et al. 1996a, 2004, Campbell et al. 2001). Coral trout were collected each year from 1995 to 1999 from 24 reefs grouped into four clusters of six adjacent reefs on the GBR. These clusters are known as the Lizard Island, Townsville, Mackay and Swains regions. Four of the study reefs in each region (16 reefs) had been closed to fishing for 10-12 years before surveys began in 1995. Coral trout samples on these closed reefs are the focus of this report. Although some illegal fishing may have occurred on some closed reefs, estimates of life history characteristics from individuals on these reefs are likely to be our closest approximation to those of populations not modified by fishing (Mapstone et al. 2004).

An index of relative growth was taken as the average fork length of four-year-old coral trout and compared between regions and years. Age four was chosen because this is the age at full recruitment to the fishery, i.e. when all coral trout are large enough to be caught by the line-fishing gear. At younger ages none or only some coral trout are large enough to be caught. Annual survivorship was measured as the proportion of fish in each year class (fish born in the same year) surviving from one year to the next. Survivorship was then compared between year classes, reefs and regions.

Results and discussion

Patterns in biological characteristics and indications of stock structure

The average age and size of four-year-old coral trout differed between regions, while these patterns changed between years (Fig. 1 and 2). Average age of the catch in particular, varied between years and in no single region were coral trout consistently younger or older than other regions (Fig. 1).

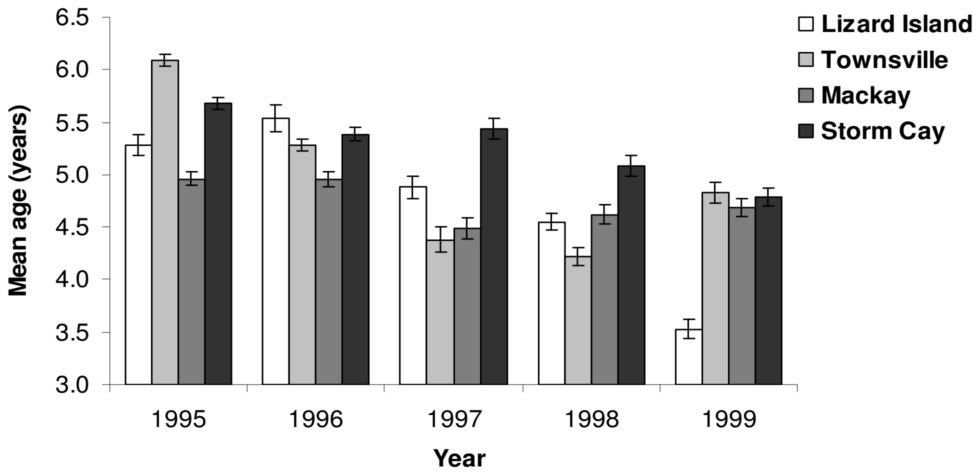

Figure 1. Average age of common coral trout collected each year between 1995 and 1999 in four regions (Lizard Island, Townsville, Mackay and Storm Cay) of the Great Barrier Reef (Bars = SE).

A few more patterns emerged in the average size of four-year-old coral trout (Fig. 2). The growth rate up to four years was in 1995 to 1997 greater in the two middle regions of the GBR, Townsville and Mackay, than in the southern most Storm Cay region (Fig. 2). When compared between years, growth of coral trout was consistent in Storm Cay and Mackay, while variable in the Lizard Island region, where average size of four-year-olds increased between 1995 and 1999.

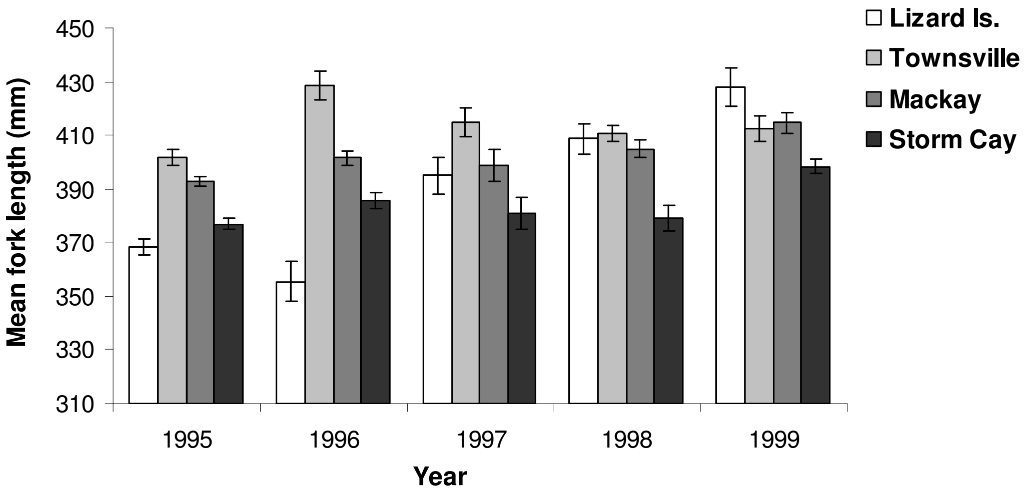

Figure 2. Average fork length of four-year-old common coral trout collected each year between 1995 and 1999 in four regions (Lizard Island, Townsville, Mackay and Storm Cay) of the Great Barrier Reef (Bars = SE).

Percent survivorship was also variable between regions (Fig. 3). Fewer individuals (48%) survived from one year to the next in the Mackay region than in Townsville and Storm Cay. Survivorship was highest in the Townsville region (66%). The estimates are based on averages of survivorships from six year classes in each region. Because survivorship was quite variable between year classes, there is some uncertainty in the estimate for each region. This uncertainty is represented by the error bars in Figure 3 (also called confidence limits), which indicate how much variability there is in the estimate of the mean.

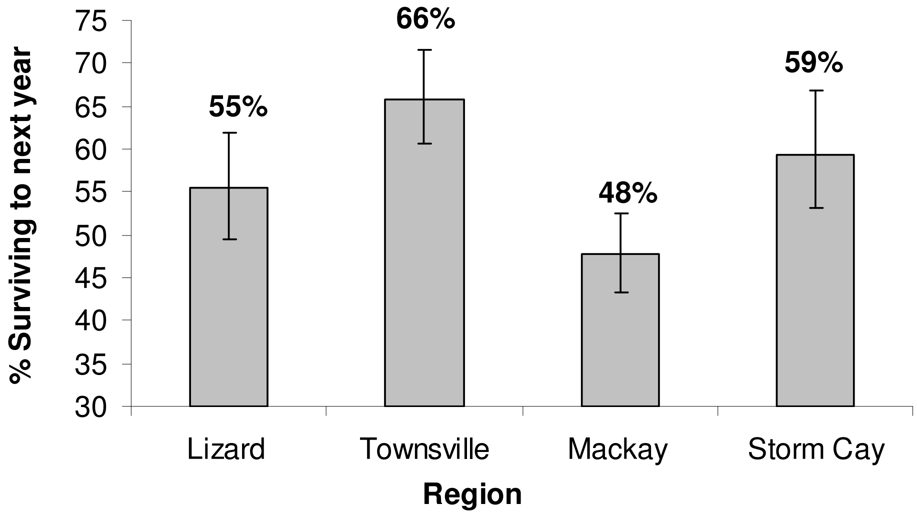

Figure 3. Percent common coral trout surviving from one year to the next in four regions of the Great Barrier Reef. (Bars = 95% CL).

Based on the average age of the catch, average size of four-year-olds and survivorship, at least four different stocks of coral trout may be present on the GBR, one in each region. The stock structure, however, could be defined differently based on the biological characteristics measured and the year in consideration. For example, in 1995 and 1996 all regions showed different average ages and sizes and consequently at least four stocks could be assumed. Average age or growth in 1999, on the other hand, suggested two or three stocks, respectively. Four stocks could also be assumed if survivorship alone was taken into consideration.

Management considerations

Although the stock structure of coral trout defined from the biological characteristics measured in this study was not static, these results have some important management implications. Differences in biological characteristics between stocks suggest disparities in their productivities. Stocks can be variable in terms of their reproductive output, or through different abundances, natural mortality and recruitment rates and therefore catches could be likewise variable. Stocks in the southern two regions, Mackay and Storm Cay, with lower average survivorship and greater abundances would appear to have greater and more reliable annual recruitment than those of the two northern regions, Lizard Island and Townsville. These results point to the likely existence of more productive coral trout stocks (in terms of catch rates by the fishery) in the two southern regions than in the northern regions. This is supported by the consistently greater catch per unit of effort (CPUE) of the commercial fishing sector in the two southern regions (Mapstone et al. 2004, Ayling et al. 2000). Therefore, maintenance of optimum sustainable levels of stocks and yields may require different harvest strategies in the different regions.

Before establishing management strategies that consider the stock structure of coral trout on the GBR, the following issues need to be considered. First, in the present study only a single cluster of neighbouring reefs in each of the four regions was investigated. There is a possibility that if biological characteristics of coral trout were examined between and outside the areas investigated, more than four stocks would be suggested. Alternatively, the differences in biological characteristics identified in these results may be simply points along a gradient of continuous variation. Further research is necessary to determine the number of stocks present, where the boundaries of these stocks are situated and their temporal persistency.

Second, as outlined earlier, it is believed that a less productive stock will not be able to sustain the same amount of fishing pressure as a stock that is more productive. However, little is known of the magnitude of difference required in the biological characteristics between stocks to warrant separate management strategies and whether some biological characteristics are more sensitive than others in maintaining a fished population. I am in the process of examining some of these questions using a computer model (ELFSim) designed by the CRC Reef Research centre for the GBR line fishery to evaluate the possible consequences of different management strategies to the coral trout population (Mapstone et al. 2004) when stock structure varies. The model is developed from observed data of the biology of coral trout and the dynamics of the fishery. The model will be used to simulate potential future scenarios of the relative change (with certain measures of uncertainty) in the coral trout population that show spatial variability in biological characteristics and are subject to different fishing pressures.

Coral trout on the GBR are currently managed under a total allowable catch with no restrictions of where this catch can be taken (except for waters closed to fishing in the Great Barrier Reef Marine Park). I will use ELFSim to explore questions such as 'what is likely to happen to the coral trout population if there was a shift in fishing effort from one stock to a less productive stock in response to changing weather, social, economic or regulatory factors?' The results from this study may provide advice for improving management strategies for the coral trout population on the GBR.

Third, very little is known about the connectivity of different stocks in terms of the exchange of larvae. Such information is fundamental to the understanding of the replenishment of different stocks and consequently how much fishing a stock can sustain. Information on the exchange of larvae between areas is notoriously difficult to collect, and until techniques are available to better investigate this issue we will have to rely on estimates of larval recruitment from indirect methods such as catch trends in commercial fishing logbooks, population information from structured research surveys or hydrodynamic computer modelling.

Finally, it is important to note that the current estimates of life history characteristics from my study are derived from natural populations (from areas closed to fishing). It is highly likely that fishing has an effect on the life history characteristics of the population open to fishing on the GBR. Knowledge gained from this study of the 'natural state' of a population is important to estimate its productive potential as a baseline, so that in developing management strategies there is a point of reference against which to measure impacts of fishing and the status of harvested populations.

Until more is known about the number of stocks, larval connectivity, the long-term changes in life history characteristics and the consequences of spatial differences in life history characteristics, defining a regionally explicit management strategy for coral trout on the GBR may be difficult at this time. However, I suggest a precautionary approach to management of this species, including estimating conservative limits for the total allowable catch considering the change in the stock structure and biological characteristics from both region-to-region and year-to-year. To help fill the information gaps, a monitoring program in collaboration with the fishing industry could be set up to monitor the commercial catch to examine long-term spatial variability in biological characteristics.

Conclusion

The spatial patterns in the biological characteristics of growth, age and survivorship of common coral trout suggests the presence of at least four stocks of common coral trout on the GBR, although the stock structure varied over the five-year study.
Several issues, including the determination of stock boundaries, larval connectivity and the consequences of spatial variability in biological characteristics to the population under different harvest strategies need to be addressed. Regionally explicit management may be difficult to implement at this stage, but strategies should be based on the precautionary approach and include a conservative limit for the total allowable catch based on spatial and temporal variability in biological characteristics.

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DISCUSSION MINUTES

Question (Annabel Jones): Did you look at differences in size at maturity? Can you comment on the relevance of this to management of size limits?

Response (Mikaela Bergenius): No I didn't. Sam Adams did, however, but found no difference between regions. This was only for two or so years though and maybe this would change with time.

Question (Martin Russell): Did you look at the relative fishing pressure from the regions – whether fishing pressure affected differences in biology?

Response (Mikaela Bergenius): There is more fishing effort in the southern regions. All biological characteristics were taken from closed reefs though, so from a population not modified by fishing.

Comment (Martin Russell): There may be more to fishing pressure on nearby reefs though and therefore effect characteristics on closed reefs

Response (Mikaela Bergenius): If fishing pressure is high around closed reefs it could influence recruitment to these reefs.

Response (Ashley Williams): Bruce Mapstone looked at fishing pressure in the areas Mikaela used. There was less pressure in the north than in the south, i.e. the catch per unit effort data did look very similar to the abundance estimates that was shown in the presentation.

Comment and Question (Greg McBeth): Fish are bigger in the north. Is this linked to water temperature? We also get very different currents than other areas such as down south?

Response (Mikaela Bergenius): It is possible, although the temperature differences between the regions investigated here are small and less than 2 degrees.

Comment and Question (Mike Cappo): The general theory of fish growth with latitude is that fish get bigger at the southern end of their range. What you found was the converse to that?

Response (Andrew Tobin): Once you get off the reef structure you get big trout on the Sunshine coast, but in the reef itself it's the reverse. This supports this theory.

Comment (David Williams): The patterns of abundance have been fairly stable since the 1970's and 80's. Fish in the Capricorn-Bunker group are very large compared to other reef areas. In the Swains they are small and numerous. There is a lot of biological data to suggest that the Pompey-Swains area is more productive than areas in the north.

Comment (Gavin Begg): The graph of length of 4yr olds is a proxy for growth rates where you showed that the fish at Lizard Island are different from the other regions. Around Lizard is where the prevailing ocean current bifurcates so this may explain why Lizard seems to be different.

Response (Mikaela Bergenius): Work done by Howard Choat and colleagues on the genetics of common coral trout indicates that in Lizard Island 40% of the individuals were genetically quite different from other regions

Response (Howard Choat): Yes. Two things appeared from this preliminary study. Some individuals were genetically different in the Lizard Island region and in the very southern area, Hervey Bay, but the rest of the GBR seems to be quite homogenous.

Question (David Bateman): All the work you have done were on closed reefs. Do you consider the 33% of the reef now closed is enough to follow the precautionary approach to management?

Response (Mikaela Bergenius): I don't know. The next part of my study when I will use ELFSim to examine the consequences of different harvest strategies may shed some light onto this.

Comment (Gavin Begg): Stock in this context is a management unit, not a genetic unit.

Response (Mikaela Bergenius): There have been many definitions used for the term stock and I think the main thing to remember is to define a stock with regards to the reason for defining it in the first place. It we are interested in the genetics of a species then look for stocks that are genetically different, if the reason is for fisheries management then biological characteristics are more important since stocks of such may respond differently to harvest.

Question (David Bateman): Close inshore there seem to be another stock of coral trout?

Question (Andrew Tobin): Are they perhaps bar-cheeked coral trout? Shallow water may also explain the difference in size. There could be inshore varieties and deeper water varieties.

Question (Jeff Snell): You said that coral trout do not actually travel much. Does this mean that GBRMPA are lying when they say that Green Zones will mean more and bigger fish across the reef? They say that fish will migrate from one reef to another to restock poor reefs.

Response (Mikaela Bergenius): I think they would be referring to larval recruitment. Adults most likely will not move but larvae from the protected reef may travel to recruitment poor reefs.

Comment (Martin Russell): We still don't know much about sink / source reefs. If Green Zones have a lot of source reefs included this will be very good, if the other is true, it is not as good. If people fish a source reef then the reproductive output and recruitment to surrounding reefs may be reduced.

Comment and Question (Howard Choat): You will find a really sharp distinction between the Capricorn Bunker group and the rest of the GBR. Fish in higher latitudes (lower temperature) often maintain higher growth rates resulting in larger and often older fish. Temperatures in the Capricorn Bunker group are low and the highest temperatures are in the Torres Strait and Lizard Island areas. Is the Capricorn Bunker group included in the ELF Experiment?

Response (Mikaela Bergenius): No it is not and we do not have data from that area.

Response (Gavin Begg): The QDPI&F Long Term Monitoring Program may be able to get some information for this area.

Comment (Howard Choat): I agree with Mike Cappo that if you look at the Capricorn-Bunker group area you may well see very different results in that area. There may be underwater visual survey data available for the Capricorn Bunkers from Tony Ayling's work.

Question (Greg McBeth): Has there been much work done on spawning aggregations. I have never seen it in the Torres Strait.

Response (Mikaela Bergenius): There has been limited research only.

Comment (Martin Russell): There has been limited work on spawning aggregations and certainly not reef wide. There is mainly the work done by Melita Samoilys on coral trout off Cairns and anecdotal data from some fishermen that there are aggregation sites for various species throughout the reef. However, aggregations seem to be very patchy, and inconsistent in most areas. Primary aggregation sites are predictable in time and area, but secondary aggregation sites may change from year to year.

Comment (Gavin Begg): Stock structure is very connected to recruitment characteristics, which we know very little about, but is very important, and it is the key to lots of modelling work.

Question (Neil Green): It is reassuring that we have a growing population. We already have 30% closures as well as a total allowable catch, minimum legal size, spawning closures and other restrictions. Did you look at why trout grew better in some years and in some areas?

Response (Mikaela Bergenius): Not directly and it is a difficult question to answer. Differences in growth could be related to the variation in the environment, cyclones, etc. In 1997 when we had Cyclone Justin for example, the water temperature in the southern part of the GBR decreased quite a lot. This could certainly have influenced biological characteristics in at least that year.

Question (Ashley Williams): I'd be interested in comments on management. Are regional specific management strategies feasible?

Response (Andrew Tobin): No. How could you have different minimum legal sizes in different areas? How would you manage the catch on boats coming into port that have been on the boundary of the regions? Further regional management is scary.

Response (Gavin Begg): Regional management is already in place if you consider Torres Strait which has different minimum legal sizes.

Response and Question (Andrew Tobin): There are not many boats working in the area. The Long Term Monitoring Program will be good for investigating the long term effects of the Representative Areas closures and the quotas. Will fishers maximise catch and effort at times of the year when there is a maximum dollar value for that species? This could have a knock-out effect in areas used by fishers at different times of the year.

Response (David Williams): Yes, the general picture is that fishers are holding back at the moment. The reasons for this are complex due to economics, buy-backs, etc. Certain species are being targeted at different times, when previous fishers would have targeted them for longer periods. People appear to be holding off waiting for high prices.

Response (Danny Brooks): We are seeing changes in fishing practices. Some are fishing for red throat emperor while prices are high. Others are waiting on agreements on buy back schemes. I don't think they will catch the quota this year.

Response (Terry Must): With changes of moon phase you can get very different catches of red throat emperor. There are certainly less boats in Bowen, but we are not seeing a big difference in the coral trout catch compared with last year in the Bowen area. 11 tonnes in October last year, compared with 10.5 tonnes this year.

Response (Danny Brooks): Some investors are hoarding quota, this may mean that we may never see the quota reached.

Response (Terry Must): The federal buy back scheme will be finalised by the end of this month, this will settle some arguments.

Question and Question (Gavin Begg): Some fishers have indicated that they would like to see regional total allowable catch (TAC) to keep other boats out of their area. Are regional TAC's viable?

Response (Terry Must): It would be very difficult to put a fence up and very difficult to police.

Response (Martin Russell): Boundaries can be difficult to regulate, however, there are other options for regionalisation though. For example reduced total allowable catch for specific areas and fishers may be restricted to a region.

Response (Terry Must): VMS may help.

Comment (Andrew Tobin): There are some boats that are multi-faceted in their targeting behaviour and travel to different areas. They can target a whole range of fish; coral trout and Spanish mackerel.

Comment (Renae Tobin): The issue of regional management is complex. Inshore areas may be very different to reef areas, and some fishers here seem to be interested in regional management plans.

Predicting the impacts of fishing on a long-lived reef fish.

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Abstract

This study researched the biology and likely impacts of fishing on populations of red bass, identifying some important considerations for fisheries management. Firstly, the maximum age estimated for this species was 54 years. This extreme longevity indicates an exceptional life history for this species, which was supported by other findings for its growth and maturity. Secondly, observed results were consistent with existing theory, which predicts a higher vulnerability of this species to overfishing. This might also be likely for other large tropical snappers. Thirdly, the biological structure of populations – like those of other tropical snappers – was indicated to be spatially complex, which has implications for the placement of management zones on the GBR. Evidence was also presented on the timing of red bass spawning. These results highlighted issues relevant to the management of red bass and other reef fish in general, and these were suggested as topics for discussion.

Introduction

The study species of my thesis was the red bass, *Lutjanus bohar.* It's a large, predatory reef fish that can grow to over 10 kg in weight and 80 cm in length on the Great Barrier Reef (GBR). The red bass is a tropical snapper or "lutjanid", so is closely related to species such as mangrove jack (*Lutjanus argentimaculatus*), red emperor (*L. sebae*), and fingermark snapper (*L. johnii*). On the GBR red bass are abundant on mid- to outer-shelf reefs (Newman & Williams 1996), where it is often caught by recreational and commercial line fishers targeting coral trout. Red bass are also caught in the Torres Strait.

This fish is recognised most for its implications in causing ciguatera fish poisoning. The red bass, chinaman fish (*Symphorus nematophorus*) and paddle-tail fish (*L. gibbus*), have recently been regulated as "No-Take" species on the GBR because of their potential for causing ciguatera poisoning. Prior to this, some commercial operators retained smaller red bass for sale because these were considered safe to eat. This harvest was not specifically documented, although historically it is known that red bass were commonly eaten and possibly caused a few cases of ciguatera poisoning locally (Gillespie et al. 1986). In the Torres Strait red bass can still be caught for consumption.

