Using commercial and recreational fisher knowledge to reconstruct historical catch rates for Queensland Snapper (*Chrysophrys auratus*), Spanish Mackerel (*Scomberomorus commerson*) and Coral Trout (*Plectropomus* spp.)

Long-term data for incorporation into future stock assessments

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31st January 2016

FRDC Project No 2013-018

ISBN 978-1-74272-123-1

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Project 2013-018

2016

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The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Acknowledgments

This project was funded by the Fisheries Research and Development Corporation (project number 2013-018). The Great Barrier Reef Marine Park Authority also provided funding for the Coral Trout component of the research. We wish to thank both funders for their support.

We thank staff at the FRDC, members of the Queensland FRAB, the Queensland Government Department for Agriculture and Fisheries, and the Great Barrier Reef Marine Park Authority, who provided invaluable advice throughout the project. In particular, Drs Alex Campbell, Michael O'Neill, George Leigh, Wayne Sumpton, Warwick Nash, John Kung, Lenore Litherland, Jonathan Staunton-Smith, and Jo Langstreth (DAF), Dr Rachel Pears, Dr David Wachenfeld, Darren Cameron, Doon McCall and Carolyn Thompson (GBRMPA). We also wish to acknowledge the help and advice from members of Info-fish Australia, in particular, Bill Sawynok, Sunfish Queensland, Queensland Seafood Industry Association, and Matt Barwick from Recfishing Research. Also, Drs Renae Tobin, Andrew Tobin, Julian Pepperell, Mr Paul Aubin, and Ray Joyce (Pacific Marinelife Institute).

Finally, we wish to acknowledge and thank the many recreational, commercial and charter fishers who gave their time and expertise to take part in the project. Without their participation this project would not have been possible.

Executive Summary

What the report is about

Long-term commercial and recreational fishers along the coast of Queensland, from Cooktown to Tweed Heads, were interviewed about their observations of change in Queensland's east coast Snapper (*Chrysophrys auratus*), Spanish Mackerel (*Scomberomorus commerson*) and Coral Trout (*Plectropomus* spp.) fisheries. Our aim was to use fisher knowledge to provide a longer-term perspective on perceptions and trends witnessed in these fish stocks and the fisheries over time, and thus help fill knowledge gaps in our understanding of past trends.

Background

Throughout the world, studies have used fisher knowledge to facilitate a deeper understanding for scientists and resource managers of changes that are occurring in our environment. Both Snapper and Spanish Mackerel are iconic species throughout Queensland, while the Coral Trout fishery is the most economically significant fin-fishery in Queensland, but a lack of long-term data means that uncertainty remains regarding long-term trends in these fisheries. Using archival data and fisher knowledge gathered from commercial and recreational fishers along the east coast of Queensland, we aimed to fill gaps in long-term knowledge for these fisheries. The provision of such data should help to inform environmentally sustainable fishing by determining past changes to catch rates, locations fished, the introduction and impact of new technology and fishers' perceptions of change to the fishery over their lifetime.

Objectives

1. To reconstruct relative changes in abundance and distribution of Snapper (*Chrysophrys auratus*), Spanish Mackerel (*Scomberomorus commerson*) and Coral Trout (*Plectropomus* spp.), using commercial and recreational fishers' testimony and historical data.

2. To use fishers' data to expand our temporal scope of knowledge by providing robust historical data, thereby reducing uncertainty in past exploitation rates and making information available for potential use in future management decisions.

3. To determine the impact of evolving fishing technologies, fishing effort and changing management regimes upon fish catches and abundance over time.

4. To compare perceptions of change between commercial and recreational groups, and identify common areas/species of concern held by both groups.

Methodology

We conducted interviews with commercial, recreational and charter fishers who had targeted either Snapper, Spanish Mackerel or Coral Trout for 10 years or longer along the coast of Queensland. Major locations visited included, Cooktown, Port Douglas, Cairns, Townsville, Bowen, Mackay, Yeppoon, Gladstone, Bundaberg, The Sunshine Coast, Brisbane, The Gold Coast and Tweed Heads. Minor locations between each of these towns were also visited. Semi-structured interviews were conducted with individual fishers and ranged from 1-5 hours, taking an average of 2 hours to complete. Fishers' were questioned about their personal fishing history and perceptions of change to their gear and technology, management measures, catch rates, as well as areas of concern or threats that they perceived to the fishery.

Results

Using fishers' testimony we were able to reconstruct recalled catch rates and individual fishing histories for spatially discrete areas throughout the geographical range of the three fisheries as far back as the 1940s. Despite the distances from shore and depths targeted increasing for these fisheries (with the exception of Snapper north of the Sunshine Coast, and commercially-targeted Coral Trout), recalled catch rates for all species declined throughout the time series. Concurrently, technological innovations have been rapidly adopted by both commercial and recreational sectors as they became available, whilst engine power has rapidly increased throughout the 20th century, suggesting that effective fishing ability has dramatically increased. Technological innovations most commonly adopted by recreational and commercial fishers from all fisheries included GPS, colour echo sounders and four-stroke engines. Both sectors adopted these technologies at the same time and at the same rate. Recreational Snapper fishers also rapidly adopted braid line and soft plastics from the year 2000. Down riggers/paravenes and live bait were increasingly adopted by both commercial and recreational Spanish Mackerel fishers from the 1990s, while recreational Coral Trout fishers recalled first shifting from handlines to rod and reel fishing, then the adoption of braid line.

The majority of Snapper fishers perceived management measures (green zones, bag limits, size limits) to have had no impact upon their catch rates, although recreational fishers were split 50:50 as to whether bag limits had impacted their Snapper fishing or not. Most Spanish Mackerel fishers perceived green zones to have had no impact on their catch rates. The majority of recreational Spanish Mackerel fishers perceived bag and size limits to have had no impact on their catch, whilst the majority of commercial Spanish Mackerel fishers perceived no impact from the introduction of quotas or licensing. Three-quarters of the commercial Coral Trout fishers interviewed perceived green zones to have had a negative impact on their catch rates, although only one-quarter of recreational fishers perceived the same. The majority of fishers perceived bag and size limits to have had no impact upon their catch, Overall, the majority of fishers perceived a decline in fish abundance throughout their experience, and although not all fishers perceived these fisheries to be under threat, those that did were largely in agreement that the major threats came from fishing pressure, the impact of improving technology and poor management.

Our results show that fishers from both sectors are willing to engage in research about the past condition of fisheries, and that they have the ability to recall both extent and timings of change in past catch rates, technological innovations and management measures. We conclude that fisher knowledge has the potential to provide novel information about the changing conditions of fisheries and the ecological and social impact of introduced technology and management measures.

Implications for relevant stakeholders

Our results suggest that over the last few decades, fishers have perceived declines in catch rates for these three Queensland species, despite improvements in technology and spatial shifts in the fisheries. Gathering these retrospective accounts of change from fishers along the coast of Queensland has enabled us to ascertain long-term trends that pre-date contemporary logbook data, and that present an additional perspective (incorporating both social and ecological outlooks) that may not previously have been available to management. These data provide a perspective on patterns in long-term fishery trends, as well informing managers and stock assessment modellers of fishers' perspectives of change in fish abundance.

Recommendations

The main recommendation for this project is that the researchers collaborate with fisheries managers and stock assessment modellers to determine how the data can be best used to inform future management strategies. Also, that in future studies of this type, researchers include fisheries managers and stock assessment modellers at the earliest stages of project development and sampling design to enable the standardisation of recalled historical catch rates, account for biases and increase the potential for adoption into fisheries assessments.

Keywords

Coral Trout; Fisher Knowledge; Historical Ecology; Local Ecological Knowledge; Snapper; Spanish Mackerel

Introduction

Snapper (*Chrysophrys auratus*) and Spanish Mackerel (*Scomberomorus commerson*) are two fish species that hold particular economic, social and cultural importance along the Queensland coast. Both species have been targeted for over 100 years and are iconic recreational fisheries. Coral Trout (*Plectropomus* spp.) is also a popular recreational fishery along the tropical Queensland coast, and since the 1990s has formed the basis of a lucrative live fish trade centred on supplying Southeast Asia. However, despite their long history, a lack of data exists for these fisheries prior to the introduction of individual logbook records in 1988 (Halliday and Robins 2007). Data available prior to 1988 consists of landings data gathered as fish were marketed through the Queensland Fish Board, yet it is widely acknowledged that these data were incomplete as not all fish landed were marketed through these outlets. Thus, historical information that can supplement existing data are of value as they present a longer-term perspective that may help reduce uncertainty associated with projected historical trends.

During a review of the 2008 Queensland Snapper stock assessment, Francis (2009) called for consultation of 'knowledgeable people' in order to reconstruct past catch histories, thereby improving estimates for future stock assessments. In recent decades, scientists have increasingly turned to historical data and fisher knowledge to help fill gaps in their understanding of past change (Jackson et al. 2001; Pandolfi et al. 2003; Ames 2004). Studies have shed light on trends in species abundance (Mallory et al. 2003; Eddy et al. 2011), loss or declines in spawning components (Ames et al. 2004), as well as changes to the wider ecosystem, for example, non-target species or habitat components (zu Ermgassen et al. 2012). Archival data have provided illustrations of past environments and subsequent changes over timescales of decades to centuries, whilst fisher knowledge has the ability to extend our temporal depth of knowledge by several decades, as well as fill in gaps in our contemporary understanding. For example, data derived from resource users can provide clues as to how they alter their behaviour to accommodate changes in management or technological innovation (Neis et al 1999; Robins et al. 1998), or how they are likely to respond to future management decisions (Shackeroff et al. 2011). Studies using different generations of fishers and historical accounts have also identified the existence of shifting environmental baselines, where long-term environmental changes are masked by intergenerational shifts in what is perceived as natural (Pauly 1995; Sàenz-Arroyo et al. 2005). A study on the New Zealand Snapper fishery used fisher interviews and anecdotal accounts to describe a historical fishery very different from the fishery known by fishers and scientists today (Parsons et al. 2009). This study highlighted the ability of historical research to investigate periods prior to formal record keeping and the value of historical data for presenting a longer-term context for contemporary records, potentially enabling resource managers to make better-informed decisions about what are appropriate exploitation goals for the system in question.

Snapper is widely distributed throughout Australia's temperate and sub-tropical seas. In Queensland its range extends from Proserpine in the central coast, south to the border with New South Wales. The east coast stock exploited in Queensland waters is also shared with New South Wales, although the two states manage the stock separately (Ferrell and Sumpton 1997; Allen et al. 2006). It is a hugely iconic recreational species, and has been targeted in Queensland's offshore waters by parties of recreational anglers since the 19th century. A 2009 stock assessment classed Snapper as overfished (Campbell et al. 2009), a finding that has divided public opinion.

Spanish Mackerel is common throughout northern Australian tropical and sub-tropical waters (McPherson 1992). Three genetically distinct populations of Spanish Mackerel form three distinct fisheries in Australian waters (Ovenden and Street 2007). We focus our research on the Queensland's East coast genetic stock, a transient aggregating species that forms predictable exploited migrations along the east coast of Queensland between Cairns and northern New South Wales (Mapstone et al. 1996; Tobin et al. 2013). It has a long history of exploitation and for many decades was the most economically significant commercial finfish in central and north Queensland (McPherson 2007). A 2012 stock assessment stated that east coast Spanish Mackerel was fully fished, but uncertainty remains regarding assessing the fishery as a single stock due to the confounding influence of hyperstability (Campbell et al. 2012).

Coral Trout describes a number of related species, all of which may be targeted by recreational or commercial fishers. These include Common Coral Trout (*Plectropomus leopardus*), Barcheek Coral Trout (*P. maculatus*), Bluespotted Coral Trout (*P. laevis*), Passionfruit Coral Trout (*P. areolatus*), in addition to *Variola* species. The Queensland fishery has been classified as a sustainable stock but has witnessed a number of major social and economic changes over the last few decades. In particular, since the early 1990s, significant numbers of commercial fishers have targeted Coral Trout for the Southeast Asia live fish trade. Catch rates from the Coral Trout fishery have also been significantly affected by cyclones in recent years (Tobin et al. 2010).

Assessments for the above fisheries suffer from a lack of detailed long-term data. Pre-1988 records exist for Queensland fisheries in the form of state (Queensland Fish Board) landings records. However, in addition to these records being incomplete, estimates of catch and effort do not exist during this period. Using archival data and fisher knowledge gathered from commercial and recreational fishers along the east coast of Queensland, we aim to fill gaps in long-term knowledge for Queensland's Snapper, East coast Spanish Mackerel and Coral Trout fisheries. The provision of such data should help to inform environmentally sustainable fishing by determining past changes to catch rates, locations fished, the introduction and impact of new technology and fishers perceptions of change to the fishery over their lifetime.

Objectives

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Methods

Interviews

We conducted interviews with commercial, recreational and charter fishers who had targeted either Snapper, Spanish Mackerel or Coral Trout for 10 years or longer. Commercial fishers were initially contacted by talking to industry representatives and local businesses, further interviewees were then gathered using snowball sampling, where additional contacts are generated via interviewee referral (Faugier and Sargeant 1997). Recreational fishers were contacted through fishing clubs, at boat ramp access points, a southeast Queensland fishing conference and through fishing tackle shops. Further contacts were then engaged using snowball sampling. Interviews took place along the east coast of Queensland, a distance of >1,500 km (Fig. 1). Major locations visited included, Cooktown, Port Douglas, Cairns, Townsville, Bowen, Mackay, Yeppoon, Gladstone, Bundaberg, Sunshine Coast, Brisbane, Gold Coast and Tweed Heads. Minor locations between each of these towns were also visited.

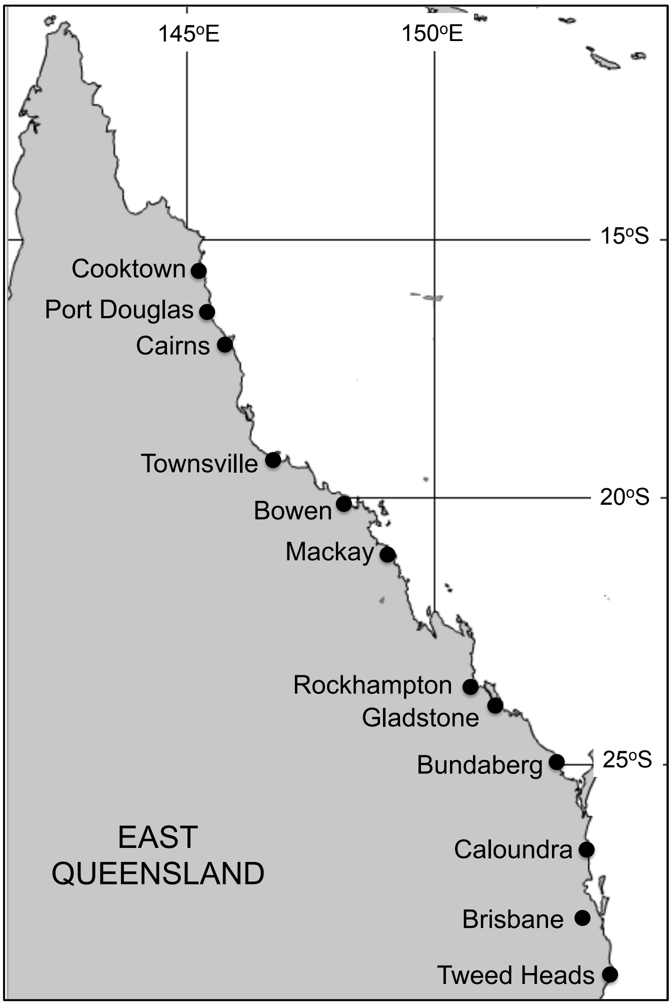

Figure 1. Map of study area. Major locations along the coast of Queensland where fisher interviews took place.

Interviews were undertaken individually with fishers, with follow-up questions by phone if required. When fishers were unable to be interviewed because of a lack of time or because they were working offshore, interviews were undertaken by phone, although we always endeavoured to make contact face to face with each fisher either before or after the interview. Fishers were informed of the objectives of the research, and that the interviews complied with the ethical standards as set out by the University of Queensland. Interview questions were semi-structured, allowing fishers' to expand upon their response and to include additional information if they wished. The length of interviews ranged from 1-5 hours and took an average of 2 hours to complete.

Initial questions focused upon each fisher's personal fishing history. We asked them what age they began fishing, what species they had targeted over time (Coral Trout were defined to species, using pictures of the different species of Coral Trout if fishers were unsure), how often they fished, where and how it changed over time. Questions then focused upon fishers' gear and technology; what year they had upgraded particular technology, which had the most impact upon their fishing, and what years they upgraded their vessels and engines. Proportional uptake of technologies was calculated as a cumulative frequency distribution. The year that each fisher started using each technology was recorded, as was the year that each fisher entered and exited the fishery. Proportional uptake only included fishers present in the fishery each year, hence if a fisher subsequently left the fishery they were no longer counted. Fishers were also questioned about management measures and whether these had impacted their fishing, if at all.

During the second part of the interview, fishers were asked to recall good, average and poor daily catches for Snapper and/or Spanish Mackerel and Coral Trout during the past year or when they most recently fished. Good catches were defined as catches that had occurred more than once, but not on a regular basis. Average catches were defined as typical catches i.e., what a fisher would expect to land on a regular basis. Poor catches were defined as catches that were lower than typical catches, and that didn't occur on a regular basis. We purposefully refrained from giving fishers' examples of catches which would be described as good, typical or poor, to prevent biasing of fishers' recall (e.g., Daw et al. 2011; O'Donnell et al. 2012). After fishers recalled these catches, they were asked how long they would typically fish for, and how many individuals participated. These values were used to construct catch rates (n/kg fish angler^{-1} hour^{-1}) for that particular period. Most fishers remembered catches as numbers of individual fish, but if fishers recalled catches in kg they were asked to provide a conversion rate to numbers of fish. Fishers were then asked about good, typical and poor daily catches for the period when they first began targeting these species. After this, fishers were asked to recall daily catches for particular periods that they could recall between the period they began fishing and present day. Catch rates were recalled to year, and are presented in this report by decade. Finally, fishers were questioned about general trends in abundance and size of fish as well as drivers of change and threats they perceived to the fishery (see Appendix 4 for fisher questionnaire).

Data analysis

We included charter operators with recreational fishers in our analyses, as charters operate under the same bag and size restrictions as recreational fishers.

Linear mixed effects models were used to analyse the relationship between year and fishers' recalled catch rates, distance travelled offshore, depth fished, boat length, and engine power. We used the lmer function in the lme4 package (Bates et al. 2012) in R (R Core Team 2012). Fishers' response (i.e., recall of catch, depth, distance fished) was entered as a response term, year was entered into the model as a fixed effect, whilst fisher ID was entered as a random effect. Catch rates were transformed to satisfy the distribution assumptions of the model prior to analysis. P-values were obtained by likelihood ratio tests of the full model with the effect of year against a null model that excluded the effect of year (Barr 2013).

Archival data

In addition to the fisher interviews funded by the FRDC, archival data mining was undertaken as part of a broader project that aims to unravel changes over time in Australia's marine environments, funded by the Australian Research Council's Centre for Excellence in Coral Reef Studies. Archival data examined included government reports, newspaper articles, popular reading materials and early fisheries statistics. Most of these materials were sourced from the Queensland State Library in Brisbane. In this report we complement our fisher knowledge findings by summarising key information on the early period of Queensland's Snapper, Spanish Mackerel and Coral Trout fisheries (see Appendix 4 for a list of historical data sources and years consulted).

Determining the accuracy of fisher knowledge

We also summarise data on the reliability of fisher knowledge over time, which was collected as part of a separate project funded by the University of Queensland (New Staff Start-Up Fund awarded to RT). Individual logbooks were gathered from fishers to compare their recall of past daily catch with the average daily catch recorded in their logbooks for the corresponding period of time. We determined how accurately fishers' recalled typical past catches by calculating the percentage difference between recalled typical catch and median logged catch for each individual fisher (as per Daw et al. 2011), and for good and poor catches by comparing recalled catches with ranked logged catches for the corresponding period. We then used a general linear mixed model to test if the difference between recalled and logged catches differed with time: fisher identity was included as a random factor, with year as a covariate (Thurstan et al. *In press, a*).

Results

We contacted approximately 400 potential interviewees. Of these, 18 refused and 32 were not available for interview. In total, we conducted 350 interviews with long-term fishers along the east coast of Queensland. Many fishers targeted more than one species throughout the year: 221 had fished for Spanish Mackerel, 110 had fished for Snapper, and 120 had fished for Coral Trout for >10 years. Because the geographical range, locations fished and methods of targeting differ for the three species, we present our results for each species separately.

Snapper

Historical data

The earliest quantitative records for offshore Queensland Snapper catches can be derived from Brisbane newspapers. An article in 1871 recorded the growing popularity of offshore Snapper fishing,

"*Schnapper fishing is becoming quite a fashionable amusement among Brisbaneites, and considering the little difficulty there seems to be in making a good haul of these fish, it is surprising that professional fishermen don't turn their attention to catching them. The supply seems inexhaustible.*" The Brisbane Courier, 7 Sept 1871.

From then on, Snapper catches were sporadically recorded in southeast Queensland newspapers. In addition to quantitative records of early catches, these articles also recorded the type of fishing gear used, the method of fishing, the locations fished and the social aspect of these early fishing trips. During the late 19th century, Snapper fishing was predominately a recreational sport, although many of the fish landed were also sold to local markets. Media interest in the Snapper fishery peaked in the years after 1905, when a popular book was published about Snapper fishing in southeast Queensland (Welsby 1905). During this period, 10-12 steamboats regularly took Snapper parties to fish the offshore grounds surrounding Brisbane. The number of anglers on board ranged from 8 to 50, with 20 anglers a typical size fishing party. In 1905 Brisbane's Inspector of Fisheries reported that it was rare for these parties to arrive back into port with less than 200 fish (Marine Department Report 1905), although occasionally catches of >1000 Snapper occurred (Fig. 2a).

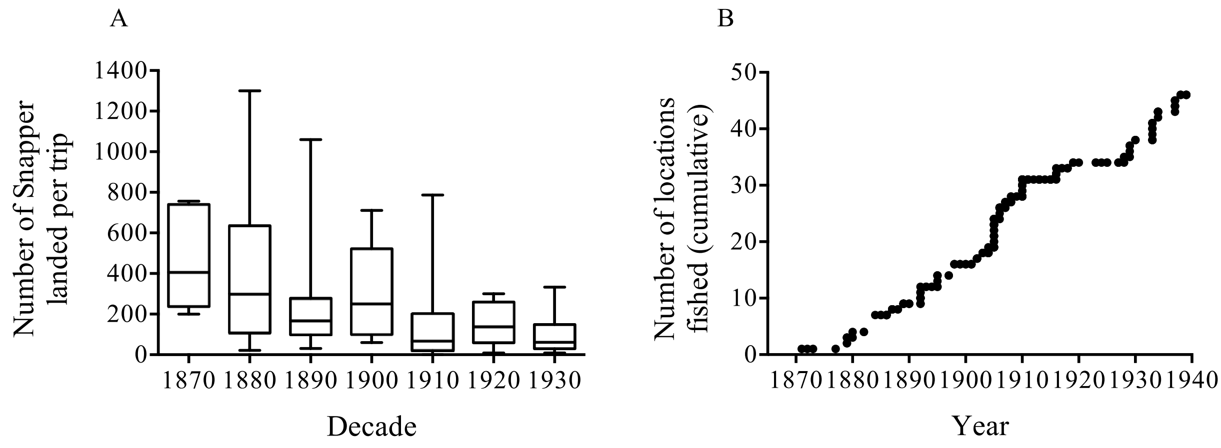

Figure 2. Number of Snapper landed per trip and number of locations fished prior to World War II, derived from archival data sources. A) Distribution of the number of Snapper landed boat^{-1} trip^{-1} (n = 100) by decade (1871-1939). B) Cumulative number of locations where Snapper was reported as targeted (1871-1939).

Whilst parties would bring back a variety of different species, Snapper was the iconic species to catch. Despite no 'commercial' fishery existing during this period, in 1904 the Marine Department estimated that charter boats landed 25,000 fish (including Snapper) into Brisbane (Marine Department Report 1905). Most trips took place around Brisbane, in many of the same locations where Snapper is still targeted today, although these locations expanded over time as new grounds north and south of the Brisbane region were identified and explored (Fig. 2b). Despite no formal records being kept, these anecdotal accounts suggest that a significant and rapidly expanding offshore fishery for Snapper existed up to 7 decades prior to the commencement of official statistics (1870-1940).

Interviews

Of the 110 Snapper fishers, 51 (46%) classed themselves as recreational fishers, 18 (16%) as charter and 41 (37%) as commercial fishers. 16 fishers (3 recreational, 1 charter and 12 commercial) had retired from fishing at the time of interview. Fishing experience ranged from 10 years to 68 years with a mean of 35 years.

