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EXPLOITATION DYNAMICS AND BIOLOGICAL CHARACTERISTICS OF THE QUEENSLAND EAST COAST SPANISH MACKEREL (*SCOMBEROMORUS COMMERSON*) FISHERY.

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OBJECTIVES

1. Identify the biological characteristics (catch-at-age, catch-at-length and sex ratios) of both recreational and commercial sectors harvesting Spanish mackerel from four distinct regions on the Queensland east coast.

2. Compare the biological characteristics of harvested mackerel between sectors and regions

3. Assess the effectiveness of current minimum legal size and level of latent effort present in current recreational bag limits. Advice will be issued to management where applicable.

1. Non-technical summary

1.1 Outcomes Achieved to Date

The project:

- Collected data that allowed catch estimates for the recreational and commercial fisheries to be re-calculated with greater certainty than previously available.

- Re-defined the catch characteristics of the commercial fishing sector and provided a regional description of the catch characteristics of both the commercial and recreational fishing sectors, information that was not previously available. This data will be invaluable to ensuring future stock assessment and monitoring exercises can be undertaken with greater certainty and with clearer interpretation than currently available.

- Demonstrated age- and length-structure sampling protocols need to be carefully designed to ensure valid representation of actual fishery harvests. The variable effect of fishing sector and coastal region on the size and age composition of landed catches identified by the project will allow age- and length-structuring sampling protocols to be better designed and targeted than the current processes in place achieve.

- Collected age structured data that provides strong evidence that the fishery is largely supported by years of above-average recruitment that are dispersed with years of poor recruitment. The demonstration that these processes occur will ensure future interpretations of annual fluctuations in both harvest levels and CPUE indices are interpreted with greater certainty than currently available.

- Provided data to discuss the validity of current minimum size limits and recreational angler in possession limits currently enforced in the fishery.

The project sampled Spanish mackerel captured by recreational and commercial fishers from four spatially discrete coastal regions (Townsville, Mackay, Rockhampton and south-east Queensland) on the Queensland east coast. Data was collected on the length, sex and age structure of catches as well as information on what fishing gears were used to harvest Spanish mackerel.

The information presented in this report is a summary of biological catch sampling that was facilitated by the voluntary participation of fishers from recreational and commercial fishing sectors. Recent preliminary assessments of the status of east coast Spanish mackerel fishery identified a distinct lack of suitable information with which to parameterise assessment models. Further the outcomes of the assessments were bleak with outputs surrounded with uncertainty and the fishery concluded to be fully exploited. Advice to management was to proceed cautiously and conservatively until better quality information was available to parameterise assessment models with greater certainty. This project has collected some of this needed data and information.

Recent catch data for the recreational and commercial fishing sectors indicates that between 680-850t and 380-720t are landed per annum by each sector respectively. Previous to this research no information was available to describe the biological characteristics of the recreational sector harvest and information describing the characteristics of the commercial sector harvest was limited both spatially and temporally.

The project identified biological characteristics of harvested catches of Spanish mackerel on the east coast of Queensland vary with both fishing sector and coastal region. The commercial fishing sector lands a more selective component of the east coast Spanish mackerel resource than the recreational fishery. In harvesting Spanish mackerel, commercial fishers are faced with marketing considerations with landed catches dominated by specific length and age ranges of mackerel. Conversely, recreational fishers largely harvest mackerel opportunistically targeting mackerel when and where they are available for exploitation. Consequently, the landed catches of the recreational fishing sector tend to be more diverse in length and age structure. Regional analysis demonstrated biological characteristics of commercial catches were stable between regions relative to the variable nature of the recreational catch characteristics between the same regions.

On the basis of data collected by the project and some data collected by the RFISH program of the Queensland Fisheries Service, the appropriateness of current size limits and bag limits are discussed.

In conclusion, the project has defined important resource parameters that will ensure future stock assessments of the east coast Spanish mackerel fishery are completed with far greater certainty than is currently available. Further, the project has collected data that describes the harvesting selectivity's of both the recreational and commercial fishing sectors that will allow future monitoring of the status of this important resource to be better targeted.

Keywords: **Spanish mackerel, *Scomberomorus commerson,* Age, Sex, Length, Mortality, Otoliths, Fishery effects, Regional patterns**

2. Acknowledgements

Over the period of the project many people provided assistance that enabled this research to be completed. Commercial, recreational and charter fishers as well as many other individuals associated with the fishing industry assisted in collecting biological samples and data for the project. We gratefully acknowledge all of these people.

We thank the many commercial fishers and fish wholesalers whom voluntarily collected samples and data for the project. Further, during many conversations these individuals also provided insight into the many aspects of the history and operation of the east coast Spanish mackerel fishery. These contributions were greatly appreciated. Specifically we thank the following commercial fishers and fish wholesalers - Paul D'Auria, Chris Nettleton, Wade Tappenden, Col Lounds, Neil the wheel, Herb Murray, Peg Hanson, Trevor Draper, Barry Sheldon, Ian Davidson, Peter Truman, Peter Moody, Mal Stakey, Peter Spinner, Chris and Carl Svenson, Damon Blessing and Garry from Mooloolaba Fish World. Thank you also to all those other fishermen who provided useful feed back during phone conversations and meetings.

Recreational fishers also played a major role in collecting samples for the project and the contribution of these individuals was greatly appreciated. In particular Bill Bowtell who's enthusiasm and interest in the project was very refreshing. Other recreational fishers who similarly made very helpful contributions to the project include Andrew Bradford, Andy Orr, Ashley Moore, Barbara Leptig, Brad Moses, Brett Tivnes, Brian Puroy, Cameron Murchie, Chad Lunow, Chris Davidson, Chris Nash, Cliff Daley, Colton Perna, Darren Simpson, Dave Eakin, Gavin Nash, Geoff Whaling, George Morgan, Graham Morris, Greg Cairns, Graham Tabel, Hayden Tilley, Heath Zygnerski, Jeff Meares, Jeff Philp, Jeremy Arnold, Jillian Kratz, John Goebels, John Haenke, Kevin Olhm, Len and Rob Wiltshire, Lynelle Moses, Mark Pitkin, Mathew Sexton, Miochael Guse, Neil Costecco, Nick Papadimentrio, Paul Tabel, Peter Speare, Pitzy Folk, Renato Narrmino, Richard Brown, Richard Hearle, Rohan Voller, Rowley Newton, Russell O'Brien, Russ Bowman, Scott Baker, Shane Darmenter, Shaun Chandler, Steve Smith, Tim Hascle, Tony Austen, Tony Katsaras, Vern Veitch and Warren Ferrington.

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From the Queensland Fisheries Service, Jim Higgs is gratefully acknowledged for supplying catch data on the recreational fishing sector; Stephanie Slade and Clare Bullock were particularly helpful in providing catch data for the commercial fishing sector; Darren Rose and Sue Helmke are gratefully acknowledge for providing commercial catch data collected as part of the QFS Long Term Monitoring Program; and Darren Rose again was particularly helpful in discussions on ageing methods and protocols.

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3. Background

3.1 Introduction

Spanish mackerel, *Scomberomorus commerson* inhabit tropical and sub-tropical waters of the Indo-West Pacific from South Africa and the Red Sea east to Fiji, Japan and Hong Kong (Kailola *et al*., 1993; Collette & Russo, 1984). Throughout this wide range, Spanish mackerel are harvested and support important commercial, recreational and artisanal fisheries (Collette & Russo, 1984).

During their lifecycle Spanish mackerel inhabit shallow inshore waters where low salinities and high turbidities may be encountered, out to the edge of the continental shelf (McPherson, 1985a). Adult fish are epi-pelagic, usually associated with reefs, shoals or current lines, and rarely found in depths greater than 100 meters (Collette & Nauen, 1983). Spanish mackerel are easily targeted by fishers throughout their distribution due to factors such as a preference to shallow coastal and continental shelf waters (Quinn, 1993), known annual migration routes and areas of aggregations (Collette & Nauen, 1983; Mapstone *et al*., 1996), and a voracious feeding behaviour (Anon, 1973).