In my thesis I explored the population biology of this species on the GBR. In previous work, I estimated its maximum age to be over 50 years, which is exceptional for a tropical reef fish.

When I commenced this study, red bass could still be caught and sold for consumption on the GBR, which enabled the collection of samples from commercial fishers for my research. I presented preliminary results of red bass biology at the first CRC Reef Student-Stakeholder Workshop entitled, "Bridging the Gap: a workshop linking student research with fisheries stakeholders," held on March 14, 2001 (Williams et al. 2002).

The objectives of this paper were: (i) to explain why the red bass, now a No-Take species, is of importance to fisheries management on the GBR; (ii) to present results on the population biology of red bass that are of relevance to its management; and (iii) to stimulate discussion on how issues raised from this study of red bass could be relevant to the management of other fish caught on the GBR and in the Torres Strait.

Is red bass relevant?

One might question the relevance of research on red bass to current and future fisheries management on the GBR, particularly since it is now regulated as a No Take species. It is important to note that the "No-Take" status of a species does not mean that it will not be caught by fishers in future[1]. If a species resides in an area that is fished (i.e., it is "available") and is capable of being caught by the fishing method (i.e., it is "selected" for) then it will be caught by fishers as "by-catch". The process of catching and releasing fish might reduce chances of subsequent survival, which could have implications for fish populations and the reef ecosystem. It is likely that red bass will continue to be a significant component of by-catch for the fishery because in areas where it is abundant it is known to be a major competitor with the primary target species, the common coral trout (*Plectropomus leopardus*), for a baited hook. For these reasons the red bass remains a species of importance for research and management on the GBR.

Importantly, if the catch-and-release of by-catch such as red bass impacts significantly on their populations it is uncertain what ramifications this might have for populations of target species of the Queensland Coral Reef Fin Fish Fishery (CRFFF) on the GBR through a possible disruption of the ecosystem. Large predators such as red bass have important roles within the reef ecosystem because they help to control the population sizes of many prey species, and predation is thought to be an important process that helps facilitate the high species diversity of tropical coral reefs (Sale 1980). Reductions in the populations of such species could thus potentially affect indirectly the structure of other fish populations in the ecosystem.

Commonwealth legislation has recently been introduced for the assessment of all export fisheries in Australia, including the CRFFF, to ensure that these industries satisfy criteria to achieve objectives for Ecologically Sustainable Management. The assessment process is underway for the CRFFF by the Department of Environment and Heritage (DEH) and is mandatory for the future of this export industry. According to the "Guidelines for the Ecologically Sustainable Management of Fisheries" (Commonwealth of Australia 2001), one of the major objectives (Principle 2, Objective 1) of this legislation is "The fishery is conducted in a manner that does not threaten by-catch species." Since the red bass is a by-catch species, it is important to ensure that red bass populations on the GBR are not threatened by fishing operations of the CRFFF.

[1] People can also apply for a QDPI General Fisheries permit to take No-Take species.

Age, growth and maturity indicate a higher vulnerability to fishing impacts

As mentioned above, I estimated red bass to be exceptionally long-lived. Since the first CRC Reef Student-Stakeholder Workshop I have investigated and verified the accuracy of age estimates, which has strengthened this result. Another result I mentioned at the previous workshop was that red bass are also relatively slow-growing. This is demonstrated by the relationship between fish length and age that I have quantified for red bass populations on the GBR (Fig. 1).

Estimated fish age is on the horizontal axis of Figure 1, and the maximum observed age was 54 years old. On the vertical axis the maximum average length described by this trend is approximately 65 cm fork length, which is about 70 cm in total length. The curvature of the trend is relatively gradual, from the average length of the youngest fish, where growth is fastest, to the maximum length reached for the oldest fish, where growth eventually ceases and the trend line becomes horizontal. As such, one can infer that this growth trend, on the whole, is relatively slow for red bass because it takes a long time to reach this maximum size.

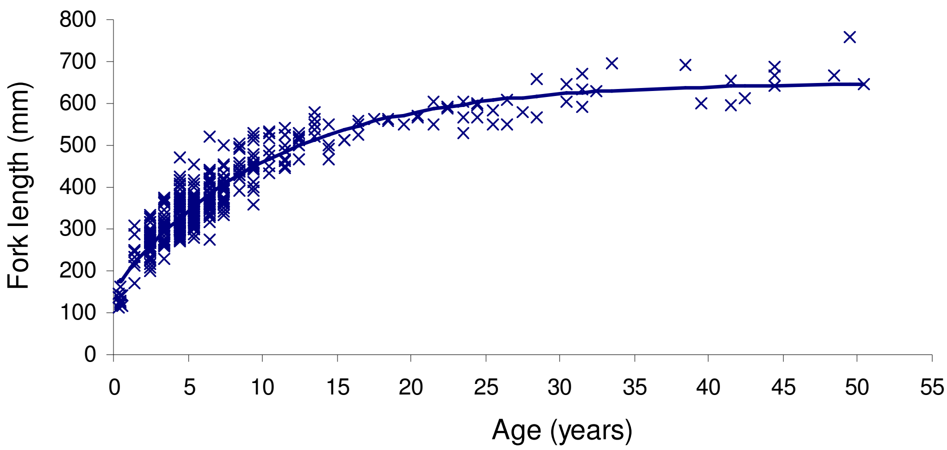

Figure 1. Relationship between age and length for red bass on the GBR.

Longer-lived, slower-growing fish are expected to grow for a longer time before they are ready to mate and thus generally mature and reproduce much later in life. This is a general finding in nature, which is observed, for instance, when one compares the life histories of dogs and humans. Dogs and humans are both mammals, but most dogs reach sexual maturity in the first 6 to 12 months of life and are faster-growing and shorter-lived than humans. Humans are slower-growing because it takes us about 10 to 13 years to reach maturity and, shortly afterwards, our maximum size. A slower rate of "population turnover" occurs for species with delayed maturation because a longer time to reach maturity for each individual and each generation cumulatively limits the rate at which the population can replenish its numbers through reproduction.

Longer-lived, slower-growing species have generally been found to be most vulnerable to fishing impacts (Parent & Schriml 1995, Jennings et al. 1998, Musick 1999). This might be because fish populations with slower rates of population turnover are less capable of replacing the fish removed from their populations by fishing at the same rate as they are caught. Also, a delayed maturity increases the likelihood of immature fish being caught or encountering fishing gear because immature juveniles are available to be fished for a longer period than for other species (Crouse 1999). As such, there is likely to be a much lower probability for each individual reaching maturity to reproduce at least once in a fished population of long-lived, slow-growing fish like red bass.

Given this, do red bass mature late in life as expected? From an analysis of the percentage of female red bass that were mature with successive length and age groups, I calculated that 50% of females were mature at a fork length of approximately 43 cm and an age of approximately 9 years (Fig. 2). This is a relatively old age for a reef fish to reach 50% maturity. Although the lengths and ages of males at 50% maturity could not be determined due to insufficient sample sizes, they matured over a smaller size range and younger age range than females.

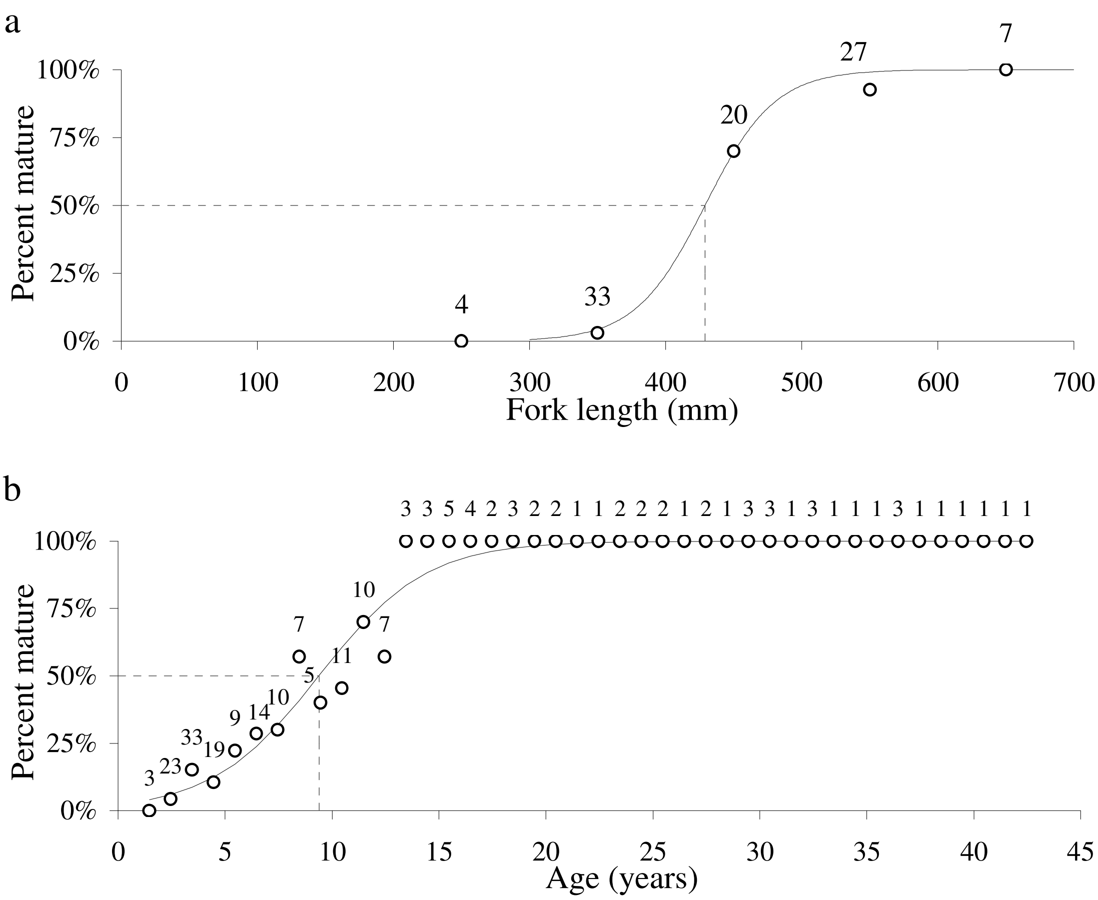

Figure 2. Trends of maturity at (a) length and (b) age for female red bass. Percentage maturity data in (a) are for 100 mm fork length groups sampled in November. Percentage maturity data in (b) are for successive age groups (years). Data in (a) and (b) have been combined across three years of sampling on the GBR (i.e., 1999 to 2001). Numbers above data points represent sample sizes per length/age group. Dashed lines indicate the length and age at 50% maturity for females, as predicted by the maturity models (solid lines). Note: This figure was not presented at the workshop.

To put this result into perspective, I compared it to other results recently published for lutjanids, in Figure 3. "Growth trend curvature" on the *x*-axis is a parameter that describes the initial increase in length at age: low values indicate a gradual increase and slow growth like in Figure 1; high values indicate a steep increase and thus relatively fast growth. This graph shows that the result from this study for red bass (represented by the filled triangle) is one of the oldest ages at maturity and slowest growth trends reported for lutjanids.

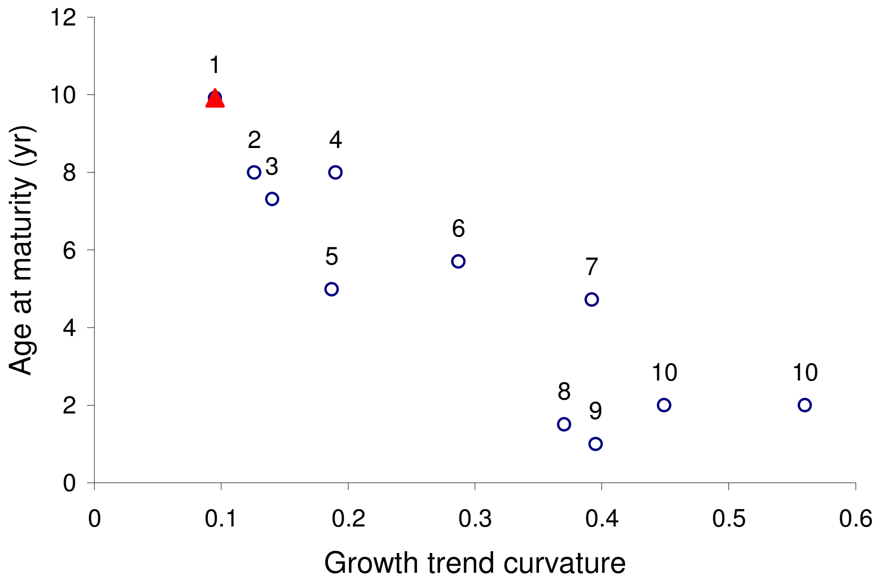

Figure 3. Published results for age at maturity and growth trend curvature for the lutjanids (tropical snappers). Results are for studies published since the previous reviews of lutjanid age-growth and reproductive characteristics done by Manooch (1987) and Grimes (1987), respectively (i.e., post 1986). "Growth trend curvature" (i.e., *K* from the von Bertalanffy growth model for length at age) is a measure of the steepness of the length at age relationship: low values indicate relatively slow growth; high values indicate relatively fast growth. Species results: 1 = red bass (this study); 2 = mangrove jack (Russell et al. 2003); 3 = red emperor (McPherson et al. 1992, Newman et al. 2000); 4 = red snapper (U.S.A./ Gulf of Mexico; Goodyear 1995, Wilson & Nieland 2001); 5 = gold-band snapper (Newman & Dunk 2003); 6 = large mouth nannygai (McPherson et al. 1992, Newman et al. 2000); 7 = small mouth nannygai (McPherson et al. 1992, Newman et al. 2000); 8 = brown-stripe hussar (Davis & West 1992, 1993); 9 = lane snapper (Bermuda; Luckhurst et al. 2000); 10 = stripey / Spanish flag (Newman et al. 2000, Kritzer 2002, 2004).

A general trend also emerges on this graph, as it appears that slower-growing lutjanids have older ages at maturity than faster-growing lutjanids. As mentioned previously, this is a general finding in nature. Also, a similar age at maturity and growth trend curvature was reported for mangrove jack (point 2; Fig. 3) and red emperor (point 3; Fig. 3), which are also large and relatively long-lived lutjanids with maximum age estimates of 37 (Russell et al. 2003) and 22 (Newman et al. 2000) years, respectively. There appears to be some indication of a trend with the maximum size of different lutjanid species, since smaller species such as the brown-striped hussar (*L. vitta*; point 8) and the stripey (*L. carponotatus*; points 10) tend to exhibit faster growth and an earlier maturity than these larger lutjanids.

Period of reproduction

I also investigated when and for how long red bass are reproductively active on the GBR each year. I found that red bass have quite a long reproductive period because ovaries of mature females were observed to be "ripe" (i.e., contained developed eggs or ova to be spawned) in 8 months of the year (i.e., February, March, April, August, September, October, November and December). Such an extended period of reproduction is commonly reported for lutjanids, and thus this result lends support to this general finding.

This is a different pattern of reproduction to that reported for some other species caught by the line fishery. For example, the common coral trout has a much narrower spawning period (Samoilys 1997) over the new moons in October, November and December each year. "Spawning closures" to reef fish fishing on the GBR during these times were recently introduced. Therefore, it is likely that a significant amount of spawning of lutjanid populations may occur outside of these spawning closures. Further, although I haven't observed red bass spawning directly, I've been told that red bass aggregate to spawn at sites in the Solomon Islands, Papua New Guinea (Johannes & Hviding 2000, Hamilton 2003) and Palau (L. Squire, unpublished data), and other lutjanids have been reported to form spawning aggregations (e.g., Wicklund 1969, Carter & Perrine 1994, Heyman et al. 2001, Sala et al. 2003). Therefore, spawning aggregations of lutjanids could potentially be vulnerable to fishing outside of the times of current spawning closures on the GBR.

Population structure

I found there was evidence of a spatially-complex population structure of red bass on the GBR. This is indicated by Figure 4, which is a representation of two samples of red bass caught by line fishing near Lizard Island: one sample (a) was caught from fishing shallow waters, from 0 to 30 m depth, and sample (b) was caught from fishing further offshore in deeper waters, from 30 to 50 m depth. Larger red bass were more frequently caught from deeper waters and fewer (if any) of the smaller size classes were caught in deeper water.

This indicates the occupation of different habitats — either cross-shelf or at different depths — by different-sized fish, and thus of individuals at different stages of life. A cross-shelf trend is also apparent for other lutjanids on the GBR, such as mangrove jack and red snappers (*L. erythropterus*, *L. malabaricus*, and *L. sebae*). Juveniles typically reside inshore; either up creeks in mangroves (Russell et al. 2003) or on shallow water trawl grounds, on seagrass beds (Williams & Russ 1994). Red bass juveniles are different because they typically reside on coral reefs, but my results indicate they also progress to deeper, offshore waters as they grow.

The occupation of different habitats (depths and/or cross-shelf position) on the GBR by individuals at different stages of life should be an important consideration with respect to the placement of marine protected areas. Ideally, all life history stages should be afforded at least some protection from fishing to avoid the disproportionate harvest of any particular size or age class in the population.

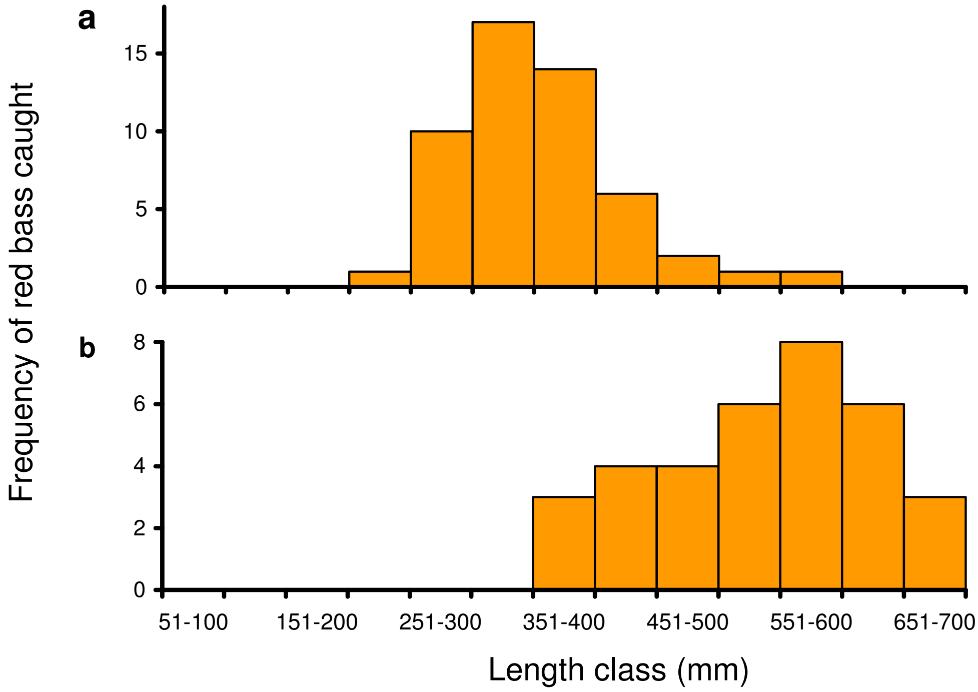

Figure 4. Population size structure of red bass at different depths. Bar charts are length frequency distributions of red bass caught by line fishing near Lizard Island (a) from 0 to 30 m depth and (b) closer to outer-shelf, from 30 to 50 m depth.

Relevance to broader management issues and lead-in to discussion

The long-lived, slow-growing, and late-maturing characteristics of red bass indicate that their populations are intrinsically vulnerable to direct or indirect impacts of fishing. Therefore, although red bass is now a No-Take species on the GBR, populations of red bass could potentially be impacted by fishing in future because of its biology and susceptibility to capture by fishers as by-catch. Notwithstanding this, I believe that my research findings for red bass could also be applied to the management of other species caught in the CRFFF in concept because of general trends in biology that are apparent among reef fish (e.g., Figure 3) and because some aspects of red bass biology are common to other species that are currently harvested. I suggest the following topics for discussion.

The first suggested discussion topic concerns potential impacts on No-Take species due to post-release mortality. This issue not only applies to red bass, but also to other No-Take species of the fishery, including barramundi cod (*Cromileptes altivelis*), hump-head Maori wrasse (*Cheilinus undulatus*), chinaman fish and paddle-tail fish. Relevant issues include possible ecosystem impacts, which could result in a change in species catch composition, and DEH legislation for the Ecologically Sustainable Management of the CRFFF.

Another suggested discussion topic is the potential importance of deep-water components of fished populations. The majority of biological research effort on the GBR has been constrained to relatively shallow-water environments (0-30 m), yet if significant components of exploited populations reside in deeper water (30+ m) we may have an incorrect and biased understanding of the population dynamics of reef fish and their likely resilience to fishing. For instance, a significant component of red bass populations on the GBR comprised of larger (and older) fish was found to reside in depths greater than 30 m. If this is the case for other reef fish then many reef fish populations could be more resilient to fishing than currently thought. The existence of a greater abundance of larger, older individuals than is currently suspected in exploited populations would suggest that rates of annual reproductive output may be higher than current estimates. Larger, older fish generally produce a greater amount of better quality, more viable offspring and therefore are likely to contribute more significantly to a population's reproductive output (Chambers & Leggett 1996, Kjesbu et al. 1996, Trippel et al. 1997, Marteinsdottir & Steinarsson 1998, Heyer et al. 2001, Palumbi 2004).

The appropriate placement of marine protected areas on the GBR is another suggested topic for discussion because it is relevant to the management of species (such as red bass) that have different life stages occupying different areas on the GBR. This is typical of other commercially- and recreationally-important lutjanids, including mangrove jack and red snappers. The juveniles of these species that reside in inshore, shallow areas may be impacted by recreational fishing and commercial trawling. This is important, because ideally all life stages should be afforded at least some protection from fishing.

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DISCUSSION MINUTES

Question (Annabel Jones): Given the figures you presented for mangrove jack with regard to its late maturity etc., can you comment on implications of your results for these fish?