Reconstructing relative changes over time

Catch rates described by recreational and commercial fishers were split into two different geographic sections: the Sunshine Coast and south to Tweed Heads, and locations north of the Sunshine Coast to Mackay. We split the two areas because the locations south of the Sunshine coast are where much of the fishing pressure historically occurred. In total, 15 commercial Snapper fishers were able to recall past catch rates from the northerly region, whilst 21 recreational fishers recalled catches in this area. In contrast, many more fishers concentrated in the south, with 35 commercial and 66 recreational fishers able to recall past catch rates from this area.

Good catch rates recalled by commercial fishers in the south of Queensland showed a significant decline with time (p-value = 0.003, Fig. 3a, Table S1). Both average and poor values declined slightly with time, but were not statistically significant (p-values = 0.262 and 0.209, respectively, Fig. 3a, Table S1). Good, average and poor catch rates recalled by recreational fishers in the south all showed a significant decline with time (p-values = <0.001, <0.001 and 0.015, respectively, Fig. 3b, Table S1). Good and average catch rates recalled by commercial fishers in the northern section of our study also declined with time, although changes in poor catch rates were not significant (good p-value = 0.018, average p-value = 0.013, poor p-value = 0.288, Fig. 3c, Table S1). Recreational catches in the north appear stable, with no significant trends over time (good p-value = 0.797, average p-value = 0.547, poor p-value = 0.206, Fig. 3d, Table S1).

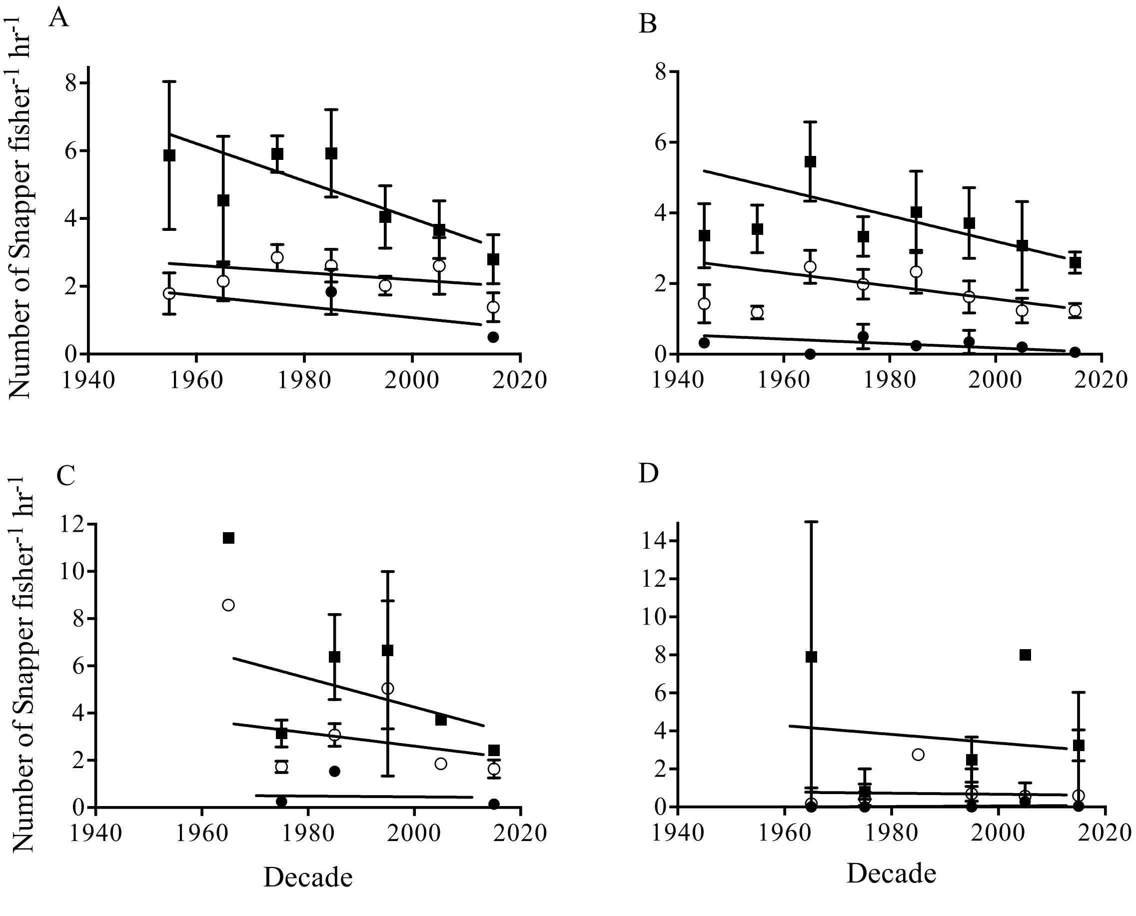

Figure 3. Mean catch rates (number of Snapper fisher^{-1} hour^{-1}) recalled by commercial and recreational fishers. Closed squares show ‘good’ catch, open circles show ‘average’ catch and closed circles show ‘poor’ catch. Vertical lines show the standard errors, whilst horizontal lines show linear regressions. A) Catch rates recalled by commercial fishers between the Sunshine Coast and Tweed Heads. B) Catch rates recalled by recreational fishers between the Sunshine Coast and Tweed Heads. C) Catch rates recalled by commercial fishers north of the Sunshine Coast to Mackay. D) Catch rates of recalled by recreational fishers north of the Sunshine Coast to Mackay.

The distance fished from shore (i.e. the distance from the fisher's home port to his preferred fishing grounds) significantly increased for both commercial and recreational fishers over time (p-value = <0.001 and 0.002, respectively, Fig. 4a, Table S1), although the trend was steeper for commercial fishers. The increasing trend in the depth fished by commercial fishers was significant (p-value = 0.005, Fig. 4b, Table S1), as was the increasing trend for recreational fishers (p-value = 0.002, Fig. 4b, Table S1).

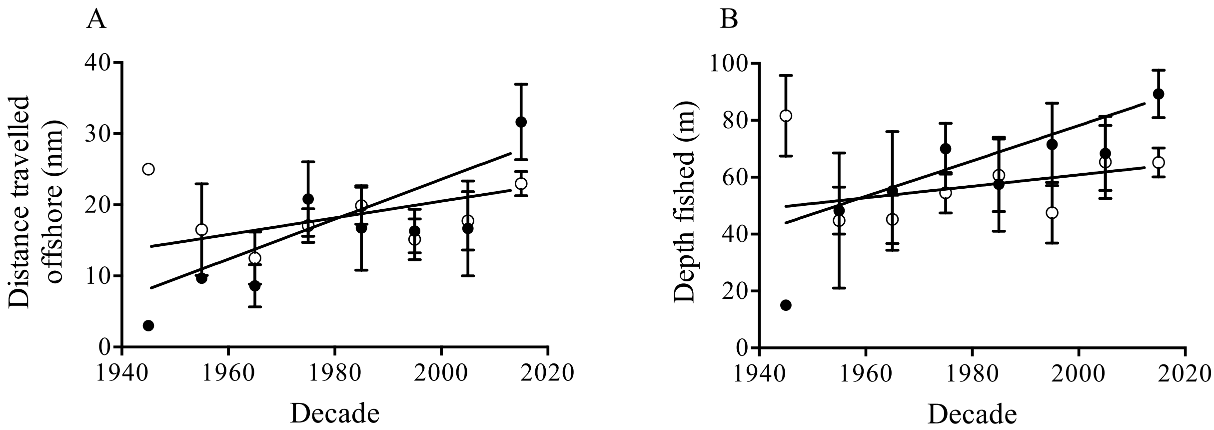

Figure 4. Changes in the average distance and depth fished from shore over time, by sector. A) Distance fished from shore and B) average depths fished by decade. Open circles show recreational (including charter) fishers, closed circles show commercial fishers recall. Vertical lines show the standard error, whilst horizontal lines show the linear regression.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

Technologies that were considered by both commercial and recreational fishers to have had the most significant impact upon catch rates of Snapper were geographical positioning systems (GPS), colour echo sounders and 4-stroke outboard engines. There was no significant difference in the timing and percentage uptake of GPS, colour echo sounders and 4-stroke outboard engines between recreational and commercial sectors, so Fig. 5a shows both sectors together. Uptake of GPS and colour echo sounders increased rapidly after 1988, with over 80% of fishers using both technologies by the year 2005. The three most commonly mentioned techniques adopted by recreational fishers (although some commercial fishers also used these methods) in recent decades, were float-lining, a method by which a line is gently floated down to the school of fish, thereby attracting the larger fish at the top of the school towards the bait, braid line and soft plastics. Both braid and soft plastics were rapidly adopted after the year 2000, whilst float-lining was more gradually adopted from the 1960s onwards (Fig. 5b).

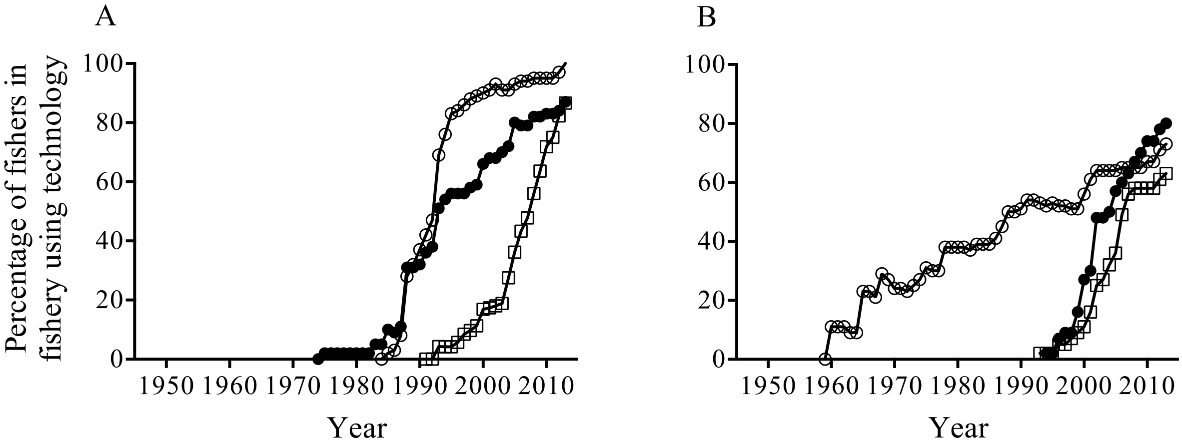

Figure 5. The percentage of fishers in the Snapper fishery that adopted new technologies each year. A) shows the percentage adoption of GPS (open circles), colour sounders (closed circles) and 4-stroke outboard engines (open squares) for both recreational and commercial fishers. B) shows the percentage adoption of float-lining (open circles), the use of braid line (closed circles) and soft plastics (open squares) by recreational fishers.

The length of boats used by fishers to target Snapper over time significantly increased within both sectors (commercial p-value = 0.014, recreational p-value = <0.001, Fig. 6a, Table S1), with no major difference in size between commercial and recreational vessels, although early recreational vessels were larger than contemporary vessels. Average engine power significantly increased over time for both commercial (p-value = <0.001) and recreational (p-value = <0.001) vessels, although engine power of commercial vessels stabilized in the last 2 decades (Fig. 6b, Table S1).

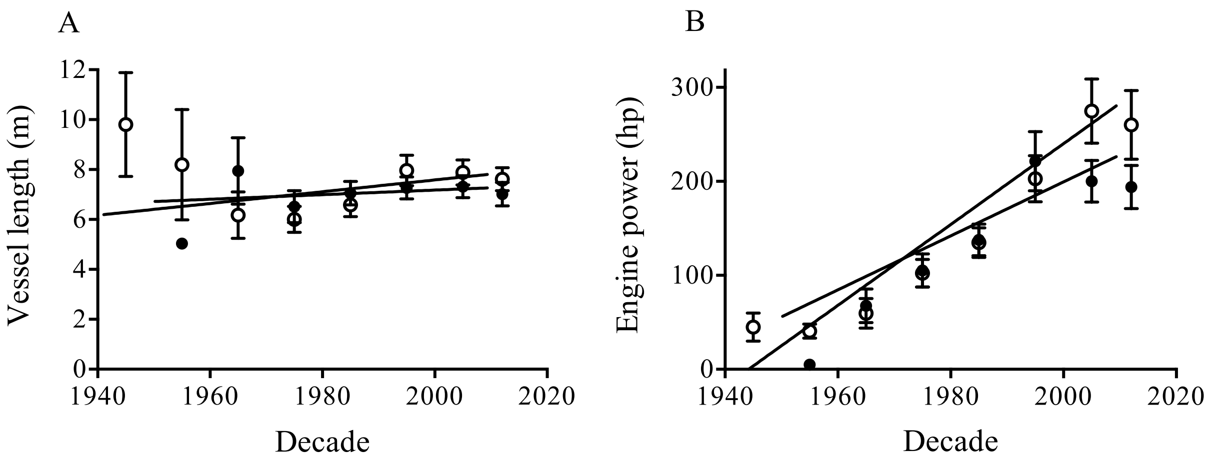

Figure 6. Changes in vessel length and engine power over time, by sector. A) Average vessel length and B) engine power by decade. Open circles show recreational (including charter) fishers, closed circles show commercial fishers recall. Vertical lines show the standard error, horizontal lines show the linear regression.

Fishers were asked how their catches had been affected by management measures, in particular, no-take zones, bag limits and size limits (Fig. 7). A majority (69%) of recreational fishers stated that no-take zones had not altered their catches of Snapper, with 31% stating that their catches had decreased as a result. Commercial fishers results were similar, with 69.5% stating no change, and 30.5% stating a decrease. 50% of recreational fishers believed that bag limits had decreased their catches, whilst 50% believed that bag limits had no impact upon their catch. Only 16% of recreational fishers believed that size limits had reduced their catches, whilst 84% stated that their catch had remained the same. Again, commercial responses were similar, with 9% believing their catch had reduced as a result of size limits being implemented, and 91% stating that they had seen no change as a result of these management restrictions.

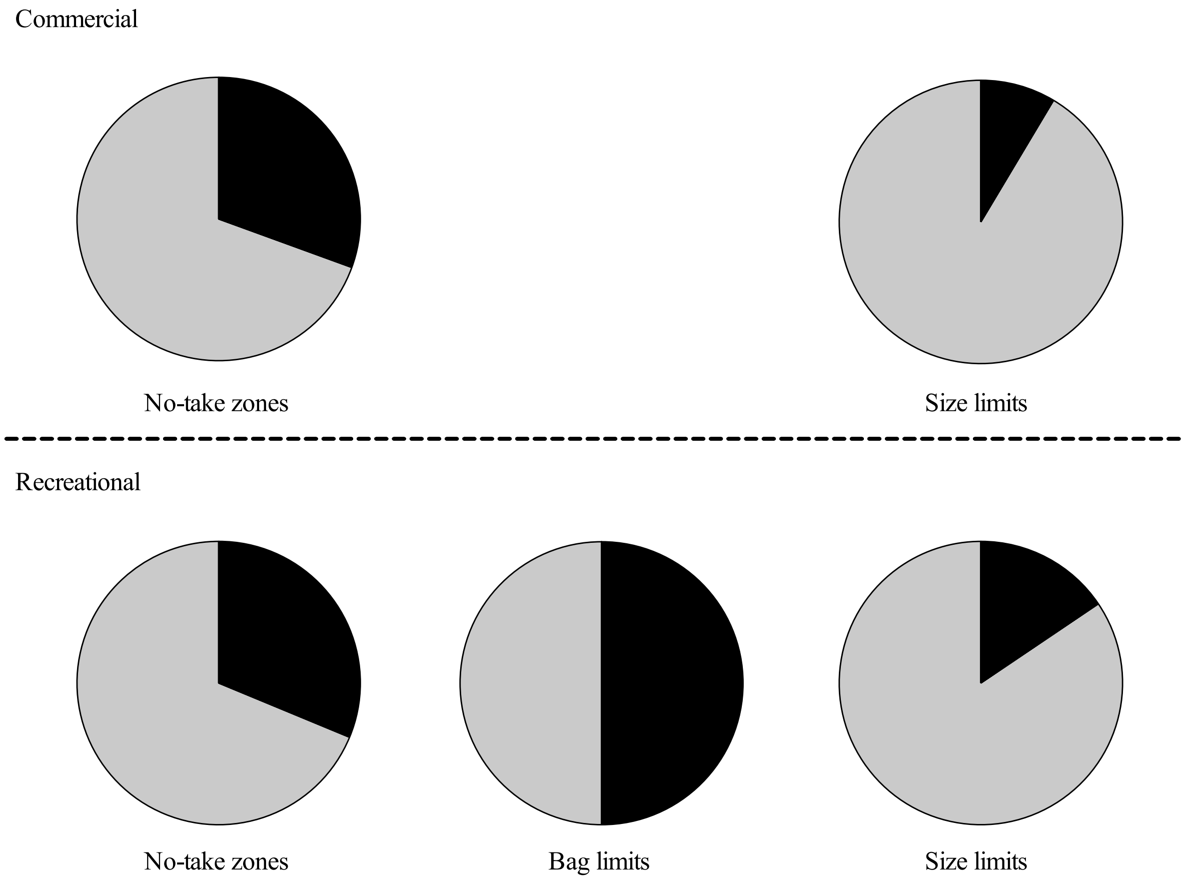

Figure 7. The effect of different management measures on fishers' catch of Snapper. The upper panel shows responses from commercial fishers, the lower panel recreational fishers. Pie charts show the percentage of fishers who stated that their catches had either decreased (black), increased (white) or not altered (grey) as a result of management measures.

Fishers' responses about no-take zones, bag limits and size limits on the Snapper fishery were also scored as positive, negative or neutral (Fig. 8). The majority (69%) of recreational fishers provided a neutral response to no-take zones, although 31% perceived these negatively. Of commercial fishers, 28% perceived no-take zones negatively, 64% were neutral and 8% were positive about no-take zones. Bag limits were perceived positively by 37.5% of recreational fishers, 21% were negative and 41.5% were neutral. Size limits for Snapper were regarded as positive by 17% of recreational fishers and 8.5% of commercial fishers, negative by 7% of recreational fishers and 3% of commercial fishers, whilst 76% and 88.5% of recreational and commercial fishers respectively, were neutral towards size limits.

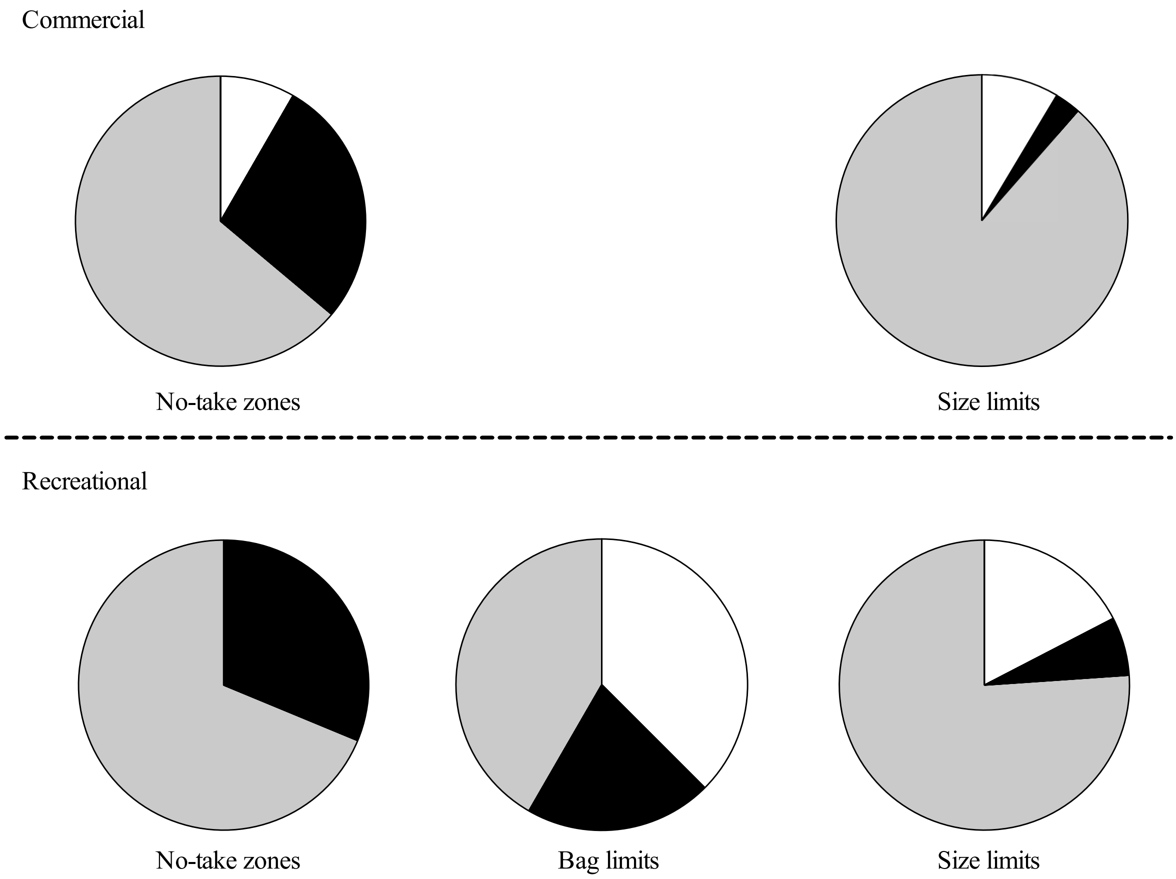

Figure 8. Fishers' views of the impact of management measures on the Snapper fishery. The upper panel shows responses from commercial fishers, the lower panel recreational fishers. Pie charts show the percentage of fishers who perceived the measures positively (white), percentage who perceived the measures negatively (black), and those fishers who were neutral towards the management measures (grey).

Overall trends in abundance and size

Towards the end of the interview, each fisher was asked about their perceptions of how overall Snapper abundance and size had changed throughout the course of their experience. The majority of fishers, both commercial and recreational, perceived an overall decrease in Snapper stocks (71% and 65%, respectively), although some (15% of the total) qualified this by saying that they had witnessed a recent increase in stocks, mainly in the last 3-4 years (Fig. 9a). Of recreational fishers, 35% perceived stocks as stable (versus 22.5% of commercial fishers). A minority (6.5%) of commercial fishers and 0% of recreational fishers stated they had perceived an overall increase in Snapper stocks throughout their career (Fig. 9a). Fishers' responses were more varied regarding changes in the size of Snapper, which was perceived as stable by 51% of recreational fishers and 42% of commercial fishers, while 46% of recreational fishers and 54% of commercial fishers perceived a decrease in size. Just 3% and 4% of recreational and commercial fishers respectively had witnessed an increase in overall size of Snapper (Fig. 9b).

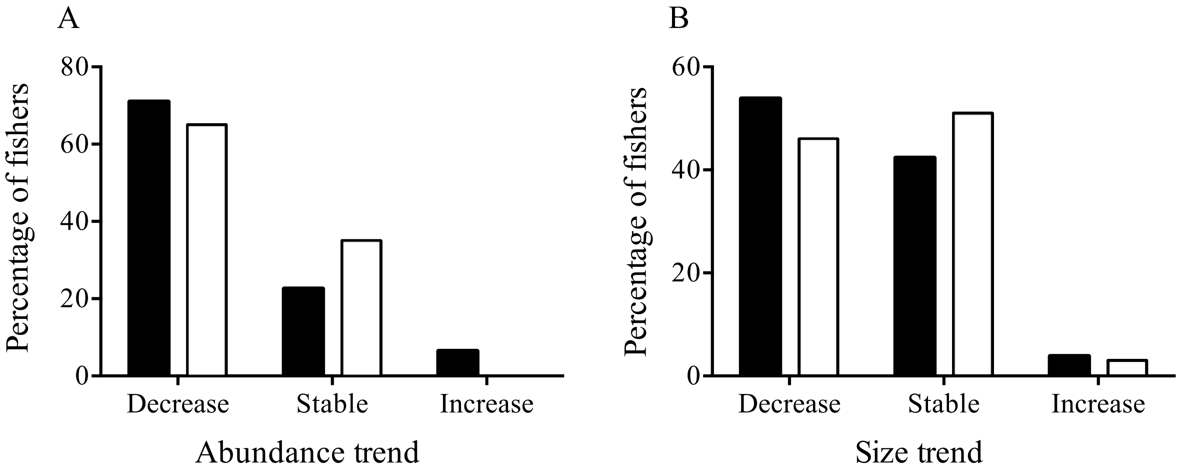

Figure 9. Fishers' perceptions of change in Snapper abundance and size over time. A) Overall changes in abundance of Snapper and B), overall changes in size of Snapper. Black bars = commercial, white bars = recreational fishers.