In Australian waters, *S. commerson* are commonly found in northern tropical and sub-tropical areas south to about 30^0S latitude (McPherson, 1992), though may on occasions be found as far south as Geographe Bay and St Helens on the west and east coasts respectively (Kailola, *et al.,* 1993). It has long been postulated that large-scale migrations occur annually along the east and west coasts of Australia with the migrations of mackerel linked to the warmer currents that push down the west (Donohue *et al*., 1982) and east (McPherson, 1982) coasts during the summer months. Two distinct stocks of Spanish mackerel are known to occur in Queensland waters. First proposed by McPherson (1978b), later work by Shaklee *et al* (1990) identified two discrete genetic stocks of Spanish mackerel, an east coast stock consisting of fish from south-eastern Torres Strait to southern Queensland waters, and a Gulf of Carpentaria/Torres Strait stock.

More recent stock discrimination of Spanish mackerel by Buckworth *et al* (2003) has identified that mackerel in northern and western Australian waters conform to a meta-population type stock structure. That is, adult Spanish mackerel do not undertake lengthy seasonal migrations as previously assumed but show a high degree of site attachment. Critically, Buckworth et al (2003) warn that the combination of the schooling habit of Spanish mackerel with a meta-population structure renders stocks highly susceptible to localised and serial depletions.

Specialised fisheries have developed and target *S. commerson* from regional coastal ports in Western Australia, the Northern Territory, Queensland and to a lesser extent northern New South Wales (Begg *et al*., 1997). On the Queensland east coast, regional fisheries have long been developed along the coastline (migratory path) with effort and landings reflecting the seasonal abundance of *S. commerson* throughout the year (McPherson, 1981).

Throughout tropical and sub-tropical Australia, the Queensland east coast stock is the most heavily exploited by both commercial and recreational fishers with recent catches estimates indicating combined landings exceed 1400t in most years. The Queensland east coast stock of Spanish mackerel displays a strong migratory behaviour that allows fishers to accurately predict and target Spanish mackerel as schools of fish move through or temporarily reside in particular regions along the Queensland east coast.

Inner reef areas northeast of Townsville are the most important fishing grounds for commercial fishers of Spanish mackerel, where around a quarter to a third (around 200t) of the annual commercial catch is harvested. Further, the large majority of the annual commercial catch taken from this area is captured during the well recognised spring spawning season when both mackerel and fishers aggregate within specific reef areas during the dark moon phases of October and November. During this short period approximately 1500 boat days of fishing effort may be accumulated yielding a catch of around 200t (Ludescher, 1997). Though most effort is accumulated around this area (Mapstone et al., 1996), the entire Queensland east coast is important for mackerel fishing (Hundloe, 1985).

Spanish mackerel are harvested from the waters off east coast Queensland by commercial and recreational anglers. Recreational anglers may harvest mackerel under their own means (such as private pleasure craft) or by commercial charter fishing operations. Participation in the recreational fishery involves a diverse array of individuals with widely ranging expertise and equipment. The large majority of annual recreational harvests are taken from the south-eastern corner of the state coinciding with areas of high population as well as proximity to suitable mackerel fishing grounds.

3.2 The Commercial Fishery

3.2.1 Description

Spanish mackerel is the most dominant pelagic species of the Queensland east coast commercial line fishery (Mapstone et al 1995) with total effort and catch recently reported as varying between 8,000 and 12,000 boat-days and 400 and 770 tonnes per year respectively (McPherson and Williams, 2002).

Historically, the Spanish mackerel fishery has operated as a troll fishery (McPherson, 1989), with fishing methods and gears changing little between the 1940's and 1980's (Williams & O'Brien, 1998). Although a reasonable proportion of active commercial fishers still use the time-respected troll fishing techniques, the last two decades has seen alternate fishing methods and gears developed in some regions by some fishers.

Traditional fishing methods of commercial fishers entailed trolling mostly rigged baitfish and occasionally artificial lures behind economical diesel powered dories. Petrol outboard powered dinghies were rarely used, as high catch rates were required to make this method of trolling economically viable (O'Brien, 1994). The trolling gears used generally consisted of varying lengths of 1.14mm bowden cable (or similar) main line with a length of wire trace attached to the terminal rig (rigged baitfish or artificial lure)(McPherson, 1989). Fishing activity occurred during the early hours of the morning and last hours of the afternoon as fishers coordinated their fishing effort with recognised feeding times of Spanish mackerel. Generally troll fishing began at first light and stopped about mid-morning when fish went off the bite or the catch required processing. Fishing them resumed mid-afternoon and continued until dark (Williams & O'Brien, 1998).

Anecdote reports that the traditional fishing methods and behaviours were so universally adopted that an unspoken gentlemen's agreement on fishing behaviour was formed. The agreement set down two daily fishing periods of dawn to 9am and 3pm to dusk. Fishers accepted this agreement because it was widely believed that catch rates generally slowed as the sun shone higher in the sky and it was good

practice to “spell” schools of mackerel rather than troll over them all day. Further, the mid-day break gave fishers time to process and freeze their catches.

As early as the mid-1980s some commercial fishers experimented with variant gear and fishing techniques encouraged by a combination of inquisitive nature and improved catch rates (Commercial fishers, pers com). In place of the traditional robust bowden cable and wire trace, fishers experimented with lighter and more cryptic monofilament line and shorter lighter wire trace fished through rod and reel gears. These more cryptic gears and rigging methods, combined with the skill developed by fishers to use long whippy rods to impart significant action on the bait or lure, resulted in better bight rates and daily catches. Anecdote suggests that at certain times this method resulted in significantly higher catch rates and accounted for more larger female fish than the traditional troll methods.

The fishery that exists today is a mix of generations and a mix of fishing gears. Traditional troll methods are still employed by the large majority of fishers targeting the large aggregations of spawning mackerel that form each spring north-east of Townsville. In contrast, localised fisheries in southern areas of the state where aggregations of mackerel are generally much smaller and exposed to much higher relative fishing pressures, the more cryptic rod and reel fishing gears dominate. Further, the pressure on individual fishers to maintain commercial quantities of catch in some areas has seen some fishers convert to live-bait fishing.

Fishing gear and method developments aside, the biggest single change within the commercial fishery over the last decade has been the change in marketed form of product. Historically, the east coast fishery operated predominantly as a fillet fishery, with blocks of frozen fillet (generally 10kg lots) sold domestically. Catch records from the 1970s indicate that around 1000t of mackerel fillet were marketed annually. The landing and marketing of whole-iced Spanish mackerel was initiated in the early 1990s in response to the development of a specialist Asian cuisine market. Initially this market demand was fulfilled by New South Wales fishers; however by the mid-1990s many Queensland fishers also began marketing their product in the whole-iced form. By this time, whole mackerel was marketed both nationally and internationally.

The Queensland commercial fishery is managed by the Queensland Fisheries Service (QFS) through a combination of limiting licences and an array of input (vessel, gear and area restrictions) controls and a single output control (a minimum size limit of 75cm TL applies). For commercial fishers it is mandatory to log daily catch and effort information in logbooks supplied and managed by QFS.

3.2.2 Catch characteristics

After coral trout, Spanish mackerel is the second most targeted species by Queensland commercial line fishers and is the dominant pelagic catch in most regions (Mapstone *et al*., 1996). The earliest records available that document historical landings are from the Queensland Fish Board (QFB) and indicate in the vicinity of 1000t of Spanish mackerel were harvested and sold annually throughout the 1970s. It is important to note that it is likely these early figures underestimate the actual harvested tonnages because of the perceived presence of a considerable black market.