Response (Ross Marriott): Work that has been done on mangrove jack thus far has found that in inshore areas most fish caught were immature and not likely to contribute significantly to spawning. Commercial fishers are known to catch larger, mature mangrove jack on the outer GBR. So the situation with mangrove jack is that the inshore component of the stock is largely immature and heavily fished, whilst the offshore component is comprised of the larger breeders and not as heavily fished. This is an important aspect to consider for the future management of mangrove jack because it is important that enough immature fish survive to maturity to replace the older spawners when they eventually die.

Question (David Bateman): A lot of top predators are now No-Take or released because of the risk of ciguatera poisoning. What effect is the protection of top end predators likely to have on other fish stocks and their prey?

Response (Ross Marriott): Red bass move and feed broadly. It is not easy to address this question or make predictions because on the GBR we are dealing with complex food webs – there are many predator and prey species. Do you have any comment on this Howard?

Response (Howard Choat): Most reef fish are generalist predators and have a broad diet. Results from research done in some of the last remaining pristine areas, in the Cocos and Keeling Islands, suggest that where top predators were removed there was not a detectable effect on the remaining prey species.

Question (David Bateman): In the Cocos, everything is protected and so fish are a lot more abundant there than on the GBR, where only a few species are protected. What are the numbers for red bass, and how do they compare with the abundance of red emperor?

Response (Ross Marriott): I haven't researched the abundance of red bass, but they are known to be abundant on the outer GBR.

Response (Howard Choat): Red bass are fairly abundant, but it is difficult to compare the abundance of red bass with red emperor because red emperor are difficult to count.

Comment (Andrew Tobin): Even though we don't know the impact of post-release mortality yet, it is unlikely that post-release mortality would be detrimental to red bass stocks on the GBR.

Response (Ross Marriott): Those studies that have been done on post-release mortality have shown that different species are more susceptible to post-release mortality than others and mortality rates are higher when fish are caught from greater depths. There is the potential for post-release mortality to have a detrimental impact particularly for those red bass caught from greater depths. Also, red bass would probably be the first to show such detrimental effects due to their life history characteristics.

Comment (Renae Tobin): It's likely that bigger catches of red bass are made by the deeper water commercial fishers. This could have an effect on red bass populations through post-release mortality.

Comment (Ross Marriott): I know that some deeper water commercial fishers were catching and selling a lot of red bass up to a certain size (i.e., several tonnes in a year) prior to the implementation of its No-Take status. Some of these fishers commented to me that these fish had little chance of survival after being caught at depth.

Question (Gavin Begg): Do we have any idea of the numbers of red bass from using BRUVs (i.e., Baited Remote Underwater Video cameras used by Mike Cappo in his research at AIMS)?

Response (Mike Cappo): I haven't analysed data from the video tapes yet, but from memory 140 m is the deepest I've observed red bass to occur.

Question (Ross Marriott): What about other species? I raised in my presentation the possibility that there could also be a significant component of older, larger fish of exploited populations in deeper waters that have not yet been studied and accounted for in stock assessments. Have you found coral trout and other commercial species at deeper depths?

Response (Mike Cappo): In these deeper depths I also observed goldband snapper, red emperor, and some of the smaller snapper species such as hussar on rocky bottoms and inter-reef areas. From memory there weren't many coral trouts at these depths over sandy bottoms, but I would need to look at the tapes again from rocky bottom areas to answer this.

Question (Martin Russell): Ross, you've only mentioned your research on the GBR so far, but can you tell us about your research on red bass in other areas?

Response (Ross Marriott): Yes, I've focused on my results from the GBR today, but I also researched red bass in the Seychelles, where they are heavily fished because ciguatera poisonings do not occur there.

Comment (Martin Russell): Your work on the GBR will also be useful for management of red bass in heavily fished areas overseas because you've studied relatively unfished populations on the GBR which will indicate what exploited populations in these other areas might have been like prior to fishing.

Comment (Gavin Begg): How do we manage long-lived, slow-growing species? That is something we need to address. Are we doing enough to safeguard these species? With the legislative requirement to show sustainability in fisheries and the by-catch issue it is important to justify any action we take. Are standard measures such as TAC, bag limits, size limits, etc., adequate for such longer-lived species? Maybe we need to look differently at the management of such species.

Question (Terry Must): Is there a threat that red bass could be over-fished?

Response (Ross Marriott): That is difficult to say without data on the catch of red bass from the GBR or detailed information on its abundance. With a multi-species fishery it is possible for by-catch species to be over-fished because the catch of these species are typically not monitored and therefore it is possible for declines in the catch of these species to not be noticed until such populations are severely depleted.

Comment (David Bateman): We now have the highest protection available to red bass, as well as protecting 30% of their habitat. I don't feel that we really need to consider any more protection for this species.

Comment and Question (Renae Tobin): It is important to note that this is not just about red bass. There are probably a lot of fish in deep water that are also older than individuals of the same species that are fished in shallower water. If so, should this deeper water component be managed differently?

Response (Andrew Tobin): The TAC has essentially separated out the different groups of fishers: that is, reef line compared with L8 fishers. Given the small quota that L8 fishers have been given for coral trout and red throat emperor they would probably sell this.

Comment (Terry Must): We don't throw much of the other species back now. We are actually throwing back more large coral trout than anything else because of the quota.

Comment (Danny Brooks): This is also fishing for the live trade, so fishing in shallow water would have probably a higher rate of survivorship for discarded fish.

Question (Martin Russell): Is there a vulnerable time of year for these long-lived lutjanids?

Response (Ross Marriott): Many snappers have long spawning seasons. In other countries lutjanids have been observed to form spawning aggregations. For instance, some of Bob Johannes' work in the early 1980's showed that the daily life of local fishermen in Palau was largely organised around fishing during new and full moon periods when certain species, such as red bass, were known to form these spawning aggregations and could be targeted. This could also occur on the GBR in months outside of the current spawning closures.

Comment (Terry Must): I've never come across a spawning aggregation of red bass. I have seen spawning aggregations of red throat emperor and Maori wrasse though.

Question (Martin Russell): Do the current spawning closures protect red bass, and if so, other lutjanids?

Response (Ross Marriott): I've found evidence that red bass have a long spawning period. Although I haven't observed red bass spawning, Lyle Squire has told me that he has observed them preparing to spawn in an aggregation at a well known spawning aggregation site in Palau.

Comment (David Williams): The cross-shelf distribution may be important. The vast majority of red bass are on the outer shelf. If there is a threat it could come from increased focus on outer-shelf fishing.

Question (Howard Choat): Ross, from your work in the Seychelles where red bass is fished, is there any evidence of over-fishing or targeting of spawning aggregations?

Response (Ross Marriott): I did collect data on catch and effort statistics of red bass by the Seychelles fishery (provided by the Seychelles Fishing Authority), but was not able to get fine-scale information to address the question of targeting of spawning aggregations there. For my PhD I also used the catch and effort data to model the harvest of red bass in the Seychelles, which indicated that the deeper water, less available component of the stock may have acted to buffer impacts of fishing, which could explain the apparent persistence of this population to the relatively high historical levels of harvest. However, recent information indicates that catches of red bass have dropped markedly in the Seychelles.

There is also evidence that larger reef fish such as red bass are particularly vulnerable to fishing impacts. For instance, a study by Gary Russ in the Philippines showed that the larger reef fish were the first to decline when fished and took the longest to recover when protected from fishing.

Question (James McLellan): The mangrove jack fishery is a potential concern given the high amount of fishing of the inshore juveniles.

Response (Ross Marriott): I recall that a recent FRDC report on mangrove jack (Russell et al. 2003) predicted the current level of exploitation to be sustainable, but this was not my area of research.

Question (Rachel Pears): What information did they use to make that prediction?

Response (Ross Marriott): It was largely a biological study.

Question (David Bateman): There are no reports of red bass moving into mangrove areas. Are they solely a reef fish?

Response (Ross Marriott): Unlike other lutjanids, red bass juveniles settle in and inhabit coral reefs. Interestingly, the juveniles also look quite different to the adults and resemble a damselfish in appearance.

Comment (Neil Green): I think that the inshore fishery is generally recreational at the moment, but commercial fishers may change to target different species such as mangrove jack because of recent changes to State government legislation. This may indicate that more research into mangrove jack may be very important given what has been presented today.

Biology and management of the flowery cod and the camouflage cod – how similar are they?

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Abstract

The flowery cod (*Epinephelus fuscoguttatus*) and camouflage cod (*E. polyphekadion*) are very similar in appearance, although their maximum body sizes differ at approximately 100 cm and 70 cm total length respectively. These two species of grouper are harvested throughout the Indo-Pacific region, and are an important component of the Asian live reef food fish trade. In Queensland, fisheries management arrangements recently introduced for both species include fish size regulations (50 cm min, 100 cm max) for all fishers, total allowable catch for commercial fishers and bag limits for recreational and charter fishers. My research confirms both species share several biological characteristics associated with low resilience to fishing such as a long lifespan, slow growth, low natural abundance, spawning aggregation behaviour and protogynous sex change, hence management changes to protect these species were prudent. Due to differences between each species in maximum body sizes and in the size distributions of breeding females and males, the effectiveness of current size limits for each species differ. Of particular concern is that the fished component of the flowery cod population still includes most of the female spawning stock and all of the males. Given the new information, a review of size limits for these species is advisable and a suggested lower maximum size limit discussed. These species are also vulnerable to depletion by fishing of their spawning aggregations. Limited protection may be afforded by current seasonal fishing closure periods on the Great Barrier Reef, but a longer closure period would be more precautionary.

Introduction

This paper focuses on two similar-looking species commonly known as the flowery cod (*Epinephelus fuscoguttatus*) and camouflage cod (*E. polyphekadion*)[1] which are managed using the same size limits under Queensland fisheries legislation. I examine how similar these two species are in terms of their biology and likely resilience to fishing and evaluate how effective current management arrangements are for each species. Flowery cod and camouflage cod belong to the Family Serranidae, which includes fishes commonly called cods, groupers and coral trouts in Australia. The term "groupers" is used here to refer to all of these types of fish.

There are two main problems related to managing groupers in Queensland. Firstly, for practical reasons, similar-looking or similar-sized groupers tend to be grouped together by fishers and managers. However, such species may have different biological characteristics and consequently the same management arrangements may not suit all species. Secondly, groupers have several characteristics that make them vulnerable to overfishing, such as aggregating to spawn in large numbers (Sadovy 1994a).

Flowery cod and camouflage cod are often mis-identified as they both have very similar body shapes, patterns and colouration (see Figure 1). In fact, they are commonly lumped together with several other species, known locally as cods. Adult flowery cod and camouflage cod are mostly found on coral reefs, but may also occur on inshore habitats or deep slopes. Flowery cod and camouflage cod are caught by baited hook and line or spear. In Queensland, they are caught by the commercial, charter and recreational sectors of the coral reef fin fish fishery as both target and by-catch species. Flowery cod and camouflage cod are sold in significant numbers in the live reef fish trade in south-east Asia (Lau & Parry-Jones 1999, Sadovy et al. 2003), and these fishes are also valued by dive tourism because of their large size (D. Miller pers. comm.).

[1] FAO international common names are brown marbled grouper (*Epinephelus fuscoguttatus*) and camouflage grouper (*E. polyphekadion*).

Grouper stocks have been severely depleted in many parts of the world (e.g. Koslow et al. 1988, Sadovy 1994a, Koenig et al. 1996, Bentley 1999, Huntsman et al. 1999, Musick et al. 2000, Pogonoski et al. 2002), and now there are growing efforts to conserve groupers, for instance by IUCN (The World Conservation Union, see IUCN Groupers and Wrasse Specialist Group website at www.hku.hk/ecology/GroupersWrasses/iucnsg). On the east coast of Queensland, recent management changes affecting these species include the Coral Reef Fin Fish Fishery Management Plan (2003) and the re-zoning of the Great Barrier Reef Marine Park (see www.gbrmpa.gov.au).

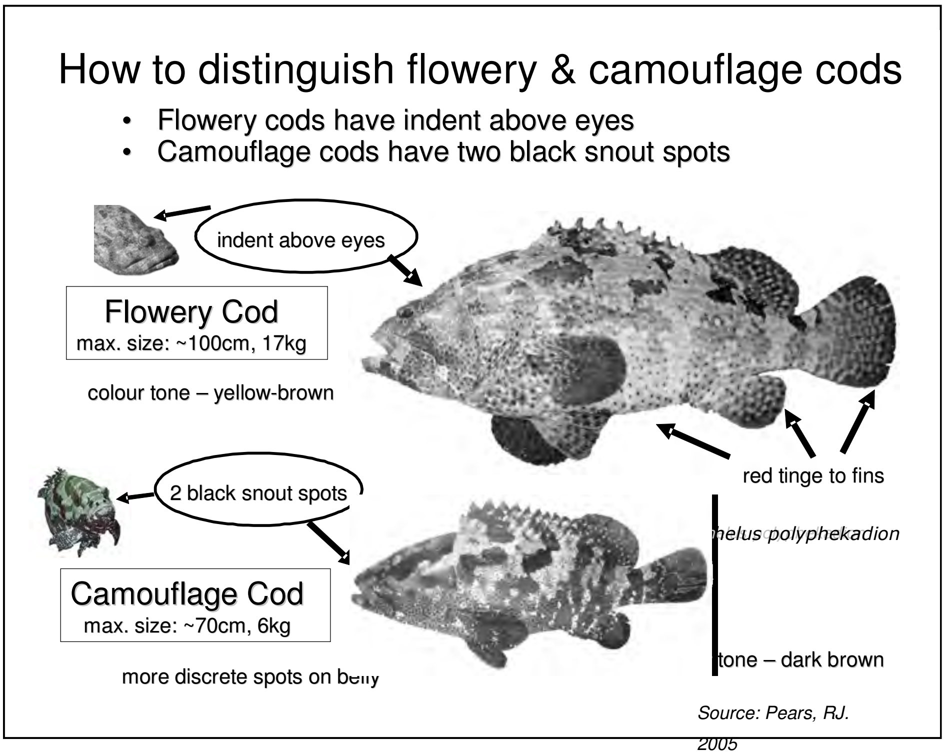

Figure 1: Identification of flowery cod and camouflage cod.

Biological characteristics such as body sizes and maturity need to be taken into account in fisheries management. One of the main ways this is addressed under Queensland fisheries legislation is through fish size regulations (i.e., minimum and maximum legal sizes fishers can take). Because flowery cod and camouflage cod are so similar in appearance and are often confused with each other, having the same size regulations for these two species makes good sense. As such, a common size limit was introduced in

Queensland in December 2003. Until now only limited biological data were available for determining appropriate biologically-based size limits for these species.

In the next two sections, I describe the key similarities and differences in the biology of flowery cod and camouflage cod. In the final section, I focus on management, particularly the effectiveness of current size limits in light of new biological data. The findings are from my PhD research at James Cook University in collaboration with CRC Reef, and full details of the methods and results can be found in Pears (2005).

Similarities between flowery cod and camouflage cod

Growth and longevity

Growth curves for flowery cod and camouflage cod are shown in Figs. 2A and 2B, respectively. Flowery cod can live at least 42 years and camouflage cod at least 36 years. The patterns of growth (shape of the curves) are similar for the two species; fast growth initially (steep curves) and slower growth for older fish (curves flatten off). Compared to other reef fishes, both flowery cod and camouflage cod are relatively slow growing and long-lived.

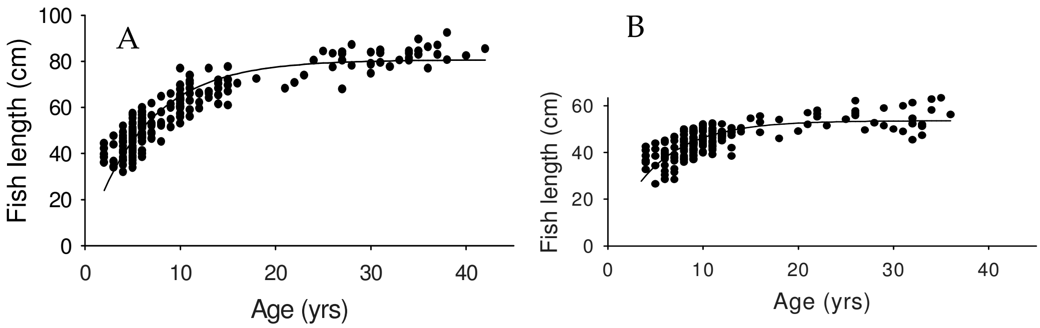

Figure 2 Growth curves fitted to size and age data for (A) flowery cod and (B) camouflage cod from the GBR.

Abundance and catch

Figure 3 shows abundance estimates for the main species of groupers that occur on the Great Barrier Reef (GBR) from visual surveys conducted to assess grouper abundance.

The abundances of flowery cod and camouflage cod are much lower than common coral trout *(Plectropomus leopardus)*, the main target species of the fishery. However, data from Lau and Parry-Jones (1999) showed that both species were in the top six or so species sold in the Hong Kong live reef food fish trade, partly because large catches of flowery cod and camouflage cod are taken from spawning aggregations on occasion. This is supported by an analysis of over four years of detailed fishing data from one commercial fishing boat on the GBR. This analysis showed that total monthly catch and average catch per fishing day of flowery cod and camouflage cod increased by one to two orders of magnitude during the spawning months of December and January. This was due to occasional large catches in these months, such as that shown in Figure 4. On most days, catches varied between 0 to 40 kg, but an exceptionally large catch of these two species was taken, totalling 1500 kg in 2 ½ days, reported to be from a spawning aggregation. There are anecdotal reports from other fishing boats on the GBR of similar large catches of these species during spawning times.

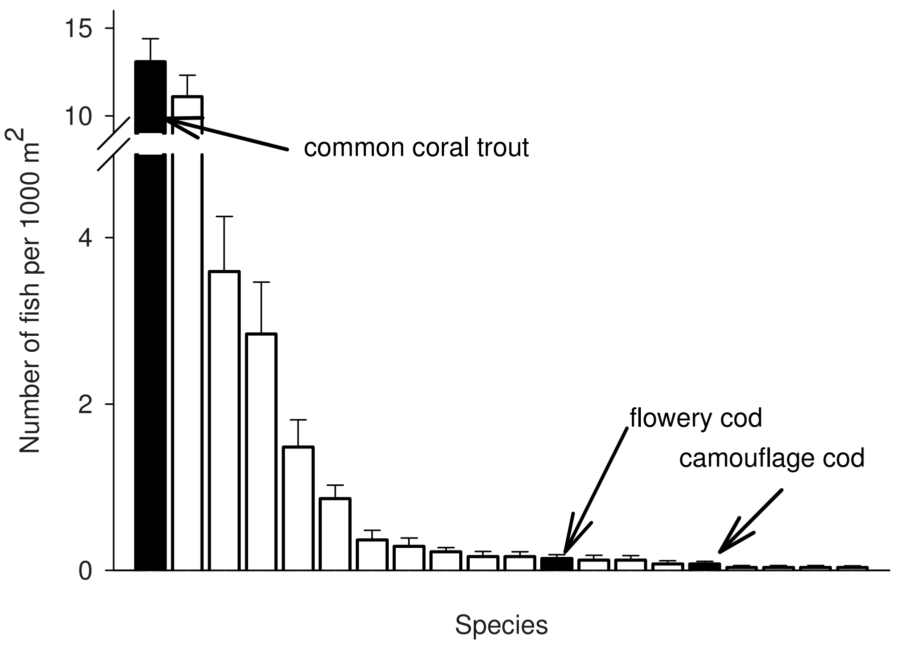

Figure 3 Abundance data from visual counts of groupers from mid-shelf reefs in the GBR showing low abundance of flowery cod and camouflage cod compare d to common coral trout, the main target species of the fishery. Error bars are standard errors.

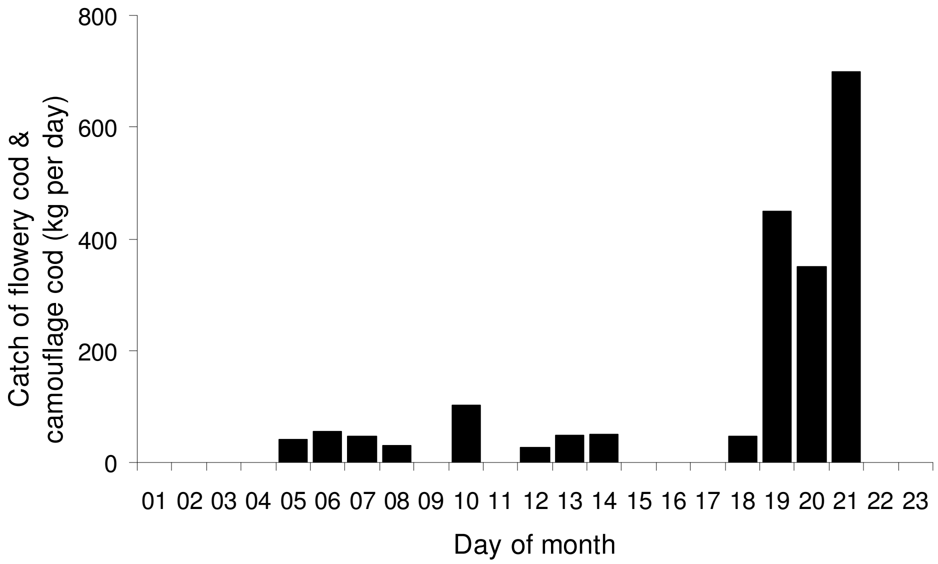

Figure 4 Extract from long time series of catch data of flowery cod and camouflage cod combined from a commercial line boat on the GBR, showing a large catch, totalling 1500 kg over 2.5 days (days 19 to 21), reported to be from a spawning aggregation.

Spawning behaviour and season

Occasional peak catches are possible for species such as these cods that aggregate in large numbers to spawn. Fishing of spawning aggregations is a key factor that has led to depletions of grouper stocks worldwide (see Society for Conservation of Reef Fish Aggregations (SCRFA) website www.scrfa.org). The disappearance or decline of some grouper spawning aggregations of flowery cod and camouflage cod and a coral trout species (*Plectropomus areolatus*) in Palau is thought to be due to overfishing (Johannes et al. 1999). Out of 29 records for flowery cod in the SCRFA global spawning aggregation database, 12 spawning aggregations (41%) are decreasing and one has gone. Similarly, out of 34 records for camouflage cod, 16 (47%) are decreasing and one has gone. These species are clearly vulnerable to targeted fishing of their spawning aggregations.