Areas of concern

The majority of commercial and recreational fishers (47.5% and 33%, respectively) did not believe that there were any particular anthropogenic threats to Snapper, but of the threats perceived, the most commonly mentioned by both sectors was fishing pressure (27.5% commercial, 27.5% recreational), followed by advances in technology (12.5% commercial, 10% recreational) and poor management (12.5% commercial, 17% recreational) (Fig. 10).

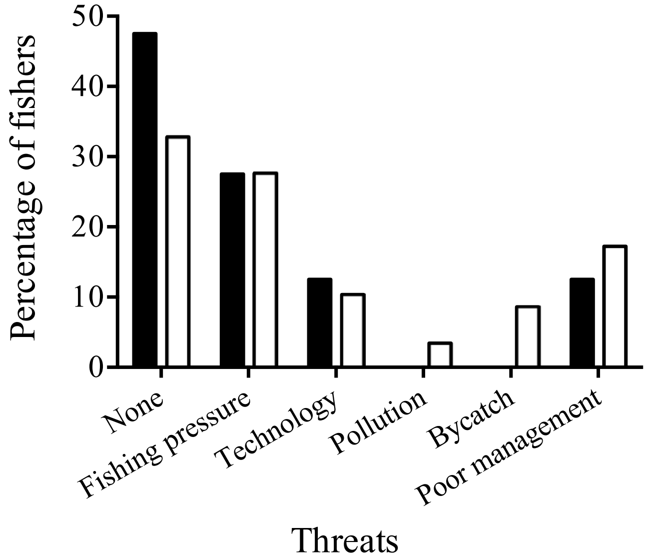

Figure 10. Fishers' perceptions of anthropogenic threats to Snapper. Black bars = commercial fishers, white bars = recreational fishers.

Spanish Mackerel

Historical data

Beginning in 1911, the Spanish Mackerel fishery represents the first recorded commercial line fishery targeting spawning aggregations on the Great Barrier Reef (Townsville Daily Bulletin, 1934). The earliest commercial quantitative recording of Spanish Mackerel can be derived from the Townsville Daily Bulletin in 1934. From 1934 to 1947 the newspaper regularly recorded individual vessel's trip landings during the spawning season, which occurred between October and November each year. Records indicate that single vessel operations landed catches of up to 540 fish in a two-day fishing trip (Fig. 11a).

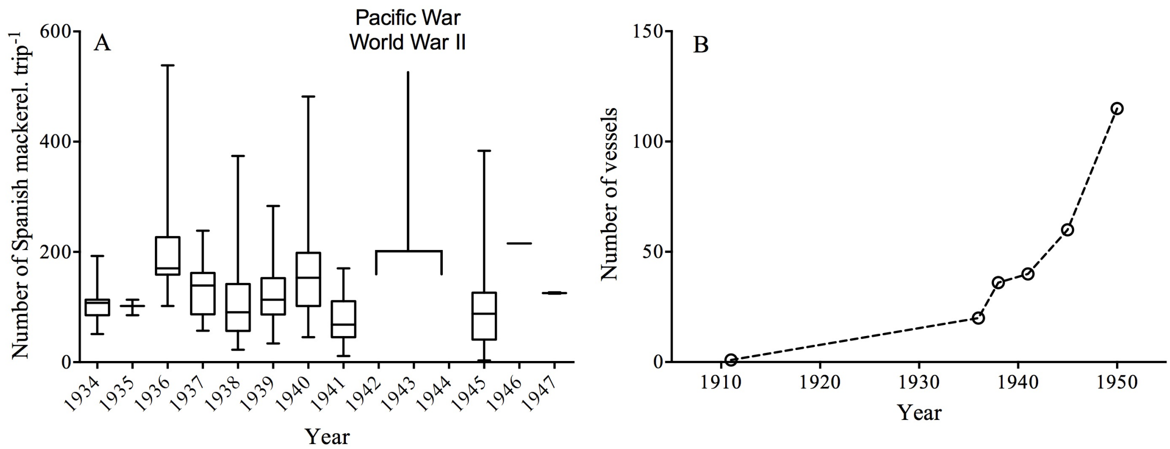

Figure 11. Historical range of catch from Spanish Mackerel fishing trips and numbers of vessels operating in the fleet during the early 20th century. A) Boxplots showing the distribution of the number of

Spanish Mackerel landed per trip (n = 340) by year, derived from historical sources between 1934 and 1947. B) Number of commercial vessels operating in the spawning fishery by year, derived from historical sources between 1911-1950.

In addition, these historical newspapers document the development and expansion of the Townsville spawning Spanish Mackerel fishery during those same years. Articles revealed total fleet effort, total season's catch, vessel specifics, locations fished, gear used and fish size (Table 1).

Table 1. Quantitative and qualitative data sourced on early Spanish Mackerel spawning fishery, together with the source and date of the quote. Text in bold highlights in the different types of information gathered from historical data sources, as per 'subject' column.

Subject	**Source and date reported**	**Quote**
Size of catch landed	Townsville Daily Bulletin 20 Oct 1934	*"Last Monday, Ra'ata, Sunbeam and Crescent landed at the wharf hauls of approximately **2400, 2000 and 1800lbs**. respectively."*
Name and specification of fishing vessels used	Townsville Daily Bulletin 20 Oct 1936	*"The **May B**, owned and operated by W. Haack of Yeppoon is another very seaworthy craft well fitted for her purpose. Her dimensions are: **Length, 35ft**.; **beam, 10ft**.; **draught, 1ft 6ins**. She is powered with a **Palmer 15 h.p. engine** and has a **capacity for 4,000lbs**."*
Fishing area where fish were caught	Townsville Daily Bulletin 13 Nov 1954	*"One of the fishermen in port who communicated with other fishermen at the Great Barrier Reef learned that the fish at one of the best reefs on the grounds **Bramble Reef**, were not hitting. All the boats at the grounds have bow moved to **Rib Reef** but the quantity of catches were unknown."*
Size of fish	Townsville Daily Bulletin 1 October 1934	*"Combining size (**90lbs.** is not an exceptional weight) with excellent eating qualities these fish are sought keenly by northern fishermen"*
Total fleet effort	Townsville Daily Bulletin 13 Oct 1936	*"Approximately **29 launches** are working from Townsville during the present kingfish season, the majority of which are from the South."*
Total season's catch	Townsville Daily Bulletin 8 Dec 1938	*"With 36 boats operating at one time, it is believed that at least **300 tons** of fish has been taken. On one occasion there was no less than 21 boats trolling within a small area less than 300 yards square."*

During the early 20th century, Spanish Mackerel was primarily a local inshore commercial fishery. The fleet size increased gradually from 1 boat in 1911 to 20 in 1936. Once fishers from the 'South' (from Brisbane to

Bowen) became aware of the lucrative spawning fishery, a rapid increase to 36 vessels occurred in 1937 and continued to 115 vessels by 1950 (Fig. 11b). Coinciding with this fast developing fleet, articles reveal a shift in fishing effort from inshore to offshore grounds from 1910 to 1950 (Fig. 12). In 1910 vessels targeted sites around Townsville, however, to maintain catches fishers abandoned early exploited spawning grounds to locations further offshore spawning grounds of the Townsville region. Thus archival records reveal the transition from a local inshore fishery to the first major line commercial fishery in the Great Barrier Reef prior to formal records and monitoring taking place.

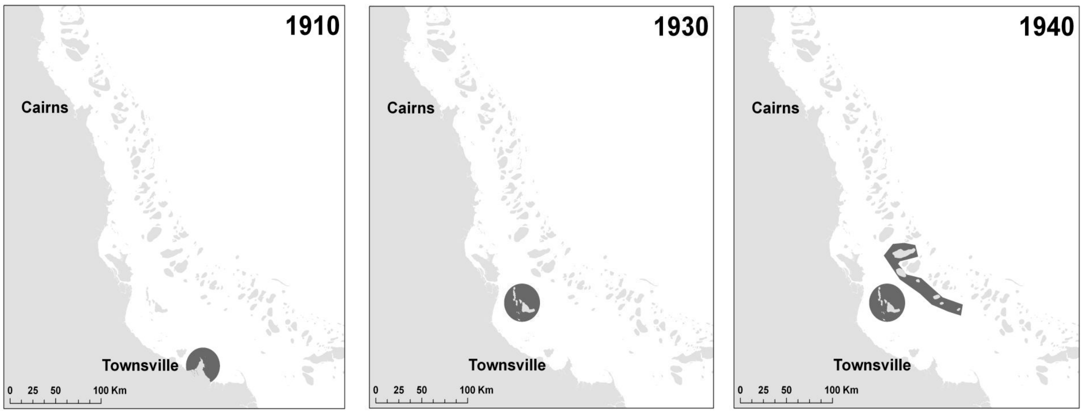

Figure 12. Spatial expansion in the exploited Spanish Mackerel spawning grounds during the early decades of the spawning fishery. Fished areas were listed by decade using archival data; the shaded area represents exploited fishing grounds.

Interviews

In total, 221 interviews with active and retired fishers were conducted, 106 (48%) classed themselves as commercial, 106 (48%) classed themselves as recreational and 9 (4%) classed themselves as charter. 75 fishers (64 commercial, 3 charter and 8 recreational) had retired from fishing at the time of the interview. Most fishers were males (95%), ranging age from 23 years to 87 years. Fishing experience ranged from 10 years to 70 years with a mean of 39 years.

Reconstructing relative changes over time

Catch rates were split into three different geographic sections: North; Cooktown - Bowen, Mid; Airlie Beach – Bundaberg, South; Fraser to Tweed Heads. We split the three areas because much of the historic Spanish Mackerel catch was derived from locations north of Airlie Beach, the fishing gear and techniques differ between regions and also the fishing pressure for each sector varies through the regions over time. In total, 62 commercial Spanish Mackerel fishers were able to recall past catch rates from the north, whilst 48 charter and recreational fishers recalled catches in this area. 38 commercial and 34 recreational and charter fishers recalled catch in the mid region. In contrast, more recreational fishers are concentrated in the south, with 32 commercial and 48 recreational fishers able to recall past catch rates from this area, with some fishers able to recall back to the 1940s.

Good and average catch rates recalled by commercial fishers in the north showed a significant decline with time (p-value = 0.003 and <0.001, respectively). Poor values declined with time, but were not statistically significant (p-value = 0.424, Fig. 13a, Table S2). Good, average and poor catch rates recalled by recreational fishers in the north showed a significant decline with time (p-values = 0.019, <0.001 and <0.001, respectively, Fig. 13b, Table S2). Good and average catch rates recalled by commercial fishers in the mid-section of our study showed a significant decline with time (p-values = 0.001 and 0.001, respectively), whilst the declining trend in poor catch was not significant (p-value = 0.426, Fig. 13c, Table S2). Good, average and poor catch rates recalled by recreational fishers from the mid-region declined significantly (p-value = <0.001, <0.001 and 0.001, respectively, Fig. 13d). Commercial fishers in the south region of our study reported significant declines in good and average catch rates over time (good p-value = <0.001, average p-value < 0.001), while poor values did not change significantly with time (poor p-value = 0.635, Fig. 13e). Similarly good and average recreational catch types declined significantly over time in the south (good p-value < 0.001, average p-value = <0.001), while poor values did not (poor p-value = 0.062, Fig.13f, Table S2).

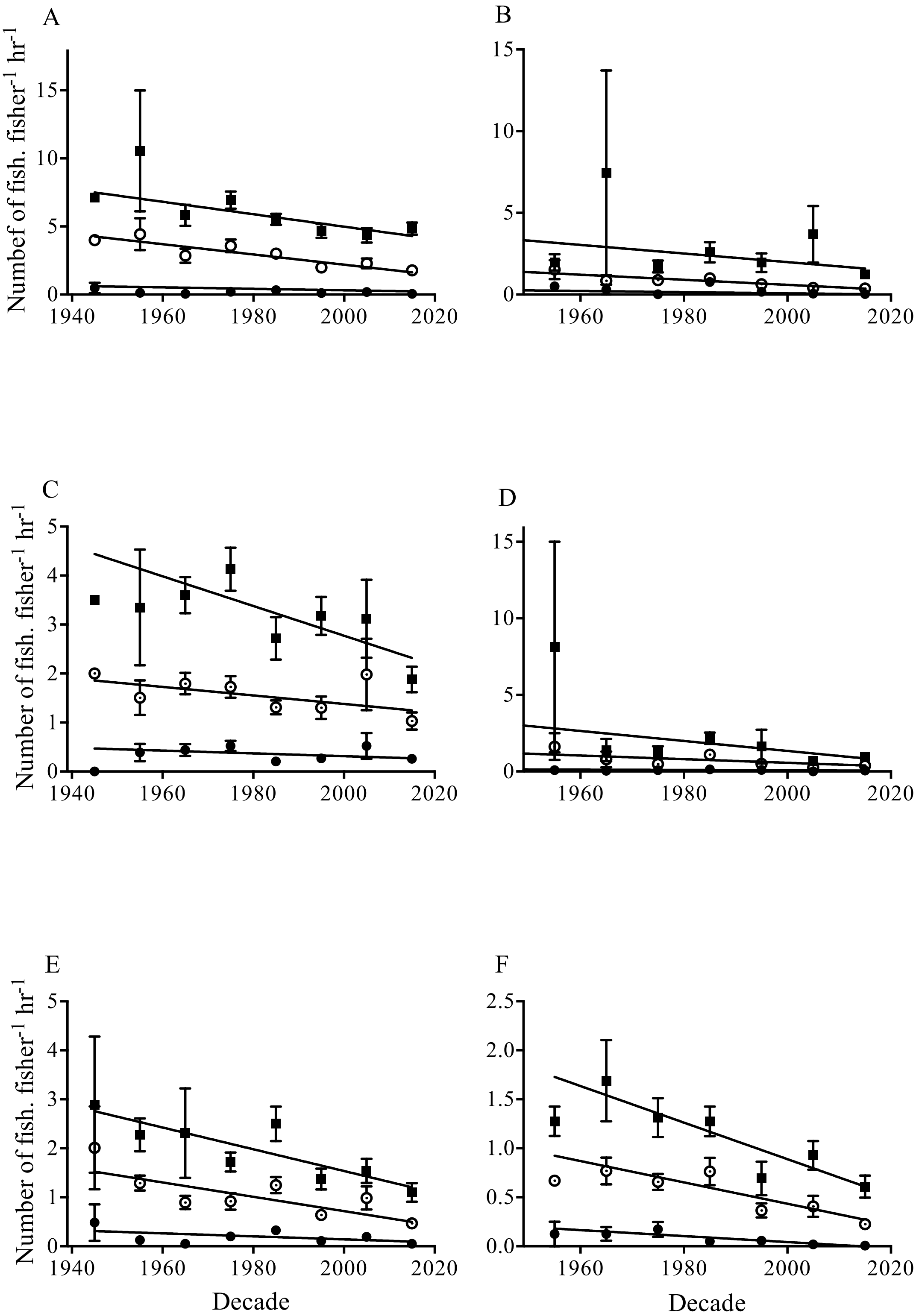

Figure 13. Mean catch rates (number of Spanish Mackerel fisher^{-1} hour^{-1}) recalled by commercial and recreational fishers. Closed squares show 'good' catch, open circles show 'average' catch and closed circles show 'poor' catch. Vertical lines show the standard error, whilst horizontal lines show the linear regression. A) Catch rates recalled by commercial fishers in the north. B) Catch rates recalled by recreational fishers in the north. C) Catch rates recalled by commercial fishers in the mid region. D) Catch rates of recalled by recreational fishers in the mid. E) Catch rates recalled by commercial fishers in the south. F) Catch rates of recalled by recreational fishers in the south.

An increasing trend in the distance fished from shore by commercial and recreational fishers was significant (p-value=<0.001and <0.001, respectively, Fig. 14a). Similarly, the average depth fished significantly increased for both commercial and recreational fishers over time (p-value <0.001 and p=<0.001, respectively, Fig. 14b, Table S2), however, the trend was steeper for commercial fishers.

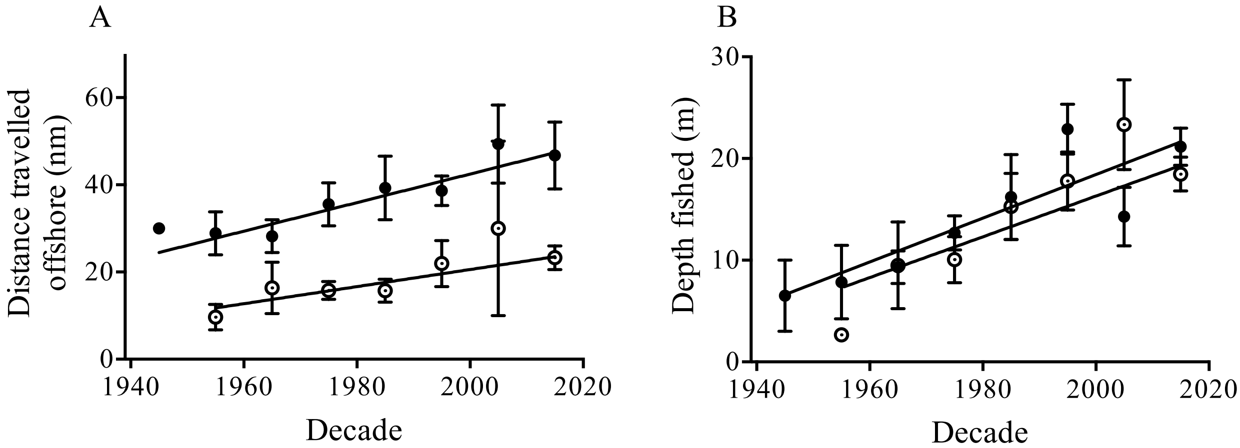

Figure 14. Changes in the average distance and depth fished from shore over time, by sector. A) Average distance fished from shore and B) depth fished by decade. Closed circles show commercial fishers and open squares show recreational (including charter) fishers recall. Vertical lines show the standard error, whilst horizontal lines show the linear regression.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

The technologies that were considered by both commercial and recreational fishers to have had the most significant impact upon catch rates of Spanish Mackerel were geographical positioning systems (GPS) and colour echo sounders. The third most cited technological innovation was the onset of refrigeration by the commercial fishers, whilst the introduction of affordable, fuel-efficient 4-stroke outboard engines was widely stated by recreational fishers. The two most commonly mentioned techniques adopted by commercial and recreational fishers in recent decades were paravenes/downriggers, a gear that allows the line to reach deeper depths to attract the fish towards the bait, and live bait. GPS and colour sounders were rapidly adopted by commercial fishers from 1995 (Fig. 15a). The adoption of refrigeration was gradual and reached a peak of 50% adoption by commercial fishers in 2000, followed by a slight decline. Downriggers and live bait have been gradually adopted by commercial fishers since their onset, from the 1960s and 1980s respectively (Fig. 15a). The timing of uptake of these technologies (with the exception of refrigeration, which wasn’t adopted by the recreational sector) was about a decade later for the recreational sector compared to the commercial sector. Both GPS and colour sounders were rapidly adopted after the year 2002, whilst 4-stroke outboard motor was more gradually adopted from the 1980s onwards. Downriggers and live bait have been more gradually adopted since the early 1970s (Fig. 15b).

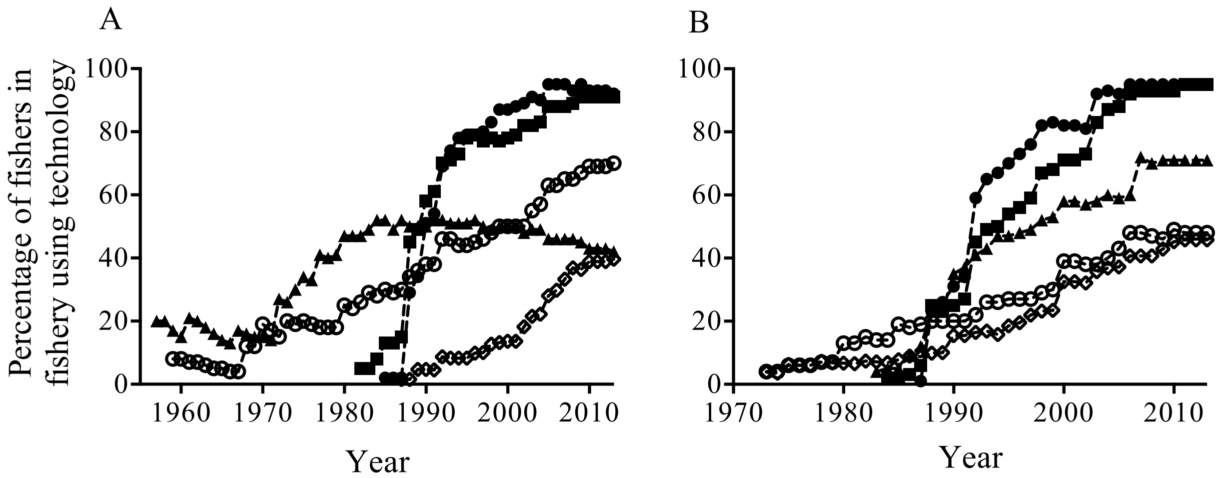

Figure 15. The percentage of fishers in the Spanish Mackerel fishery that adopted new technologies each year, by sector. A) Proportion of commercial fishers that adopted refrigeration (closed triangle), paravenes/downriggers (open circles), colour sounders (closed circles), GPS (closed squares) and live bait (open diamonds) through time. B) Proportion of recreational fishers that adopted a 4-stroke motor (closed triangle), downriggers (open circles), colour sounders (closed circles), GPS (closed squares) and live bait (open diamonds) through time.

No significant change in the length of boats used by commercial fishers to target Spanish Mackerel was found over time (p-value =0.355), however there was a significant increase in recreational vessel size (p-value= <0.001, Fig. 16a, Table S2). Average engine power significantly increased over time for both commercial (p-value = <0.001) and recreational (p-value = <0.001) vessels, although the engine power on recreational vessels declined in the last decade, 2010 (Fig. 16b, Table S2).

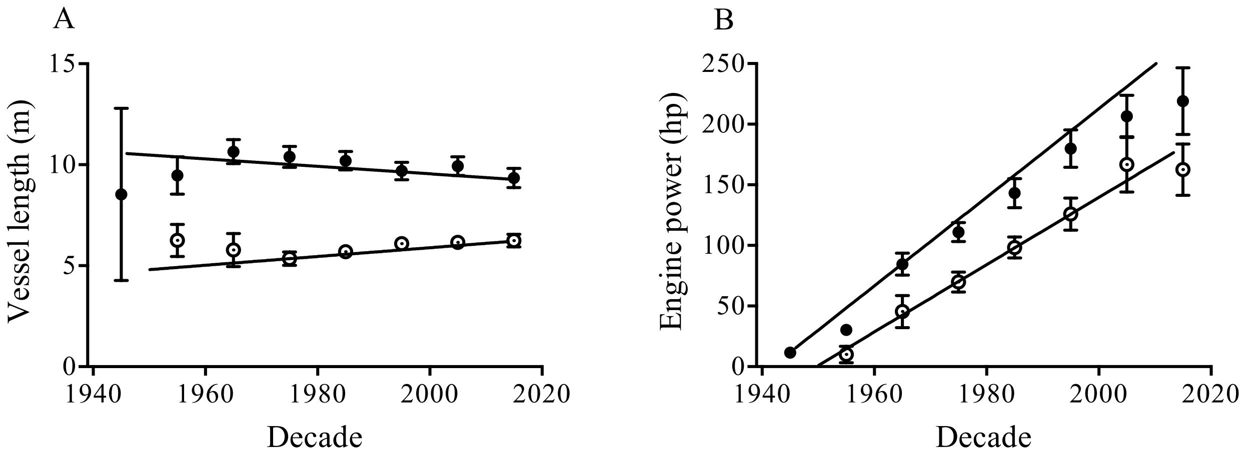

Figure 16. Changes in vessel length and engine power over time, by sector. A) Average vessel length and B) engine power by decade. Closed circles show commercial fishers, open squares show recreational fishers recall. Vertical lines show the standard error, whilst horizontal lines show the linear regression.

Fishers stated how their catches had been affected by management measures, in particular, no-take zones, quota and licensing were mentioned the most by commercial fishers whereas no-take zones, bag limits and size limits by recreational fishers (Fig. 17). The majority (75%) of commercial fishers stated that no-take zones had not altered their catches of Spanish Mackerel, with 23% stating that their catches had decreased and 2% cited that it had actually increased their catch as a result. Recreational fishers results were similar, with 75% stating no change, 15% stating a decrease and 6% stating an increase in catch. The majority (81%) of commercial fishers cited that quota had no impact on their catches and 19% noted it had decreased their catch rate. Similarly, 6% of commercial fishers believed their catch had reduced as a result of the license restructure being implemented, and 94% stated they had seen no change as a result of the management restriction. Only 15% of recreational fishers believed that bag limits decreased their catch, whilst 75% believed that bag limits had no impact on their catch and 10% stated it had increased their catch. A minority (7%) of recreational fishers believed that size limits had increased their catch and 93% stated that their catch had remained the same.