Throughout the mid-1980s no logbook or method for recording of commercial catches existed. A compulsory commercial logbook (known as the CFISH program)

was introduced in 1988 and has been operational since. Throughout the history of the CFISH program, the annual catch of Spanish mackerel has climbed from a low of 446t in 1988 to a maximum harvest of 770t in 1999 (McPherson and Williams, 2002). Unfortunately however, these recent estimates of the annual commercial harvests derived from CFISH records have been marred by inappropriate data conversion factors (CFs)(Hoyle, 2002). CFs are used to convert the logbook entries into estimates of whole wet weights of fish landed as commercial fishers can land and record their catch information as weights of fillet, trunks, gilled and gutted fish and whole fish. Specifically, the diverse market form of Spanish mackerel has confused the estimation of total wet-weight harvests. Correct CFs are mandatory to estimate the total wet-weight of annual harvests.

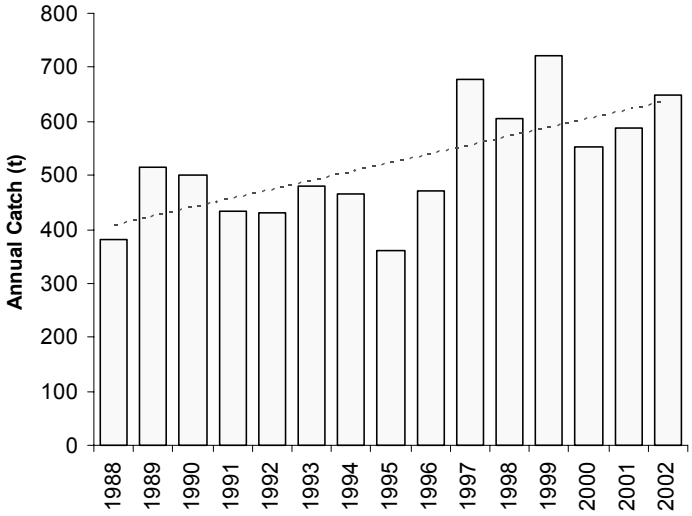
Due to the logistics associated with the field sampling program of this project, we were unable to estimate conversion factors for Spanish mackerel harvested from the east coast. However, the recently completed FRDC Project 1999/181 investigating the Western Australian Spanish mackerel fishery, were able to estimate accurately CFs for Spanish mackerel, and we have used those here (Mackie and Lewis, 2003).

Analysis of CFISH data

We collated and analysed the commercial logbook data collected through the CFISH program to identify gross annual trends and regional trends in Spanish mackerel harvests. Using product conversion factors estimated by FRDC Project 1999/201 we estimated total harvest of Spanish mackerel from the Queensland east coast has fluctuated between a low of 382t in 1988 to a high of 721t in 1999, with an annual average harvest during this period of 508t (Figure 3.1). Importantly, we noted that recently reported catch estimates (see McPherson and Williams, 2002 and Cameron and Begg, 2003) have over estimated commercial harvest by up to 20% in some years due to the inaccuracy of previously used catch conversion factors.

The annual commercial landings of Spanish mackerel on the east coast of Queensland have demonstrated a significant increasing tendency throughout the history of the CFISH logbook program. Regression analysis indicated that a significant positive relationship exists between time and product landed ($MS = 76{,}932$; $df = 1,13$, $F = 11.77$; $p < 0.005$). Catches between successive years have varied by up to 30% indicating that the fishery may well be driven by isolated years of good recruitment.

Figure 3.1 Annual landings of Spanish mackerel on the east coast of Queensland by the commercial fishing sector as recorded in the compulsory CFISH logbook program. Catch estimates are total wet-weights determined by using product conversion factors estimated and proffered by FRDC Project 1999/159. The fitted regression line represents a significant positive trend of catches increasing through time.



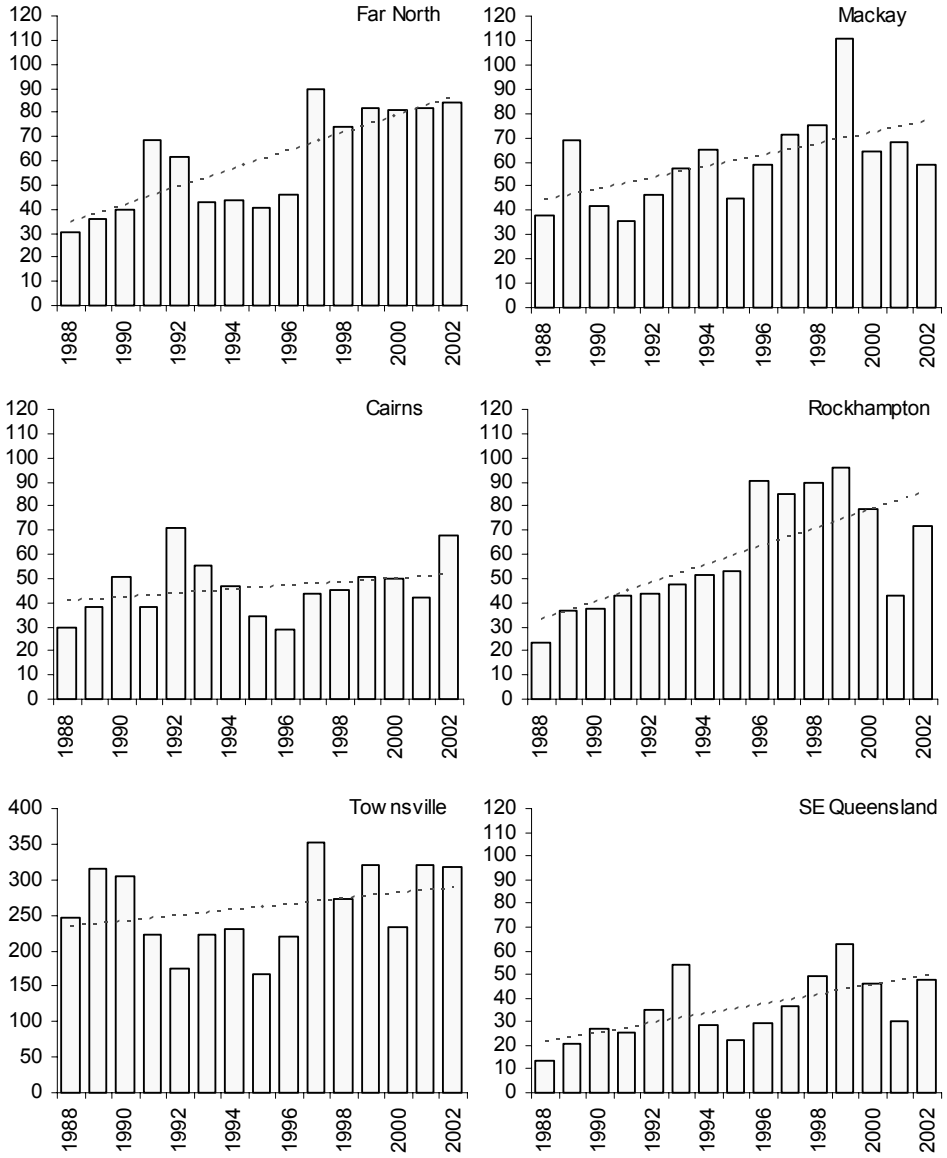
Regional Analysis

Analysis of the CFISH data on the regional scale indicated annual catches in some areas have increased significantly throughout the 1988-2002 period while others have demonstrated no such trend (Figure 3.2). Outputs from regression analysis displayed in Table 3.1 show that commercial catches in the Cairns and Townsville regions have shown no significant increasing tendency between the 1988 to 2002 year period. We estimated annual commercial catches for the six regions – far north, Cairns, Townsville, Mackay, Rockhampton and south-east Queensland – as delineated in the methods section Figure 7.1.