Results from this study show that for the GBR, important spawning months for flowery cod and camouflage cod are November, December and January. Current knowledge indicates that flowery cod and camouflage cod may spawn not only on new moons, but at other times of the lunar cycle and aggregations may last for about two weeks (Johannes et al. 1999, Rhodes & Sadovy 2002). As aggregating behaviour may occur throughout much of the lunar cycle between November and January, the recently introduced seasonal closures on the GBR for nine day periods around the new moons in October, November and December are likely to offer only limited protection for flowery cod or camouflage cod. The timing of the GBR seasonal closures was chosen to encompass the spawning period of the common coral trout and some other reef fishes. Fishers can still potentially catch large numbers of aggregating fish outside the spawning closures. This impact would be lessened to a degree by the no fishing zones or "Green Zones" protecting 33% of the GBRMP. The no fishing zones may provide indirect protection of some spawning aggregations of these cods, so are an important complement to the Fisheries (Coral Reef Fin Fish) Management Plan (2003). Research to understand spawning behaviour and monitoring of spawning aggregation sites on the GBR would be useful.

Reproduction

Fecundity (the number of eggs produced per female) is an important characteristic as not all female fish are alike – larger females of both species produce many times more eggs than smaller ones. This means that large females are very important breeders as they produce many millions of eggs over their long reproductive lifetimes of 30+ years. Moreover, recent evidence from diverse fish species indicates that for large old female fish the quality, as well as quantity of eggs and larvae is higher (Hislop 1988, Marteinsdottir & Steinarsson 1998) and rates of early growth and survival are enhanced (Berkeley et al. 2004), making large old females particularly important breeders for future generations (Palumbi 2004).

Many, but not all, species of groupers change sex from female to male, which can make them more vulnerable to overfishing than fish that do not change sex, e.g. if fishing selectively removes larger (mostly male) fish and upsets the natural sex ratio and reproduction (Bannerot et al. 1987, Sadovy 1994b, Alonzo & Mangel 2004). My results confirmed that both flowery cod and camouflage cod change sex from female to male and that each species has many more females than males, which is typical for sex-changing reef fish.

To summarise the similarities (see Table 1), both species have long lifespans of about 40 years, and are slow growing. In addition, as well as looking alike and both being found on reefs, flowery cod and camouflage cod are similar in their rareness (Figure 4, less than 1 fish per $1000m^2$). Consequently, they are normally only a small part of GBR line catches, but big catches are occasionally taken from spawning aggregations on the GBR and other places. Large females are important breeders, and both species change sex from females to males, and there are relatively few males. Importantly, most of these shared characteristics are linked with low resilience to fishing, and therefore, both flowery cod and camouflage cod will have intrinsically low resilience to fishing. In particular, their naturally low abundance and spawning aggregation behaviour mean both species are vulnerable to fishing of spawning aggregations.

Table 1 Similar characteristics of flowery cod and camouflage cod from the GBR, most of which are associated with low intrinsic resilience to fishing.

Similarities
Naturally low abundance (so usually only low numbers in catch)
Spawning aggregation behaviour
Long-lived (approx. 40 yrs)
Large females are important breeders with very high fecundity
Sex change, relatively few males
Also similar appearance, habitat and distributions (widespread throughout Indian and Pacific Oceans)

Differences between flowery cod and camouflage cod

The most readily observed difference between these two cods is that the maximum body sizes of each species differ. Flowery cod grow to about 100 cm total length (TL), whereas camouflage cod only grow to about 70 cm TL. (Anecdotal reports suggest a few flowery cod may attain sizes over 100 cm.) The other main biological differences that are important for determining the appropriateness of current size regulations are maturity of females and the size distributions of females and males in each population (Table 2).

Table 2 Differing characteristics of flowery cod and camouflage cod from the GBR that influence how the same size regulations act on the two species.

Differences
Maximum body sizes (flowery cod approx. 100 cm, camouflage cod approx. 70 cm)
Maturity of females (female flowery cod mature at a larger size and older age than camouflage cod)
Flowery cod: approx. 56 cm and 9 yrs
Camouflage cod: approx. 38 cm and 5-6 yrs
Size distributions of females and males in population

Female maturity

The size and age at which females start to spawn differs for the two species; flowery cod do not spawn until a much larger size or age. Estimates of 50% effective maturity calculated from the percentage of females that were sexually active during the spawning season were approximately 56 cm TL and 9 years for flowery cod (Pears et al. Submitted) and about 38 cm TL and 5 to 6 years for camouflage cod.

Size distributions

Size distributions for each species are shown in Figure 5. These plots are based on samples from spawning months only to illustrate the different types of females. These plots show important differences between the two species, i.e. the different distributions of breeding females and males with size. Figure 5A for flowery cod shows that: (1) the high fecundity female breeders do not occur until almost 60 cm TL; (2) there are females up to at least 85 cm TL; and (3) there were no males until almost 70 cm TL. In contrast, for camouflage cod (Figure 5B), males as small as 40 cm TL were found, and there is much more overlap in sizes of females and males. The high fecundity females and the males are important to protect due to their reproductive importance.

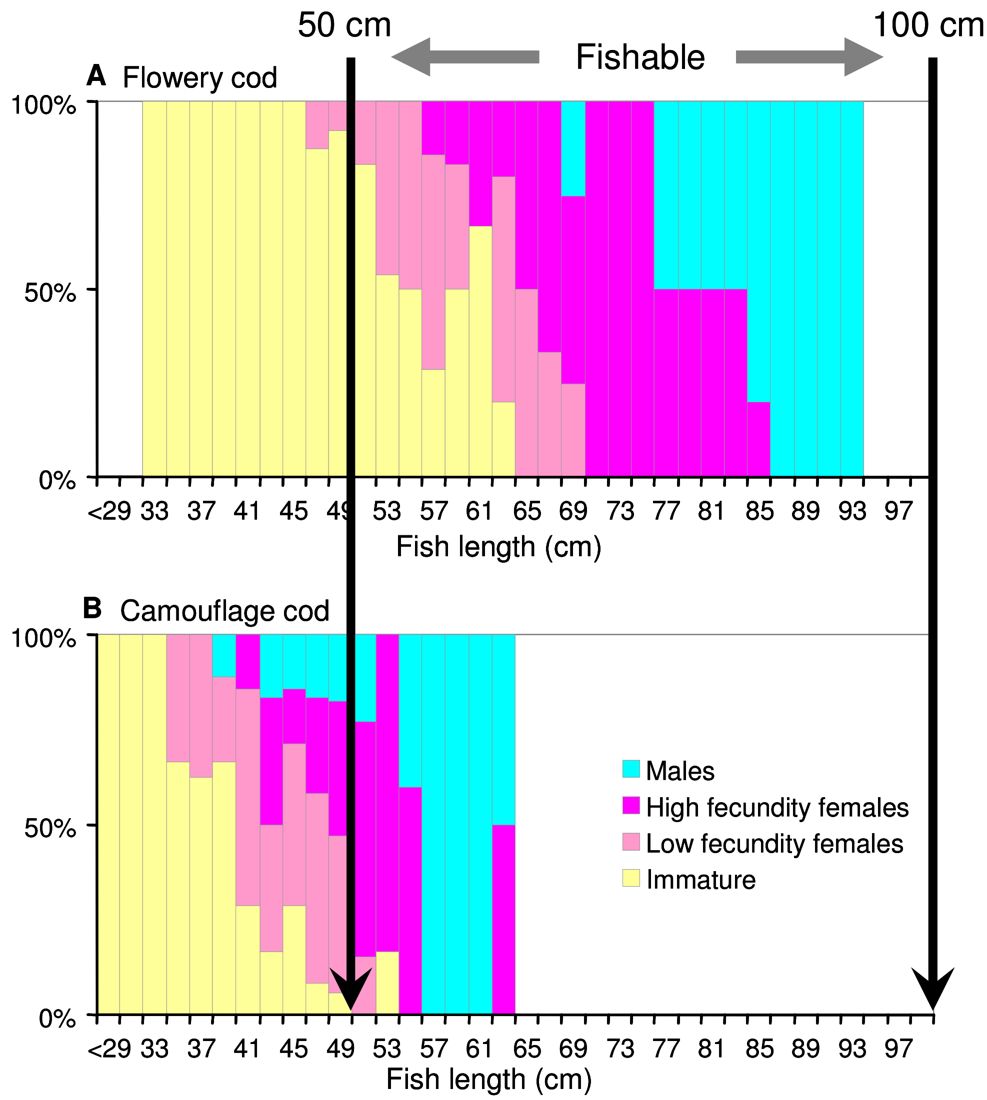

Figure 5 Size distributions for (A) flowery cod and (B) camouflage cod with indication of current legal size limits in the Queensland fishery. Samples are from spawning months only to show the effective maturity status and fecundity of females.

Implications for fish size regulations

In this section, I evaluate how effective the new Queensland size limits are for flowery cod and camouflage cod based on the biological data presented. The minimum size limit is 50 cm TL and the maximum size limit is 100 cm TL. A common interpretation of size regulations is that minimum size regulations are intended to allow a reasonable proportion (typically at least 50%) of the fish stock to spawn at least once before being taken, and maximum size limits are intended to protect large breeding females and males (usually the less common sex in sex-changing fish). Additional considerations that may be taken into account by managers when setting size limits include identification problems, compliance, overall fishing pressure, interests of different stakeholder-groups, such as iconic value, and survival of under- or over-sized fish.

Evaluation of current minimum size limit

The minimum size limit in Queensland (at 50 cm) is marked on Figure 5 A and B, with the protected under-sized fish to the left on each plot. Currently, the minimum size limit only protects a small proportion of the reproductive population of flowery cod as most of the females, including the large breeders, can still be legally caught. For camouflage cod, the same minimum size limit of 50 cm protects more of the female spawning stock, as well as some of the smaller males.

Evaluation of current maximum size limit

The current maximum size limit of 100 cm (Figure 5 A and B) is slightly bigger than the local size record for flowery cod (maximum recorded length 97 cm) and much greater than the maximum recorded length of camouflage cod (< 70 cm). This maximum size limit therefore protects few if any fish of either species. For flowery cod in particular, in conjunction with the minimum size limit, this means none of the large breeding females or male are afforded any protection. This leads to two questions: firstly, is a maximum size limit warranted? Secondly, if so, what is an appropriate maximum size?

Suggested size limits

Let's consider each species in turn. For flowery cod, it is important to protect some of the larger individuals on the right of Figure 5A because these are the large breeding females with high fecundity, and the males, which are essential for successful reproduction. Maximum size limits are warranted, therefore, for protecting some of these large individuals from fishing. I suggest lowering the GBR maximum size limit to about 70 cm to better protect the reproductive population. For example, setting the maximum size limit at 70 cm would help protect approximately 60% of the large breeding females and most males. By taking the age data into account (see Figure 6) it is evident a reduced maximum size limit of about 70 cm would also help protect older flowery cod. Older fish may be important to a process known as the "storage effect" that helps to maintain populations in long-lived species with variable recruitment (Warner & Chesson 1985).

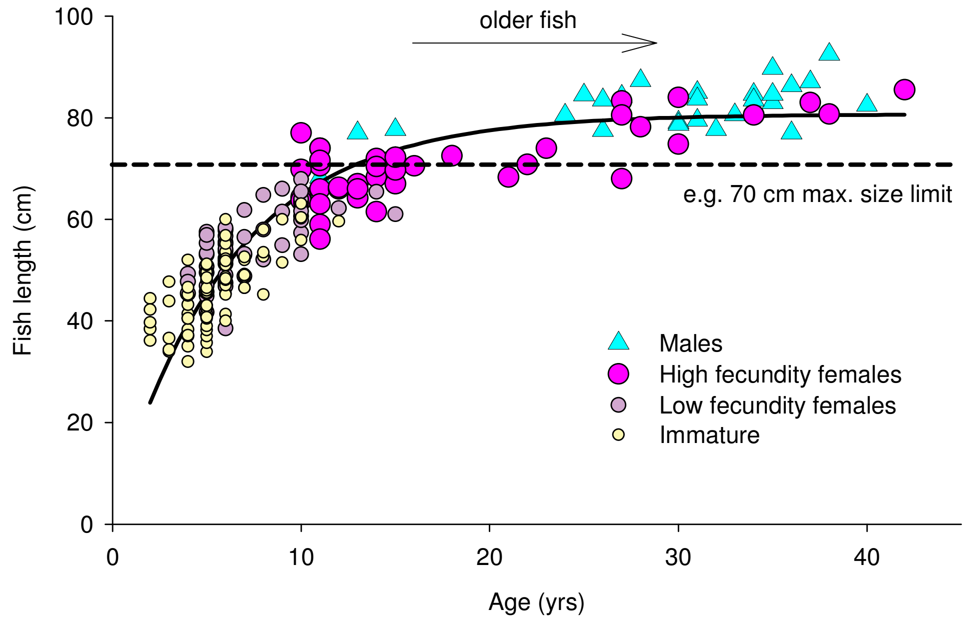

Figure 6 Growth curve for flowery cod showing suggested maximum size limit (horizontal line at 70 cm). Symbols indicate sex and reproductive status as shown.

For camouflage cod, I suggest that as they are better protected than flowery cod by the current minimum size limit (with females being allowed to breed more than once before recruiting to the fishery, and some males protected), camouflage cod have less need for a maximum size limit. Nonetheless, due to the difficulties most people have in distinguishing between these two species and the need to better protect the reproductive elements of the flowery cod population, a common maximum size limit for these two species should be retained but selected to suit flowery cod.

Conclusions and recommendations

Both flowery cod and camouflage cod have intrinsically low resilience to fishing due to their relatively long lifespans and slow growth, rarity, spawning aggregation behaviour, sex change, and the relatively few males in the population. These species are vulnerable to depletion by fishing of their spawning aggregations, and only limited protection may be gained from the current seasonal fishing closure periods on the GBR. A longer closure period would be more precautionary. The current size limits under Queensland fisheries legislation have afforded these species with some protection, but considering this new information, revision of these management arrangements is advisable. The differences in the biology of the two species, particularly in their maximum body sizes and the size distributions of breeding females and males, mean that the effectiveness of the common size regulations will differ for these species and is of particular concern for flowery cod.

The maximum size limit is ineffective for either species (essentially it is too high). This is of most concern for flowery cod, because the minimum size limit only protects a small proportion of the breeding females and none of the males, hence the fished component of the GBR population of flowery cod still includes most of the female spawning stock and all of the males. For camouflage cod, the minimum size limit is more effective as it allows females to breed more than once before recruiting to the fishery and protects small males.

I recommend that the current size limits for these species are revised. Considering the need for ease of compliance, I suggest that the common 50 cm minimum size limit is maintained, and that the maximum size limit be lowered to about 70 cm for both species. This will help to ensure reproductive success for these two species.

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DISCUSSION MINUTES:

Question (Ashley Williams): Is there catch data that shows size frequency to determine the impact of the suggested lower maximum legal size?

Response (Rachel Pears): We have size frequency data from the Effects of Line Fishing project and have looked at how many fish will be protected from suggested lower maximum legal size. There would still be a good number of fish available to the fishery as middle-sized fish make up a large proportion of the catch.

Question (Danny Brooks) Do you have any idea of post-release mortality? From anecdotal information, the larger the fish, the less chance of survival of released fish.

Response (Rachel Pears): I agree that larger ones may have higher post-release mortality as they are more difficult to handle, so potentially have higher mortality on release. There is no real data on this though. The depth they are caught at may also be a factor.

Comment (Terry Must): Regarding the figure showing 2.5 tonnes of catch of cod caught in two days - this is from my boat. This was caught with 3 other fishers and included flowery cods, camouflage cods and Maori wrasse. This was from a spawning site in the central GBR. I asked GBRMPA to close that reef as it is an important site and should be a Green Zone.

Response (Rachel Pears): Interesting, as the data I showed is from another boat and occasion – which indicates fishing of spawning sites for these cods may have happened regularly.

Comment (Neil Green): Now with TACC (total allowable commercial catch) for "other fish", this is a small quota and you probably won't get these sorts of catches any more.

Question (Danny Brooks): How valuable are these fish?

Response (Terry Must): We were selling them live in those days for $10 per kg. We would take any size cod at that time on the live reef fish market. The cods were easy live fish to handle with good survival rates. Now with new size limits it's not viable to target them for the live market. You can't keep them in the same tank as coral trout.

Response (Rachel Pears): We need to remember that the dynamics of what people catch changes over time. Fisheries are affected by changing market demands, and the species composition of the catch has changed from 10 yrs ago, and may well be different in 10 yrs time.

Response (Ashley Williams): TACC of "other species" is actually large (around a third of the total TACC). If value for cods goes up in the future, fishers could start targeting cods again.

Response (Rachel Pears): As these cods are low abundance species, if by-catch increases, or recreational or commercial fishing interest increases, there would be reason for concern. No matter what the size regulations are, some under or over sized cods will be caught as by-catch.

Response (Terry Must): I don't catch many of these outside the spawning season.

Response (Howard Choat): There is a humphead Maori wrasse spawning site on the same Central GBR reef that is also a cod spawning site.

Response (Martin Russell): Spawning season closures may help cod protection.

Response (Rachel Pears): My data suggests that protection may be limited for flowery and camouflage cods as their spawning aggregations may occur at least partly outside of the closure period.

Response and Question (David Williams): I had input into the Coral Reef Fin Fish Fishery Plan. It was difficult to include spawning aggregations for all species, especially for cods and Maori wrasse. Seasonal closures have been put in, and these are a relatively crude implement centred around coral trout, considering the north to south change in spawning time. What would be more effective measures to protect species such as cods and Maori wrasse instead of what is in place at the moment?

Question and Comment (Terry Must): Aren't size limits effective? Fish size limits protect them as it makes it not economically viable to target them. We don't see the numbers of cods being caught these days, probably due to the new size limits.

Response and Question (Rachel Pears): Isn't this to do with changed targeting because of quota?

Response (Terry Must): No, you don't discard fish, if it's a $10 per kg fish – if its part of your catch, you will keep it as it is worth money.

Comment (Danny Brooks): Less fish coming ashore could mean less fish out at sea available to be caught, so size limits might not be working.

Question (Neil Green): Is there any research on catching these species from off-reef areas?

Response (Rachel Pears): No, generally they are not identified as specific species in the catch records; therefore, it is difficult to get information about this.

Response (Neil Green): Most of our catch is from deep water and the northern section.

Question (Gavin Begg): What about in the Torres Strait?

Response (Greg McBeth): We discourage fishers (in the Torres Strait) from keeping cods. As we have a freezer boat we don't want to fill up on lower value species (cods compared with coral trout). The Torres Strait fishery is mostly shallow water and a few cods may go belly up when released, but generally they release OK. We won't keep them if we go live as they have to be kept in separate tanks.

Question (Annabel Jones): Are camouflage and flowery cods confused with any other species of cods?

Response (Rachel Pears): Yes – greasy cods (*Epinephelus tauvina)* and several other cods and groupers. I have developed keys to identify all these species, but it can be difficult. It may be possible to teach fishers to identify different fish species, but it is probably better to have the same management for similar-sized and similar-looking species.

Response (David Williams): There are difficulties for some fishers to identify various species. One reason for the 100cm size limit is it helps protect Queensland groper from mis-identifications.

Comment and Question (Rachel Pears): The GBR Marine Park Protected species regulations now prohibit taking any cods and groupers (of the genus *Epinephelus*) over 100 cm in length. The question is: are we adequately protecting flowery cods with the current size limits, particularly the 100 cm maximum size? The limit needs to match the species biology.

Comment and Question (Gavin Begg): The importance of large breeders can not be overstated. They produce a lot more eggs, but there is also some evidence from overseas that shows that larger and older females produce offspring that have a better chance of survival (larger eggs, larvae, etc). So size limits to protect larger breeders is very important. What about making these species no-take?

Question (Renae Tobin): What is the catch of these species in the recreational sector?

Response (Rachel Pears): Again, these are not identified specifically in recreational catch records. From spear fishing competitions on the GBR, catches of flowery cods in particular can be significant, and they especially target larger fish.

Question and Comment (Terry Must): How far do you go? If you want to protect these species close spawning sites. They are important species for Asian customers. We need to have some fish to fill the commercial market. If you include more species as no-take, you will put a lot of pressure on what fish you can catch.

Comment (Andrew Tobin): With a TACC on coral trout, most coral trout will go to the live fish trade, and this will put increased demand on other species to fill the domestic commercial market. We need to come to some better solution with respect to size limits.

Question (Danny Brooks): What is the eating quality of these large fish?

Question (David Bateman): Flowery cod - is this the same as estuary cod? Do they come inshore?

Response (Rachel Pears): No, they are different species. You don't really see small individuals of these flowery and camouflage cods on reefs, and we are not sure where the juveniles are, may be between reefs, inshore or are very cryptic. There are some reports of them being caught inshore in other countries.

Question (David Bateman): Is it more important to protect the upper or lower end of the size scale? Is more required?

Response (Rachel Pears): The upper end, because it protects both males and females. All evidence shows that larger individuals are very important and should be better protected. If you only have minimum size (50 cm), you don't protect any male flowery cods nor large female breeders as the maximum size currently provides no protection to either flowery cods (or camouflage cods). It may also be important to have larger fish for spawning aggregation function and large females make a very important contribution to reproduction. So, I suggest keeping the current minimum size limit and bringing the maximum size limit down to protect large fish. Of course, it would still be vital that enough small fish remain in the population and grow up to reach the maximum size.

Comment (Renae Tobin): As you probably know, an upper and lower size limit is not new, it is in for barramundi and now flathead. Sometimes it takes a little while to be accepted.

SESSION 2: INCORPORATING SOCIAL AND ECONOMIC INFORMATION INTO FISHERIES MANAGEMENT

Predicting social resilience to policy change within the commercial fishing industry in Queensland.