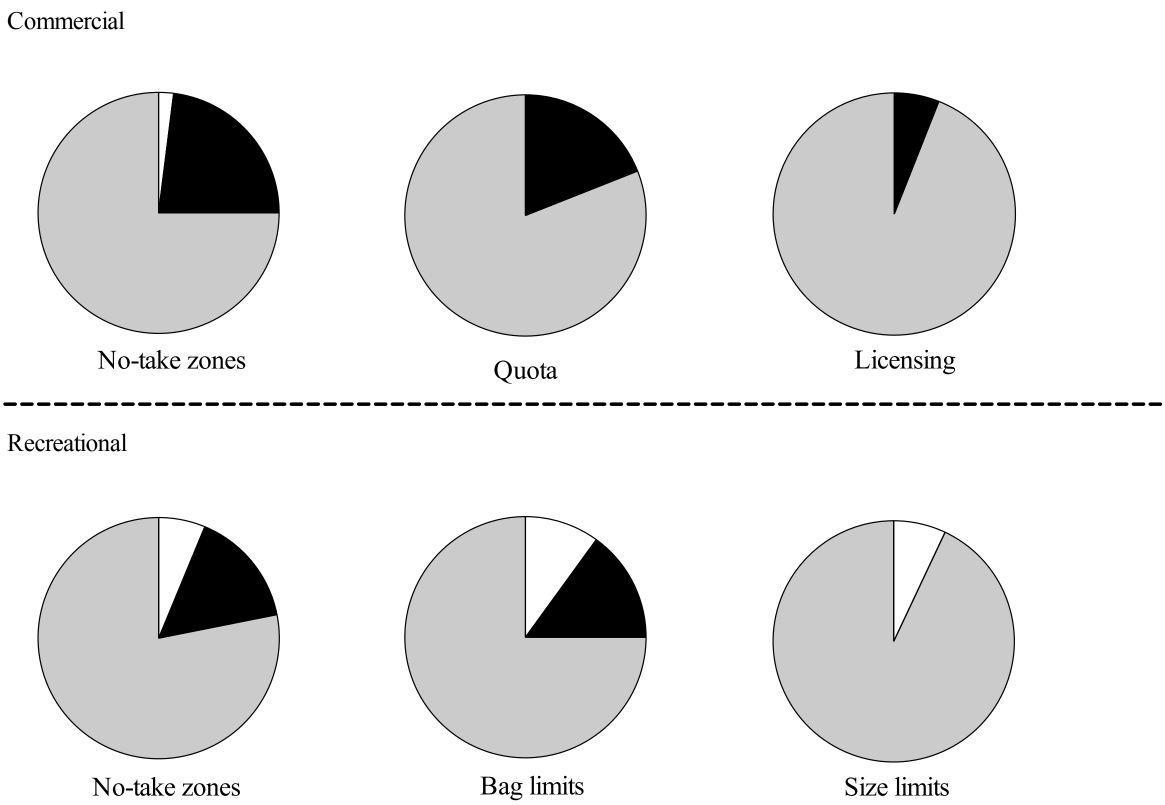

Figure 17. The effect of different management measures on fishers' catch of Spanish Mackerel. Pie charts show the percentage of fishers who stated that their catches has either decreased (black), increased (white) or not altered (grey) as a result of three most cited management measures by commercial (upper panel) and recreational fishers (lower panel).

Fishers' responses about no-take zones, bag limits and size limits on the Spanish Mackerel fishery were also scored as positive, negative or neutral (Fig. 18). Of commercial fishers, 46% provided a negative response to no-take zones and 44% perceived it neutrally, whilst only 10% perceived it positively. Similarly, 45% of recreational fishers perceived no-take zones negatively, 25% were neutral and 30% were positive about no-take zones. The restructure of Spanish Mackerel licenses were perceived negatively by 30% of commercial fishers and 70% were neutral. The majority (60%) of commercial fishers were neutral about the quota system, 32% regarded it negatively and 8% positively. The majority of recreational fishers (82%) perceived bag limits positively, 14% were negative and 4% were neutral. Size limits for Spanish Mackerel were regarded as positive by 88% of recreational fishers, negative by 6% and 6% were neutral about the management restriction.

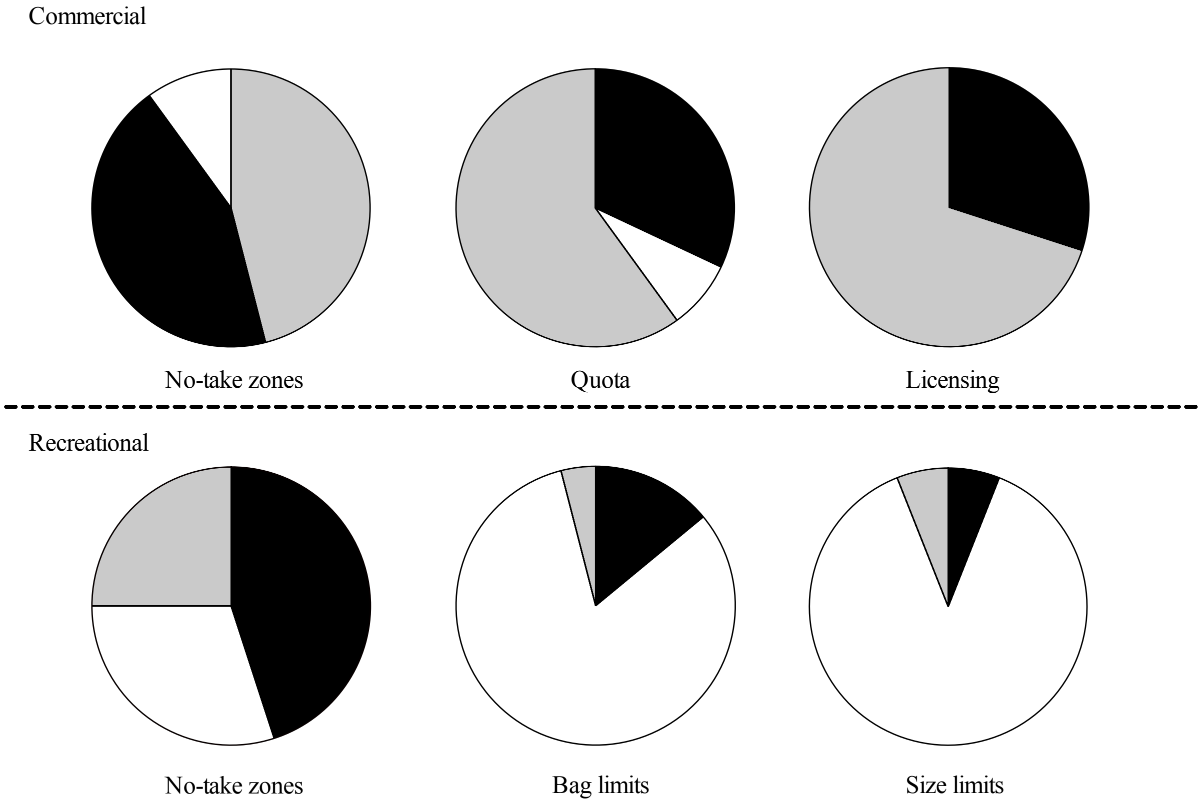

Figure 18. Fishers' views on the impact of management measures on the Spanish Mackerel fishery. Showing how fishers' perceived the three most stated management measures: commercial; no-take zones, quota and licensing and recreational; no-take zones, bag limits and size limits. Pie charts show the percentage of fishers who perceived the measures positively (white), percentage who perceived the measures negatively (black), and those fishers who were neutral towards the management measures (grey).

Overall trends in abundance and size

Towards the end of the interview, each fisher was asked about their perceptions of how overall Spanish Mackerel abundance and size had changed throughout the course of their experience. The majority of fishers, both commercial and recreational, perceived an overall decrease in Spanish Mackerel stocks (68% and 65%, respectively). A similar percentage (27%) of commercial fishers and recreational fishers (25%) perceived stocks as stable. Only 5% of commercial fishers and 7% of recreational fishers stated they had perceived an overall increase in Spanish Mackerel abundance throughout their career (Fig. 19a). Both commercial and recreational fishers' responses were similar regarding changes in the size of Spanish Mackerel. When asked about size, 52% of commercial fishers and 46% of recreational fishers perceived the size of Spanish Mackerel to have remained stable, while 38% of commercial fishers and 39% recreational fishers cited that Spanish Mackerel has decreased in size over time. Only 10% and 13% of commercial and recreational fishers respectively had witnessed an increase in overall size of Spanish Mackerel (Fig. 19b).

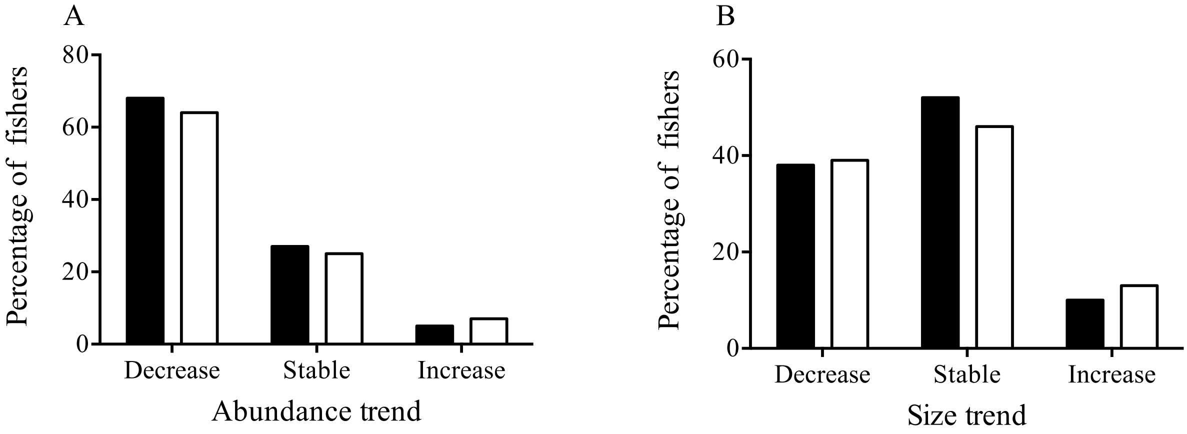

Figure 19. Fishers' perceptions of change in Spanish Mackerel abundance and size over time. A) Overall changes in abundance of Spanish Mackerel and B), overall changes in size of Spanish Mackerel. Black bars = commercial, white bars = recreational fishers.

Areas of concern

Recreational and commercial fishers shared the same areas of concern regarding anthropogenic threats to Spanish Mackerel, however the ranking of these threats varied between the commercial and recreational sectors (Fig. 20). The most commonly mentioned by both sectors was fishing pressure (56% commercial, 53% recreational), while 36% of commercial fishers perceived the second major threat as poor management or lack of management, and 30% of recreational fishers were concerned about the advances in technology. The third most cited threat by commercial fishers was advances in technology, 17%, while 28% of recreational fishers noted by-catch of Spanish Mackerel in other fisheries. Some (12%) of commercial fishers cited both pollution and by-catch as areas of concern for Spanish Mackerel stocks, while 21% of recreational fishers mentioned poor management as an area of concern and only 6% of recreational fishers noted pollution as a threat. A minority of commercial and recreational fishers (12.5% and 14%, respectively) did not believe that there were any threats to Spanish Mackerel.

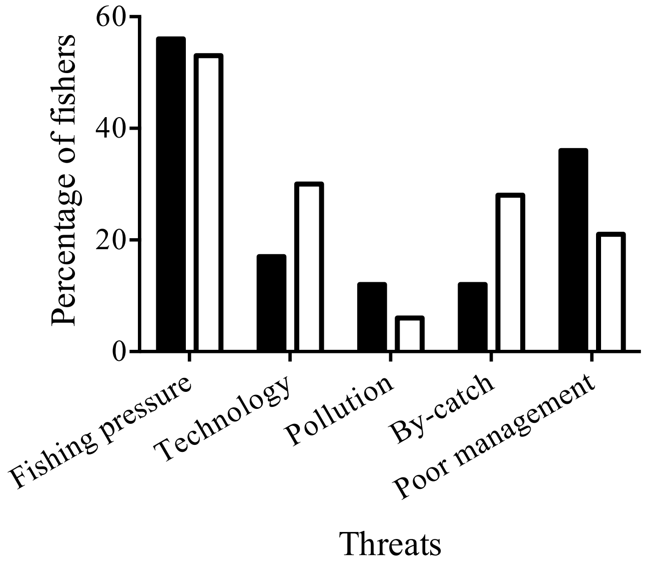

Figure 20. Fishers' perceptions of anthropogenic threats to Spanish Mackerel. Grey bars = commercial fishers, white bars = recreational fishers.

Coral Trout

Historical data

Historical sources on Coral Trout fishing activities were less abundant than for Snapper and Spanish Mackerel, and little information on early catches could be gained from popular media or other archival sources. The earliest sourced newspaper article we were able to find dated from 1927, and described a fishing party visiting the islands of the Great Barrier Reef (The Queenslander, 29 Dec 1927). Although few articles specifically mentioning Coral Trout could be found, occasional quantitative information on catches of mixed reef species (including Coral Trout), were gathered from newspaper reports, for example,

"*The catch was [...] estimated at between 200 and 300lbs, so that the 40 or so minutes of fishing for eight lines was [...] among the higher flights of piscatory art."* Morning Bulletin, 1 April 1931.

These few reports made it clear that during the early 20th century large regions of the Great Barrier Reef were still little explored. Between the 1920s and 1940s, recreational fishing trips via charter boat operators became increasingly popular, and during these early years fishing parties from southeast Queensland and New South Wales frequently visited North Queensland to fish the reefs around the islands and further offshore (e.g., The Queenslander, 29 Dec 1927; The Courier Mail, 29 Nov 1936). By the 1950s, amateur fishing clubs had become increasingly popular along the Queensland coast, with clubs holding regular deep-sea or reef-focused competitions that included catches of Coral Trout (e.g., articles from the Townsville Daily Bulletin, 1 Dec 1952; Daily Mercury, 1 Dec 1954; Cairns Post, 9 Dec 1954). Very little quantitative information could be extracted from these sources, but occasionally large specimens of Coral Trout were recorded, including a

Coral Trout caught at Sudbury Reef that weighed 24lb when cleaned (Cairns Post, 15 Apr 1954), and a 31lb Coral Trout landed at Heron Island (The Courier Mail, 16 Jun 1954). Neither of these individual Coral Trout were identified to species.

Prior to 1940, commercial catches of coral trout were rarely documented in archival sources. In an article from 1941, Coral Trout is described as "*one of the lesser known fish*" (The Courier Mail, 1 Mar 1941), suggesting that coral trout was not one of the more recognised species by the fish-eating public. However, by the 1950s Fish Board reports show that Coral Trout, while only commanding a small percentage of commercial fish landed by weight (5-15% according to records from the Cairns Fish Board), fetched higher prices than other reef species, and was targeted by commercial fishers outside of the Mackerel season from Gladstone to Cairns (Cairns Post, 9 Mar 1950).

Interviews

In total, 120 interviews with active and retired fishers were conducted, 55 (46%) classed themselves as commercial, 53 (44%) classed themselves as recreational and 12 (10%) classed themselves as charter. 13 fishers (8 commercial, 5 recreational) had retired from fishing at the time of the interview. Most fishers were males (96%), ranging age from 28 to 90 years. Fishing experience ranged from 10 years to 66 years with a mean of 33 years.

Reconstructing relative changes over time

Coral Trout catch rates were split into three different geographic sections: the far north; north of Cooktown to Port Douglas, north; Cairns to Airlie Beach, and mid region; Mackay to Gladstone (including the Swains region). These three areas appeared to be a natural split as they corresponded to the regions in which commercial fishers stated they historically fished, although many fishers had moved locations at least once during their career, and some commercial fishers today fish in more than one region. In total, 16 commercial fishers recalled past catch rates from the far north, while only 3 recreational fishers recalled catches in this area. 29 commercial and 48 recreational and charter fishers recalled catch rates in the north region. 16 commercial and 18 recreational fishers were able to recall past catch rates from the mid region.

Good, average and poor catch rates recalled by commercial fishers in the far north all showed a significant decline with time (p-value = <0.001, <0.001 and 0.006, respectively, Fig. 21a, Table S3). Recreational catch rates in the far north were unable to be calculated due to a low sample size. Good, average and poor catch rates recalled by commercial fishers in the north also all showed a significant decline with time (p-value = <0.001, <0.001 and 0.041, respectively, Fig. 21b, Table S3), as did recreational fishers' recalled catch from that same region (all p-values = <0.001, Fig. 21c, Table S3). Catch rates recalled by commercial fishers in the mid region showed a significant decline with time (good p-value = 0.007, average = <0.001 and poor = 0.003, Fig. 21d), as did recreational fishers' recalled catch rates (p-value = 0.001, <0.001 and 0.026, respectively, Fig. 21e, Table S3). Recalled catch rates from the far north began 2 to 3 decades after the mid and north regions. The earliest recalled catch rates came from commercial fishers in the Swains, in the mid region, and from recreational fishers in Cairns, the north region.

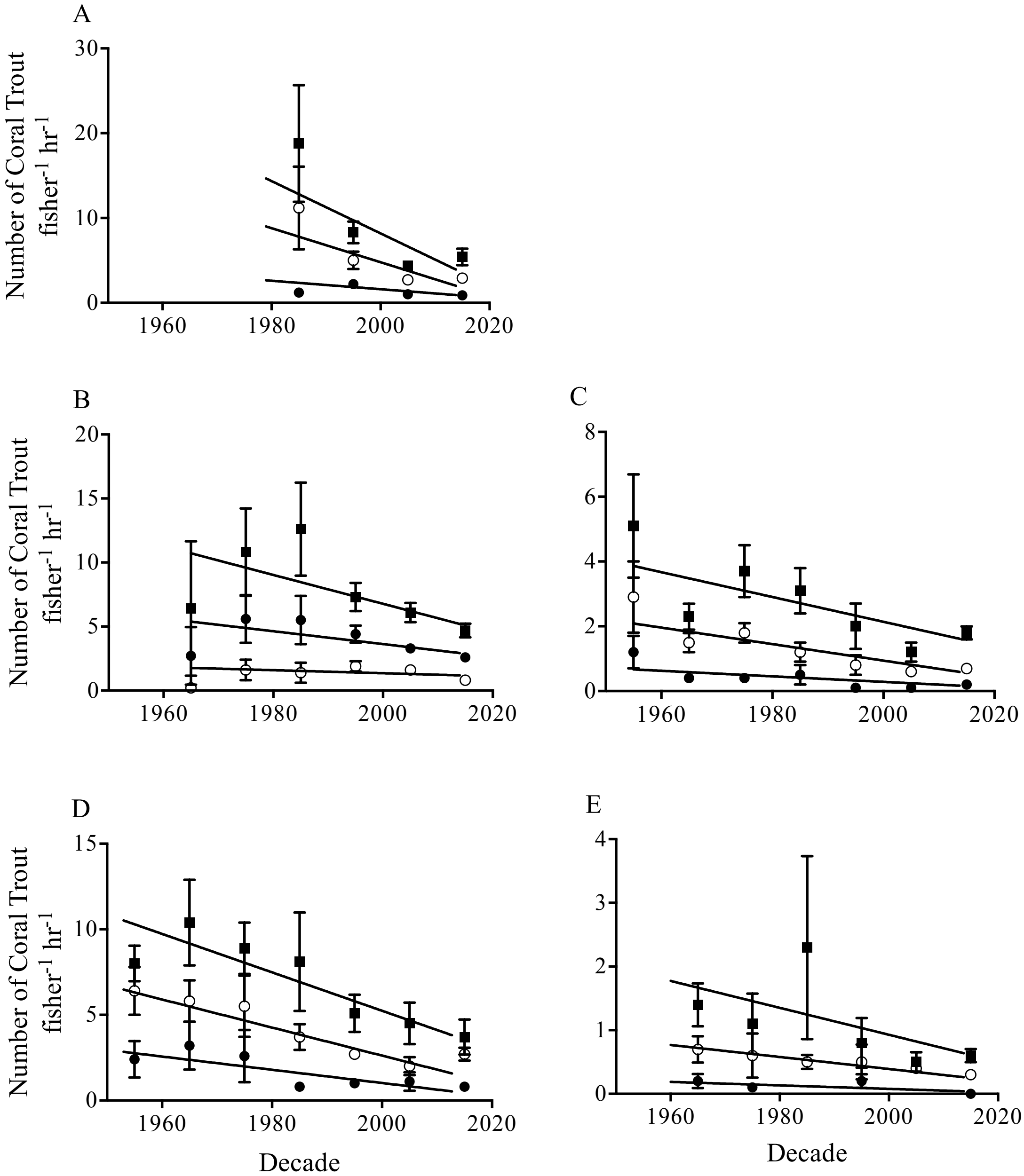

Figure 21. Mean catch rates (number of Coral Trout fisher^{-1} hour^{-1}) recalled by commercial and recreational fishers. Closed squares show ‘good’ catch, open circles show ‘average’ catch and closed circles show ‘poor’ catch. Vertical lines show the standard error, whilst horizontal lines show the linear regression. A) Catch rates recalled by commercial fishers in the far north region. B) Catch rates recalled by commercial fishers in the north. C) Catch rates recalled by recreational fishers in the north. D) Catch rates of recalled by commercial fishers in the mid region. E) Catch rates recalled by recreational fishers in the mid region.

Coral Trout comprises more than one species, hence during the interview fishers were asked to confirm which species it was they recalled catch for. All commercial fishers responded that the majority of their catch (90-95%) was comprised of Common Coral Trout, although other species were sometimes caught, and 5 commercial fishers recalled instances where they had caught large numbers of Bluespotted Coral Trout.

These catches, however, did not occur regularly and could not be used to define trends in catch rate for this species. 54 recreational fishers provided one or more catch rates for Common Coral Trout, 17 provided catch rates for Barcheek and 3 for Bluespotted Coral Trout. Due to the lower sample sizes for Bluespotted Coral Trout, we were unable to analyse catch rates for this species. Recreational catch rates for Common Coral Trout (all regions) showed significant declines in good, average and poor recalled catches throughout the time series (all p-values=<0.001, Fig. 22a, Table S3), while declines in good and average recalled catches for Barcheek Coral Trout were also significant (good p-value = 0.007, average = <0.002 and poor = 0.186, Fig. 22b, Table S3). Catch rates for Barcheek Coral Trout were also significantly lower than Common Coral Trout throughout the time series.

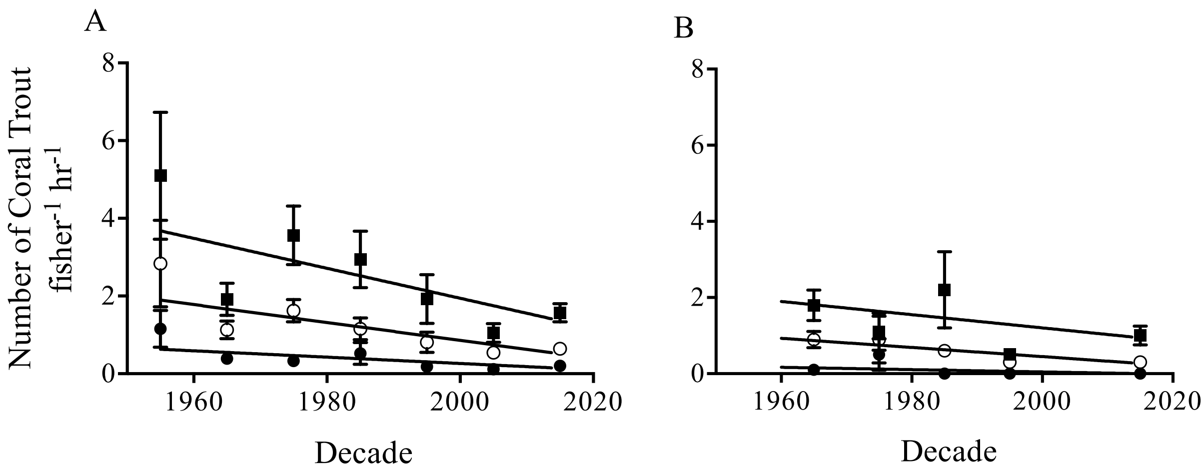

Figure 22. Mean catch rates (number of Coral Trout fisher^{-1} hour^{-1}) recalled by recreational fishers from all regions. Closed squares show ‘good’ catch, open circles show ‘average’ catch and closed circles show ‘poor’ catch. Vertical lines show the standard error, whilst horizontal lines show the linear regression. A) Catch rates of Common Coral Trout. B) Catch rates of Barcheeked Coral Trout.