Table 3.1 Analysis of regression indicated significant positive increases in catches of Spanish mackerel by commercial fishers in four of six regions on the Queensland east coast. Data is whole weight of landed fish and estimated from collations of the CFISH logbook data. Product conversion factors estimated by FRDC Project 1999/201 were used.

Region	MS	F	df	p	Average Annual Catch
Far North	6879.4	22.89	1, 13	**0.000**	**60.0**
Cairns	178.3	1.22	1, 13	0.290	46.1
Townsville	4380.8	1.34	1, 13	0.268	261.3
Mackay	1569.6	6.12	1, 13	**0.028**	**60.4**
Rockhampton	3965.5	13.42	1, 13	**0.003**	**59.2**
SE Queensland	1076.4	8.62	1, 13	**0.012**	**35.3**

Figure 3.2 Annual landings of Spanish mackerel within six regions of the east coast of Queensland by the commercial fishing sector as recorded in the compulsory CFISH logbook program. Catch estimates are total wet-weights determined by utilising conversion factors supplied by FRDC Project 1999/159. Fitted trend lines are linear regressions of annual catches on year.

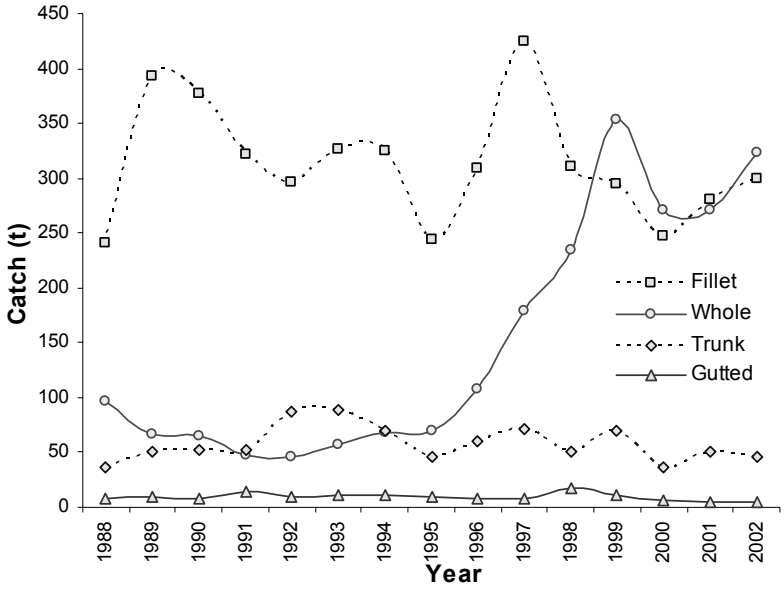


3.2.3 Changes in the Form of Marketed Product

The form of product landed by the commercial fishery has changed markedly throughout recent years. In the fifteen year period from 1988 to 2002, the fishery has diverged from landing predominantly fillet product (75% of total landings in 1989) to a fishery dominated in recent years by whole fish product (49% of total landings in 2002)(Figure 3.3). The whole fish market for Spanish mackerel developed rapidly from the mid-1990s, although prior to this time a stable but low demand for whole mackerel existed (Figure 3.3). The current whole fish market largely fulfils the demand of Asian purchasers (both nationally and internationally) who prefer to purchase fish in this form for both aesthetic and quality control reasons.

Understandably, many commercial fishers have been eager to support and supply the whole fish market as handling and processing times are significantly reduced, supporting gears and infra-structures are generally cheaper, and the whole fish product returns very competitive prices ($6 to $8.00 / kg for whole fish).

Figure 3.3. The total wet weight of mackerel landed and marketed as four different product forms as recorded in the commercial logbook program. A significant change in the form of marketed product occurred between 1988 and 2002 (chi-squared = 956.6, df = 42, p < 0.0001), with whole fish product dominating the harvest output of the fishery in recent years.



3.3 The Recreational Fishery

3.3.1 Description

Spanish mackerel are considered a highly prized catch for recreational anglers throughout Australia as the species is well renowned for both its fighting and eating qualities. The recreational fishery for Spanish mackerel has expanded considerably over the last two decades and although historic catch data is not available, catches are likely to have been considerable for many years (Kailola *et al*., 1993).

Recreational fishers use rod and reel gear almost exclusively (McPherson, 1989). Particular gears and methods can vary considerably with a wide range of live and dead fish-baits as well as various artificial lures and flies employed at times. Anecdote suggests there are two main types of Spanish mackerel fishing and capture undertaken by recreational anglers: 1. Specific target and capture – where anglers fish well recognised locations at certain times of year and employ gears and methods that specifically target and increase the chances of hooking and landing mackerel; and 2. Opportunistic target and capture – where mackerel are taken by fishers as an incidental capture to their primary fishing activity. Often fishers targeting demersal reef and shoal fishes will have an unattended line set for incidental mackerel catches.

The adoption of new technology such as GPS (Global Positioning System) technology and powerful colour video sounders has changed the behaviour of recreational fishers within the last decade. With these new technologies at their disposal, fishers are able to reliably and repeatedly locate and fish previously difficult to find cryptic habitats such as deepwater shoals that hold large aggregations of

Spanish mackerel during particular seasons. Fishers targeting mackerel in these locations use a variety of fishing methods including vertical jigging of spoon or metal lures. Although such techniques have been recognised for some time, their popularity of use in some areas has expanded considerably in recent years possibly changing the catch characteristics of the recreational fishing fleet in some regions.

Though the monitoring of the recreational catch was suggested as early as 1981 (McPherson, 1981a), historical catch levels are not available for the recreational sector. In recent years, the QFS have instituted a recreational fisher diary program (RFISH) from which catch estimates for the years 1997 and 1999 have been possible.

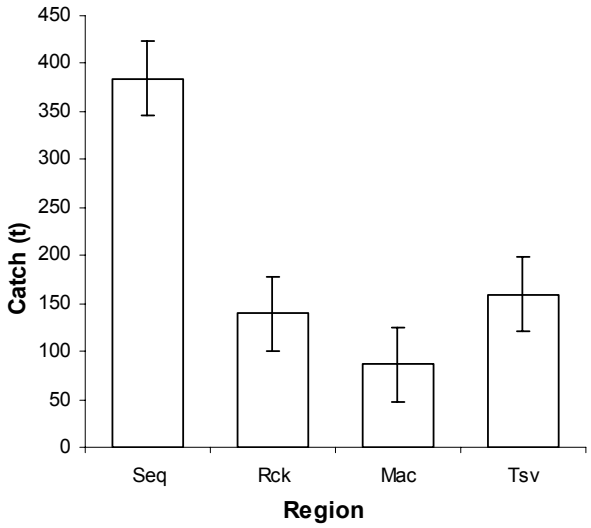
The QFS manages the recreational fishery for Spanish mackerel by input (various gear restrictions) and output (minimum legal size of 75cm and a bag limit 10 fish) controls.

3.3.2 Catch Characteristics

The bi-annual RFISH diary program implemented by the QFS has recently estimated recreational catches of Spanish mackerel throughout Queensland. Estimates of annual catches for the years 1997 and 1999 are 853t and 687t respectively (Higgs and Tobin, RFISH unpublished data). These annual catch estimates were recently revised using weight and average weight data collected and provided by this project.

At a regional level (four east coast regions defined in Section 7.1), south-eastern Queensland anglers harvest most Spanish mackerel with average annual landings close to 400t (Figure 3.4). In comparison, anglers in the Rockhampton, Mackay and Townsville regions harvest far fewer mackerel with average annual landings less than 160t per region. The large disparity between catches in the southeast corner and more northerly regions likely reflects the higher numbers of recreational anglers and registered recreational fishing vessels present within this area.