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Abstract

Social hardship is frequently associated with setting limits on the use of our natural resources. Resources have been mostly managed using ecological and economic knowledge. Evidence is now accumulating showing that incorporating social factors into the decision making process may improve resource protection through decreasing conflicts and increasing compliance whilst enabling the social costs associated with protecting natural resources to be understood. In my PhD study, I am looking at the resilience of the commercial fishing industry to changes in fisheries policy. Ways in which resilience can be defined and recognised are explored. Factors that influence resilience are also examined. One-hundred fishing families in 5 coastal communities in northern Queensland were interviewed. They were asked to complete a structured survey relating to their business, their background, their family, their relationship with decision makers, the fisheries resource, and their community. Results suggest that the level of dependency on the fisheries resource, the way in which policies are interpreted and certain personal and family characteristics are important in determining how resilient a fishing family might be to a change in policy. It is hoped that this study can be used to stimulate discussion as to how social information can be better incorporated into the decision-making process so that policies can be

designed that not only protect the resource, but minimise associated social impacts.

Introduction

Natural resources have been mostly managed using ecological knowledge, but evidence is now accumulating to suggest that the incorporation of social factors into the decision-making process can enhance conservation and improve resource sustainability (Roe 1996, Pomeroy & Fitzsimmons 1998). Basing decisions, in part, on an understanding of social factors and dynamics can decrease conflict and increase compliance, whilst minimising acute and chronic social impacts (Jones 1999).

Policy decisions that set limits on extractive use of natural resources can impact on people's daily lives and businesses (Freudenberg & Keating 1985, Adger 2000). The nature and magnitude of these effects depends upon a multitude of factors (Harris et al. 1998). For example, the social impacts associated with the placement of Marine Protected Areas (MPAs) will depend, to a large extent, on whether the people affected are tourists, tourism operators, commercial or recreational fishers. The level of socio-economic dependency that they have on the marine environment will determine, to a large degree, the significance of impacts that might be experienced. A role of social sciences in the management of natural resources is to provide information on what the social impacts - or social costs - of protecting resources are likely to be (Vanclay 2002). However, how people respond to change and adapt is the "most neglected and the least understood aspect in conventional resource management and science" (Gunderson 2000). Understanding how people cope with and adapt to policy change provides decision-makers with the opportunity to design policies that minimise the social costs associated with protecting our natural resources whilst maximising conservation goals.

Although social resilience has been studied in other contexts (e.g. psychology, medicine, anthropology) the concept of resilience has only been recently introduced into the 'sustainability sciences' (Holling 1973, Adger 2000, Folke 2001). The concept of social resilience can be used to examine the extent to which resource policies can be introduced into a resource-dependent community without affecting its ability to cope and adapt (Vayda & McCay 1975, McCay 1981, Holling et al. 2000). However, the concept has only rarely been applied within a fisheries context (Seixas & Berkes 2004, Carpenter & Brock 2004).

This paper has two main aims. The first is to examine the concept of social resilience in the management of marine resources using the commercial fishing industry in north Queensland as a case study. The second aim is to present key results that describe the social resilience of the fishing industry and identify factors that are likely to influence it. I conclude with a brief discussion of the relevance of my findings to the management of fisheries in Queensland.

The concept of social resilience

Resilience refers to the ability of a system (e.g. social, ecological, cultural and political) to cope with externally imposed change (Holling 1973). A resilient system can 'bounce back' from a particular disruption, it has the capacity to learn and reorganize, and it is adaptive (Holling et al. 1998, Sonn & Fisher 1998, Adger 2000). A system that loses its resilience will move closer to its 'threshold of coping' (Gilden & Smith 1996). A system that crosses this threshold will 'flip' into another state, a condition that is mostly irreversible and 'undesirable' (Holling 1973, 1996). A consequence of loss of resilience is the loss of opportunity, constraint during periods of reorganisation and an inability of the system to work differently (Carpenter & Gunderson 2001). For instance, a viable fishing community that can no longer catch sufficient fish due to a change in policy may move towards its threshold of coping, becoming increasingly dependent upon welfare and marginalised in the broader community. However, if the community has the ability to learn and adapt to its changing environment, it may continue to function and thrive, since, in the words of Charles Darwin, "it is not the strongest species that survive, nor the most intelligent, but the ones most responsive to change".

Social resilience is typically examined retrospectively. The aim of this study is to provide some predictive capacity about the phenomenon by examining the way in which commercial fishers in North Queensland respond and adapt to generic policy change. Such information may provide valuable insights for resource managers, facilitating the prevention of irreversible socio-economic impacts (Folke et al. 2004).

Social resilience within the commercial fishing industry in Queensland

Much social science research in fishing communities is contained within Social Impact Assessments (SIA), in which social profiles of fishing industries are collected to provide decision-makers with some indication as to the expected social impacts of their decisions (e.g. Fenton & Marshall 2001a, b, c). SIA work already undertaken in the commercial fishing industry in Queensland has revealed that there are around 1400 master fishers in Queensland dependent upon line fishing, trawling, netting and crabbing within the Great Barrier Reef (Fenton & Marshall 2001a). Most of the fishing businesses within Queensland are small; only 6% of vessels are greater than 19 m in length, and most businesses (91%) are owner-operated and do not employ any crew (Fenton & Marshall 2001a). The median gross value of production for each fishing business is $129,000 and 43% have production values less than $100,000. Over half (56.1%) of the fishing businesses are run by families. Although the majority of fishing businesses in Queensland are well-established, 28% are relatively new and have been owned for less than five years. The average age of master fishers is 47 years, 83% are married and the mean total family size is 4 people. Most fishers have relatively little formal education (only 46% have completed schooling to a Year 10 level) and 60% do not have any debt associated with their fishing business. The average income taken home each year by fishers is $39,400 (Fenton & Marshall 2001a).

Although fishers and their families are frequently subjected to changes in fisheries policy (McPhee & Loveday 2000, Howe 2002), our understanding of how the industry might cope and adapt, is limited (Force et al. 1993, Hughey 2000). There are no available guidelines to measure or predict the resilience of the industry (Carpenter & Brock 2004).

Researchers working outside of the fishing industry have measured resilience using mostly economic indicators, such as debt levels (e.g. Machlis & Force 1988, Randall & Ironside 1996). However, the ability to cope and adapt is not always related to economic concern, and thus knowledge of social issues may be vital in developing this understanding (Carroll & Lee 1990, Adger 2000).

Another problem in studying social resilience within the commercial fishing industry is the difficulty in recognising resilient traits: people make decisions about their future that extend beyond the confines of the fisheries system (Milestad & Hadatsch 2003). For example, if fishers 'reinvent' themselves, or exit the industry as the result of a change in policy, they are not necessarily of low resilience. For example, trawlers that are significantly affected by a change in policy may become successful as line fishers. They have shown the capacity to reorganise and adapt. Even if they leave the industry and become a farmer, they have still demonstrated resilient properties at a societal level; if they are paying the same tax as before, they have maintained at least one of their functions in society. Similarly, some fishers may remain within the industry not because they have demonstrated resilient properties, but because they do not know what else to do: they have no other option. As such, whether a fisher remains within the industry or not, is not necessarily an adequate measure of their resilience to change in fisheries policy.

Recognising resilience remains a key challenge for researchers and managers alike (Davidson-Hunt & Berkes 2004, Olsson et al. 2004). A researcher must be able to tell the difference between a fisher who remains within the industry because of the possession of resilient traits, as opposed to a fisher who has low resilience. A researcher must be able to interpret the reasons behind a fisher leaving the industry; whether the capacity to adapt by 'reinvention' is being displayed. A researcher must be able to interpret whether a fisher that is exiting the industry is moving into another state that is equally, more or less 'desirable'. However, what is a desirable state and what is an undesirable one is not necessarily the same for each individual. Hence, social resilience is proposed here as being a measure of 'wellbeing': if people are happy to embrace change – and can reorganise and adapt, either within or outside of the industry, then they are likely to be resilient to the negative effects of policy change. Incorporating the concept of 'well-being' into an assessment of resilience within the industry may thus provide an ability to understand the nature and extent of the likely ramifications of a change in fisheries policy.

The importance of identifying factors that can influence resilience

The way in which people respond to events is often unpredictable because of the dynamic nature of systems, and because human behaviour can be irrational (Holling 1986, Geisler 1993). Some individuals, industries and communities will respond to policy change negatively, and others will respond positively. The outcome is likely to depend upon characteristics of people (such as their skills, knowledge and attitudes) and of the community they belong to (such as its history, stability and extent of opportunities) (Krannich & Zollinger 1997, Hofferth & Iceland 1998, Adger 2000). That is, social resilience to policy change can be modified and influenced. Yet, a social impact assessment rarely provides an indication of what the likely responses to a proposed change are under a range of conditions. In fact, the importance or influence of factors in determining social outcomes is conspicuously absent from the social impact assessment literature, even though such knowledge would significantly progress our understanding of how people cope with and adapt to change (Al-Naser & Sandman 2000).

A new concept for defining social resilience

A concept for defining and measuring social resilience to policy change is important in the management of natural resources. If individuals can cope with the effects of a policy change and maintain their function within their industry, they are described as being socio-ecologically resilient (Berkes & Folke 1998). However, if individuals chose to learn, re-organise and adapt to a policy change by exiting the industry and maintaining their well-being, they are referred to as being socially resilient. Thus, a study of social resilience requires an assessment of the response of individuals to changes in policy that can extend beyond the resource system under investigation. It was thus proposed to evaluate the likely response of fishers to generic changes in fisheries policy and measure their ability to learn, reorganise and adapt, using standard self-assessment techniques as provided through structured surveys.

Methods

In order to measure social resilience and identify the factors that might be important in influencing how a fisher might respond to a policy change I initially reviewed the literature and undertook a scoping study in which 15 fishing families in Townsville were interviewed. The factors that were identified as potentially significant influences on social resilience included the level of dependency on the resource, and the perception of policy change (Machlis et al. 1990, Scoones 1999). Resource dependency is a concept that includes economic, social and environmental factors (Carroll & Lee 1990, Trosper 2004, Bailey & Pomeroy 1996, Bailey 1997). Social statements were included to measure a fisher's level of attachment to their occupation, employability, family circumstance and level of attachment to the community. Economic statements were included to measure a business size, business approach and financial situation (debt and income levels). Environmental statements were included to measure the level of specialisation within the industry, the interest in issues of sustainability and the amount of time spent fishing. The ways in which policies were perceived included components describing policy implementation, interpretation and involvement (Berkes 1985, Berkes & Jolly 2001).

In order to measure a fisher's resilience to policy change and to determine the significance of resource dependency and policy perception, I developed 16 summated rating scales (Spector 1992). A rating scale is a means by which attitudes, perceptions and situations can be quantified, and is one of the most frequently used tools in the quantitative social sciences (Zeller & Carmines 1980, Mueller 1986). Each scale consisted of multiple statements about each of the factors measured, and fishers were asked to respond to each statement using a 4 point Likert scale where fishers could agree or disagree with each statement (Spector 1992). The statements were pre-tested with 15 families in Townsville to ensure that the questions were readable and unambiguous. The final survey comprising 240 statements was then administered to the first 100 fishers and their families that I could contact in five coastal communities in north Queensland; Cooktown, Port Douglas, Innisfail, Townsville and Bowen. I contacted each family in advance and explained my research. I then conducted a 2-3 hour qualitative interviews in their homes in order to interpret the results of the quantitative survey accurately, and left the survey with them to be collected the following day. All fishers were enthusiastic participants in the study, and I obtained a response rate of 100%.

In order to test the influence that resource dependency and policy perception had on social resilience, a Principal Component Analysis (PCA) was used to reduce the number of potentially significant independent variables (Spector 1992). A PCA is a standard technique that allows the natural groupings within a large number of statements to be identified. Components of resource dependency and policy perception were correlated against components of social resilience in order to identify the nature and magnitude of the relationship between them (Mueller 1986). Detailed methods can be found elsewhere (Marshall in prep.)

Results

Measuring social resilience

Four principal components were extracted from the twelve statements generated to assess social resilience (Table 1). These components, representing 60.1% of the variance, represent the 'adaptive capacity' of commercial fishers which is their ability to cope with, and adapt to, generic changes in fisheries policy.

The first component, representing 23.4% of the variance, consisted of statements relating to the level of confidence in absorbing and adapting to change. For example, the statements made reference to the ability to secure work elsewhere if the need arose, as well as the ability to cope with small changes within the industry. This component was interpreted as, "the assessment of risk associated with policy change".

Table 1. Rotated component matrix for defining social resilience

Survey statements (variance explained = 60.1%)	**PC 1 23.4%**	**PC 2 18.6%**	**PC 3 9.6%**	**PC 4 8.5%**
I have many options available if I decide to no longer be a fisher	.808			
I am confident that I could get work elsewhere if I needed to	.787			
I am too young to retire and too old to find work elsewhere*	.625			
I would be nervous trying something else*	.603			
I can cope with small changes in industry	-.462			
I have planned for my financial security		.858		
Every time there is a new change I plan a way to make it work		.746		
I am more likely to adapt to change compared to other fishers		.628		
I do not think I am competitive enough to survive much longer*			.682	
I am confident things will turn out well for me			.637	
If there are any more changes I will not survive much longer*			.547	
I am interested in learning new skills outside of the industry				.936

Notes:
- PC=Principal Component
- Factor loading scores less than 0.45 are not displayed
- * The data for negative worded statements were reversed prior to analysis
- Extraction Method: Principal Component Analysis.
- Rotation Method: Varimax with Kaiser Normalization.
- Rotation converged in 5 iterations.

The second component, representing 18.6% of the variance, consisted of statements relating to the ability to plan and reorganise through developing strategies and financial planning, as well as comparing one's ability to adapt with other fishers. This component is interpreted as the "ability to plan and reorganise".

The third component, representing 9.6% of the variance, consisted of statements relating to the extent to which fishers thought that they could absorb change compared with other fishers in the industry (for example, "I do not think I am competitive enough to survive much longer"). This component is interpreted as the, "ability to cope with and change".

The fourth and final component, representing 8.5% of the variance, consisted of the single statement, "I am interested in learning new skills outside of the industry". This statement reflects the ability of fishers to reorganise and 'bounce back' from the effects of policy change. This component is interpreted as, "the level of interest in change".

Measuring the significance of other factors in influencing social resilience

Each of the four components of social resilience was significantly correlated with components of resource dependency and the way in which policies were interpreted (Table 2).

In brief, the combined effect of the level of attachment to the occupation and employability of fishers was significantly correlated with two dimensions of social resilience: the assessment of risk and the perception of the ability to cope with change. The combined effect of business size and approach was also significantly correlated with two dimensions of social resilience: the ability to plan and reorganise and the perception of the ability to cope with change. The combined effect of policy involvement, interpretation and implementation was correlated with the assessment of risk and the perception of the ability to cope with change. Detailed results can be found elsewhere (Marshall in prep.)

Table 2. Results of the Pearson Correlation matrix. Significant correlations between social resilience and resource dependency and policy perception are highlighted by asterisks.

	PC1: Risk	PC2: Planning	PC3: Coping	PC4: Interest
RESOURCE DEPENDENCY				
Social factors				
Place, family circumstances	-.116	.133	-.016	.071
Employability, attachment to occupation	-.678**	-.106	-.340*	-.073
Economic factors				
Business size & approach	.250	.436**	.309*	.083
Financial situation	.194	.130	.121	.104
Environmental factors				
Specialisation, time, interest	.032	.057	.034	.055
POLICY PERCEPTION				
Implementation, involvement, interpretation	.239*	-.001	.344**	-.041

Notes:
* significant to $p<0.05$
**significant to $p<0.01$

Discussion

Results indicate that the way in which fishers are likely to respond to change has four dimensions that reflect their ability to cope with and adapt to policy change. The resilience of fishers to changes in fisheries policy is determined primarily by: 1) their assessment of risk in approaching change, 2) their ability to plan and reorganise, 3) their ability to cope with change, and 4) their interest in reorganising and changing. These results illustrate and capture how complex the response to policy change is; where some fishers may respond positively to policy change in some dimensions, but negatively in others. Some fishers may have an interest in adapting to policy change (component 4), for example, but not have the skills with which to do so (component 2). The combined response to each of the four components identified provides a measure of how resilient each fisher is to changes in fisheries policy.

Results also indicate that social resilience can be influenced. The level of dependency upon the resource can have significant influence on a fisher's ability to cope and adapt. Specifically, fishers that are more dependent upon the fisheries resource are more likely to be impacted upon as the result of a change in fisheries policy. Fishers that are more dependent on the fisheries resource are those that are especially attached to the fishing occupation, have a low employability (as measured by age, education and attitude), and have a small business with a "lifestyle" approach. They contrast with larger-scale fishers that treat fishing mostly as a growing business venture. Larger-scale fishers tend to be less attached to the occupation and are more employable since they are generally younger and have more diverse business skills. Larger-scale fishers also have a larger 'financial buffer' with which to incorporate the costs of change. The options available to these fishers are thus more diverse. Hence they are less socially and economically dependent upon the fisheries resource and are better able to incorporate the requirements of policy change into their working lives.

The perception of policy change was also observed to be a significant influence on social resilience. Specifically, fishers that interpreted policies more positively were more positive in their response to policy change. Fishers that were meaningfully involved in the decision-making process tended to interpret policy change more positively.

These results illustrate that resilience is not a static quality. Resilience is dependent upon certain conditions existing. Once these conditions change, then the level of resilience within the industry can also be expected to change. That is, if fishers were younger and better educated, for instance, their resilience to policy change could be different. If fishers were encouraged to interpret policy changes more positively, for example, their ability to cope with change and adapt may also be different. Results show that a possible strategy to encourage fishers to interpret policy change more positively is to increase the level of meaningful involvement in the decision-making process. Fishers that are more involved in the process than other fishers tend to be more strategic: they plan, learn and re-organise better than other fishers (component 2). This may be because fishers that are involved in the decision-making process are more strategic generally. It may also be because fishers that are involved in the process are more aware of the severity of impending change and have understood what the likely consequences might be.

Social resilience within a primary resource industry such as the commercial fishing industry is a complex phenomenon. This study has demonstrated that the role of policy in the maintenance of social resilience and the level of dependency upon the fisheries resource are both important in determining how resilient commercial fishers are to changes in fisheries policy.

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DISCUSSION MINUTES

Comment (Gavin Begg): We are looking at the tip of the ice berg when we consider the potential of social science.

Question (James McLellan): Is there a correlation between the age of a fisher and the level of debt?

Response (Nadine Marshall): Yes. Older fishers are more likely to have repaid their debt. In 2000 we found that 60% were debt free and that many were over 50 years of age. Debt is not a major issue for the industry now.

Question (Annabel Jones): Would demographics have changed from the 2000 study?

Response (Nadine Marshall): Yes. In the two years between projects we found that the average age of fishers has increased by 3 years. During this period there have been many changes (i.e., Trawl Plan, Line Plan, etc). Younger fishers have possibly left the industry because they can, leaving the older fishers behind, and younger fishers are not entering the industry because it is not as attractive an industry as it used to be.

Comment (Sue Bandaranaike): I can see parallels with the sugar industry. The average age of farmers is also increasing. Younger farmers are leaving (and possibly going to the mining industry). There has been a $440M package to assist farmers to leave the industry, but many did not take it up. Now cane prices have increased again, and many no longer want to leave. Children are not interested in entering into the industry and go to university instead. The success of the industry depends on locality, resources, knowledge, etc. Increases in farm size need to occur in order to be viable, and they will probably have to do so in the fishing industry as well.

Question (Martin Russell): For guys that have gone out of the industry and got back in again in another fishing sector, isn’t this an indication of their resilience? I am also not sure given your research, if this knowledge would have changed the way we have gone about management to date (e.g. Trawl Plan etc).

Response (Nadine Marshall): I think that the best way my research can help with management is by providing some indication of what the social impacts – or social resilience – of various drafts of possible management plans could be. That is, with each possible variation on the Line Plan, my research could have given some prediction as to what the social costs were likely to be – or more specifically, who were the most vulnerable people and why?

Question (Danny Brooks): What are your thoughts on how fisheries are going, given that fisheries are managed as a single fishery, but they are really multi-sectorial and one affects the other?

Response (Nadine Marshall): The theory is that in unpredictable environments, generalists – who target multiple species – are likely to be more resilient because they can switch species as the need arises. In stable environments like Australia, fishers can become specialists because the situation is more predictable. If the situation becomes unstable, however, then specialists are less likely to do well. However, my results have not picked up that one fishery is more resilient than the other.

Question and Comment (Neil Green): This seems to be important research. How can we translate this research into a useable form? If you look at fishing communities which are predominantly made up of small multi-endorsed fishermen who are having their endorsements taken from them to address latent effort; this in turn is taking from them the opportunity to use these licences as stepping stones to other fisheries after financially establishing themselves. This is also taking the opportunity from them to diversify and is a reason licences are not being handed down to future generations. It concerns me for these reasons we do not have younger fishermen continuing on in our industry.

Question (Renae Tobin): Considering how the industry changes over time, is there a tool that could be ready to put in place when a new plan is being discussed, rather than afterwards.

Response (Nadine Marshall): Yes. Long term monitoring of ecological parameters is normal to help managers understand what changes are occurring at any time on the GBR, but social science is not yet at that level. Monitoring social data may reveal important changes that are occurring within the industry that managers and industry might like to be aware of.

Comment and Question (Steve Sutton): This is an important point. Social science is a new addition to fisheries management. It will not answer all the questions, as it is still in its early days. It will also take some time for managers to know how to use this information. What kind of reaction do you get from fishers when you ask these questions? Do they see this is as a way of getting their voices heard, or do they see it as an imposition?

Response (Nadine Marshall): The response rate for my survey was very high. In fact it was 100%. This shows how keen fishers were to have their views heard and circumstances understood.

Question (Chloe Lucas): Your results showed that fishers that were involved in policy were more resilient. Did the fishers that were involved in this research get anything from being involved?

Response (Nadine Marshall): No. Fishers were keen to gain information from me as to what was going on with the development of the plans of management, but I made it quite clear that I wasn't really useful in this way.

Question (Mikaela Bergenius): Were there any differences in resilience between different towns, depending on the size of town? For example in a town such Cooktown, there is less opportunity for other employment. Is this important?