Neither distance travelled nor depth fished significantly increased over time for commercial fishers (p-value=0.122 and 0.076, respectively, Fig. 23a,b). However, the increasing trends in the distance fished from shore and depth fished by recreational fishers were significant (p-value=<0.001and 0.007, respectively, Fig. 23a,b, Table S3). Commercial fishers fished further offshore than recreational fishers, although depths were similar for both sectors throughout the time series.

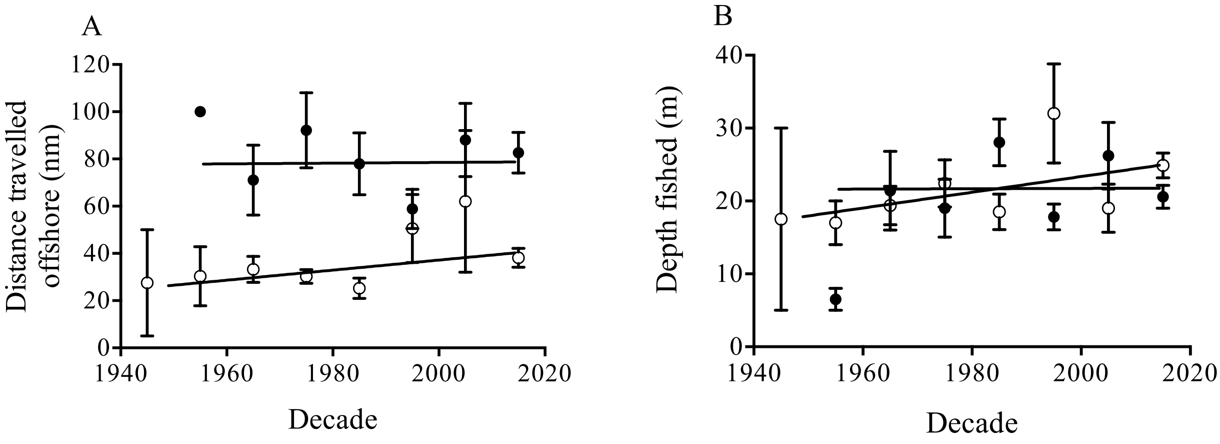

Figure 23. Changes in the average distance and depth fished from shore over time, by sector. A) Average distance fished from shore and B) depth fished by decade. Closed circles show commercial fishers and open squares show recreational (including charter) fishers recall. Vertical lines show the standard error, whilst horizontal lines show the linear regression.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

The technologies that were considered by both commercial and recreational fishers to have had the most significant impact upon catch rates of Coral Trout were geographical positioning systems (GPS) and colour echo sounders (Fig. 24). Both sectors rapidly adopted these technologies from the late 1980s, with >70% of individuals from both sectors now using these instruments. Commercial fishers also mentioned the rapid adoption of pilchards as bait from the 1970s, and the emergence of the live fishery beginning in the early 1990s (Fig. 24a): by 2014 70% of commercial fishers fished for live Coral Trout. The two most commonly mentioned techniques adopted by recreational fishers in recent decades were rod and reel and the introduction of braid line (Fig. 24b). All commercial fishers still used monofilament hand lines, while most recreational fishers began with hand lines but by 2014, 76% used rod and reel, and 61% used braid line. A small number of commercial fishers (n=5) recalled 'wogging' for Coral Trout, where a lure was used across the surface of the water, commonly across the tops of reefs in the Swains region, but all the active commercial fishers we interviewed now use bottom-fishing techniques. 4-stroke outboard motors were adopted from the late 1990s onwards by the recreational sector.

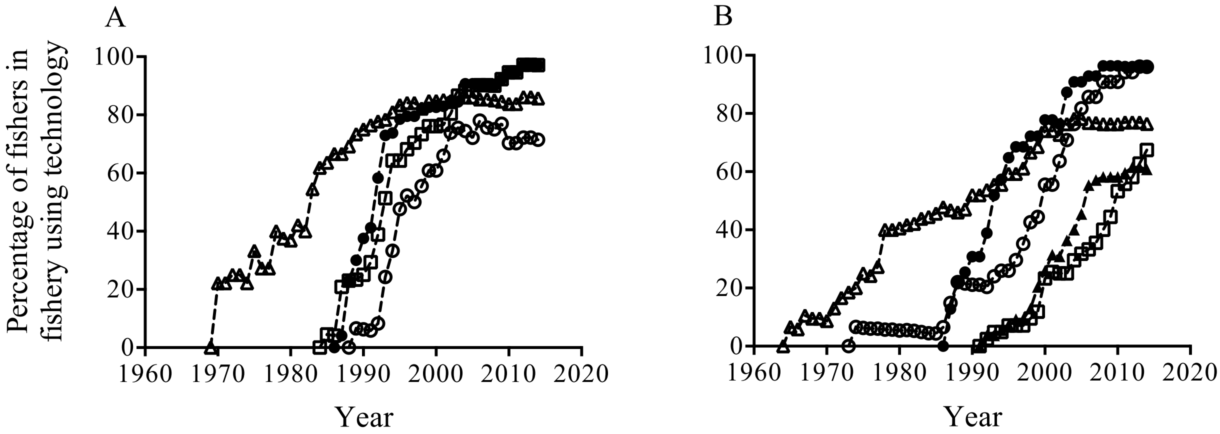

Figure 24. The percentage of fishers in the Coral Trout fishery that adopted new technologies/techniques each year, by sector. A) Percentage of commercial fishers that adopted GPS (closed circles), colour sounders (open squares), the use of pilchards as bait (open triangles) and targeting of the live fishery (open circles) through time. B) Percentage of recreational fishers that adopted the use of rod and reel (open triangles), GPS (closed circles), colour sounders (open circles), braid line (closed triangles) and 4-stroke motors (open squares) through time.

Both sectors witnessed significant changes in the length of boats used to target Coral Trout over time (p-value = <0.001 for both sectors, Fig. 25a, Table S3), although recreational vessels remained smaller than commercial vessels over the time series. Average engine power significantly increased over time for both commercial (p-value = <0.001) and recreational (p-value = <0.001) vessels (Fig. 25b, Table S3).

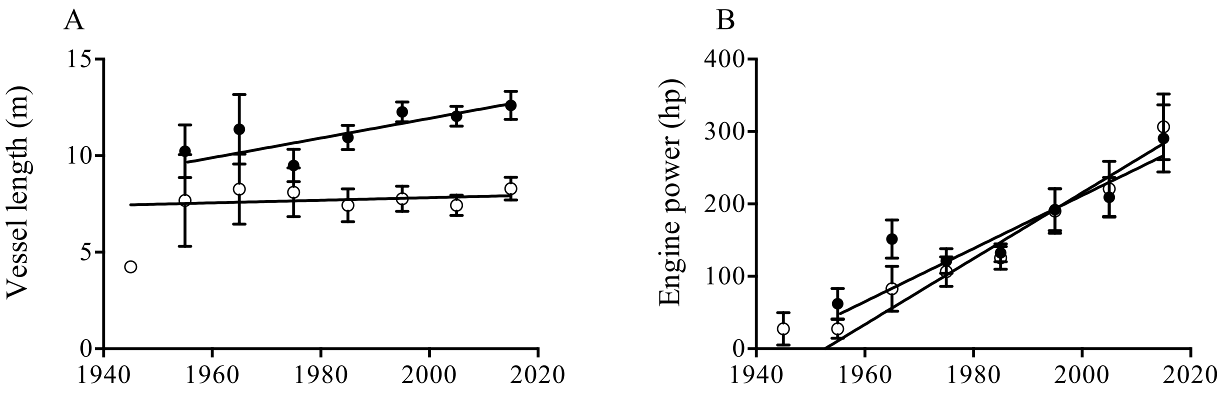

Figure 25. Changes in vessel length and engine power over time, by sector. A) Average vessel length and B) engine power by decade. Closed circles show commercial fishers, open squares show recreational fishers recall. Vertical lines show the standard error, whilst horizontal lines show the linear regression.

Coral Trout fishers stated how their catches had been affected by management measures. In common with Snapper, no-take zones and size limits were mentioned the most by commercial fishers, while no-take zones, bag limits and size limits were most commonly mentioned by recreational fishers (Fig. 26). A majority (76%) of commercial fishers stated that no-take zones had decreased their catches of Coral Trout, with 21% stating that their catches had not altered. When asked about size limits, 63% of commercial fishers believed their catches had not altered as a result of size limits, with 13% stating their catches had decreased as a result. When asked about no-take zones, 73% of recreational fishers stated that these had not altered their catch, while 23% stated their catch had decreased as a result of no-take zones. Only 22% of recreational fishers believed that bag limits decreased their catch, whilst 78% believed that bag limits had no impact on their catch. A majority (88%) of recreational fishers believed that size limits had not altered their catch, with 12% stating that their catch had decreased.

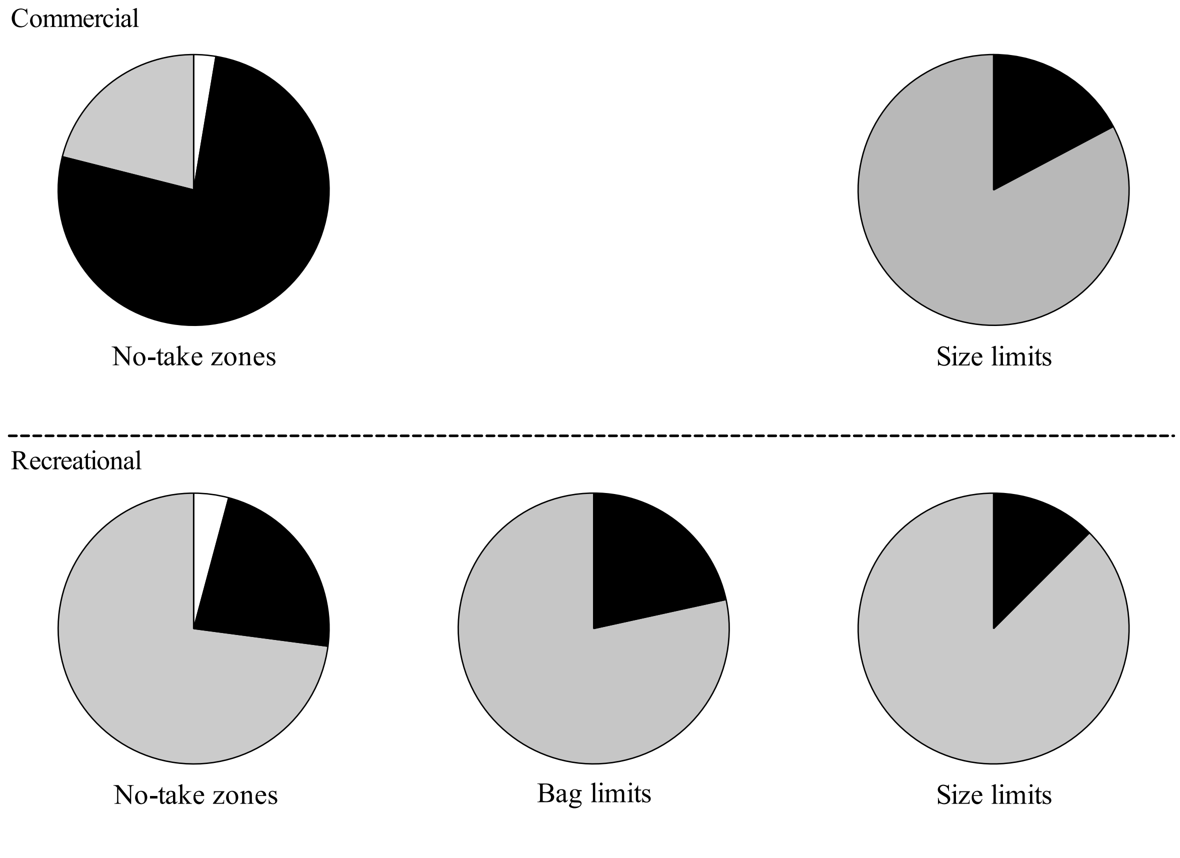

Figure 26. The effect of different management measures on fishers' catch of Coral Trout. Pie charts show the percentage of fishers who stated that their catches has either decreased (black), increased (white) or not altered (grey) as a result of three most cited management measures by commercial (upper panel) and recreational fishers (lower panel).

A majority (73%) of commercial Coral Trout fishers felt negatively towards no-take zones, while 20% and 7% perceived no-take zones neutrally and positively, respectively. Conversely, 45% of recreational fishers perceived no-take zones negatively, while 27% were neutral and 28% were positive about no-take zones. The majority of commercial and recreational fishers (68% and 58%, respectively) were neutral regarding size limits, while 28% commercial and 41% recreational felt positively about this management measure. Recreational bag limits were regarded as positive by 60% of recreational fishers, and neutrally by 40%.

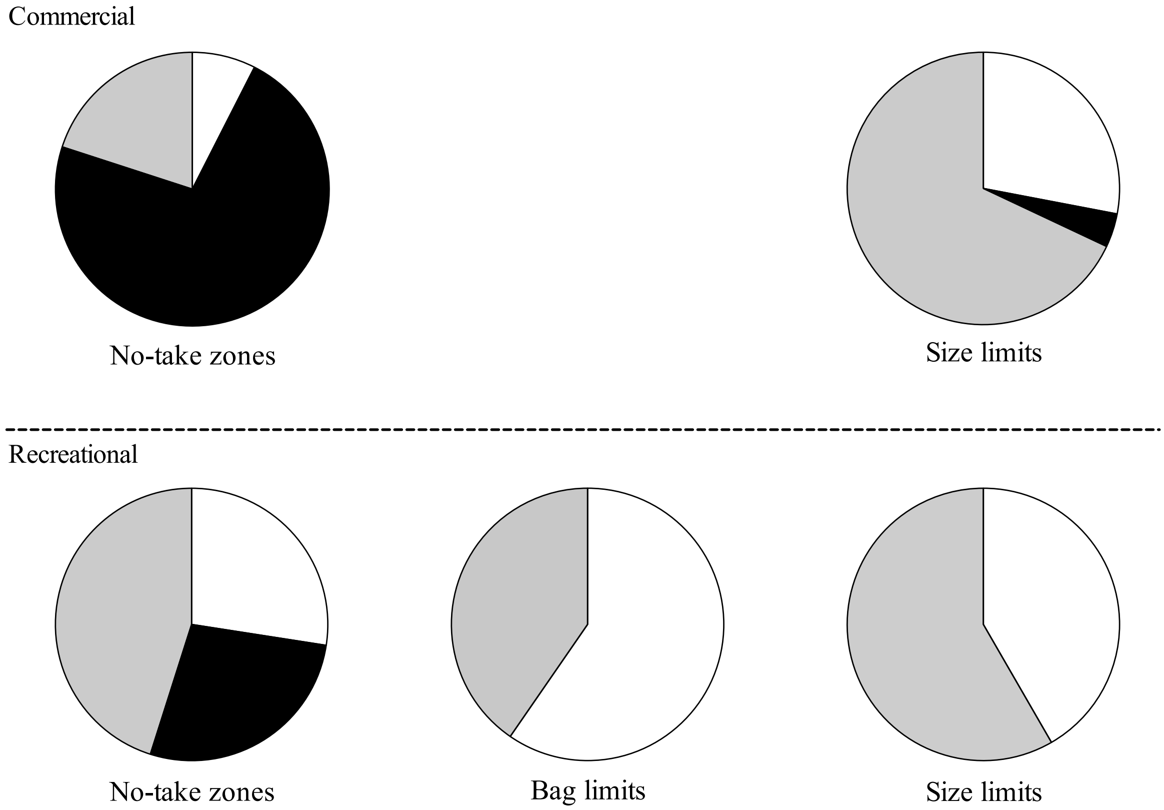

Figure 27. Fishers' views on the impact of management measures on the Coral Trout fishery. Showing how fishers' perceived the three most stated management measures: commercial; no-take zones, quota and licensing and recreational; no-take zones, bag limits and size limits. Pie charts show the percentage of fishers who perceived the measures positively (white), percentage who perceived the measures negatively (black), and those fishers who were neutral towards the management measures (grey).

Overall trends in abundance and size

The majority of commercial and recreational fishers perceived an overall decrease in Coral Trout abundance throughout their experience (51% and 80%, respectively). Stocks were perceived as stable by 40% of commercial fishers, compared to only 15% of recreational fishers. A minority (9%) of commercial fishers and recreational fishers (5%) stated they had perceived an overall increase in Coral Trout abundance (Fig. 28a). When asked about changes in size, 46% of commercial fishers and 60% of recreational fishers perceived a decrease in the size of Coral Trout, while 48% of commercial fishers and 35% of recreational fishers cited that average Coral Trout size had remained stable over time (Fig. 28b).

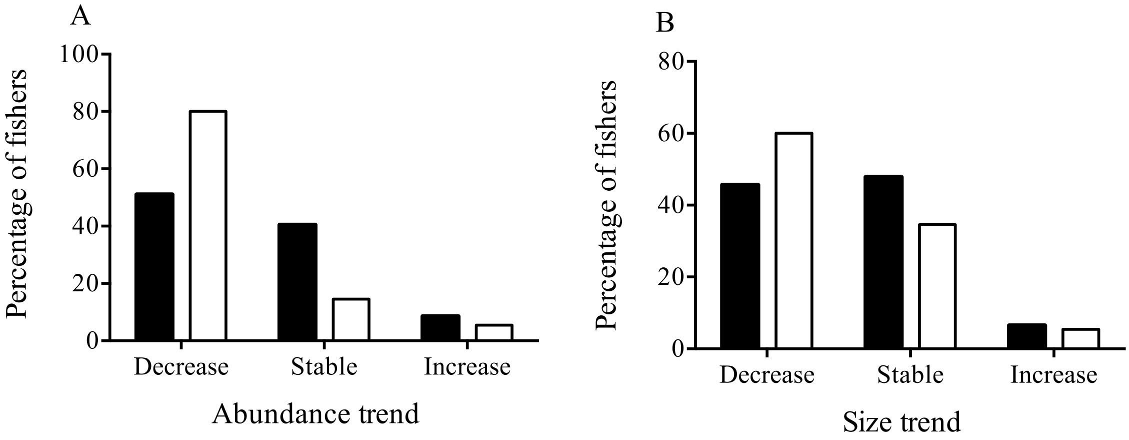

Figure 28. Fishers' perceptions of change in Coral Trout abundance and size over time. A) Overall changes in abundance and B), overall changes in size. Black bars = commercial, white bars = recreational fishers.

Areas of concern

Recreational and commercial Coral Trout fishers shared many of the same areas of concern regarding anthropogenic threats (Fig. 29). The most commonly mentioned by both sectors was fishing pressure (38% commercial, 63% recreational), while 23% and 17% of commercial and recreational fishers, respectively, did not perceive any threats to Coral Trout. Poor management or lack of management was perceived as a threat by 26% of commercial fishers, while pollution or poor water quality was also of concern to 17% commercial and 10% of recreational fishers.

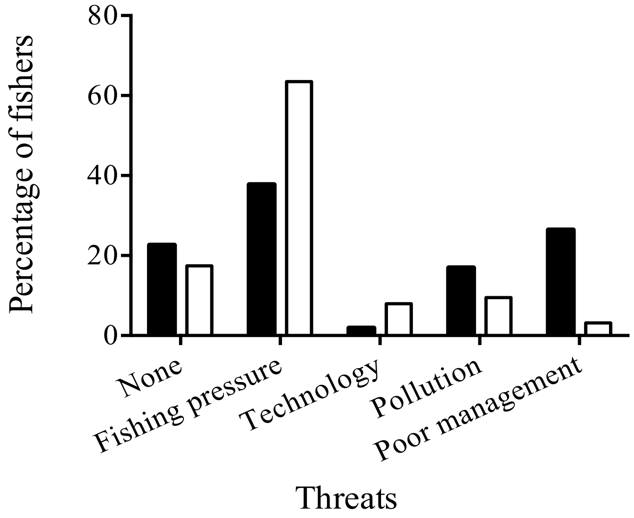

Figure 29. Fishers' perceptions of anthropogenic threats to Coral Trout. Black bars = commercial fishers, white bars = recreational fishers.

To what extent can we rely on fisher knowledge?

To determine the reliability and accuracy of fisher knowledge we gathered individual logbooks from 74 fishers (55 line, 13 net and 6 trawl fishers; 72 commercial, 2 recreational). 21 fishers provided personal logbooks, whilst 53 fishers provided the researchers with permission to access their government logbooks from Fisheries Queensland. Recalled catches that corresponded with logbook records dated back as far as 1964 and cover a range of fisheries, including Snapper, Spanish Mackerel, Coral Trout and Mullet, in addition to invertebrate fisheries. The accuracy of fishers' recall was very variable (Fig. 30), with fishers' both under- and over-estimating typical catches compared to their logbook data (Fig. 30b). Taken as a whole, fishers overestimated past typical catches by 36% compared to the median catch recorded in their logbooks. Fishers' typical recall also became significantly less accurate as time elapsed (p-value=0.041). However, this trend was very gradual at a rate of 0.65% per year. While typical catches were generally overestimated, good and poor catches fell within the upper and lower range of logbook catch records, with no significant changes over time (Fig. 30a,c, see also Thurstan et al. *In press*, a).

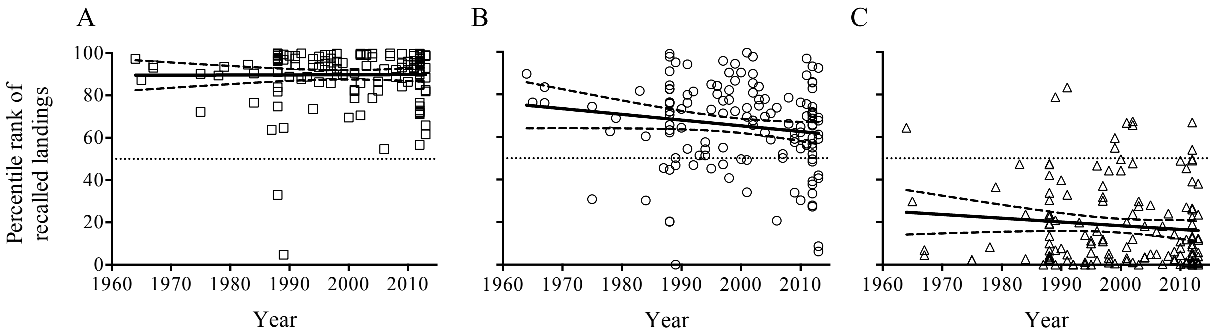

Figure 30. Fisher's recall of good, average and poor daily catch compared to their logbook data for each corresponding period of time (n = 74). The solid line indicates the linear regression line, long dashed lines indicate 95% confidence intervals. Short dashed line indicates the 50th percentile. Derived from Thurstan et al. (*In press*, a).

Discussion

Snapper

Reconstructing relative changes over time

Some fishers were able to recall catches back to the 1940s, reflecting the long history of Snapper fishing in southeast Queensland. In the south, recalled good and average catch rates declined with time for both commercial and recreational fishers (Figs. 3a and 3b). Throughout the time series commercial fishers' recalled catch rates were slightly higher than recreational fishers, until the last decade when commercial and recreational catch rates aligned.

In the north section only 2 commercial fishers were able to recall catch rates back to the 1960s, and these values were much higher than later recalled catch rates (Fig. 3c). This could be due to exaggeration on the part of the individual fishers, but both the fishers concerned stated that these high catch rates were a function of the discovery of unexploited grounds during this period, and that these catch rates were not maintained once exploitation in these regions intensified.

Recreational fishers also did not recall catches from the north region any earlier that the 1960s (Fig. 3d). This was not a consequence of the age of the fishers, but more to do with the fact that some of these fishers had moved from areas such as Brisbane or the Gold Coast to the north, hence did not commence fishing in these areas until later years, or were not interested in targeting Snapper until later years. Recreational catches appeared stable. This may have been due to a lower sample size (as shown by the large error bars), but fishers in this region also tended to report that they had not seen declines in the northern part of the fishery, with many fishers perceiving this to be due to lower fishing pressure compared to the Gold Coast or Brisbane region.