Figure 3.4 Average annual landings of Spanish mackerel by recreational sector in four regions – southeast Queensland (Seq), Rockhampton (Rck), Mackay (Mac) and Townsville (Tsv) – of the Queensland east coast. The data are annual catch estimates generated by the RFISH program for the years 1997 and 1999. Analysis of variance (Region – fixed orthogonal factor, Years – random replicate sampling unit) demonstrated significant effects of region on annual catches (measured in weight): ANOVA: MS = 12069.3, df = 3,4, F = 11.51, p = 0.019. Error bars are standard errors.



3.4 Historical and Recent Research

The large majority of research pertinent to the Queensland east coast Spanish mackerel resource was conducted by QDPI fisheries biologist, Geoff McPherson in the late-1970s and early-1980s. The research included numerous popular articles (McPherson, 1985a, 1985b), as well as biological programs that determined age and growth (McPherson, 1992) reproductive biology (McPherson, 1993), migratory behaviour (McPherson, 1978b, 1981a, 1982, 1987b) and diet (McPherson, 1987a). Some investigations into larval dispersal (Munro,) and stock structure of northern Australian Spanish mackerel (Shaklee et al, 1983) complete the Queensland research history. The findings and conclusions of these research articles were recently summarised by Tobin (2000).

Unfortunately, although concerns about the status of the east coast Spanish mackerel fishery have long been voiced by fishers from all sectors, the fifteen year period between the early 1980s and 1999 passed without any dedicated Spanish mackerel research or monitoring of catches.

In recent years two preliminary assessments of the status of the fishery have been conducted (see Section 3.6) and a monitoring program enacted (see Section 3.5) due to the on-going concerns of many stakeholders regarding the status of the east coast fishery.

3.5 Current Fisheries Monitoring

The QFS initiated an annual monitoring program of the Queensland east coast Spanish mackerel fishery in 1999. The program has been designed and implemented to monitor specific components of the fishery in an attempt to collect a time series of data that will form a basis from which stock assessment models and predictive and forecast models may be produced in future years.

Catch monitoring of the east coast Spanish mackerel fishery occurs each November where a fishery dependent sampling program collects biological samples from catches taken by commercial fishers pulse-fishing the annual spring spawning aggregation located north-east of Townsville. This approach has been adopted in consideration of logistic and economic costs while maintaining an emphasis on the collection of important biological parameters required for resource monitoring and assessments.

The program monitors the catch from as many commercial vessels as possible for 14 days in November each year. Biological samples are collected to determine and length and age composition of the east coast stock under the premise that all age-classes of mackerel are represented on the fishing grounds at this time reflective of the length and age composition of the complete stock.

In recent years, some concern has been expressed about the spatial and temporal limitations of the implemented sampling schedule. The current sampling design is acknowledged to limit biological collections to fishers who continue to participate in the fishery as traditional “wire fisherman”. It has been previously acknowledged that these fishing methods are particularly selective to a short modal length and age range (McPherson, 2002), and are likely to under-sample larger older mackerel that are almost certainly present on the fishing grounds. Thus samples collected by these methods may not accurately represent the true length and age composition of the sampled population.

Importantly, the monitoring of and collection of appropriate data from fisheries resources requires careful planning and implementation to ensure accurate length, age and sex composition of catches is obtained. As part of this requirement, it should be considered mandatory that any potential effect of region, fishing sector or gear type on catch characteristics be thoroughly investigated. Understanding these dynamics if they do occur within a fishery is fundamental to the validity and accuracy of future fishery monitoring and assessment exercises.

3.6 Current status, uncertainties and concerns

There is considerable uncertainty surrounding the status of the east coast Spanish mackerel fishery. In recent years, two stock assessments have been conducted with both producing similar outcomes and conclusions.

The first preliminary assessment of the status of the east coast Spanish mackerel stock was conducted by O'Neil and McPherson (2000) who applied an age-structured model to all available data. The analysis suggested that the exploitable biomass may have been significantly reduced (by up to 75%) across the period from the early 1970s through to 1999 and that the fishery may be teetering on collapse. However, the authors conceded that the data available for the assessment was limited. In particular, age structure information inputted into the model was out-dated historic data collected in 1977/78 and required urgent updating.

With marginally better catch history and age structure information available, the age-structure based assessment was again run for the east coast fishery in 2002 (Welch *et al*., 2002). The outcome was similar to the previous assessment with exploitable biomass predicted to have fallen to dangerously low levels since 1970. The authors stressed that a precautionary approach to the management of the fishery was appropriate, and advised that fishing effort should not be allowed to increase above current levels. The assessment similarly prioritised the need for gathering up-to-date length and age structured information from the fishery.

In addition to the assessments of Welch *et al* (2002) and O'Neil and McPherson (2000), concern about the status of the east coast Spanish mackerel fishery has been voiced for considerable time by numerous representatives from all major stakeholder groups (commercial and recreational fishers, pers comm., Williams and McPherson 1995; Williams and McPherson, 2002). Anecdotal information received from both recreational and commercial fishers suggests an appreciable decline in both numbers and size of mackerel harvested in southern Queensland waters has occurred over the last decade.

Some scientists (McPherson, 2001) and stakeholders have also expressed concern that the cryptic rod and reel gears used by some commercial fishers and the majority of recreational fishers harvest disproportionably more larger female mackerel from the population than once occurred.

4. Need

Concern regarding the status of east coast Spanish mackerel has been expressed by both commercial and recreational sectors and fisheries biologists over the last decade. In recent years, two preliminary assessments of the fishery concluded that worse-case scenario indicated the fishery may be teetering on collapse with the exploitable biomass having been reduced to very low levels (see O'Neil & McPherson 2000; Welch *et al* 2002). Importantly, both assessments acknowledged a significant degree of uncertainty surrounded the outputs of the assessment models and highlighted the depurate state of relevant biological information and reliable catch data mandatory for a confident assessment of the true status of the east coast fishery. The assessments further acknowledged that current biological data available for the east coast stock of Spanish mackerel may be questionable in representing the current biological status of the fishery.

In conjunction with the recent stock assessments, a management strategy evaluation (MSE) of the east coast fishery has also been recently undertaken (see Hoyle, 2003). Similarly to the two recent fishery assessments, the MSE also identified a number of shortfalls in available fishery data. In particular the MSE identified a need for the age structure of the east coast stock to be determined with greater certainty by sampling catches taken by both the recreational and commercial fishery sectors. Further, any age structure sampling needs to target a broad spatial range of the fishery as it is possible that some spatial subdivision occurs within the stock.

The need is also present to define the operating characteristics and resultant catch components of both fishery sectors. It is generally considered that commercial fishers focus on catching the most profitable sizes of Spanish mackerel, generally avoiding schools of small mackerel and shying away from targeting very large mackerel due to handling and marketing difficulties, and potential gear damage. Conversely, recreational anglers are considered as a whole to opportunistically target all sizes of Spanish mackerel by using a wide variety of fishing techniques. In order for any future management changes to achieve their targeted objectives, strategies will need to be tailored in consideration of effect on current fishing behaviours and their resulting catches.

5. Objectives

1. Identify the biological characteristics (catch-at-age, catch-at-length and sex ratios) of both recreational and commercial sectors harvesting Spanish mackerel from four distinct regions on the Queensland east coast.

2. Compare the biological characteristics of harvested mackerel between sectors and regions

3. Assess the effectiveness of current minimum legal size and level of latent effort present in current recreational bag limits. Advice will be issued to management where applicable.

6. Achievement of Objectives

Identify the biological characteristics (catch-at-age, catch-at-length and sex ratios) of both recreational and commercial sectors harvesting Spanish mackerel from four distinct regions on the Queensland east coast.