Response (Nadine Marshall): The theory is that the bigger the town, the more employment opportunities are available. However, my research did not show a difference between communities. Perhaps this is because fishers find it difficult to secure work elsewhere, regardless of the community they come from.

Question (David Bateman): Do you think fishers would be happy if there were set guidelines to assist with the allocation of resources? Will your research come up with any recommendations for the Government when allocating resources?

Response (Nadine Marshall): Yes. Legally, the Government needs to conduct a Social Impact Assessment prior to any major change being implemented. We just haven't known how to do these assessments very accurately in the past. My research can help.

Question (Gavin Begg): What about the traditional and recreational sectors of the fishery? We should consider resilience in these sectors also.

Response (Nadine Marshall): Yes, of course. I have looked at commercial fishing, but the same principles apply elsewhere.

Question (Neil Green): Have you talked to BRS (Bureau orf Rural Sciences)?

Response (Nadine Marshall): My supervisor, Mark Fenton, does a lot of work with them.

Comment and Question (John Marrington): People involved in the process tend to be more resilient and more strategic. This shows there is a need for a good communication strategy. Did you speak to fishers or just owners? I think you may see differences between shore-based owners and those that actually fish.

Response (Nadine Marshall): I spoke to fishers with a Masters Licence. Most of them fished, but several conducted a fishing business from the shore. As far as communication strategies go, I met many fishers who wanted to be involved in the decision-making process, but knew that if they did then they would be taking time away from their core-business; fishing. These people will be difficult to involve in the process.

Competition and conflict between recreational and commercial gillnet fishers in north Queensland estuaries: perception or reality?

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Abstract

Conflict between recreational and commercial fishers resulting from competition for shared fish stocks is a significant concern in the management of fisheries resources throughout Australia, with each sector calling for tighter restrictions on the activities of the other. In north Queensland, competition for a share of the barramundi resource is apparent through numerous media articles outlining opinions of both sectors. Opinions expressed in the media can influence decisions by managers and politicians who allocate and distribute access to fisheries resources, though usually it is not known whether such opinions are representative of the general fishing population. To address this uncertainty, a questionnaire program was implemented for recreational line fishers and commercial gillnet fishers. Questions focussed on fishers' perceptions about competition and conflict between the sectors, their view and knowledge of their own and the competing sectors' impacts, and their suggested solutions to competition. Results indicate that fishers from each sector holds negative opinions of the competing sector, and positive opinions of their own sector, perhaps indicating a likelihood for blame for negative outcomes, such as declines in catches. Negative opinions, however, appear to be based on perceptions that are not supported by scientific research, suggesting that correct information about fishing impacts of each sector is failing to reach the general fishing public. Solutions suggested by respondents include improving education and communication within and between sectors, or segregating the sectors via Recreational Only Fishing Areas (ROFAs). Overall, results suggest that current conflict between sectors may be eased through increased education

and communication, highlighting the importance of social research into such situations.

Introduction

Fisheries managers, while ensuring overall harvest is sustainable, must also act as arbitrators between competing user groups (sectors). Some managers consider that appropriately allocating fisheries resources has become their second most important goal, after conserving the stocks and habitat (Beaumariage 1978, Henry 1984, Hall 1993, Gresswell & Liss 1995, van der Elst *et al.* 1997, Armstrong 1998, Marshall & Moore 2000, Kearney 2002a).

Competition and conflict between the recreational and commercial fishing sectors is a historic and current reality in many fisheries (Ruello & Henry 1977, Gartside 1986, Green 1994, Kearney 2002a, b, Sumaila 2002). Moreover, conflict between commercial fishers and recreational fishers (anglers), may be inevitable: both sectors often fish in the same area and may target the same species, particularly inshore and close to population centres (Kearney 1995b, Ramsay 1995, Scialabba 1998, McPhee *et al.* 2002). Both sectors are increasingly finding themselves competing directly with each other at the same locations and times as the population size continues to increase, along with increasing accessibility to many fishing locations (Smith 1980, Henry 1984, Gartside 1986, Edwards 1990, van der Elst 1992, Hannah & Smith 1993, Green 1994, Kearney 2001, 2002b, Sumner 2003).

Conflict over resource allocation can be detrimental to long-term sustainability of natural resources for two reasons. Firstly, it can increase resistance of both sectors to precautionary approaches to management or further fisheries regulation without strong supporting scientific data on the relative catch shares allocated to each sector and the impact of management on such catch shares (Bennett 2000, Fisheries WA 2000). Secondly, conflict may shift the management focus from other impacts on the resource such as environmental damage (Kearney 2002a). Understanding and dealing with conflict, therefore, is an important part of effective fisheries management.

In north Queensland estuaries, competition and resulting conflict for barramundi (*Lates calcarifer*) between recreational line fishers and commercial set gillnet fishers is apparent via complaint letters to fisheries departments and letters and articles in the public media with headlines such as: "Close Cairns-Cooktown to commercial fishing" (Eussen 2001), and "Net ban call but pro says it's 'knee-jerk'" (Knowles 2001). Such letters and articles, plus threats of physical violence and vandalism of fishing gear, are common to many resource sharing situations (Ruello & Henry 1977, Henry 1984, Anderson 1999, Kearney 2002b, Pike 2003). Opinions expressed via such media frequently influence decisions that allocate or distribute access to shared fisheries resources. It is not known, however, whether the expressed conflict is experienced by the general fishing public or is predominantly the opinion of vocal minorities.

Objectives

The purpose of this paper is to examine how recreational and commercial fishers in north Queensland view competition and conflict between the two sectors, by interviewing a representative sample from each sector. Specific objectives are:

1. To determine the extent of perceptions of competition and conflict between recreational line and commercial gillnet fishers in north Queensland;
2. To examine how fishers from each sector view their own and the competing sector;
3. To document fishers' suggested solutions for resource sharing conflict.

Research methods

I used an extensive questionnaire program to examine the opinions and perceptions of recreational line and commercial gillnet fishers in north Queensland, between Cardwell and Ayr. I interviewed anglers via boat ramp surveys, and commercial fishers through pre-organised face-to-face interviews (Ethics approval H 441). All responses to questionnaires were kept confidential to encourage honesty.

A mixture of closed, partially closed and open-ended questions were developed based on the above objectives. Questionnaires were subjected to review and a pilot study with fishers and other researchers before being finalised. Each questionnaire took approximately 10 minutes to complete.

Recreational fisher boat ramp surveys

Anglers were sampled via access point (boat ramp) "Bus-Route Surveys" (BRS), where each boat ramp is treated as a "bus-stop" along a set route, similar to a bus timetable. Each ramp was visited for a set amount of time which was pre-determined according to the expected number of people that used that ramp. The BRS method reduces under-coverage bias and ensures fishers with different demographics are included in situations where there are numerous access points and relatively low fishing effort, which is consistent with the study area (Robson & Jones 1989, Jones & Robson 1991).

A total of 22 boat ramps allowing access to estuaries that are open, closed or partly closed to commercial gillnet fishing (including those within Dugong Protection Areas) were chosen randomly from a complete list of boat ramps in the study area. The study area was divided into four regions, each with 2-3 high-use and 2-3 low-use ramps. Each region was sampled for six days (three weekdays and three weekend days) in April and May 2002. In total, 377 anglers were interviewed, which is adequate to yield a 95% confidence interval with a margin of error not exceeding 5% for a population proportion (McNamara 1994).

Commercial gillnet fisher questionnaires

Due to confidentiality of commercial gillnet fishers' details it was not possible to obtain a list of fishers. As such, fishers were contacted by Queensland's Department of Primary Industries and Fisheries (QDPI&F), and were alerted to the research via *The Queensland Fisherman* magazine. Those fishers who had recorded barramundi catch in the study area in the previous five years were asked to contact me about the questionnaires. Once some fishers had made contact, additional fishers were contacted by word-of-mouth and recommendation to compensate for a low response rate to the original request from

QDPI&F. A total of 28 fishers (from an estimated 78 relevant fishers, (QDPI&F 2002)), were interviewed face-to-face at a location and time convenient to the fisher.

Results

Objective 1: To determine the extent of perceptions of competition and conflict between recreational line and commercial gillnet fishers in north Queensland.

Fishers from both sectors agreed that competition and conflict between recreational and commercial estuarine fishers is a perceived problem (at least at some level) in the local community (Fig. 1a). Over half of the anglers interviewed, however, stated competition was 'no problem' for them personally (Fig. 1b). Many commercial fishers also agreed competition was 'no problem' for them personally, but commercial fishers differed from anglers in that 40% of fishers thought competition or conflict was a 'big' problem for them personally (Fig. 1b). Reasons given were "verbal abuse" (18% of fishers), "vandalism of equipment" (18%) and "blame from anglers for perceived declines in catches" (11%).

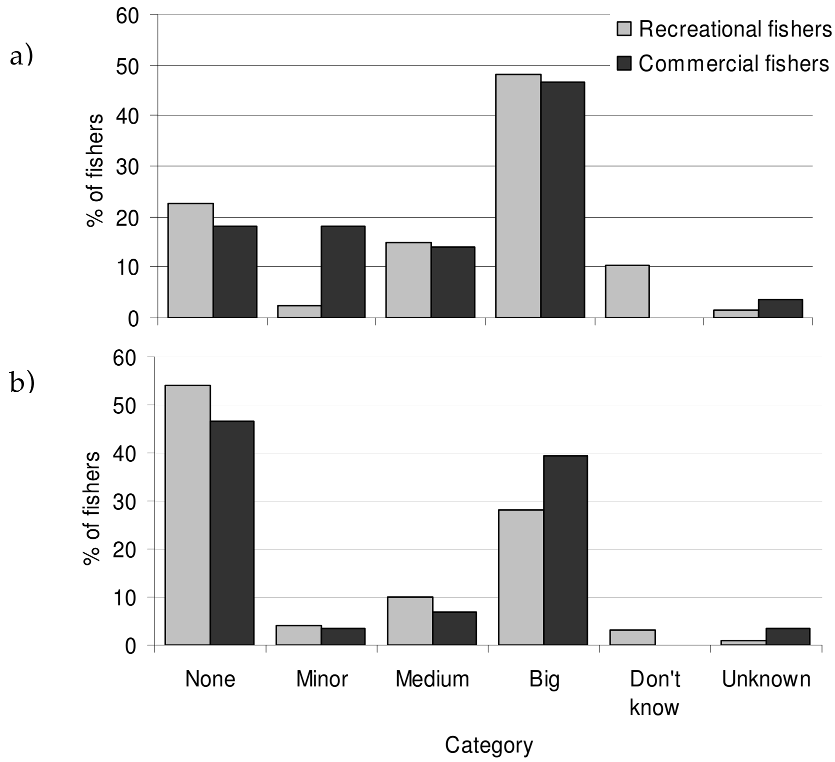

Figure 1: Percentage of recreational and commercial fishers in each answer category for the question: "Do you think competition/conflict between recreational and commercial fishers in estuaries is a significant problem a) in the local area? b) for you personally? If yes, at what level?"

Objective 2: To examine how fishers from each sector view their own and the competing sector.

Fishers from each sector had more positive views of their own sector than their competitors did (and vice versa). For instance, when anglers were asked if they thought their sector had an impact on estuarine fish stocks, the results were mixed but less than 20% thought they had a 'big' impact (Fig. 2). In contrast, 63% of commercial fishers thought the recreational sector had a 'big' impact on estuarine fish stocks.

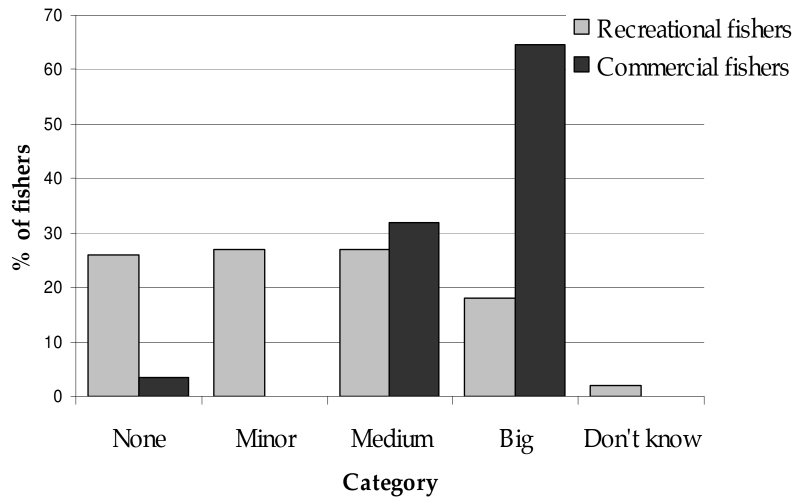

Figure 2: Percentage of recreational and commercial fishers in each answer category for the question: "Do you think recreational fishers as a group have an impact on estuarine fish stocks? If yes, to what degree?"

Similarly, 90% of commercial fishers viewed their industry as sustainable on the east coast, while only 11% of anglers thought the commercial gillnet fishery was sustainable (Fig. 3).

Despite this view, anglers agreed with commercial fishers that the commercial gillnet fishery was important to the community through the provision of fresh seafood, though this view was higher for commercial fishers (100%) than anglers (65%) (Fig. 4). Further, 88% of anglers stated they personally bought seafood to eat.

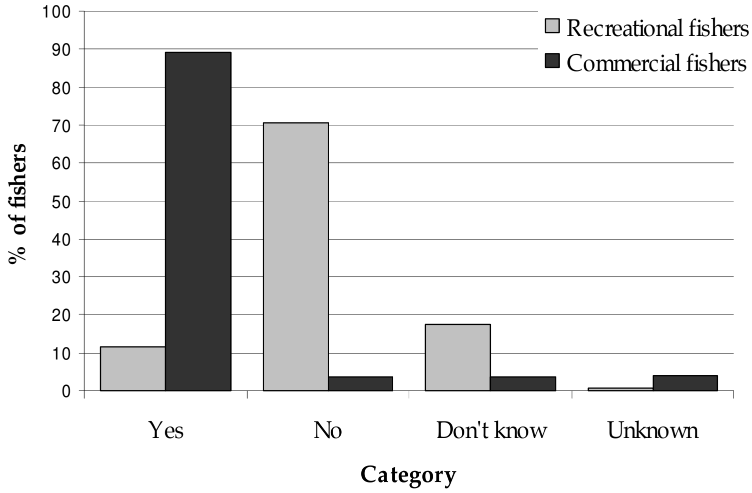

Figure 3: Percentage of recreational and commercial fishers in each answer category when asked "Do you think the commercial gillnet fishery is sustainable on Queensland's east coast?"

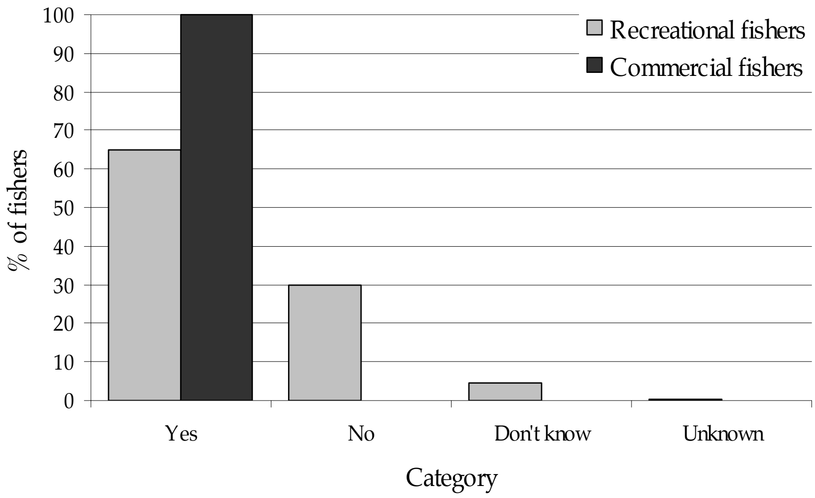

Figure 4: Percentage of recreational and commercial fishers in each answer category for the question "Do you think estuarine commercial gillnet fishing is important for the community in terms of providing fresh seafood?"

Fishers were also asked whether they 'liked' or 'disliked' the competing sector: Answers varied for the commercial and recreational sectors – many in each sector felt 'indifferent', but 55% of recreational fishers 'disliked' or 'strongly disliked' the commercial gillnet fishery, which contrasted to the commercial fishers where less than 20% 'disliked' the recreational sector (Fig. 5).

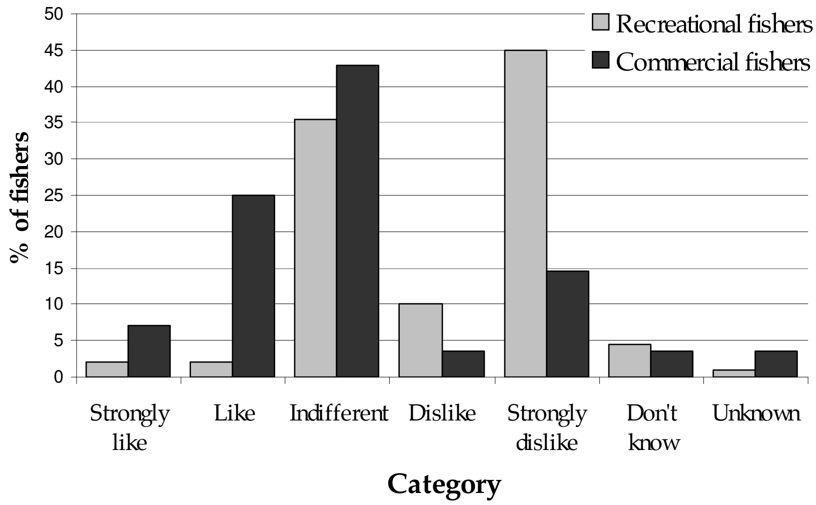

Figure 5: Percentage of recreational and commercial fishers in each answer category for the question "Do you like or dislike the competing sector (as a group)?"

There were a number of reasons given by fishers when they were asked to state, in their own words, what affected their opinion of the other sector. For those anglers that 'liked' the commercial sector, the reasons most commonly quoted were "they are necessary" (including "they provide seafood") (30%), "I have personal contact/history with the fishery" (20%), and "they are making a livelihood" (20%). For those who 'disliked' the commercial sector the most common reasons given were the commercial fishery "over-fishes" or is "unsustainable" (34%), "takes a lot of bycatch" (18%), and is "competing with recreational fishers" (14%).

For those commercial fishers that 'liked' the recreational sector, the reasons most commonly given were they had "no issue" with the recreational sector (22%) or they "also recreationally fished" (22%). The commercial fishers that stated they 'disliked' the recreational sector quoted reasons such as anglers' "lack of knowledge of commercial operations or regulations" (50%), and that "anglers don't like us" (32%). When asked directly, 60% of commercial fishers thought their sector caught less barramundi than the recreational sector on Queensland's east coast[1].

For both sectors, most fishers thought the other sector had some negative practices such as keeping undersize fish and large female barramundi (Fig. 6). Seventy five percent of commercial fishers also thought anglers regularly kept more than the legal bag limit, and 89% thought anglers kept fish to sell on the "black market". Regulations regarding barramundi for the recreational and commercial sectors are shown in Table 1.

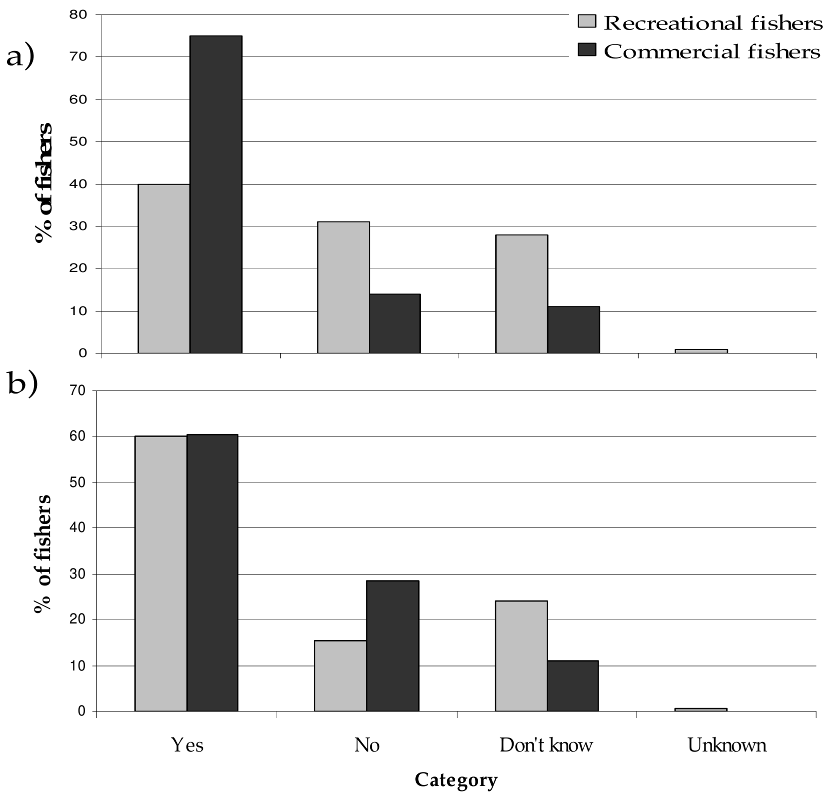

Figure 6: Percentage of recreational and commercial fishers in each answer category when asked "Do you think the other sector regularly keeps a) undersize fish?; b) barramundi over 1m (large females)?"

[1] Annual barramundi catch estimates are similar for each sector on Queensland's east coast. E.g. in 1999 the commercial sector recorded 211 tonnes of barramundi (QDPI&F 2002), while QDPI&F recreational fishing surveys estimated recreational barramundi catch at 270 tonnes (Roy Morgan Research 1999).

Table 1: Some of the regulations for barramundi fishing in Queensland waters (Fisheries Act 1994).