Overall there had been a significant increase in the distance travelled by fishers to fishing grounds (Fig. 4a). Many of the fishers, when questioned why they moved sites, replied that they moved to maintain their catch rates or to avoid the more traditional grounds, which had become popular with greater numbers of recreational fishers. Throughout the time period, commercial and recreational fishing sites overlapped, with both recreational and commercial fishers visiting the same grounds. This changed in the last decade, when commercial fishers appeared to have increased their distances fished offshore compared to recreational fishers. This is supported by commercial fishers' testimony, many of whom stated that they travelled further offshore in recent years, partly to avoid recreational fishers. Both commercial and recreational fishers had shifted to targeting fish at deeper depths over time (Fig. 4b). The wide error bars reflect the differences between fishers, some of whom prefer to fish close inshore, others whom prefer offshore grounds. The trend in Fig. 4b probably underestimates the extent of change, as one fisher noted,

"The fishing areas haven't changed, but we've now found different spots within that reef. The normal spots are the main reef that everybody fishes, sometimes it's like a main street so we try and find new spots to get away" - Recreational fisher, Brisbane.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

GPS, colour echo sounders and 4-stroke outboard engines were rapidly adopted as soon as they became available and affordable (Fig. 5a). There was no difference between the rate or timing of uptake between recreational and commercial fishers. Recreational fishers also commonly mentioned three techniques that had increased the efficiency of Snapper fishing: float-lining, the use of braid and soft plastics (Fig. 5b). Whilst the technique of float-lining was more gradually adopted over time, both braid and soft plastics were rapidly adopted after the year 2000. Many fishers, both commercial and recreational, believed that improvements in technology, GPS in particular, had had a negative impact on the fishery, but acknowledged that improved navigation systems also made fishing safer than before (Table 2).

Table 2. Quotes from fisher interviews on the impact of technology on Snapper abundance. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing technology on the fishery, and which technologies had had the greatest impact.

The impact of GPS
There was a decrease in the Snapper populations after the 1950s because of the pressure, but then in the '80s GPS knocked it – Recreational fisher, Gold Coast. *GPS is the worst thing that ever happened to the fishery* – Commercial fisher, Sunshine Coast. *When GPS was combined with good quality echo sounders that allowed us to accurately identify the little reefs* – Recreational fisher, Brisbane. *GPS gave a significant and immediate improvement; the duds got good* – Recreational fisher,

Brisbane. *With GPS even a dummy can go and find a good fishing spot when he has very little knowledge [but] they make fishing safer and more fuel-efficient* – Recreational fisher, Brisbane. *GPS hasn't harmed fisheries, it has spread the load* – Recreational fisher, Brisbane.
The impact of soft plastics
Soft plastics were good at the start because the fish weren't used to it, it also bought the catch and release fishers into the market – Recreational fisher, Gold Coast. *Certain techniques allow us to catch our fish faster than when we were bait fishing* – Recreational fisher, Brisbane.
The impact of braid line
The biggest advance is braid line; you can feel every bite – Recreational fisher, Brisbane. *Braid is one of the biggest changes in my fishing time* – Recreational fisher, Mackay.
The impact of changing fishing style
In the 1970s and 80s the style of fishing altered a lot, hook-up rates improved due to changes in fishing style – Charter fisher, Brisbane.
The impact of 4-stroke engines
In the mid-2000s cheap efficient 4 stoke outboards transformed recreational fishing – Recreational fisher, Brisbane.

Significant increases in the length of fishing vessels were observed over time (Fig. 6a). Although vessel lengths increased between the 1970s and 1990s, since the 1990s average vessel size has decreased. Early recreational vessels were also larger than today, although there was no major difference in the average length of commercial and recreational vessels after 1960. In contrast, engine power greatly increased over time for both recreational and commercial vessels (Fig. 6b). Although the trend in increasing engine size stabilized in recent years for commercial vessels, the average engine size for recreational vessels has continued to increase.

None of the three management measures (no-take zones, bag limits and size limits) were perceived by fishers' to have increased their catches (Fig. 7). Just under a third of commercial and recreational fishers perceived no-take zones to have decreased their catch of Snapper, although the majority of fishers from both sectors perceived no change. Similar proportions – around a third of fishers from both sectors – perceived no-take zones negatively (Fig. 8), whilst around two-thirds were perceived no-take zones neutrally in terms of their impact upon the Snapper fishery. Half of the recreational fishers interviewed perceived a decrease in their catch of Snapper as a result of bag limits, but 50% perceived no impact. A common statement by recreational fishers (although not all) was that they only fished for enough fish to feed themselves, thus the bag limits did not overly affect them. Many of those who perceived bag limits negatively did agree with bag limits in principle, but expressed concern that the most recent bag limit of four Snapper per angler was too restrictive. Very few fishers felt that size limits reduced their take of Snapper, and the majority of fishers, both commercial and recreational were neutral in their responses to size limits.

Fishers commonly perceived management to be poor or to have been implemented at too late a stage (Table 3). Long-term recreational fishers also commonly spoke of how attitudes had changed since the 1980s and 1990s: from fishers' attempting to catch as many fish as possible in the 1980s to adopting a more conservation-minded attitude in recent years. Most attributed this to the introduction of the 30-bag limit, the abolition of Section 35 and the rise in popularity of catch and release fishing (Table 3).

Table 3. Quotes from fisher interviews on the impact of management on the Snapper fishery and recreational fishers' attitudes towards fishing. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing management on the fishery, and whether recreational fishers attitudes to fishing had altered during their experience.

The impact of management
Management needs to be more regionalised, not a blanket rule – Recreational fisher, Bundaberg. *If the government had thought of the 4 or 5 bag limit 20 years ago, we wouldn't even be talking about this now, there wouldn't be a problem* – Recreational fisher, Brisbane. *Management evens out the population pressure but they still need to think of the future and manage for 20 years time, including monitoring the fishery* – Recreational fisher, Brisbane. *Failure to manage the fishery has caused us problems* – Commercial fisher, Sunshine Coast. *Section 35 was probably good for the boating and tackle industry, but it was really bad for the fish. There was a different mentality then* – Recreational fisher, Gold Coast. *We should have had management on Snapper in the mid-80s* – Recreational fisher, Gold Coast. *It doesn't matter what you recommend or do, the government won't take any notice of you* – Charter fisher, Brisbane.
Changing attitudes in the recreational fishery

Perceptions of fishing changed in the mid-1980s; in the 1970s and 80s people would fish for the 30 bag limit because they could get away with selling the fish, now most want to preserve stocks – Recreational fisher, Brisbane. *The 30-bag limit bent people's way of thinking about fishing and altered their perceptions. Before then it was smash and grab* – Charter fisher, Sunshine Coast. *Throughout the 1990s, but especially the last 10-15 years, the number of people wanting to slaughter large numbers of fish has decreased* – Recreational fisher, Brisbane. *The attitude changed within 5 years with anglers, from 'as many fish as possible' to 'a few will do'* – Charter fisher, Gold Coast

Overall trends in abundance and size

The majority of fishers, both commercial and recreational, perceived an overall decrease in Snapper stocks, although some had witnessed an increase in stocks in recent years (Fig. 9a, Table 4). Observations in the changes to the size of Snapper were more split between observations of an overall decline in the average size of Snapper and the size remaining stable. The majority of commercial and recreational fishers did not believe that there were any particular threats to Snapper (Fig. 10), but of threats perceived, the most commonly mentioned by both sectors was fishing pressure, followed by advances in technology and poor management. Included within these categories were bycatch of Snapper in other fisheries, a lack of scientific knowledge and a lack of management, which were perceived as threats by a minority of recreational fishers, whilst a minority of commercial fishers mentioned black marketing and a lack of enforcement as potential threats to Snapper.

Table 4. Quotes from fisher interviews regarding fishers' perceptions of the current status of Snapper. These quotes are typical of the responses from fishers' when asked about the current status of Snapper compared to when each fisher commenced fishing.

Fishers' views on the current status of Snapper
Fish don't get a rest-time anymore, too much pressure from too many people – Commercial fisher, Tweed Heads. *Snapper have declined but they are not in serious trouble: there is a difference between decreased and destroyed; it is still a good fishery* – Recreational fisher, Brisbane. *The Snapper grounds further south have been flogged* – Commercial fisher, Gladstone. *Snapper numbers are still declining inshore, even though they have changed its management* –

Recreational fisher, Sunshine Coast.

The fishery hasn't been decimated, but there is too much pressure – Commercial fisher, Brisbane.

Spanish Mackerel

Reconstructing relative changes over time

Commercial fishers recalled catches back to the 1940s, whilst recreational fishers' recall commenced a decade later. According to recreational fishers this was not due to age; interest in sport fishing for Spanish Mackerel occurred later, hence the recreational time series starts from the 1950s. In the north good and average catches significantly declined over time (Figs. 13a and 13b) for both commercial and recreational fishers. Similarly, in the south all catch rates declined with time for both sectors (Fig. 13e and 13f). Commercial fishers catch rates were consistently higher than recreational fishers over time for both the north and south regions.

Catch rates for commercial and recreational fishers differed in the mid area, where both sectors stated similar catch rates over time. Only the good catch rates recalled by commercial fishers declined over time, whilst recreational good and average catch rates declined significantly over time (Fig. 13c and 13d). The decline observed in recreational good catch rates could be due to exaggeration on the part of the individual fishers in the 1950s, but fishers concerned stated that these high catch rates were a function of selling the excess catch under Section 35. Alternatively, the higher catch could be a function of a lower sample size (as shown by the large error bars), but the majority of fishers in this region perceived declines in the mid part of the fishery over time.

In 2010 a decline in distance travelled was observed as commercial and recreational fishers fished closer inshore due to the cost of fuel (Fig. 14a). In the south and mid regions, commercial and recreational fishing sites overlapped. Fishers travelled further offshore to maintain their catch rates or to avoid the increasing fishing pressure in inshore areas, due to the rapid increase in number of recreational fishers. However in the north commercial operators travelled further offshore compared to recreational fishers since the 1940s. This is supported by commercial fishers' testimony, many of whom stated that they travelled further offshore to target the mid-shelf spawning season and avoid the increasing recreational pressure. The wide error bars in the later decades reflect the differences between fishers, some of whom prefer to fish close inshore, others whom prefer offshore grounds due to the onset of fuel-efficient 4-stroke motors.

Overall, there has been a significant increase in the depth commercial and recreational fishers target Spanish Mackerel (Fig. 14b). Fisher comments supported this noting that adoption of certain gears; paravenes, outriggers, braid, allowed fishers to drop baits to deeper depths to maintain catches. By 2000, the depth targeted decreased for commercial fishers, a function of a decrease in sample size of northern commercial fishers rather than an increase in depth fished. A similar trend was observed for recreational fishers, where the depth increased by 2010.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

GPS and colour echo sounders were rapidly adopted as soon as they became available by commercial fishers and as soon as they became affordable by recreational fishers (Fig. 15a and 15b). Commercial and recreational sectors adopted these technological innovations at similar rates but there was delay of a decade between the timing of uptake by the commercial followed by the recreational sector. The majority of recreational fishers adopted the technology when it became affordable. Both sectors commonly mentioned the influence of paravenes/downriggers and live bait that increase the efficiency of Spanish Mackerel fishing (Table 5). Both gears were gradually adopted over time and only half of the fishers use these gears. Primarily northern and mid commercial fishers adopted refrigeration. Fishers commented that using refrigeration allows fishers to increase the length of a fishing trip up to ten fold. This trend decreased in the later decade as fishers reverted to ice due to costs of fuel. Whilst recreational fishers frequently cited 4-stroke motors, which allowed fishers to travel further offshore, 40% of recreational fishers have not adopted this technology primarily due to the preference of fishing inshore sites (Table 5).

Table 5. Quotes from fisher interviews on the impact of technology on Spanish Mackerel abundance. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing technology on the fishery, and which technologies had had the greatest impact.

The impact of GPS
GPS dramatically changes fishing - it increased fishing time, decreased locating time and decreased travel time, there are no more secrets anymore. It is responsible for increased fishing pressure - everyone knows where the spots are – Commercial fisher, Townsville *GPS is very good for fishermen especially for rec fishermen, it increases the pressure hugely on fish. Now we have a sheer quantity of inexperienced fishers. It will clean the fish out*– Commercial fisher, Bundaberg. *GPS has saved a lot of fuel by getting to spots quicker, it saves time and you are more accurate fishing, it remembers spots and is great for safety* – Recreational fisher, Cairns *Advent of electronics especially GPS is deadly for recreational fishers. Offshore electronics is quite profound. It made it so much easier to increase catch rate* – Recreational fisher, Brisbane
The impact of colour sounders
Colour sounder is an improvement because it can pick up bait schools, can see structure and arches, thus increasing fishing location and catch rate - it is a lot more accurate – Commercial fisher, Mackay
The impact of downriggers
Just needed to get the lines down deeper during the Townsville season due to competition – Commercial fisher, Townsville. *Fish are getting smarter and downrigging is an effective way to catch fish* – Recreational fisher, Yeppoon.
The impact of live bait
With the onset of live baiting you had to relocate to other locations where they was no live baiting or you wouldn't catch a fish - Commercial fisher, Sunshine coast
The impact of 4-stroke engines
4 stroke outboards change things to something terrible and guys are venturing further out – Recreational fisher, Mission Beach

The impact of refrigeration
Refrigeration made a big change, you can be a bit more adventurous in going out more days fishing – Commercial fisher, Townsville

No significant change in the length of commercial fishing vessels was observed over time, however, an increase was observed in recreational vessels (Fig. 16a). Although commercial vessel lengths increased between the 1940s and 1960s, since the 1960s average vessel size has decreased. This could be a function of regions where fishers operated, as northern commercial fishers used larger vessels than southern and mid fishers. Early recreational vessels were a similar size to today, yet fishers mentioned frequently that vessel size increased over time thus improving recreational fishing efficiency. In contrast, engine power greatly increased over time for both recreational and commercial vessels (Fig. 16b). The trend in average engine size continues to increase for the commercial sector, yet the average engine size for recreational vessels has decreased in the most recent decade, 2010.

The majority of commercial and recreational fishers perceived no change in their catch rate due to the three most mentioned management measures (Fig. 17). The most cited management measure by both sectors was no-take zones. Only 2% of commercial and 6% of recreational fishers perceived an increase in their catch due to no-take zones, whilst 23% commercial and 19% recreational stated they had negatively affected their catch rates. A larger proportion of commercial (45%) and recreational (46%) perceived no-take zones negatively (Fig. 18). A common statement was that the consultation process was not conducted fairly and stakeholders were not fully accounted for. Commercial fishers did not perceive an increase in their catch as a result of the implementation of quota or licensing. Just 6% noticed a decrease due to licensing and 19% because of quota. A larger proportion, just under a third of commercial fishers perceived these measures negatively. In contrast, the majority of recreational fishers view both bag limits and size limits positively as the majority felt it did not overly affect their catch rate.

Similar to Snapper, Spanish Mackerel fishers commonly perceived management to be poor or to have been implemented at too late a stage (Table 6), whilst long-term recreational fishers commonly spoke of how attitudes had changed since the 1980s and 1990s. Most attributed this to the introduction of the 10-bag limit, the abolition of Section 35 and some the rise of catch and release fishing (Table 6).

Table 6. Quotes from fisher interviews on the impact of management on the Spanish Mackerel fishery and recreational fishers' attitudes towards fishing. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing management on the fishery, and whether recreational fishers attitudes to fishing had altered during their experience.

The impact of management
Management is a failure right through especially for Spanish Mackerel. A blind man could see what was happening with schools of fish, the biomass kept declining – Recreational fisher, Brisbane *Looking back, it was the wrong thing to do catching them during spawning when they are at their most vulnerable and failure to manage it is the demise of the fishery* – Commercial fisher, Cairns *Similar catches today as there was 20 years ago and that is due to management like bag limits and green zones* – Recreational fisher, Yeppoon *I worry about the size limit for Spanish Mackerel as females don't reproduce until the length of 90cm yet we can catch 75cm fish* – Recreational fisher, Mackay *No management has been put in place to stop decline and voicing an opinion is wasted to the wind* – Commercial fisher, Bundaberg *Getting like a policed state - don't get industry involvement when they don't listen to fishermen* – Commercial fisher, Townsville *Management just need to beat electronics* – Recreational fisher, Townsville
Changing attitudes in the recreational fishery
I used to sell surplus until the '90s as did most. The bag limits changed the meat mentality to fishing for your bag limit, becoming conservative about your catch – Recreational fisher, Rainbow Beach. *Fishers have meat mentality, without bag limits they keep on taking* – Charter fisher, Innisfail

Overall trends in abundance and size

The majority of fishers, both commercial and recreational, perceived an overall decrease in Spanish Mackerel stocks (Fig. 19a, Table 7). The minority that perceived an increase commenced fishing in the later period, from 1991 onwards. Observations in changes to the size of Spanish Mackerel were more varied, half of the commercial and recreational fishers stated the size remained stable, over a third for both sectors observed a decline and a minority noted an increase in the size of Spanish Mackerel over time (Fig. 19b). The majority of commercial and recreational fishers believed that the principal threat to Spanish Mackerel stocks is fishing pressure (Fig. 20). Both sectors highlighted the same drivers of change but the ranking in most frequently mentioned threat varied between the sectors. Commercial fishers cited technology, by-catch followed by poor management, whilst recreational fishers mentioned poor management, technology and by-catch.

Table 7. Quotes from fisher interviews regarding fishers' perceptions of the current status of Spanish Mackerel stocks. These quotes are typical of the responses from fishers' when asked about the current status of Snapper compared to when each fisher commenced fishing.

Fishers' views on the current status of Spanish Mackerel
The demise of the fishery is due to the new generation of southern fishers, they catch all day long not allowing the fish a rest – Townsville, Commercial fishers *Should limit number of fishers not number of fish caught! Too many green zones, increases overfishing of inshore areas where local stocks are depleting* – Recreational fisher, Noosa *Spanish Mackerel is locked away in green zones, it's an underused resource* - Gladstone, Recreational fisher *In terms of management of a species that is supposed to be shared it has been an absolute disaster, the spawning grounds are getting hammered* – Commercial fisher, Brisbane

Coral Trout

Reconstructing relative changes over time

Significant declines in catch rates were perceived across all regions, for both sectors, for good, average and poor catch. Time series in the mid and northern regions began much earlier compared to the far north region, the 1950s compared to the 1980s. Some of the earliest catch rates recalled by commercial fishers were from the Swains region, where much of the early Coral Trout fishery was undertaken. Fishers from Cairns recalled the earliest recreational catches, although our sample of recreational fishers had also targeted Coral Trout in the southern region since the 1960s. The archival data also hints at recreational and commercial catches in these regions during earlier periods, but we did not interview anyone who could recall earlier than the 1950s. Catch rates for commercial fishers remained much higher than recreational fishers throughout the time series. Although some commercial fishers commented on declines in catch rates as a result of cyclone events, almost all stated that their catch rates had returned to normal within a couple of years.

In the far north only 2 fishers were able to recall catch rates prior to the 1990s (Fig. 21a). Fishers recalled the far north region (i.e., Cooktown and beyond) being a 'virgin' fishery during this time, with few commercial or recreational fishers exploiting the coral trout stocks in this region. Conversely, commercial and recreational fishers have exploited the Swains and Cairns regions for the last 50 years. A number of recreational and commercial fishers felt that fishing pressure had intensified in the north region due to increasing numbers of recreational fishers, shallow-water fishing by the live fishery, and zoning closures which compressed fishers into a smaller area. While catch rates were perceived to have decreased, some fishers from this region commented that stocks remained high in green zones and in low-fished areas, and that perceived declines in catch rate were due to the above factors.

Coral Trout is the common name for several species from the *Plectropomus* and *Variola* genus, hence fishers were asked which species they most commonly caught. All commercial fishers stated that the vast majority of their catch of Coral Trout consisted of Common Coral Trout, although Bluespotted and Passionfruit were also sometimes caught. Eight fishers referred to catching Bluespotted Coral Trout in the Swains, Cairns and far north regions, but these catches were less common compared to other Coral Trout species. These fishers stated that this species had become less abundant in their experience. Recreational fishers targeted both Barcheek and Common Coral Trout, depending upon their fishing location, although more fishers targeted Common Coral Trout. Both species showed significant declines in recalled catch rates, while catch rates for Barcheek Coral Trout were substantially lower than the Common Coral Trout (Fig. 22).

Recreational fishers significantly increased the distance travelled to fishing ground and depth fished, whereas commercial fishers did not significantly increase either distance or depth (Fig. 23). Many recreational fishers in the north had moved fishing grounds as a result of the zoning closures, or because they perceived there to be fewer Coral Trout as a result of the commercial live fishing in the region. In the mid region, many fishers had previously fished around the inshore islands, targeting Barcheek Coral Trout, but had either moved offshore as a result of increased access to seaworthy vessels, or because they perceived the fishing to be better offshore. Depth had also increased, either because improvements in technology facilitated deeper fishing depths, or because recreational fishers preferred to fish deeper locations, away from the live fishery. Conversely, commercial fishers did not significantly alter the distance travelled or depth fished over time. This was partially because long distances have always been travelled in the commercial fishery, although some fishers did state that movement between reefs was more frequent now than previously and therefore overall travel distance have increased, while fishing depth had remained the same or even become shallower, thus enabling Coral Trout to survive for the live fish trade. While the commercial and recreational fishery spatially overlapped in the north region, fishers reported less overlap in the far north and mid regions.

Determining the impact of evolving fishing technologies, fishing effort and changing management regimes

GPS and colour sounders were rapidly adopted by both sectors as soon as they became available and affordable (Fig.24). There was no major difference in the rate or timing of uptake between recreational and commercial fishers. Recreational fishers also commonly mentioned 4-stroke outboard motors, rod and reel and braid line as three pieces of technology that increased the efficiency of Coral Trout fishing. While commercial fishers, without exception, still used monofilament hand lines, fishers that operated prior to the 1970s recalled the switch from mullet or squid bait to pilchards, which they stated increased their catch rate.

The 'wogging' technique, used during the 1950s and 1960s, fell out of fashion as coral trout numbers reduced and as bottom fishing (spiking) using pilchards was introduced (Table 8).

Table 8. Quotes from fisher interviews on the impact of technology on Coral Trout abundance. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing technology on the fishery, and which technologies had had the greatest impact.

The impact of GPS and sounders
Sounders and GPS meant we could find grounds that you never knew were there, you could find new grounds on shoals – Commercial fisher, Cairns. *GPS was the beginning of the end of being a fisherman; skill was no longer required. Everyone got your marks* – Charter fisher, Cairns. *Colour sounders pick up bait and structure better, especially the soft structure* – Recreational fisher, Yeppoon. *GPS made fishing easier, but you're still catching less fish now. It increased the time you could spend fishing* – Commercial fisher, Townsville. *Technology has been a quantum leap. Before you couldn't fish [coral trout] in water where you couldn't see bottom, it was all visual* – Recreational fisher, Townsville.
The impact of braid line
Braid allows me to feel the bites better, it increases catch rate as you can respond more quickly - before [the fish] hides back in the reef – Recreational fisher, Yeppoon. *I got braid 2 or 3 years ago […]. I can feel bites so my strike rate has increased, catch rate has increased by 10%* – Recreational fisher, Rockhampton.
The impact of changing fishing style and bait
Wogging disappeared with the pilchards, 20 years ago […]. Pilchards meant you didn't have to fish for bait, and the trout went stupid over them – Commercial fisher, Mackay. *Wogging mostly caught trout but was a lot of effort. Bottom fishing would catch more fish more quickly* – Commercial fisher, Rockhampton. *You're not in the race if you're not using pilchards* – Commercial fisher, Townsville.

While individual recreational fishers gradually increased the length of their boats, this increasing trend was more noticeable in commercial vessels. A significant size difference has also existed between commercial and recreational vessels throughout the recalled history of the fishery, largely because the vast majority of commercial vessels have always conducted multi-day trips with two or more crew on-board, while recreational fishers conduct more day trips. Engine power greatly increased over time for both recreational and commercial vessels (Fig. 25), with no signs that the rate of increase is declining.

Very few fishers (<5%) perceived the three management measures most commonly mentioned (no-take zones, bag limits and size limits) to have increased their catches. A majority (76%) of commercial fishers perceived their catch rates to have declined as a result of no-take zones, and a similar percentage felt negatively about no-take zones. Far fewer recreational fishers (23%) perceived a decline in catch rates from no-take zones, and a similar percentage were correspondingly negative about this measure. The majority of recreational and commercial fishers perceived size limits to have had no impacts on catch rate, and were correspondingly positive or neutral about bag and size management measures (Table 9).

Fishers (both recreational and commercial) also commonly spoke about the issues associated with the commercial fishery, including the influx of fishers into the live fishery and the conflict between the sectors, the need (or not) for closures during Coral Trout spawning, the economic and social issues affecting the commercial industry, particularly crew, and the impact of extreme weather events such as cyclones (Table 9).

Table 9. Quotes from fisher interviews on the impact of management on the Coral Trout fishery and other common concerns regarding the fishery. These quotes are representative of the typical responses by fishers when they were asked about their perceptions of the impact of changing management on the fishery.