The biological characteristics of catches landed by recreational and commercial fishing sectors were defined for four regions (Townsville, Mackay, Rockhampton and south-east Queensland) of the Queensland east coast. Commercial fishers tended to harvest a selective range of mackerel relative to the more diverse range of mackerel captured by recreational fishers. The characteristics of the commercial harvest are in line with the demands of the market that the product supplies, while the recreational harvest is a conglomeration of catches taken opportunistically by fishers when mackerel are accessible.

Compare the biological characteristics of harvested mackerel between sectors and regions.

Fishing sector was found to have a significant effect on the biological characteristics measured for landed mackerel. Regional effects were also pronounced for some characteristics measured. The analyses conducted demonstrate the need for monitoring programs to target both fishing sectors as well as incorporate a regional scale within future programs. Monitoring spatially and temporally isolated components of the fishery is likely to give no more than a partial picture of the status of the harvested stock and a partial indication of the components of the resource harvested. The analysed age structure data indicates that this fishery is dependent upon years of better-than-average recruitment that are dispersed by years of poor recruitment. The ability to monitor years or good and bad recruitment is considered mandatory in order for fluctuations in harvested volumes and catch-per-unit-effort indices to be correctly interpreted.

Assess the effectiveness of current minimum legal size and level of latent effort present in current recreational possession limits. Advice will be issued to management where applicable.

The current minimum legal size of Spanish mackerel (75cm total length) is set at a length below the reported size at maturity (89cm total length). In line with the traditional notion of setting minimum size limits - limits are set to protect individual fish from harvest until they have reached sexual maturity – some stakeholder members have suggested lifting the minimum legal size limit to 90cm total length. Using data collated by the project we determined that a minimum size limit of 90cm total length would preclude 15% and 6% of the recreational and commercial sectors harvests currently taken. Importantly though, we consider the post-release mortality rates are likely to be very high within this fishery particularly from within the recreational fishing sector. We argue that lifting the minimum size limit is likely to be counter productive with a significant proportion of captured mackerel being required to be returned to the water in a moribund state.

The current recreational fisher possession limit of 10 Spanish mackerel per angler is considered by many stakeholders to be excessively high. We analysed data collected by the RFISH program of the Queensland Fisheries Service (QFS) to demonstrate the considerable latent effort present within these limits. A reduced possession limit of 3 mackerel per angler has recently be proposed by the QFS. This limit would effectively remove the current latent effort present within this output control.

7. General methods

7.1 Research Area

The sampling area included all east coast waters of Queensland between the southern Tweed River border and the tip of Cape York. For the purposes of regional comparisons and subsequent analyses, the coastline was bisected into six roughly equal regions: far north, Cairns, Townsville, Mackay, Rockhampton and south east Queensland (Figure 7.1). Due to logistical and budgetary constraints of the project, sampling was concentrated within the four southern regions only.

7.2 Field collection of samples

Data and samples for the project were collected through the voluntary participation of recreational, charter and commercial fishers over a nineteen-month period between July 2001 and January 2003. In order to achieve the specific objectives of the project, the following capture information and biological measures of Spanish mackerel captured by fishers were collected.

Capture information:

- Date of capture
- Location and region of capture
- Gear and method of capture

Biological Information

- Fork length
- Macroscopic sex
- Age

Voluntary support of fishers was initially gathered by widely advertising the project through a range of media including industry magazines, research newsletters, regional radio interviews, oral presentations to fishing clubs, phone conversations and face-to-face meetings. Fishers agreeing to collect data for the project were briefed on the projects objectives and issued with research sampling kits. Sampling kits contained a measuring tape, waterproof data tags, clickseal bags and a pencil. The kit was accompanied with an information note on what measures and information to record, as well as how to collect and store biological samples (Appendix 1). In addition to recording fork length, location of capture and date, fishers where asked to include notes on terminal tackle used (artifical lure, dead bait, live bait etc) and fishing method (trolling, jigging, drifting etc).

7.2.1 Commercial sector samples

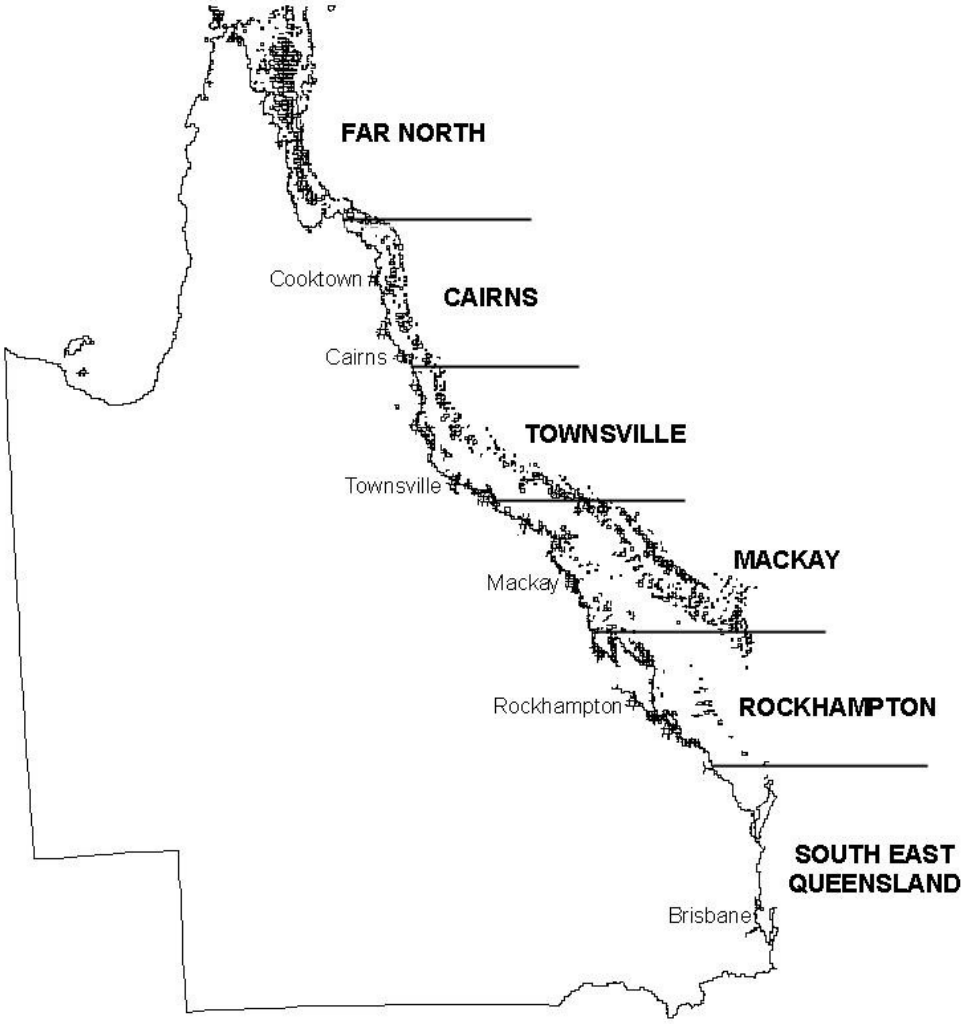
The commercial harvest was sampled by collecting capture information and biological samples from individual fishers and fish wholesalers. Due to the nature of some commercial fishers markets (landing whole mackerel for the whole fish market), the collection of biological data was not always possible. As such only length and capture information were collected from some participating commercial fishers.

7.2.2 Recreational sector samples

Initial contact with recreational fishing groups and clubs as well as tackle shops provided a list of possible participants. Recreational anglers whom regularly targeted Spanish mackerel were invited to participate in the project as well as anglers who did not principally target mackerel. Posters in tackle shops promoting the project and inviting participation were distributed throughout each region. Nominated tackle shops acted as collection sites for recreational fisher samples in each region.