Regulation	Recreational sector	Commercial sector
Minimum legal size limit	58 cm	58 cm
Maximum legal size limit	120 cm	120 cm
Bag limit	5 fish per person	Nil
Sale of catch allowed	No	Yes
Netting allowed	No	Yes

Results indicate that fishers blame the competing sector, at least to some extent, for perceived declines in catches: 65% of anglers stated their catches had declined in recent years (Fig. 7), which they attributed mostly to "commercial fishing (presence/ increase)" (30%), "recreational fishing effort" (17%), "overfishing by all groups" (16%), and "environmental damage" (9%). For those anglers that thought their catch had increased, the most common reasons given were "commercial fishing absence" (27%), "restocking" (23%), "more experience" (19%), and because of "regulations (including closed season)" (7%). Commercial fishers were varied in their opinion about decreased, increased or unchanged catches (Fig. 7). Those that thought their catches had increased most commonly quoted "weather (including wet season)", (33%), "regulations (including closed season)" (33%), and "more experience" (17%) as likely causes for the increase. Most commercial fishers quoted "weather (including wet season)" (50%) as the cause of declines in catch as well. Also listed by those claiming their catches have declined were "environmental damage" (20%) and "recreational fishing effort" (20%).

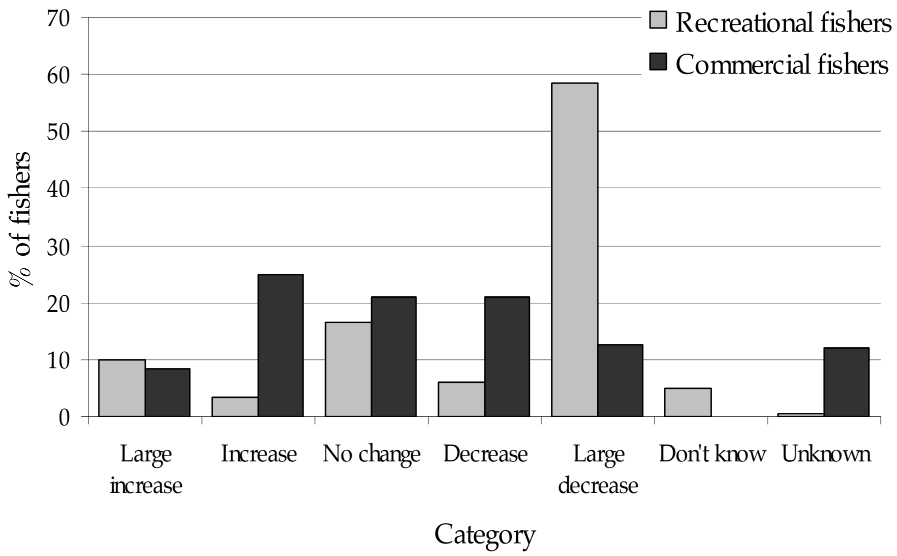

Figure 7: Percentage of recreational and commercial fishers in each answer category when asked they think "the average number of fish you catch has changed in recent years?"

When fishers were asked to list what they saw as the biggest threat to local estuarine fish stocks, anglers listed, among other things, "commercial fishing" (65%, with most citing gillnetting specifically), "overfishing by both sectors" (18%), "environmental damage" (18%), and "recreational fishing" (5%). In contrast, the most common answers from commercial fishers included "environmental damage" (79%), "illegal fishing" (25%), "increased recreational fishing" (18%), and "absence of wet season" (14%).

Objective 3: To document fishers' suggested solutions to perceived conflict.

Many anglers suggested "reducing commercial effort" (28%) and "segregating the two sectors" (21%) as methods of reducing competition and conflict. When asked directly, 75% of anglers suggested it was necessary to close more estuaries to commercial gillnet fishing, making these estuaries effectively Recreational Only Fishing Areas (ROFAs), at least for finfish. Other suggestions included "changing the current regulations for the commercial fishery" (16%), "closing areas to all sectors" (11%), "increasing communication and education of fishers" (9%), "increasing policing and monitoring" (9%), "reducing recreational effort" (8%), "increasing aquaculture as a substitute for wild-catch fisheries" (7%) and "restocking" (4%).

Most commercial fishers (82%), suggested "education" of both sectors regarding each others' operations and impacts, and "improved communication" between the two sectors, as key methods to reduce competition and conflict. Commercial fishers' other suggestions included "increasing policing and monitoring" (25%), "giving sufficient compensation to commercial fishers when segregation is introduced" (11%), "introducing recreational fishing licences and using the revenue to buy-out commercial licences" (11%), "rotating closures to all sectors" (11%), "sharing the resources" (11%), and "segregating the groups through sector-specific closures" (4%). When asked directly if more closures for commercial gillnetting were necessary, 85% of commercial fishers answered "no".

Discussion

The finding that over half of the anglers interviewed think competition and conflict is a problem within the community, but not for them individually, suggests that perhaps many anglers see the problem outlined in the local media, but don't themselves encounter commercial gillnet fishers often. Such a conclusion is supported by the recent National *Community Perceptions of Fishing* survey which concluded that very few people had direct experience with the commercial wild catch sector, and that much of the media coverage of the sector was negative (Aslin 2001). This conclusion is also supported by the opposite finding for the commercial sector: 32% of commercial fishers "like" the recreational sector, and one of the main factors that affected this opinion was that they also recreationally fish, and thus have significant contact with the sector.

Both recreational and commercial fishers held positive opinions of their own sector, and negative opinions of their competitors. In such situations, it is common for fishers to blame their competitors for adverse experiences (such as declining catch, perceived or real). The likelihood that fishers from one sector will blame the other sector for negative outcomes depends on how fishers perceive their own sector's operations and impacts, those of the competing sector, and whether they value the competing sector as an important part of the community (Holder 1992, Nakaya 1998). Blame can come from both the recreational and commercial sectors, and may be a major cause of conflict between the sectors (Jacob & Schreyer 1980, Garrell 1994, Morgan 1999, Stoll-Kleemann *et al.* 2001, Bickerstaff & Walker 2002, Kearney 2002b). Findings of this study show that most anglers hold commercial fishing as responsible for declines in catches (and the absence of commercial fishing as most responsible for increases), and most consider commercial fishing as the greatest threat to the resource. According to some studies, anglers are more likely to blame commercial fishers for declines in catch, rather than themselves or any other sector, partly due to their inability to see their individual catch as part of the overall recreational fishing harvest (Gartside 1986, Ballantine 1991, McMurran 2000, Kearney 2002b, Henry & Lyle 2003, McPhee & Hundloe 2004). This held true for this study, although anglers consider the commercial sector as important to the community, despite negative views of their operations and impacts. For commercial fishers, while recreational fishing was listed as a possible cause of catch declines and a treat to the resource, it was only listed as such by about 20% of fishers.

Importantly, blame for negative outcomes may be unnecessary, as many of the reasons fishers gave for “disliking” the competing sector are contradicted by scientific information. For example, while anglers believe commercial gillnetting results in capture of undersize barramundi and bycatch species, research from Queensland’s Department of Primary Industries (QDPI) and the Australian Institute of Marine Science (AIMS) concluded that set gillnets targeting barramundi are highly selective, with low catches of undersize barramundi and bycatch species (Halliday *et al.* 2001). Similarly, recent catch figures for the two sectors are not congruent with the opinions of anglers and commercial fishers. Commercial fishers think recreational harvest is higher than commercial take and recreational fishers think the commercial fishery is unsustainable while the recreational sector doesn’t have a big impact on fish stocks. Documented catch data, however, show the harvest of barramundi for both sectors on Queensland’s east coast is very similar (270t for recreational and 211t for commercial in 1999 (QDPI&F 2002)), Thus, many of the apparent negative opinions may be based on misinformation, suggesting accurate information about fishing practices is not reaching the general fishing public.

Improved communication between competing sectors is often suggested to reduce conflicts (Jeffries 1995, Kearney 1995b, France 1997, Ministry of Fisheries 2002), and was suggested by 82% of commercial fishers and 9% of anglers interviewed. Education of each sector regarding the operations and impacts of their own sector and their competitors may help to reduce blame and hence conflict, by reducing misperceptions which often form the basis of conflicts between commercial and recreational fishers (Berkes 1984).

Recreational Only Fishing Areas (ROFAs), which were suggested by many anglers, are commonly suggested to reduce conflict by reducing contact between the two sectors through segregation (Hendee 1974, Samples 1989, Brayford 1995, van der Elst 1997). Results indicate that anglers may already have limited contact with commercial gillnet fishers as most don't see competition as a personal problem. Contact may be limited currently through time segregation already implemented (i.e., no commercial gillnets are allowed in estuaries on weekends (Fisheries Act 1994), when anglers are most active). Thus, it is questionable whether more segregation is necessary. In addition, further ROFAs may have the undesirable affect of increasing conflict in the adjacent 'open' areas as commercial fishers relocate (Elmer, pers. comm., DPI&F 2004, Hancock 1995).

Moreover, preliminary results from the questionnaires (not shown here) indicate most anglers currently do not choose their fishing locations according to presence or absence of commercial fishing. Perhaps as a result (or a causal factor in the absence of discrimination of fishing locations), most anglers are unaware of which estuaries are currently closed to commercial gillnet fishing in their local area. This suggests that ROFAs may not segregate the sectors as intended, and thus the effectiveness of area segregation in reducing conflict remains questionable at this time. Perhaps anglers should first be informed about current closures to commercial fishing before the need for further closures is reassessed, as ROFAs also have inherent financial and social costs (Anderson 1999, Hushak 2000, Smith *et al.* 2003).

This project highlights the importance of social research in resource allocation situations. In this case, without accurate and representative information managers may be influenced to pursue potential solutions to conflict that are based on opinions of recreational anglers and/or commercial fishers assumed from the media but will prove relatively ineffective for most anglers or commercial fishers. Overall, results suggest that current conflict between sectors may be eased best through increased education and communication.

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DISCUSSION MINUTES

Comment (Mike Cappo): You mentioned that science is not being communicated – in my experience journalists are only interested in turning scientific information into controversy. Perhaps you should interview journalists!

Response (Renae Tobin): I agree, it is difficult to get a non-controversial topic out in the media, and they can often twist your words. I have had problems personally. There needs to be a way of getting the information out safely.

Comment (Mike Cappo): In the ROFA's that are in (Haughton and now Hinchinbrook) I can't catch a fish – I think fish are there, but they are difficult to catch. Fishers like to blame someone.

Response (Renae Tobin): When you talk to fishers, messages are very variable between fishing being improved in areas like Hinchinbrook since commercial netting was banned, to fishing being worse as there are more recreational fishers there now. I am hoping to look at catch information from charter fishers and SUNTAG on whether fishing has improved in Hinchinbrook since the Dugong Protection Areas (DPAs) were introduced in 1997 – it's the most recent closure and probably the only area we might be able to get before and after information.

Response (Jeff Snell): In Cardwell, 6-7 yrs ago, fish coming into fishing competitions were all measured as they were close to the Minimum Legal Size (MLS). Now very few fish are measured as they are well over the MLS, so the catch of big fish has improved.

Response (David Bateman): Also, John Harrison is running a project looking at the recreational catches in the McArthur River in the Northern Territory (NT) which has recently been closed to commercial netting – they have good before data.

Question (James McClellan): Have you looked at the economics with respect to the situation in the NT where the money generated by fishing tourism is much more valuable than it would have been if commercial fishing was at the same levels?

Response (Renae Tobin): I didn't look at economics at all, although numerous other studies have and the use of economics in such situations could generate its own discussion. NT is a very different situation, but it appears from my data here that fishers aren't choosing their current fishing locations according to presence or absence of commercial fishing. And they don't know where the current closures are. So, I suggest that fishers should first be informed about where the current closures are, then reassess whether this motivation and knowledge changes, before looking to implement more closures.

Question (James McClellan): Have you measured levels of black market of barramundi sales?

Response (Renae Tobin): It's impossible to get a good measure of that.

Question (Sue Bandaranaike): This is a good perception study Renae. Have you also looked at whether there are any gender, age or location variations?

Response (Renae Tobin): I have the data there, but haven't got to that just yet. I intend to.

Question (Danny Brooks): Is recreational fishing increasing/decreasing?

Response (Renae Tobin): I didn't really look at that, RFISH would probably be the best place to start, and their last survey suggests it is decreasing in Queensland.

Question (Danny Brooks): I also hear a lot that people won't fish now due to Green Zones.

Response (Renae Tobin): I did these surveys before the new Green Zones were introduced, and probably before they were suggested much in the public arena. People didn't have that much knowledge of closures at this stage.

Comment (Neil Green): This is excellent research and needed by the commercial sector. If you look at the Burdekin district, 70% of the area is closed to commercial net fishing and we still have conflict between recreational and commercial fishers. Conflict comes back to enforcement. In this area we don't have the officers to make sure that fishers aren't fishing in areas they shouldn't.

Response (Renae Tobin): The Burdekin may come out different to other areas as there is such a small community, and there are a lot of estuaries closed to commercial netting. I agree with the lack of enforcement – a lot of fishers (commercial and recreational) mentioned this being a problem and thought if fishers didn't fish in closed areas they wouldn't have a problem with it.

Comment (Neil Green): With big wetland areas in the Burdekin, these may influence information from this area. Public awareness, like this sort of research is very important to QSIA. At the last FIDC (Fishing Industry Development Committee), meeting we raised what's important to commercial fishers – getting information out to the general public was highlighted as a priority. I'd like to suggest a two page summary from this research to FIDC, MACS, politicians, "Science in Parliament Days", etc. as this would be very beneficial. Traditional barramundi fishers are now being pushed from flats to creeks (increased localised effort). With new State closures, this may be an important consideration as it may increase the competition in the area.

Response (Renae Tobin): Yes, this might be an issue, but many recreational fishers seem to have limited contact with commercial net fishers, as your average angler fishes mostly on weekends, and gill netting is not allowed in estuaries on weekends.

Comment (Neil Green): Yes, many are unaware of those rules – I tried to explain to the politicians that some fishers are reduced to only 12 days fishing per month due to these weekend closures and they can't make up this time as areas like the bays (where they would normally fish on the weekends) are now closed to them. I also have spoken to you Renae about regional closures in inshore areas.

Response (Renae Tobin): Yes, these were highlighted by both commercial and recreational fishers interviewed as a way to reduce conflict. For instance, when there are local fishers regularly fishing an area, sometimes other fishers come from down south, for example, and crowd the area - this upsets both local recreational and commercial fishers. Fishers also suggested that if there was regional management the fisher allocated to that area may look after it better.

Comment (Neil Green): For any future fish management, there needs to be more input from community (consultation). This research is important to that process.

Question (Donna Kwan): Why do you think there was such a difference between the recreational and commercial sectors regarding education and communication as a solution?

Response (Renae Tobin): One of the main reasons commercial fishers highlighted for why they didn't like the recreational sector was that they felt they had a lack of knowledge of the commercial fishing industry or its regulations.

Question (Donna Kwan): Does it reflect difference in management regimes?

Response (Renae Tobin): Possibly, although both industries are subject to many regulations, including new ones.

Comment (Steve Sutton): The media like conflict. One of the benefits from this sort of research is that it shows that media coverage may not be the view of the majority, but a vocal minority.

Response (Annabel Jones): There is a research project on the public's perceptions of fisheries and where they get information from, and the importance they place on it. A lot of fishers get their information from magazines. Information from Government agencies were often not taken up well by fishers. This is a key factor for any public education strategy.

Response (Renae Tobin): You need sources of information that people can trust. For instance EcoFish have the right idea in being proactive about getting positive information out about the commercial sector, but it has come from the commercial sector – do people trust it? We need an impartial source. This is difficult.

Comment (Steve Sutton): You need to know what to educate people about before we go into a communication strategy. We need to know where the misperceptions are.

Comment (Danny Brooks): Don't underestimate the power of perception – perception is politics and politics become policy.

Question (Neil Green): The recreational fishing sector tends to catch smaller fish than the commercial sector – did you find that?

Response (Renae Tobin): I asked the commercial fishers I interviewed what their preferred size was and most listed fish between 60-70 cm. Recreational fishers vary – some are interested in trophy fish, others are looking for edible fish.

Question (Andrew Tobin): Do you have information on what percentage of the recreational catch is above Minimum Legal Size?

Response (Renae Tobin): The RFISH surveys show that about a quarter of the total recreational catch is kept, but those released could either be undersize or from catch-release fishing. The logbooks I collected are not a good indication of this, as my these were mostly kept by club fishers or avid fishers that are probably better fishers, and not representative of the whole recreational fishing sector. I'm sure RFISH would have this information.

Comment (David Bateman): The general public is greatly influenced by the media even though they don't fish themselves. They influence politics so education of non-fishers is important too. We need to see if non-fishers perspectives differ from recreational fishers to see what affect the media has.

Response (Renae Tobin): Yes, we tried to submit a project last year looking at the perceptions of non-fishers, to follow on from the *National Community Perception Survey* which had low sample numbers. Unfortunately it didn't get funded, but we'd be happy to polish it up with your help and support.

SESSION 3: TRADITIONAL FISHERIES AND THEIR MANAGEMENT IN TORRES STRAIT

Kaikai fishing: traditional subsistence reef fisheries in the Eastern Torres Strait Islands.

Sara Busilacchi

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Abstract

Communities from the Eastern Torres Strait (ETS) Islands have been relying on reef fish as a primary source of food for centuries and, recently, indirectly as a major source of income. There is, however, little documented information on how much fishing is being conducted in the ETS, what species are being targeted, how this fishing is being conducted and how the fishery has changed in the last decades. Documented information on the ETS subsistence reef fishing sector is essential for an exhaustive and reliable assessment of the status of the reef fish in the region and therefore related management decisions. The objectives of this research are to characterise the subsistence reef fisheries on Darnley, Yorke and Murray Islands in the ETS collecting catch and effort data as well as recording information on past subsistence fishing practices and catches. A clear picture of the present status of the subsistence fishery and how it has changed through time will be part of the final outputs of the research. Preliminary results showed some interesting characteristics of the subsistence reef fishing sector. These included changes through time in species harvested for direct consumption and presence of undersize fish in the subsistence catch. Differences in catch composition were also detected between islands where the community sector targets reef fish and islands where reef fish are not the main target of the community sector. Results so far suggest the importance of monitoring the subsistence sector to identify its magnitude, catch characteristics and impact on the reef fish resources. Participation and involvement of the indigenous

communities in the monitoring program is essential for the positive outcomes of the research.

Introduction

Reef fisheries yield an estimated 1.4-4.2 million metric tons of fish annually, corresponding to 2-5% of the global fisheries catch. Yields are variable and range from 0.2 to 40 tonnes/km^2/yr (Russ 1991). Reef fisheries are heterogeneous, small-scale and multi-species (Pauly 1997), typically using several gear types adapted to different species and seasons (Munro 1996). These fisheries are also usually multi-sectorial, with subsistence, commercial and recreational fishing sectors. Subsistence fisheries have been estimated to account for around 80% of the fishing pressure for most Pacific islands (Dalzell et al. 1996). As such, the subsistence sector, though rarely studied (Pauly 1997), is quite significant, and therefore should always be considered when assessing the impact of fishing on shared fish stocks (Labrosse et al. 2000, Djama et al. 1997).

The subsistence reef fishery in the Eastern Torres Strait

Torres Strait, considered Australia's marine "outback", lies between Cape York, Australia, and the south coast of Papua New Guinea (Figure 1). Torres Strait Islanders are seafaring people who have a long-standing affiliation with the sea, harvesting reef fish for subsistence for centuries (Nietschamann 1989, Johannes & MacFarlane 1991). Traditionally, reef fish were harvested on home reefs using a variety of methods, including spears, hook and lines and fishing traps (Johannes & MacFarlane 1991, Harris et al. 1995). However, characteristics of the Islander subsistence fishery have changed in recent decades; the introduction of powered boats and the construction of community freezers on the islands have prompted the development of a commercial Islander (defined as "community") sector. Today, Islanders sell most of their catch, while retaining the non-saleable or non-regulated product for consumption (subsistence). Such product, including undersize fish and low value species are replacing the fish species traditionally consumed.

In the early 1990s, annual yields of reef fish per unit of area from the subsistence sector were estimated to be around 0.29 t/km^2/yr in the eastern Torres Strait (ETS) overall and 0.4 t/km^2/yr on Yorke Island alone (Johannes & MacFarlane 1991, Harris et al. 1995). Compared to yields from other tropical reef fisheries, these yields indicated a low level of exploitation of reef fish in the region. However, in the last decade, exploitation levels of reef fish for subsistence may have increased and shifted to fewer species which are taken as by-catch during commercial fishing trips.

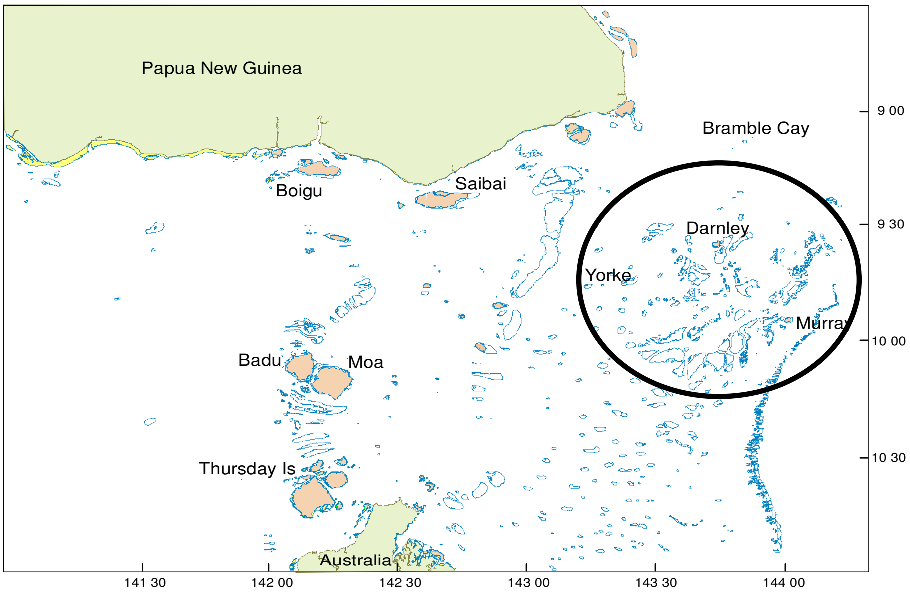

Figure 1. Map of Torres Strait. Study area and islands are indicatively highlighted in the oval.