The impact of management
The definition of sustainable may be a different story for the environment versus the industry. The grounds the fishers are targeting may not be sustainable, but stocks of Coral Trout will remain because of the green zones – Commercial fisher, Cairns. *I travel a lot more these days due to the green zones, 100 mile plus trip nowadays. Green zones put more pressure on open areas. In the past we had more shallow area to fish* – Recreational fisher, Cairns. *Green zones didn't affect Coral Trout fishers as much up north, they didn't close our favourite reefs. They should rotate the green reefs and give fished reefs time to recuperate* – Commercial fisher, Cooktown. *Only 1-5% of fishers catch their bag limit, its not often done* – Recreational fisher, Gladstone. *Bag limits are a good thing; you need bag limits to counter the 'take all' mentality* – Charter fisher, Townsville. *Quota is a joke, it gives fat cats a retirement fund, most fishers don't have quota and we're not catching it* – Commercial fisher, Cairns.
Impact of the live fishery
There's very few Coral Trout in 20m of water these days because the live trade has got them all – Commercial fisher, Townsville. *The live fishery shouldn't be allowed more dories each, it's more competition* – Commercial fisher, Townsville.
Fishing of spawning stock and spawning closures
We're not getting the spawn heads now - the big numbers of trout that we got in previous years. It is collapsing - many reefs are not producing and we have to move on – Commercial fisher, Cairns. *Years ago you could follow the spawning reefs, now you can't do that* – Commercial fisher, Cooktown. *The trout need more time to spawn, you've got to look after the fish […]. They need a month or 6-week long closure during spawning* – Commercial fisher, Cooktown. *Spawning closures are a good thing, but they're not long enough as trout will still be roed up. They're*

totally ineffective, we need three 9-day closures between September, October and November – Recreational fisher, Cairns.
Commercial industry
Crew is a massive issue, You can't get experienced people, there's no government assistance for training – Commercial fisher, Cooktown. *The commercial fishery isn't looking good. The price is there but there are not many young fishers* – Commercial fisher, Townsville. *Boats from the south shouldn't be allowed to move north, fishers' who work a particular area might look after their grounds, people who move around don't care* – Commercial fisher, Cairns.
Impact of cyclones
You don't see as many big trout since Yasi, the monster trout are not there – Charter fisher, Townsville. *It takes two years to recover from a cyclone if you get a direct hit* – Commercial fisher, Mackay.

Overall trends in abundance and size

The majority of fishers, both commercial and recreational, perceived an overall decrease in Coral Trout stocks, although not all fishers believed that declines had occurred (Fig. 28a, Table 10). Observations in changes in the size of Coral Trout were less clear-cut, with roughly half of all responses split between a decrease in size and stable size. The majority of fishers perceived at least one threat to Coral Trout, although some fishers stated that green zones and the restriction of the live fishery to shallow waters protected a substantial proportion of the fish population.

Table 10. Quotes from fisher interviews regarding fishers' perceptions of the current status of Coral Trout. These quotes are typical of the responses from fishers' when asked about the current status of Coral Trout compared to when each fisher commenced fishing.

Fishers' views on the current status of Coral Trout
[20 years ago] 4 or 5-day trips were all you needed to do. We used to fill up in two to three reefs. You could catch the same fish in 5 days then as you can in 10 days now […] I fish the same reefs now as 25 years ago, and there's not the same amount of fish on them. It's not like it used to be – Commercial fisher, Cairns. *A few years ago you'd see 50 or 60 fish on a rock, now there's 7 to 8 fish, this is really serious* –

Commercial fisher, Cairns.

I don't blame the commercial fishers, they don't get a pay these days, the amateurs clean them out too – Recreational fisher, Townsville.

Once you get outside of heavily fished areas, the fish populations are not too bad – Charter fisher, Cairns.

The fish are still there below 25 metres, live fishers are the best thing that happened to the fishery – Commercial fisher, Bowen.

Catch rates versus abundance

Our study asked fishers about their memories of catch rates and technological change, their perspectives on management, changing abundance and size of the three target species. While our data provide information on catch rate trends, changing catch rates are not always indicative of changing abundance. For example, improvements in technology might increase the catchability of fish, while fisher behaviour (i.e., targeting of spawning populations at particular times of year), variable or extreme weather patterns (e.g., tropical cyclones) and changing fish behaviour can also act to disconnect catch rate from abundance. Coral trout is a clear example of this (documented in Leigh et al. 2014), whereby catch rates have been shown to fall off dramatically after a tropical cyclone event, more so than abundance, and stay depressed for two years or more. Leigh et al. (2014) also show that catch rates of coral trout drop off much faster than abundance when the population is fished, and they advance the explanation that this is caused by social learning in coral trout. That is, they learn from seeing other coral trout caught by fishers. It is unknown whether, or to what extent, this occurs in other species. Therefore, while the trends presented in this report demonstrate fishers' changing experience they cannot, at this stage, be interpreted as changes to fish abundance.

Potential pathways to the adoption of historical data in management

This project has used archival data and fishers' knowledge to present a long-term perspective on three economically and socially significant Queensland fisheries. While issues regarding the reliability and accuracy of such data exist, there are several ways in which fisher knowledge and other historical data can potentially contribute to fisheries assessment outcomes:

1. Historical data can influence the reconsideration of model assumptions. For example, historical sources can reveal when significant levels of fishing began, which informs model assumptions on when virgin stock can be assumed (e.g., popular media state the year when targeting of spawning Spanish Mackerel commenced).

2. Historical data may help to inform other inputs to the stock assessment model, such as likely total catch. For example, popular media reports provide insights into the number of boats operating in the Snapper and Spanish Mackerel fisheries and numbers of fish caught, up to several decades prior to the commencement of systematic data collection. These could contribute to estimates of total catch within the fishery during this largely unknown period.

3. Historical data can provide contextual information that may help interpret or standardise observed trends in catch and catch rate. For example, fishers were able to provide information on what year they introduced or upgraded particular technologies. In some cases fishers were able to provide estimates of the extent to which these introduced technologies improved their catch rates. Fishers were also able to provide information on levels of fishing effort and how this varied with time (e.g., the number of dories used, number of crew, and hours spent fishing versus hours travelling during a trip).

4. While the criteria used to elicit memories of catch rates (good, typical and poor) means that fisher knowledge data cannot be directly compared to other catch records, the data do provide a relative trend at the individual level, from which a relative abundance time series proxy could be constructed, which could then be considered as part of a weight of evidence approach. A systematic consideration of this trend alongside stock assessment predictions and other biological and fisheries data would provide an avenue in which fisher knowledge data could support stock status determination. Expert opinion (for example in a Scientific Advisory Group context) may even consider this a valid data set for model fitting.

5. Finally, historical information, particularly when it takes the form of pictures or descriptive narratives, has the potential to engage a wide variety of stakeholders, thus contributing to dialogue and engagement aspects of the management process. In this way, historical data may enhance stakeholder understanding and acceptance of management decisions.

Conclusion

1. To reconstruct relative changes in abundance and distribution of Snapper (Chrysophrys auratus) Spanish Mackerel (Scomberomorus commerson) and Coral Trout (Plectropomus spp.), using commercial and recreational fishers' testimony and historical data.

We used fisher testimony to reconstruct past catch rates for spatially discrete areas throughout the geographical range of the Queensland Snapper, East coast Spanish Mackerel and Queensland Coral Trout fisheries. We also investigated how average distances and depths targeted for these three species altered over the course of fishers' experience. Despite distances and depths targeted increasing for all species, in general (with the exception of Snapper in the north and commercially targeted Coral Trout) recalled catch rates for all species declined throughout the time series. It is important to note that while the sampling design ensured that we were able to target expert and retired fishers, it does not necessarily provide a representative sample of fishers presently in the fishery, and is likely to be biased towards those fishers willing to engage with such studies. It is therefore difficult to make inferences about the population from the sample. Detailed catch rate data were able to be located from archives for the Snapper and Spanish Mackerel fisheries prior to the Second World War, although not for Coral Trout, and the quantity of fish caught per vessel suggests that both fisheries were highly productive in the earliest decades of development. However, these records did not extend past this period in the sources we examined, hence we were unable to directly compare fishers' recall and historic catch rates. Later records (such as newspaper articles and fishing magazines) do exist, but are more qualitative in nature hence cannot be used for comparison with earlier records.

2. To use fishers' data to expand our temporal scope of knowledge by providing robust historical data, thereby reducing uncertainty in past exploitation rates and making information available for potential use in future management decisions.

We included as large a sample size of fishers as the duration of the project would allow and interviewed fishers from both the commercial and recreational fishing sectors. These large sample sizes helped ensure that we incorporated as many fishers' memories of change as possible, as well as including the views of individuals from different sectors – thus providing more confidence in our results (although see above comment for issues regarding a lack of random sampling in our design). We were able to chart recalled changes in catch rates for the three fisheries over a period of 60 years, and thus present a picture of the fisheries during periods of commercial and recreational growth. Archival data also provided information on pre-War productivity and throughout the earliest development of the Snapper and Spanish Mackerel fisheries. We also included an overview of our findings on the accuracy of fishers' recall when compared to individual logbook data. Comparisons of logbook and interview data suggest that fishers' recall of average past catch rates can be exaggerated, but that memories of trends in good and poor catches are more reliable. Although fishers' recall of average catch has been shown to become more positively biased with time, this trend is very gradual and thus, when compared with the magnitude of change in catch rates recalled by fishers, do not alter our overall conclusions. We also describe potential pathways to the adoption of these data into the management process, which were drawn together after discussions with DAF stock assessment modellers.

3. To determine the impact of evolving fishing technologies, fishing effort and changing management regimes upon fish catches and abundance over time.

The uptake and influence of technology was investigated both quantitatively (e.g., percentage of fishers using different technology) and qualitatively (e.g., fishers' quotes on the impact of technologies). We were able to determine the timing, rate and total percentage adoption of particular technologies for the three fisheries. We also present two proxies of effort; boat length and engine power, and show that engine power has markedly increased in recent decades. Generally, an increase in adopted technology was perceived to have had a detrimental impact on all fisheries, although fishers' also emphasized that technologies afforded new fishing opportunities (e.g., the location of new fishing grounds, increased fishing efficiency). The impact of management was measured using fishers' responses as to how they personally perceived three management measures to have affected their fishing. These responses differed by fishery and between individual fishers, but by and large fishers perceived no-take zone negatively, and bag and size limits in a more positive light. While our study focused upon the impact of technological innovations, we note that a range of other factors may also have influenced catch rates over time, for example, coastal development, changing water quality, weather events and climate change. As mentioned previously, Leigh et al. (2014) concluded that catch rates were not a good measure of abundance for coral trout due to changes in coral trout behaviour at varying levels of fishing intensity, probably as a result of social learning. It is unknown to what extent the catch rates of Snapper and Spanish Mackerel are affected by social learning or other factors.

4. To compare perceptions of change between commercial and recreational groups, and identify common areas/species of concern held by both groups.

We compared fishers' perceptions of overall changes (i.e., throughout their entire experience of fishing) in the abundance and size of each species. The majority of fishers perceived a decline in their target species' abundance, but perceptions of changes of size diverged more. The majority of fishers in both sectors revealed they held no immediate concerns about the Snapper fishery, but fishers from both sectors who perceived threats were in agreement that these included fishing pressure, the impact of improving technology and poor management. In contrast, the majority of Spanish Mackerel and Coral Trout fishers perceived threats to the fishery, including fishing pressure and poor management. Numerous fishers also highlighted the issue of targeting Spanish Mackerel during the vulnerable spawning period.

Our results show that fishers from all sectors are willing to engage in research about the past condition of fisheries, and that fishers are able to recall both the extent and timings of change regarding a variety of factors, including past catch rates, technological innovations and management measures. Many fishers have witnessed changes in their fishery over time. We conclude that fisher knowledge has the potential to provide novel information about the changing conditions of fisheries and the impact (both ecologically and socially) of introduced technology and management measures.

Implications

The majority of fishers perceived a decrease in their catch rates over the period of time that they were fishing. During this period, fishing grounds have expanded to greater distances from shore and to deeper depths. Technology has also increased the efficiency of fishing practises. Gathering these retrospective accounts of change from fishers along the coast of Queensland has enabled us to ascertain long-term trends in catch rate, gear and technology, that pre-date detailed fishery data, and that present additional social and ecological perspectives that may not have been previously available to management.

By providing relative trends in catch rates and contextual information to aid the interpretation of existing datasets these data have the potential to be incorporated into the stock assessment and wider management process. They may also be used as a communication tool, thus promoting stakeholder engagement. Adding to available datasets, improving the interpretation of existing data, understanding commercial and recreational perspectives and engaging stakeholders, will all work towards enhancing the quality of future management advice, thus benefitting all fishery stakeholders.

Recommendations

We reconstructed historical catch histories to improve our knowledge of the trends that have occurred in the Queensland Snapper, Spanish Mackerel and Coral Trout fisheries since the earliest days of exploitation. Our aim was to use these data sources to reduce the uncertainty surrounding long-term fishery trends, inform stakeholders of fishers' perspectives of long-term changes in fish abundance, and to make this information available for managers, stakeholders and potentially for adoption into fisheries assessments. We recommend that in future studies of this type, researchers should include fisheries managers and stock assessment modellers at the earliest stages of project development and sampling design, to enable the standardisation of recalled historical catch rates, account for biases and increase the potential for adoption into fisheries assessments. We initiated exploration of biases for fisher recall and historical data sources, by a) comparing recalled catch rates with logbook records and b) comparing historical popular media with scientific sources. As further archival data comes to light there will be more opportunities to investigate what biases exist in these long-term data. The impact of technology on catch rates should also be investigated using a more quantitative approach. Quantitative estimates of the effect of new technologies on catch rates or other parameters have been achieved in other research papers, but many of the fishers we interviewed found it challenging to quantify the effect of different technologies, particularly when multiple technologies were adopted over a short period of time (although some individuals were able to estimate the impact of technologies on their catch rates). Further research into quantifying technological innovations is being undertaken. At this stage, our data provides contextual information to aid the interpretation of catch trends, and also provide a longer-term perspective to facilitate more informed dialogue between managers and stakeholders on future management of Snapper, Spanish Mackerel and Coral Trout.

Extension and Adoption

To date, our outputs include a website where our project results will be presented once the final report is completed (http://www.aussiefishtales.com). The website address will be provided to fishers who took part in the project, as well as the wider fishing community, by the website address being highlighted in the outputs described below. Historical data will also be placed on this website once the data have been published in academic journals.

We have been in contact with stock assessment modellers at the Department of Agriculture and Fisheries throughout this project to inform them of our work and our findings, and will continue to consult them during the analysis of these data for peer-reviewed papers. We also intend to disseminate and discuss with Fisheries Queensland ways in which the data can be incorporated into stock assessment and/or management decisions. In 2013 RT presented preliminary results of this research to members of CSIRO and Fisheries Queensland at a seminar held at Boggo Road, Brisbane. In addition, RT and SB presented preliminary results at three conferences held in 2012 and 2013, Oceans Past IV, the Australian Marine Sciences Association, in Australia, and the Australian Society for Fish Biology, which was held in New Zealand. RT and SB also presented more complete results at the International Marine Conservation Congress, held in 2014 in Glasgow and which attracts researchers and natural resource managers from all over the world, and the Oceans Past V conference in Estonia in 2015. We communicated our results at a workshop held in Brisbane that included several managers from the Great Barrier Reef Marine Park Authority, and at another workshop held in Townsville and hosted by a manager from GBRMPA, which included members and representatives of the commercial, recreational and charter fishing industries. In July 2014, RT presented an overview of this research at the Shine Dome in Canberra, to an audience that included academics, GBRMPA staff and policy makers. Our research was also advertised in the FISH magazine and RecFish magazine, and we received good feedback on these from several interviewees.

A further output from this research is information factsheets summarising our main findings (Appendix 6). These will be disseminated to all fishers who took part in the research, and through multiple channels including Info-Fish, Sunfish and QSIA to ensure that as many stakeholders as possible are presented with our findings.

We have also presented our completed findings to managers and stakeholders directly, including stakeholders at three LMAC meetings (these were also attended by members of the public, including recreational and commercial fishers and Traditional Owners), GBRMPA and Queensland Fisheries staff in November 2015.

Appendices

Appendix 1: List of researchers and project staff

Appendix 2: References

Appendix 3: Fisher questionnaire

Appendix 4: List of archival data sources and years examined

Appendix 5: Results of linear mixed model analyses

Appendix 6: Fact sheets for dissemination to stakeholders

Appendix 1: List of researchers and project staff

Ruth H. Thurstan – The University of Queensland

Sarah M. Buckley – The University of Queensland

John M. Pandolfi – The University of Queensland

Appendix 2: References

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Appendix 3: Fisher questionnaire (example for southeast Queensland: Snapper and Spanish mackerel)

Fisher name: Age: Date:

Location: Interview in person/on phone:

Species: Recreational/Charter/Commercial

What year did you first begin fishing?

When did you start fishing regularly?

Do you still fish today?

If not, when did you cease fishing?

(If commercial operator) How long have you been fishing commercially?

Do you target Snapper/Spanish Mackerel? How many years have you targeted this species?

Have the species you target changed over time?

At present:

How often do you go fishing?

What months do you typically fish?

How many hours do you fish for (travel time/fishing time)?

Which species do you target?

Which months usually provide peak catches?

Where do you regularly fish now (since the introduction of Green Zones)? Please list reefs you target.

How many miles offshore do you fish?

Which are your most consistent fishing grounds?

What depth do you typically fish at?

What range of depths do you target?

Repeat questions for the years when interviewee started fishing

At present:

What is the length of your vessel?

What is the engine power (horsepower)?

What is the storage capacity of your vessel?

How many lines and hooks do you use?

- What bait do you use?
- Rod/handline? Overhead/spinning reel?

- Breaking strain?
- Hook size? Outriggers/downriggers?

Repeat questions for the years when interviewee started fishing

---

Can you describe how your fishing technology e.g. boat length, engine power, changed over time?

Has other technology changed/been introduced since you first started fishing? E.g. GPS, sounders, stabilisers, braid, soft plastics?

What year did these changes take place?

How did this improve your fishing (fish per hour, fishing time, increase/decrease)

Have any management actions changed your experience of fishing e.g. bag limits, size limits, RAP, introduction of quota?

At present:

Which months do you get the biggest catches of Snapper/Spanish Mackerel?

What numbers/weight do you catch during a season?

Number of fish on a good day during the season?

Number of fish on a typical day during the season?

Number of fish on a poor day during the season?

Hours spent fishing?

Number of fish on a good day outside of the season?

Number of fish on a typical day outside of the season?

Number of fish on a poor day outside of the season?

Hours spent fishing?

Repeat questions for the years when interviewee started fishing

---

Has the abundance of Snapper/Spanish Mackerel increased, declined or remained stable over time?

When did you notice this change? To what extent?

Has the size of Snapper/Spanish Mackerel increased, declined or remained stable over time?

When did you notice this change? To what extent?

What do you see are the threats to Snapper/Spanish Mackerel?

Appendix 4: List of archival data sources and years examined

Cairns Post (1884-1954)

Endeavour surveys (1909-1913)

Fishers' logbooks, individual (various: 1964-2013) and government (various: 1988-2013)

Morning Bulletin (1878-1954)

Nambour Chronicle (1922-1954)

Queensland Figaro (1883-1936)

Queensland Fish Board Annual Reports (1939-1981)

Queensland Marine Department Annual Reports (1894-1970)

Redland Times (1931-1942)

South Coast Bulletin (1929-1963)

Sunday Mail (1926-1954)

The Brisbane Courier (1864-1933)

The Capricornian (1875-1929)

The Collected Works of Thomas Welsby (1905-1931)

The Courier Mail (1933-1954; sub-sample of years 1955-1991; 1992-2014)

The Queensland Times (1861-1954)

The Queenslander (1866-1939)

The Townsville Daily Bulletin (1910-1960)

Tweed Herald (1898-1910)

Worker (1890-1955)

Appendix 5: Results of linear mixed model analyses

Table S1: Results of linear mixed model analyses for Snapper, * denotes significance ($p<0.05$).

Response	**Model estimate**	**se**	**t-value**	χ^2	**df**	**p-value**
Commercial catch rates: North						
Good catch	-0.017	0.005	-3.48	5.600	1	0.018*
Average catch	-0.014	0.003	-3.959	6.190	1	0.013*
Poor catch	-0.002	0.002	-1.143	1.129	1	0.288
Commercial catch rates: South						
Good catch	-0.013	0.004	-3.102	8.779	1	0.003*
Average catch	-0.004	0.004	-1.140	1.2589	1	0.262
Poor catch	0.012	0.004	2.442	1.577	1	0.209
Recreational catch rates: North						
Good catch	0.002	0.009	0.264	0.066	1	0.797
Average catch	-0.002	0.004	-0.645	0.363	1	0.547
Poor catch	-0.001	0.001	-1.382	1.603	1	0.206
Recreational catch rates: South						
Good catch	-0.011	0.003	-3.444	10.937	1	<0.001*
Average catch	-0.010	0.002	-4.937	20.037	1	<0.001*
Poor catch	-0.008	0.003	-2.789	5.973	1	0.015*
Commercial technology						
Engine power	0.104	0.021	4.843	19.939	1	<0.001*
Boat length	0.001	0.001	2.509	6.063	1	0.014*
Depth	0.349	0.120	2.910	7.761	1	0.005*
Distance	0.023	0.007	3.577	11.131	1	<0.001*
Recreational technology						
Engine power	0.011	0.001	11.034	94.561	1	<0.001*
Boat length	0.002	0.000	5.449	27.05	1	<0.001*
Depth	0.345	0.080	4.315	14.780	1	<0.001*
Distance	0.150	0.043	3.490	9.328	1	0.002*

Table S2: Results of linear mixed model analyses for Spanish Mackerel, * denotes significance ($p<0.05$).

Response	Model estimate	se	t-value	χ^2	df	p-value
Commercial catch rates: North						
Good catch	-0.010	0.002	-3.713	13.713	3	0.003*
Average catch	-0.011	0.003	-4.157	16.982	3	<0.001*
Poor catch	-0.003	0.003	-1.107	2.799	3	0.4236
Commercial catch rates: Mid						
Good catch	-0.011	0.002	-3.852	15.325	3	0.001*
Average catch	-0.005	0.002	-2.509	15.199	3	0.001*
Poor catch	-0.003	0.002	-1.681	2.779	3	0.426
Commercial catch rates: South						
Good catch	-0.010	0.002	-5.230	25.338	3	<0.001*
Average catch	-0.009	0.001	-6.136	31.71	3	<0.001*
Poor catch	-0.002	0.002	-1.313	1.706	3	0.635
Recreational catch rates: North						
Good catch	-0.010	0.004	-2.703	9.918	3	0.019*
Average catch	-0.009	0.002	-5.063	30.043	3	<0.001*
Poor catch	-0.004	0.001	-2.987	20.352	3	<0.001*
Recreational catch rates: Mid						
Good catch	-0.011	0.003	-3.875	16.984	3	<0.001*
Average catch	-0.010	0.002	-4.313	22.449	3	<0.001*
Poor catch	-0.004	0.002	-2.735	16.016	3	0.001*
Recreational catch rates: South						
Good catch	-0.009	0.002	-4.479	22.952	3	<0.001*
Average catch	-0.007	0.002	-4.609	24.974	3	<0.001*
Poor catch	-0.003	0.001	-2.223	7.326	3	0.062
Commercial technology						
Engine power	0.008	0.006	14.24	186.35	1	<0.001*
Boat length	-0.001	0.001	-0.923	0.857	1	0.3545
Depth	0.041	0.001	21.7	389.93	1	<0.001*
Distance	0.038	0.003	11.29	120.06	1	<0.001*
Recreational technology						
Engine power	0.095	0.006	15.45	208.07	1	<0.001*
Boat length	0.006	0.001	6.708	43.77	1	<0.001*
Depth	0.023	0.001	19.26	299.73	1	<0.001*
Distance	0.024	0.001	14.00	173.41	1	<0.001*

Table S3: Results of linear mixed model analyses for Coral Trout, * denotes significance (p<0.05).