Numerous recreational fishing competitions were also attended by research staff to collect samples and further advertise the project. A small number of samples

Figure 7.1 The research area for determining the catch characteristics of the Queensland east coast Spanish mackerel fishery included all coastal waters between Cape York in the North and the southern Tweed River border. The analysis and summary of existing commercial catch data considered the six defined regions, while the projects fishery dependent research sampling was confined to the four southern most regions due to logistical limitations.



collected by charter operators were pooled with recreational catch samples as the fishing methods and behaviours of independent recreational fishers and recreational fishers undertaking charter trips are considered the same.

7.3 Laboratory Dissection

The form of biological samples collected for the project included chilled whole fish, chilled heads and guts, frozen heads and guts, and frozen frames. Where possible project staff dissected fresh (unfrozen) samples immediately after collection. Fork length measures (to the nearest cm) were recorded and sex determined macroscopically (male and female). Where heads were sampled without a fork length measurement, an upper jaw length measure (to the nearest mm) was taken. Using formulae determined by FRDC Project 1999/181, jaw length measures were converted to fork length measures for these fish. Sagittal otoliths were removed through the brain cavity, after the top of the head was cut away using a bone saw for fish > 700 mm fork length or heavy bladed knife for smaller fish. Though the cranial bones of Spanish mackerel were relatively easy to saw or cut, the sagittal otoliths are very fragile and removal without breaking was difficult particularly if the head and brain cavity were partially frozen. Removal of the frame and proximal vertebrae from the head provided a stable basis for the head to be rested in a vertical position while the top of the head was removed. Otolith removal from the ventral side of the head through the gills was trialled, however the need for prior removal of the gill basket slowed this process. After removal, the otoliths were washed in fresh water, dried using a soft tissue and stored in labelled 5 ml plastic vials. To ensure otoliths dried completely the vials were left open for 5 days. If wet or partially wet otoliths are stored in sealed vials, readability can be adversely affected (Lewis and Mackie 2002, Mc Pherson,1992).

7.4 Ageing

Readability of Spanish mackerel otoliths appears to vary throughout their Australian range, with different methods of preparation and reading employed in Queensland (McPherson, 1992), the Northern Territory (Buckworth, 1998) and Western Australia (Lewis and Mackie, 2002). McPherson (1992) used whole otoliths to age Spanish mackerel with marginal increment analysis and counts of daily bands used to confirm an annual cycle of band formation. Buckworth (1998) trailed both whole and sectioned methods, however recently indicated using otolith weight as an age predictor, could be a more satisfactory method for ageing mackerel from lower latitudes (Buckworth pers comm.). More recently, Lewis and Mackie (2002) outlined methods for preparing and successfully interpreting both sectioned and whole otoliths of Spanish mackerel from Western Australia.

In order to determine a suitable otolith reading protocol for the project, a pilot program aged a sub-sample of otoliths using both whole and sectioned methods. This process served multiple purposes. Firstly, it allowed the reader to become familiar with the variation in appearance and readability of individual otoliths. Secondly, we were able to determine seasonal trends in band formation that would ultimately aid otolith interpretation. Finally, the process allowed for a statistical comparison of the repeatability of the two methods (whole otolith interpretation versus sectioned otolith interpretation), and to determine if any systematic error may be produced by either method.

The over-arching goal of the pilot program was to establish a reliable though cost-efficient standardised protocol for reading Spanish mackerel otoliths sampled from the Queensland east coast.

7.4.1 Ageing Pilot Program

The pilot program aged 222 otoliths first by whole reading methods, and then by sectioned reading methods. Each otolith was read twice by a single reader. If age was not agreed then the otolith was read a third time. If two of the three ages did not agree, the age was considered undetermined.

Whole otolith reading was conducted by immersing the otolith in a small black plastic dish filled with mineral oil. Under reflected light, the whole otolith was viewed through a binocular dissection microscope at a magnification of 20 to 25 times. A quadrant on the posterior surface of the otolith (see Figure 7.3) was defined as the read area and was used where possible (though not exclusively) to derive age estimates. Reads reliably taken from other areas were included. One year was estimated after each opaque band became visible. Opaque bands observed on the margin though considered as partially deposited were noted and included in the counts.

Following determination of age by whole otolith techniques, the same sample of otoliths were aged using sectioning techniques. Otolith sections were prepared by taking a number of serial 0.03 mm sections through the nucleus of the otolith which had been blocked in Clear Casting resin. The clearest sections were mounted under cover slips on glass slides again using Clear Casting resin. The otoliths were read using reflected light over a black background with water under the slide to reduce glare. A higher power (40 x) was used to read the thin otolith sections. Similar problems with interpretation, principally determining the first band, were encountered as discussed by Lewis and Mackie (2002). The quality of the sections was very inconsistent.

7.4.2 Results of ageing method comparison

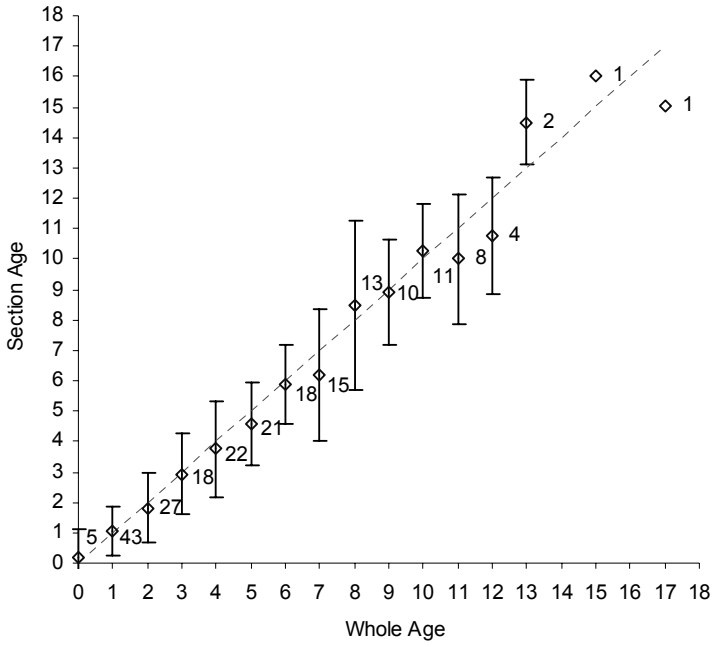
A sub-sample of 222 otoliths was aged by whole and sectioned methods. The whole ageing method was able to age a greater proportion of the otoliths than the sectioned method (Table 7.1). Further, the percentage error was lower for the whole rather than the sectioned method (Table 7.1).

Table 7.1 A sub-sample of 222 otoliths were used to compare the ageing success and reproducibility of whole and section otolith ageing methods.

Ageing Method	% aged	APE
Whole method	99.1	3.14
Section method	95.9	4.95

An age bias plot was then used to compare the ages determined by the two methods. The bias plot indicated no systematic error or difference was present between the whole and sectioned ages determined for the sub-sample of Spanish mackerel (Figure 7.2). Due to the higher percentage agreement, the smaller percentage error, and the absence of any detectable systematic error, we proceeded to age all otolith samples collected with the whole otolith method.

Figure 7.2 An age bias plot was used to determine if either the whole or sectioned ageing methods introduced a systematic bias into the age schedule.