The Islands of Darnley (Erub), Yorke (Masig) and Murray (Mer) in the ETS share the same traditional hunting and fishing areas and probably the same reef fish stocks (Figure 1). More importantly, some of these reef fish stocks are also exploited by the non-Islander commercial sector. The ETS reef line fishery is thus composed of three sectors: non-Islander commercial operating from large, mobile fishing vessels; Islander commercial from small dinghies (< 5 m); and Islander subsistence harvesting for their own consumption or for use in traditional activities (Mapstone et al. 2003, Begg & Murchie 2004). Minimum legal sizes (MLS) and other management regulations apply to both commercial sectors, community and non-Islander, while no regulations apply to the subsistence sector (Table 1).

Table 1. Management regulations for the three fishing sectors of the reef line fishery in the ETS.

Sector	Management measures			
	Limited entry	**Gear restriction**	**Area closure**	**MLS**
Commercial non Islander	Yes	3 lines/person 6 hooks/line Vessel length < 20m	Not allowed west 142° 31′ 49′′ (i.e. Cape York)	Yes
Commercial Islander	No	3 lines/person 6 hooks/line Vessel length < 20m	Not allowed west 142° 31′ 49′′ (i.e. Cape York)	Yes Main management measure
Subsistence	**No**	**No**	**No**	**No**

Any assessment of the exploitation level of the reef fish in the ETS should consider all three sectors, with their different management regulations and characteristics. Currently there are no evaluations of: (1) the impact of the fishery on reef fish of the ETS or (2) the importance and characteristics of the ETS subsistence sector to the total annual catch of reef fish. Documented information on the ETS subsistence reef fishing sector is essential for an exhaustive and reliable assessment of the status of reef fish in the region and related management decisions. The necessity of an assessment of the fishery has been highlighted (Williams 1994, Mapstone et al. 2003) and recognized by Torres Strait communities, which are actively collaborating in my research to set up long term community based monitoring programs.

Research and paper overview

My research is part of the CRC Torres Strait program within the CRC Reef Research Centre. The objective of my PhD research is to characterize the subsistence reef fishing sector on Darnley, Yorke and Murray Islands, collecting catch and effort data and recording information on past fishing practices. A clear picture of the present status of the subsistence reef fishing sector and how it has changed through time will be part of the final outputs of the research.

This project is complementary to another CRC Torres Strait project investigating the commercial sectors of the ETS reef line fishery. Together the two projects will give an overall picture of the exploitation level of reef fish in the ETS.

This paper introduces my PhD research, which started in January 2004. Particular attention will be given to the survey program which is the critical part of the project. Preliminary results obtained during my first visit to the Islands are outlined.

Survey program and community involvement

To characterise the subsistence fishing practices in the ETS, Darnley, Yorke and Murray Islands will be visited quarterly for 18 months. Two weeks will be spent on each island each visit. During this period, I will directly collect catch and effort data from the subsistence reef fishing sector and interview community members. I will train volunteer observers, involve school students in the survey, update communities with research findings and verify the collection process.

The survey program is the most critical part of the project and final research outcomes will greatly depend on the quality and quantity of the collected data. This project relies largely on the collaboration and acceptance of the research by the Islander communities. Previous studies found that participative approaches to research, in which local communities are involved and understand all stages of the research, are more likely to produce positive outcomes in terms of data collection and acceptance of subsequent research findings and management decisions (FAO/DANIDA 1999, Phelan 2001).

Issues related to the collection of subsistence fishing data have been discussed with community members who expressed an interest in being directly involved in the survey. Various approaches have been discussed and decided upon, and specific community members identified to be involved in the survey. Diversification in the data collection is necessary to ensure cross-validation among data collected and maximize the amount of data that can be collected.

Data collection methods

Apart from the data I will collect during my visits, other sources will also be used including:

1) School students will be involved in the collection of fisheries data from their household. The methodology is based on that used in previous surveys of subsistence fisheries in a Pacific island, and turtle and dugong hunting in the Torres Strait (Hosch 2000). During subsequent visits, school students will be taught about the importance of monitoring and protecting marine life. Simple logbooks will be provided to the students who will be shown how to record fisheries data.
2) One or two community volunteers, depending on the availability on each island, will be trained to routinely collect catch and effort data using simplified logbooks. A volunteer has already been trained on Darnley Island, where subsistence fishing data for the project are now regularly collected. Community volunteers, students and I will collect catch (e.g., species composition, total weight for each species in the catch and length) and effort (e.g., fishing areas, numbers of people fishing, time spent fishing, fishing gears) data.

During the surveys, information on past fishing practices will also be recorded, to help reconstruct historical catch and effort trends of the subsistence fishery and determine the historical importance of commercial species to subsistence fishing. When historical data are not available, traditional knowledge provides an invaluable tool to retrospectively analyse the resource (Haggan et al. 2001, Phelan 2001). Determination of the commencement of the community sector will also help detect changes in the subsistence sector related to their socio-biological interactions. Changes in the composition of the subsistence catch could be detected in coincidence with the development of the community sector, since undersize and low value species taken during commercial trips may have replaced the fish species traditionally eaten for subsistence.

Community members will be interviewed via structured interviews, which facilitate the collection of catch and effort data (FAO/DANIDA 1999). Traditional Ecological Knowledge (TEK) will also be collected and used, whenever possible, to complement the scientific knowledge collected on the biology and ecology of the harvested fish species. Traditional fish species and reef names will also be recorded to assist in identifying fished areas and fish species. The aim is to integrate the historical trends of the fishery and indigenous TEK in the quantitative assessments.

Reciprocal trust and respect form the basis of any collaborative research with indigenous communities. Routine meetings will be organized, posters left at the end of each visit and articles in general newsletters published to update community members about the research status and to seek their input and opinions. One to one talks with community members, however, seem to be the best way to explain the research and its importance for the communities. I found substantial interest in my research during early visits to the islands. After talking, people volunteered to be involved, informing me when they were fishing and bringing me their catch to examine after a fishing trip.

Results

At this initial stage of the research, the results may not be representative of the general and annual subsistence fishing practices as they are only a snapshot of the fishing practices during my first visit. In this section I will highlight three interesting aspects of the subsistence fishing sector found during preliminary analyses.

1) The composition of the subsistence catch may have changed in the last decade, concomitantly with the development of the community sector. In Figure 2, catch composition recorded during my first visit is compared with that recorded in a previous study (Harris et al. 1995). Due to the difficulties of monitoring their harvest, I have intentionally excluded small pelagic species (sardines and anchovies) both from mine and the previous study. Sardines were the main component of the subsistence catch (16% of the total) in the early 1990s and, from my preliminary observations, still seem to be the primary targets. Catch

composition has changed since the early 1990s, however, when commercial fishing was estimated to be only 5-10% of the total catch. Species of commercial importance (coral trouts, other Serranidae, Lutjanidae and Lethrinidae) are now more frequent in the catch.

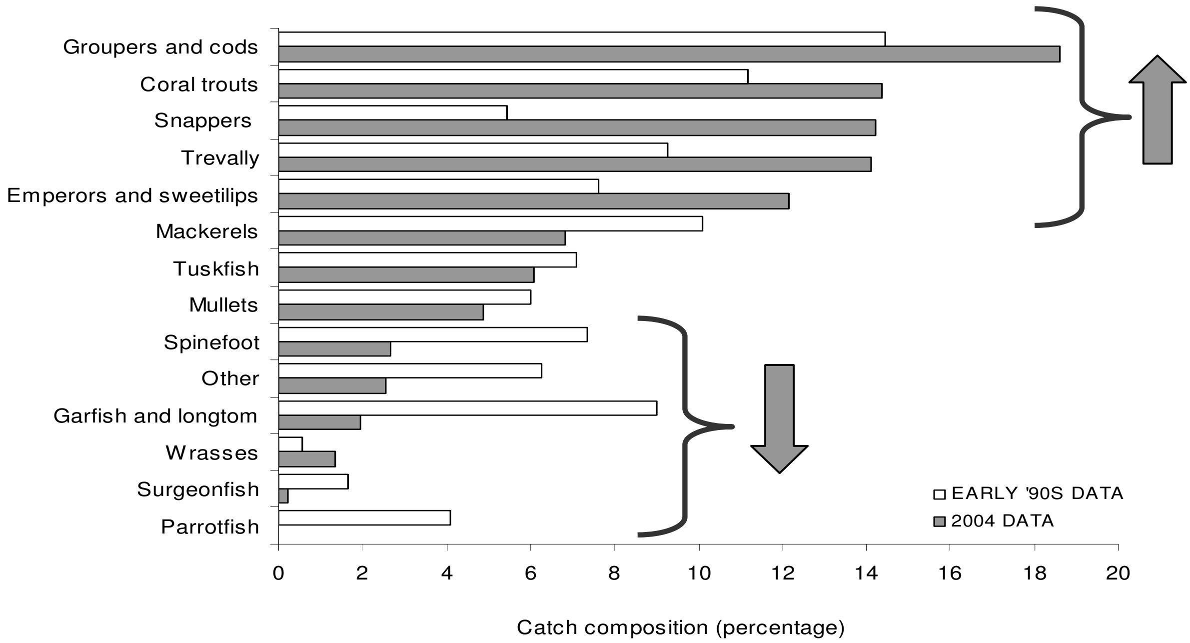

Figure 2. Comparison of the composition (percentage) of the subsistence catch in early 1990s (white bars) and in 2004 (grey bars). Total values for the three islands.

2) The species caught for subsistence during my visit were different between islands where the community sector targeted mainly reef fish and that where reef fish were not the main targeted species (Figure 3). For instance, on Yorke Island, where reef fish were not the main target of the community sector, the number of reef fish species/families harvested was higher than on the other two islands. While on Murray and Darnley Islands, where the community sector targeted reef fish, fewer species/families were present in the catch (Figure 3).

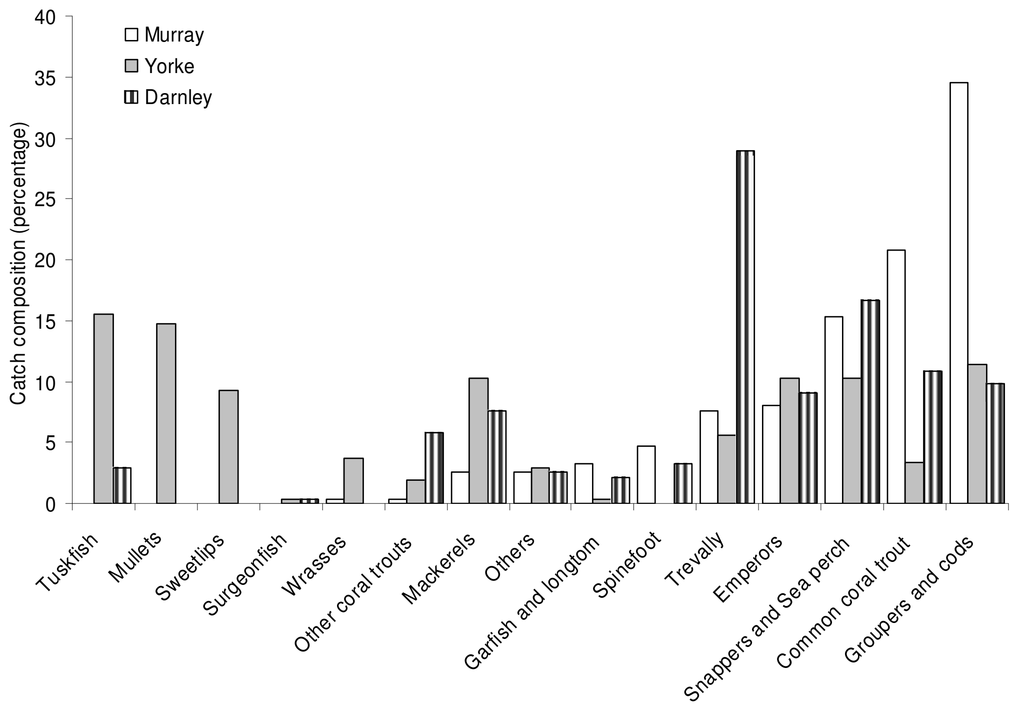

Figure 3. Composition of the subsistence catch on each island during the first visit.

3) The point to highlight is the presence of undersize fish found in the subsistence catch (Figure 4). For example, the length frequency distribution of common coral trout (*Plectropomus leopardus*) is shown, since it is the most valued commercial species and is also very frequent in the subsistence catch. In the graph, length is reported as fork length and not as total length, changing the usual MLS for coral trouts from 38 cm to 35 cm. Note that the subsistence catch is made up almost entirely of undersize fish. However, the quantities taken for subsistence are much lower than those harvested by the community sector for sale.

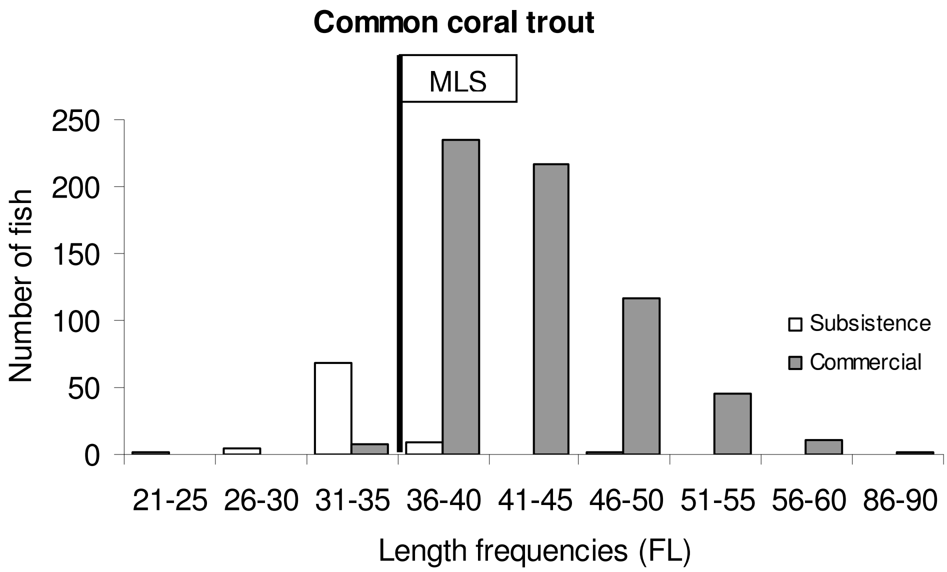

Figure 4. Quantities (number of fish) and lengths (Fork Length) of reef fish taken by the subsistence and community fishing sectors during my first visit.

Discussion and conclusions

The preliminary results showed some interesting characteristics of the subsistence reef fishing sector. These included changes through time in species harvested for direct consumption and presence of undersize fish in the subsistence catch. Differences in catch composition were also detected between islands where the community sector targets reef fish and that where reef fish are not the main target of the community sector.
Several factors may have caused the observed patterns, and cultural differences may be the main cause for the observed differences in species harvested for subsistence among the different islands. However, interactions with the community sector are likely to have a role in dictating the nature (species and sizes) of the current subsistence catch. If Islanders retain for consumption (subsistence) undersize and low values species harvested during the commercial fishing trips, they will likely fish less for the traditionally used species.
At this early stage of the research, however, it is impossible to discuss any further the results on the characteristics of the subsistence sector in the ETS. Only once the surveys and data collection are completed, will a clearer picture of subsistence fishing activities

in the ETS emerge. Results so far suggest the importance of monitoring the subsistence sector to identify its magnitude, catch characteristics and impact on reef fish resources. Participation and involvement of the Island communities in the monitoring program is essential for the positive outcomes of the research.

Further research

Once data and information on the activities of the present and past subsistence reef fishing sector are collected, mathematical models will be used to estimate the harvest of reef fish from the whole reef line fishery in the ETS. Inputs for the mathematical model will include: catch and effort data of the subsistence sector (present research project) and commercial sectors, both community and non-Islanders (complementary CRC Torres Strait research project); biological information (complementary CRC Torres Strait research project and literature); and information on historical fishing activities (present research project). The outputs of the model will include an estimate of the current level of exploitation of reef fish in the ETS, and an evaluation of long term scenarios simulating different exploitation levels and management regulations for the main harvested reef fish populations. Comprehensive results such as these analyses are rare in tropical fisheries, as usually the lack of biological information and fisheries data, which are difficult to collect, renders assessments impossible (Medley et al. 1993).

Acknowledgements

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Comment (John Marrington): With respect to minimum legal sizes (MSL), I found that lately there is more awareness of size limits within the communities and in some communities there is pressure from within to conform.

Response (Sara Busilacchi): Yes, they seem receptive to the idea and are interested in the research. People are starting to understand the importance of MLS and the biological basis for it. At one community I visited they were thinking of introducing measurement boards among the fishermen to avoid the take of undersize fish.

Comment (John Marrington): It seems the idea of size limits is becoming acceptable, 12 months ago this would have been hard to see as being possible.

Question (Andrew Tobin): Going back to the graph showing differences in catch composition between 1990 and 2000, is the change in catch reflective of changing fishing practices in the region? Are they moving away from traditional fishing methods such as fish traps and other traditional methods?

Response (Sara Busilacchi): With increased commercial fishing, fishers are bringing back home fish that can't be sold commercially, such as undersize and low value species, rather than taking fish from the traps and using other traditional fishing methods.

Comment (Andrew Tobin): When working on Torres Strait fisheries I got the feeling that fishing for subsistence was women's business while commercial fishing was for men.

Response (Sara Busilacchi): This depends on the island. Different islands have different traditions. For example, on Yorke Island women go line fishing as the men are more into diving.

Comment and Question (Sue Bandaranaike): I have found in Aboriginal communities that men wouldn't talk to me. I had to talk to women and this biased results. Are there similar problems in Torres Strait?

Response (Sara Busilacchi): The difference between men and women is not so marked in the Torres Strait communities as it is in the Aboriginal ones. I always talk to women first and then get introduced to men. But I have had no problems speaking to men as well. Fishers are interested and curious about what I am doing and speak directly to me. I do not know what will happen when I formally start interviewing people to collect historical information on the fishery.

Comment (Renae Tobin): Just for interest of different cultures, females doing boat ramp surveys in north Queensland tend to get better response rates, as the mostly male fishers don't feel as threatened or that they have to prove themselves.

Question (James McLellan): How did you contact communities? Is it hard to get into the communities?

Response (Sara Busilacchi): Toshi Nakata is the CRC Torres Strait liaison officer and he has been, and is, essential to get introduced into the communities and to build relationships within the communities. I do not think I would have been accepted without the help I have had.

Question (Martin Russell): Why aren't subsistence fishers catching bigger fish?

Response (John Marrington): They sell the bigger ones.

Question (Donna Kwan): Is it right there is no size limits for subsistence fishing?

Response (Sara Busilacchi): Yes.

Question (Andrew Tobin): If commercial fishing in Torres Strait becomes more popular with increased commercial catch, will we see increases in subsistence catch? Would it be a problem?

Response (Sara Busilacchi): This is why this research is important. It is important to quantify how much undersize fish is taken for subsistence and assess whether this can impact the stock. My guess is that undersize fish make up only a small percentage of the subsistence catch and will not impact the stock.

Question (Andrew Tobin): How would communities accept new MLS for subsistence fishing?

Response (Sara Busilacchi): I am not suggesting introducing MLS to the subsistence sector with my research. If management measures will be required I think other options would be better. I think education and information will play a major role. If Torres Strait Islanders see the need for size limits they will accept it.

Question (Gavin Begg): One challenge to this project is to get information out. How do you envisage working with school children will go?

Response (Sara Busilacchi): I do not know yet if it will work. There are some examples in the Pacific from engaging school children in research programs, but it remains to be seen how well it works in Torres Strait. If school students get involved I will be able to collect data for a large part of the community.

Question (Nadine Marshall): How do you gain the parent's trust and understanding?

Response (Sara Busilacchi): Most of the parents are also commercial fishers and the communities are small. So they know about the research and what is going on.

Question (Renae Tobin): What percentage of the community are fishers?

Response (Sara Busilacchi): It depends on what sort of fishing is considered. On each Island there are few real commercial fishers who go out fishing daily. More go fishing commercially occasionally when they need money. Most people in the communities fish for subsistence. Fishing is also the main form of recreation on the Islands.

Question (Donna Kwan): Do they just fish? Do they hunt at the same time?

Response (Sara Busilacchi): They are doing both.

Question (Donna Kwan): Can you incorporate information on fishing for turtle and dugong in this research? There may be some interesting interactions between fishing for these and reef fish.

Response (Sara Busilacchi): I am collecting information on the number of turtles taken.

Question (Gavin Begg): On the east coast the industry is getting older and there are few young people coming into the industry. Is it the same for the Torres Strait?

Response (Sara Busilacchi): Yes. They are trying to involve young people in the fishing industry. There is a lot of training of young people, but I am not sure how successful this is.

Question (Greg McBeth): Is there a law stopping locals taking part in commercial fishing?

Response (Sara Busilacchi): No.

Response (John Marrington): There are some laws/policies that have been established to encourage involvement of Islanders in industry, e.g., there is no restriction on Islanders obtaining master fishing licences. There may be internal pressures on Islanders not to enter the industry at the same level as non indigenous fishers, e.g., the use of freezer boats, but it is not discouraged. There is definitely a desire by the Torres Strait people to let regulators know that they are totally reliant on their marine resources. They are interested in collaborating with the project and are keen to get the data and findings out to the general public and government bodies.

PARTICIPANTS AT THE WORKSHOP

From left to right (back & centre): Gavin Begg, Toshi Nakata, Ashley Williams, Tim Harvey, James Aumend, John Marrington, David Williams, Greg McBeth, Bill Nason, James McLellan, Andrew Tobin, Mike Cappo, Chloe Lucas, Neil Green, Terry Must, Ross Marriott, Danny Brooks, David Bateman, Sue Bandaranaike;
(Front): John Picard, George Leigh, Mikaela Bergenius, Rachel Pears, Martin Russell, Nadine Marshall, Stephen Sutton, Jeff Snell, Renae Tobin, Melissa Cowlishaw.

STUDENTS PRESENTING AT THE WORKSHOP:

From left to right: Rachel Pears, Renae Tobin, Ross Marriott, Mikaela Bergenius, Sara Busilacchi, Nadine Marshall.

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