Response	Model estimate	se	t-value	χ^2	df	p-value
Commercial catch rates: Far North						
Good catch	-0.030	0.006	-4.816	18.447	1	<0.001*
Average catch	-0.030	0.007	-4.149	13.826	1	<0.001*
Poor catch	-0.019	0.007	-2.863	7.5289	1	0.006*
Commercial catch rates: North						
Good catch	-0.023	0.005	-4.329	15.407	1	<0.001*
Average catch	-0.015	0.004	-3.667	11.62	1	<0.001*
Poor catch	-0.008	0.004	-2.179	4.1868	1	0.041*
Commercial catch rates: Mid						
Good catch	-0.024	0.008	-2.960	7.2541	1	0.007*
Average catch	-0.019	0.004	-4.625	15.659	1	<0.001*
Poor catch	-0.015	0.005	-3.280	8.6133	1	0.003*
Recreational catch rates: North						
Good catch	-0.020	0.004	-4.862	19.865	1	<0.001*
Average catch	-0.012	0.002	-6.962	37.529	1	<0.001*
Poor catch	-0.008	0.002	-4.167	15.678	1	<0.001*
Recreational catch rates: Mid						
Good catch	-0.010	0.003	-3.658	10.416	1	0.001*
Average catch	-0.007	0.002	-3.747	11.210	1	<0.001*
Poor catch	-0.004	0.002	-2.314	4.965	1	0.026*
Recreational catch rates all regions: Common Coral Trout						
Good catch	-0.022	0.004	-5.639	25.469	1	<0.001*
Average catch	-0.012	0.002	-7.045	37.605	1	<0.001*
Poor catch	-0.0074	0.002	-4.300	16.902	1	<0.001*
Recreational catch rates all regions: Barcheek Coral Trout						
Good catch	-0.016	0.005	-3.044	7.357	1	0.007*
Average catch	-0.008	0.002	-3.357	9.602	1	0.002*
Poor catch	-0.003	0.002	-1.350	1.752	1	0.186
Commercial technology						
Distance	0.018	0.011	1.622	2.390	1	0.122
Depth fished	-0.004	0.002	-1.986	3.152	1	0.076
Engine power	0.021	0.003	7.659	49.629	1	<0.001*
Boat length	0.009	0.002	3.813	13.735	1	<0.001*
Recreational technology						
Distance	0.006	0.002	3.615	11.612	1	<0.001*
Depth fished	0.010	0.004	2.749	7.194	1	0.007*
Engine power	0.164	0.016	10.252	85.679	1	<0.001*
Boat length	0.007	0.001	7.013	43.332	1	<0.001*

Appendix 6: Fact sheets for dissemination to stakeholders

Fact sheets for dissemination to the fishers who took part in the research are attached alongside this report. These fact sheets will also be made available to other stakeholders through recreational and commercial fishing peak bodies, and the website.

Using fishers' knowledge to reconstruct the history of Queensland fisheries: Snapper (*Pagrus auratus*)

A project conducted by Ruth Thurstan and Sarah Buckley at The University of Queensland

Snapper fishing has a long history in southeast Queensland, and was targeted by recreational fishers from the 1870s, as this excerpt from The Queenslander newspaper (7 September 1871) shows:

'"Schnapper fishing is becoming quite a fashionable amusement among Brisbaneites, and considering the little difficulty there seems to be in making a good haul of these fish, it is surprising that professional fishermen don't turn their attention to catching them. The supply seems inexhaustible".

What we did

We identified active and retired fishers along the coast of southeast Queensland who had a long experience of snapper fishing. We spoke to recreational, commercial and charter fishers along the coast of Queensland, from Tweed Heads to Mackay. We asked about personal experiences of changes over time. Questions included changes in catch rates, fish abundance, areas fished, changes in gear and technology, the impact of technology and the effects of management on fishing activities.

In total we spoke to 110 fishers, including some who recalled snapper fishing as far back as the 1940s.

What we found

Both recreational and commercial fishers **increased the distance from shore and average depth** they fished over time. In the 1950s both sectors fished at an average depth of 50m; by 2010 commercial fishers fished at an average depth of 90m, while recreational fishers targeted snapper at 65m on average.

Fishers' stated that technology had a huge impact on their fishing activities. **Over 80%** of all fishers had adopted GPS and colour echo sounders by 2005, while **over 60%** of recreational fishers used braid and soft plastics by 2013 (Figure 1).

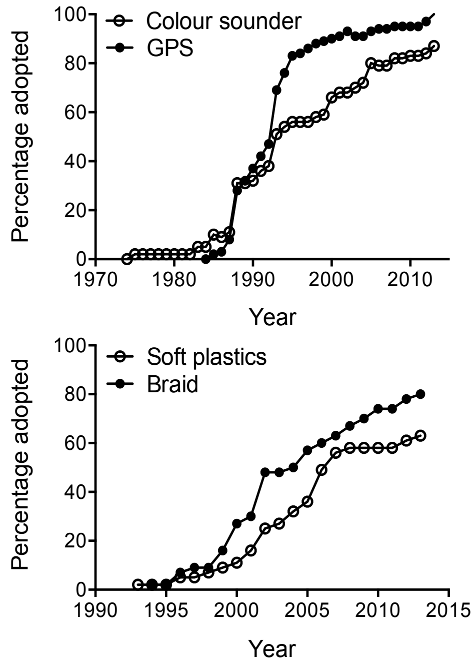


Figure 1. Percentage of fishers in the fishery that used these technologies each year.

Why is this research important?

Fishers' have a detailed understanding of their target fishery and the marine environment, and scientists and managers are increasingly recognising the value of fishers' knowledge. This research highlights that fishers' knowledge often spans longer periods than scientific monitoring, and that this information is an important step towards improving our understanding of changes the marine environment, as well as social and technological changes in the fishery over time.

The majority of commercial and recreational fishers perceived **declines in catch rate** of snapper, and over half of all fishers believed snapper to have **declined in abundance** since they began fishing (Figure 2). However, the majority of fishers (48% commercial, 33% recreational) **did not perceive snapper to be under any particular type of threat**.

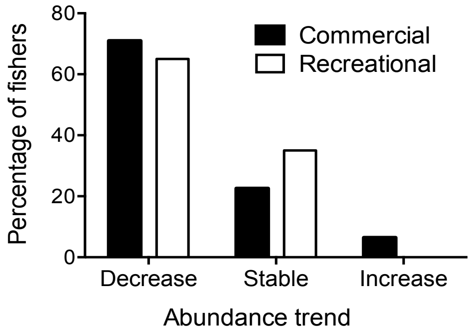


Figure 2. Changes in the abundance of snapper perceived by fishers

Recreational fishers also noted that **attitudes towards fishing had changed** since the 1990s, largely as a result of bag limits, but also due to the popularity of catch and release fishing. Fishers also commented on past and present management efforts, with 12% of recreational and 17% of commercial fishers believing that **poor management** is a threat to the snapper fishery.

Changing attitudes

The 30-bag limit bent people's way of thinking about fishing and altered their perceptions. Before then it was smash and grab – Charter fisher, Sunshine Coast.

The attitude changed within 5 years with anglers, from 'as many fish as possible' to 'a few will do' – Charter fisher, Gold Coast

Throughout the 1990s, but especially the last 10-15 years, the number of people wanting to slaughter large numbers of fish has decreased – Recreational fisher, Brisbane.

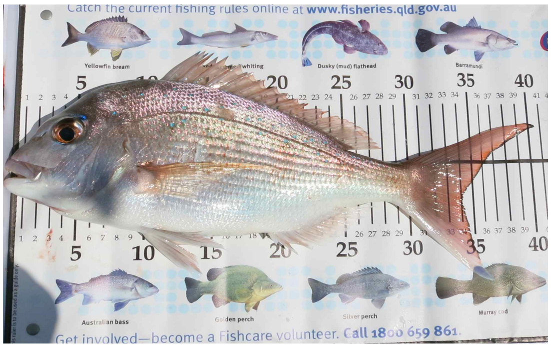
Management

Management evens out the population pressure but they still need to think of the future and manage for 20 years time – Recreational fisher, Brisbane

Snapper did decline but recent restrictions should see the stocks come back – Commercial fisher, Brisbane

Management needs to be more regionalised – Recreational fisher, Bundaberg.

We should have had management in the mid-'80s – Recreational fisher, Gold Coast.



Photos by Welsby (1905) and Ruth Thurstan (2014)

Thank you to all the fishers who gave their time to take part in this survey.

If you would like more information about the project please email r.thurstan@uq.edu.au, check out www.aussiefishtales.com, or write to Ruth Thurstan, Gehrmann Building, School of Biological Sciences, University of QLD, St Lucia, 4072.

Using Fishers' Knowledge to Reconstruct the History of the East Coast Spanish Mackerel Fishery

Research by Sarah Buckley, Ruth Thurstan and John Pandolfi

FRDC

The University of Queensland Australia

Spanish Mackerel is Queensland's oldest line fishery, having been solely commercially exploited since **1911** in the Great Barrier Reef to a position of relatively even split in harvest by both commercial and recreational sectors in the 1990s along the East coast of Australia to current day dominance by the recreational sector.

The aim of this research was to provide a more in depth and long term history of past changes in the Spanish mackerel fishery

What we did

We interviewed **221 fishers**; **50% commercial, 45% recreational and 5% charte**r who had at least 10 years fishing experience. We met fishers along the the East coast of Australia, from Cooktown to Tweed Heads. We asked fishers about their **personal experiences of change** in catch rate, locations fishes, changes in gear and technology and their impact, effects of management and other sectors. Fishers **recalled fishing** for Spanish mackerel as far back as **1942**.

What we found

The **majority** of commercial and recreational fishers **perceived declines in catch rate** of Spanish mackerel and to have **declined in abundance** since they began fishing (Figure 1). Both commercial and recreational fishers perceived **fishing pressure** (54%), **poor management** (28%) and impact of **technology** (23%) as the **major threats** to Spanish mackerel**.**

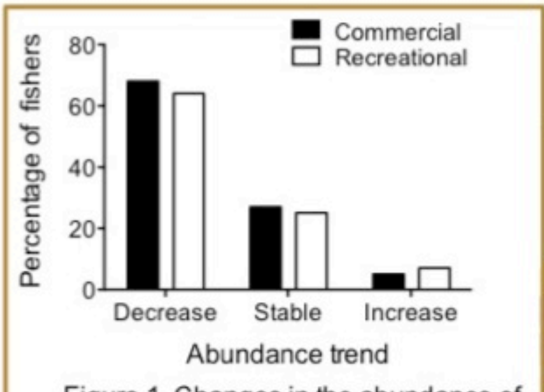


Figure 1. Changes in the abundance of Spanish mackerel perceived by fishers

Over time, both commercial and recreational fishers **increased the distance they fished from shore and depth** in response to declining catch trends and management changes.

Fishers' stated that gear and technology had a huge impact on their fishing activities. Over **80%** of all fishers had adopted **GPS and colour sounders** by the late 1990s, whilst **downriggers and live bait** have been **more gradually adopted** since the early 1960s (Figure 2).

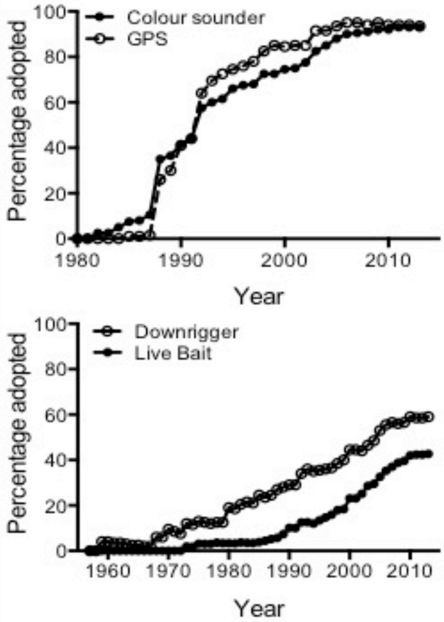


Figure 2: Percentage of fishers in the fishery that used these technologies each year.

Fishers commented on the effects of past and present management efforts:

Management

Management is a failure! A blind man could see what was happening, the biomass kept declining – Recreational fisher, Brisbane

Looking back, it was the wrong thing to do catching them during spawning when they are at their most vulnerable and failure to mange it is the demise of the fishery – Commercial fisher, Cairns

Similar catches today as there was 20 years ago and that is due to management like bag limits and green zones – Recreational fisher, Yeppoon

Getting like a policed state - don't get industry involvement when they don't listen to fishermen – Commercial fisher, Townsville

Why is this research important?

Fishers' have a detailed understanding of their fishery and the marine environment. Scientists and managers are increasingly recognising the value of fishers' knowledge. This research highlights that your knowledge spans longer periods than scientific monitoring, and the information is an important step towards improving our understanding of changes in the biological, social, technological and governace components of the fishery.

Thank you to all the fishers who took time to take part in this survey. We could not have collected this valuable knowledge without your support and cooperation.

If you would like further information, please look at www.aussiefishtales.com, contact Sarah Buckley at s.buckley2@uq.edu.au or Ph. 0431827132

Photos by Stead (1911), Stevens (1960), Huylands (1970), Sainsbury (1980), Spinner (1985) and Buckley (2014)

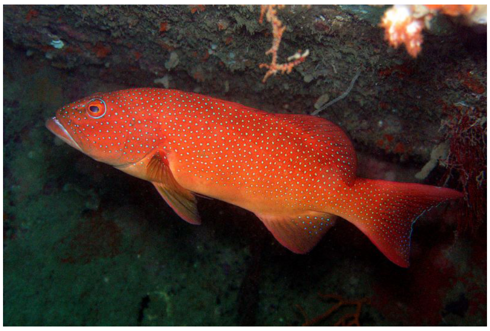
Using fishers' knowledge to reconstruct the history of Queensland fisheries: Coral trout

A project by Ruth Thurstan, Sarah Buckley and John Pandolfi at The University of Queensland

Supported by the Australian Research Council, Fisheries Research and Development Corporation and the Great Barrier Reef Marine Park Authority

Coral trout fishing has a long history. Records of charter fishing activities along the Great Barrier Reef exist from the 1920s onwards, with people travelling from northern New South Wales and southern Queensland to take part in fishing trips.

By the 1950s coral trout, while only commanding a small percentage of the commercial fish landed (5-15% by weight), fetched higher prices than other reef species, and was targeted by commercial fishers from Gladstone to Cairns outside of the mackerel season (Cairns Post, 9 Mar 1950).



What we did

We identified active and retired fishers along the east coast of Queensland who had a long experience of coral trout fishing. We spoke to recreational, commercial and charter fishers from Mackay to Cooktown. We asked about personal experiences of changes over time. Questions included changes in catch rates, fish abundance, areas fished, changes in gear and technology, the impact of technology and the effects of management on fishing activities.

In total we spoke to 120 fishers, including some who recalled coral trout fishing as far back as the 1950s.

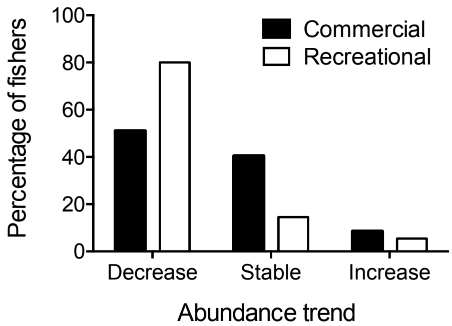


Figure 1. Changes in the abundance of coral trout perceived by fishers

What we found

The most frequently caught species was common coral trout (*Plectropomus leopardus*), which comprised 90-95% of commercial fishers' catch of trout. Recreational fishers also caught barcheek trout (*P. maculatus*). Other species (e.g., bluespotted, passionfruit) were occasionally caught.

Both commercial and recreational fishers perceived significant declines in catch rates of coral trout. 51% of commercial fishers believed coral trout had declined in abundance since they started fishing, while 40% perceived stocks to be stable. 80% of recreational fishers perceived declines (Figure 1).

76% of commercial and 23% of recreational fishers believed their **catch rates had declined as a result of the implementation of no-take zones**.

Why do this research?

Fishers have a detailed understanding of their target fishery and the marine environment, and scientists and managers are increasingly recognising the value of this knowledge. This research highlights that fisher knowledge often spans longer periods than scientific monitoring, and that this information is important for improving our understanding of ecological, social and technological changes in the fishery.

Thank you!

To all the fishers who generously gave their time to take part in the survey.

The University Of Queensland Australia
ARC Centre of Excellence Coral Reef Studies
FRDC Fisheries Research & Development Corporation

Recreational fishers increased the distance from shore and average depth fished over time. However, the distance fished from land by commercial fishers had not increased over time. The **depth fished by commercial fishers had also not increased**, mainly due to the need to target shallow waters for live fish.

Over 70% of all fishers now use GPS and colour sounders, these were rapidly adopted from the late 1980s (Figure 2). The adoption of frozen pilchards from the 1970s and the live trade (beginning early 1990s) have had a significant impact upon the commercial fishery, and **over 70%** of commercial fishers interviewed now target **live coral trout**.

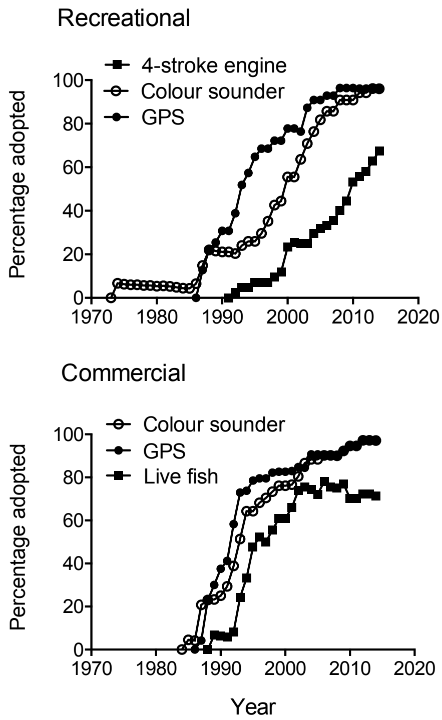


Figure 2. Percentage of fishers in the fishery that used these technologies each year

The most commonly perceived threat to coral trout stocks was **fishing pressure** (38% commercial, 63% recreational). Commercial fishers also considered **poor management** (26%) and **poor water quality** (17%) as threats. 20% of fishers did not perceive any threats to coral trout.

In addition to changing abundances, fishers also spoke of the technological, economic and social changes surrounding the coral trout fishery. Both sectors spoke of the dominance of the **live fish trade** and the **impact of green zones** and other management measures on their fishing activity. Commercial fishers spoke of **spawning closures**, and issues with **sourcing crew**.

LIVE FISH TRADE

"Live trout was the biggest devastation of a fishery I've ever seen. Cairns copped it first, then they moved away as reefs declined." Charter fisher, Cairns.

"Because most people are targeting live trout, they're leaving the deep brood stock alone." Commercial fisher, Bowen.

SPAWNING AND CLOSURES

"We're not getting the spawn heads now - the big numbers of trout that we got in previous years. It is collapsing - many reefs are not producing and we have to move on." Commercial fisher, Cairns.

"Spawning closures are a good thing, but they're not long enough as trout will still be roe'd up." Recreational fisher, Cairns.

CREW

"Crew is a massive issue; you can't get experienced people, there's no government assistance for training." Commercial fisher, Cooktown.

"The commercial fishery isn't looking good. The price is there but there are not many young fishers." Commercial fisher, Townsville.

IMPACTS OF MANAGEMENT

"I travel a lot more these days due to the green zones, 100 miles plus. In the past we had more shallow area to fish." Recreational fisher, Cairns.

Photos: www.fishesofaustralia.net.au and Ruth Thurstan

For more information contact Ruth on: r.thurstan@uq.edu.au, 0450 586 263 or check out www.aussiefishtales.com.

Can fishers' knowledge provide accurate estimates of the past?

Ruth Thurstan, Sarah Buckley, Juan Ortiz and John Pandolfi

Supported by the Australian Research Council, The University of Queensland New Staff Start-up Grant and the Fisheries Research and Development Corporation

Fisher knowledge can provide novel perspectives on changes through time, and is increasingly accepted as a valuable tool for fisheries management.

However, little is known about the reliability of such information, particularly for catch data or for data extending several decades into the past. This makes it more difficult to apply such data to management.

To address this problem, we compared fishers' recollections of their past catches with corresponding logbook data to provide a perspective on the accuracy of fisher knowledge.

Methods

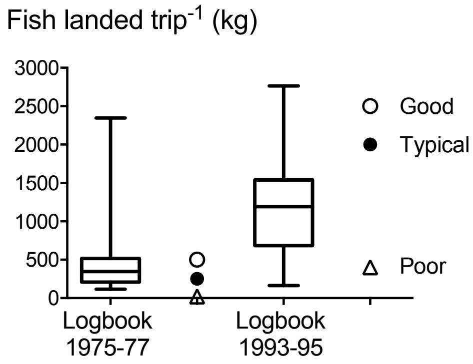
We identified active and retired fishers along the coast of southeast Queensland who had a long experience of fishing and who had kept records of their daily catches (either governmental or personal). We asked each fisher for permission to access their personal records and to use them for the purposes of this study.

Fishers were asked to recall 'good', 'typical' and 'poor' catches for their most recent year of fishing and the earliest period for which logbook data were available. Their recollections were compared to catch data from their logbooks for the corresponding period, to determine differences between recalled and recorded catch and whether these differences altered over time (Figure 1).

We gathered logbook records from 74 Queensland fishers who targeted a variety of species. Some of these records stemmed as far back as the 1960s.

Results

Fishers' recall of good, typical and poor catches reflected the distribution of their catch records over time.



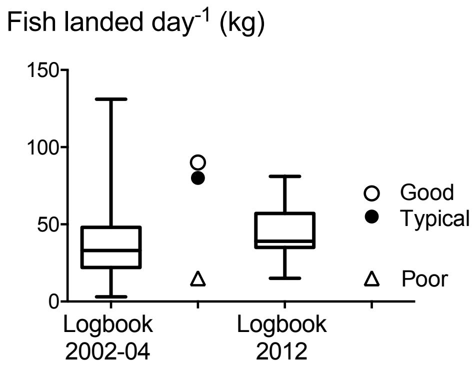


Figure 1. Examples of 2 individual fishers' recollections alongside their corresponding logbook data. Boxplots show the median catch and distribution of catches. Symbols to the right of each box plot represent each fisher's recollection of 'good' (open circle), 'typical' (closed circle) and 'poor' (open triangle) catches for the corresponding time period.

Thank you to all the fishers who gave their time to take part in this survey and who generously gave us permission to access their logbooks. This project would not have been possible without you!

Even when recalling catches from decades ago, fishers were still able to recall 'good' and 'poor' catches with accuracy, and no significant differences over time occurred. Fishers' recollections of 'good' catches fell within the 89th percentile rank of their recorded catch distribution, meaning that the 'good' catch they recalled was greater than 89% of their catch records for that same period (Figure 2). 'Poor' catches fell within the 18th percentile rank of their recorded catch distribution (Figure 2).

When recalling 'typical' catches, fishers tended to overestimate compared to their average recorded catch. Levels of exaggeration also tended to increase as time passed for 'typical' catch. Overall, recalled 'typical' catches fell within the 65th percentile rank of recorded catch (Figure 2).

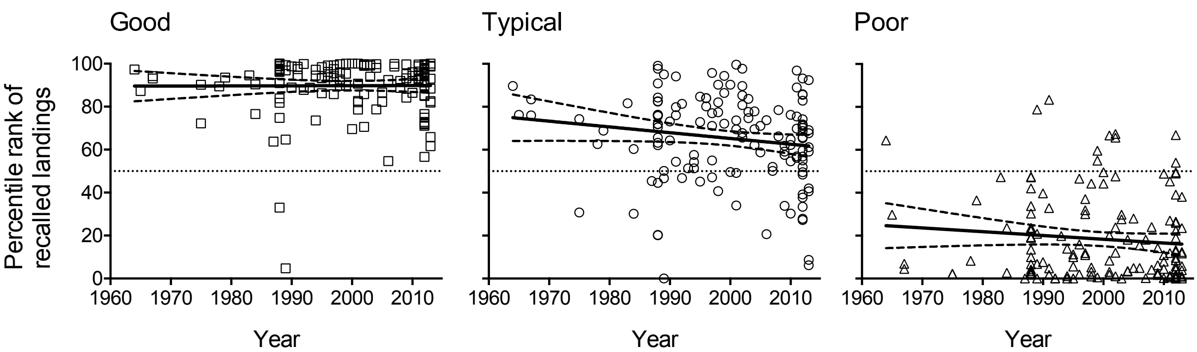


Figure 2. Fishers' recollections of good, typical and poor catches compared to their logbook records. Recorded catch distributions are plotted as percentiles and fishers' recalled catches are assigned a percentile rank according to where their recalled catch fell within their catch distribution. Regression (solid line) and 95% confidence intervals (long dashed line) are shown. Short dashed lines indicate 50th percentile of records.

Why is this research needed?

Resource user accounts provide critical information on past change but their reliability can rarely be tested, hence they are often perceived as less valid than other forms of scientific data. This remains a major hurdle in terms of successfully integrating resource users' knowledge into science and management. This research provides insights into the level of reliability of data based upon fisher recall across several decades and different fisheries (Figure 3) to further its use in management.

Figure 3. Species targeted by interviewees: (a) mullet (b) mackerel (c) snapper (d) prawns and (e) coral trout. Photos: Sunshine Coast Libraries, National Archives of Australia (item number A1200, L24364), and Queensland State Archives (digital image ID 11986), Ruth Thurstan.

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This research is published in *Conservation Letters* and is freely available to read in full online at: http://onlinelibrary.wiley.com/doi/10.1111/conl.12184/abstract