7.4.3 Project Aging Protocol

Determining the age of sampled mackerel was conducted using whole sagittal otoliths which had been dried for a period of at least 5 days. Where possible the right hand otolith was used for age determination unless it was missing or damaged then the remaining otolith was used. Whole sagittal otoliths of Spanish mackerel were read immersed in mineral oil over a black background with reflected light. Using a binocular dissecting microscope with the magnification set between 20x - 25 x. Magnification was important due to the variation in banding width and appearance. A transverse section on the posterior of the whole otolith was defined as the read area and was used where possible but not exclusively to derive age estimates (Figure 7.3). Reads reliably taken from other areas were included. One year was estimated after each opaque band became visible. Opaque bands on the margin were noted and included in the counts.

7.4.4 Margin Interpretation

Because samples were collected throughout the year there was notable variation in the width of translucent or opaque material on the margin of the otolith. The variation in the width of the marginal band was most apparent in fish from one to four years of age as the bands during the early years of growth are often very wide and distinct. We defined a number of categories to describe the appearance of the margin band in order to determine whether a clear seasonal pattern of opaque and translucent growth occurs in the otoliths of Spanish mackerel, and if so when are the periods of opaque and translucent band deposition. The category system we used here is similar to one used to classify margin growth of Spanish mackerel otoliths in Western Australia (Lewis and Mackie, 2002)(Figure 7.4). The results of the margin interpretation exercise are shown in Section 7.4.5.

Margin Interpretation Categories

- 0 – An opaque band is observed on the margin of the otolith and there is no translucent material visible outside the opaque margin. This opaque material is clearly visible and continuous along the length of the read area.

- 1 – An area of translucent material is visible outside the opaque band which is clearly visible and continuous within the read area. This translucent material is narrow judged to account for 1/3 to ¼ of the translucent band laid down in the previous year of growth.

- 2 – There is an area of translucent material outside the opaque band which is clearly visible and continuous within the read area. The area is approximately half as large as the area laid down in the previous year of growth.

- 3 – There is a large translucent with some opaque material on the margin but it is not continuous or consistent along the read area.

7.4.5 Categorical Margin Increment Analysis

A final marginal increment category was recorded if any two of three margin reads for a single otolith agreed. Margin categories could only be reliably given for fish aged between 1 and 4 years as for fish older than 4 years band-stacking prevented confident categorisation. The analysis of the margin categories demonstrates a clear pattern of seasonal growth. Figure 7.4 demonstrates that for all collected data (fish aged from 1 to 4 years of age) opaque bands appeared on the margin of the otolith as early as July with the peak occurrence coinciding with the spawning months of October, November and December. Similar results using the categorical margin increment analysis have been found in Western Australia (Lewis and Mackie, 2002). Interestingly, the peak of opaque band formation we have identified here does not coincide with the period of opaque band formation defined by McPherson (1992). McPherson used a system of marginal increment measurements to conclude that opaque band deposition occurred primarily in the winter months of June, July an August. A possible explanation of this disparity can be found in Lewis and Mackie (2002) who stated the use of a category system rather than measurements was more effective for marginal increment analysis of whole sagittal otoliths of Spanish mackerel.

Figure 7.3 The lateral-distal surface of a 950 mm FL female Spanish mackerel otolith collected from the Townsville region in October, showing 2 annuli (black dots) and 2 translucent zones (black arrows). The read area is defined by the dotted lines and margin category was determined as 0.

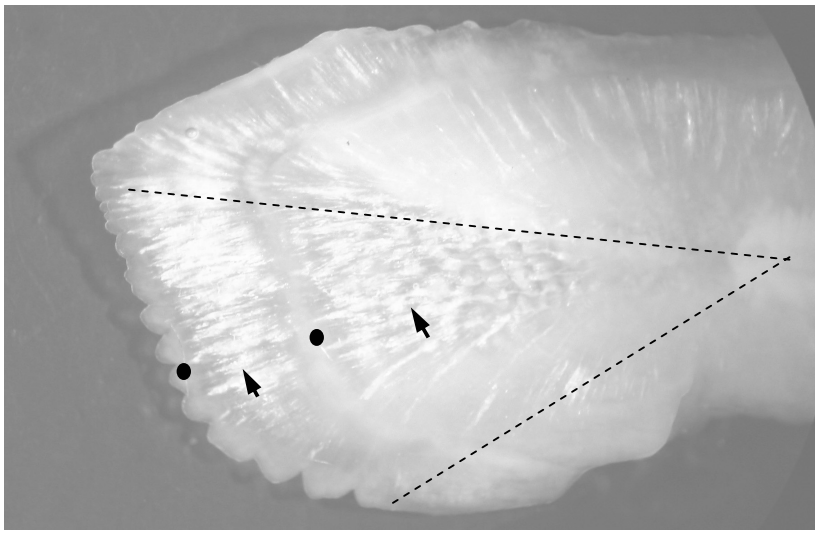
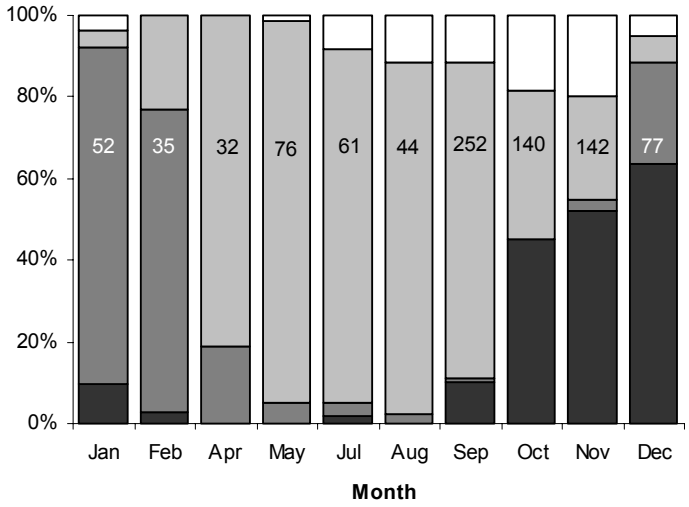


Figure 7.4 Marginal increment analysis was used to define the periods of opaque and translucent band deposition in the sagittal otoliths of Spanish mackerel. We used a categorical system to describe the band present on the otolith margin. Dark shading - opaque band on margin; Medium shading – partial translucent band on margin; Light shading – half complete translucent band on margin; No shading – complete translucent band on margin.



8. Biological characteristics of recreational and commercial harvests of Spanish mackerel.

8.1 Introduction

Spanish mackerel are recognised as both a high valued food and sportfish (Kailola, 1993). As a result, the species is targeted by a mix of fishers who angle for the species to satisfy a diverse array of intent. Some fishers capture Spanish mackerel for sport, others for personal food consumption, with others again for commercial sale. The diversity in fisher intent is matched by a diversity of gears and methods utilised by fishers to capture or harvest mackerel. In a fishery where mackerel representing a large range of lengths and ages are available to fishers, it is likely that variant fishing gears result in the capture of different components of the available resource. Understanding the characteristics of the mackerel harvested by the different fishery sectors is mandatory for assessing the status of the fishery as well as implementing management measures that ensure sustainable harvesting occurs.

Some limited data exist on the length, age and sex structure of catches of Spanish mackerel harvested from the east coast of Queensland by commercial fishers. The data is limited however, to historic sampling events conducted in the late 1970s. Further, these sampling events were spatially restricted to reefal areas between Cairns and Townsville. A considerable proportion of the annual harvest of Spanish mackerel taken by the commercial fishing sector is captured by fishers operating from coastal ports between Townsville and the southern Tweed River border. Very little information is available to describe the catches from these regions.

More concerning, is the absolute lack of information available to describe the length, age and sex structure of catches of Spanish mackerel harvested from the east coast of Queensland by recreational fishers. This absence of information exists despite long held concerns about the impact of harvesting undertaken by recreational fishers. Compounding this situation is the realisation in recent years that annual landings of Spanish mackerel by the recreational sector may exceed the annual harvest taken by the commercial fishing sector. Further, in the vicinity of half the annual harvest of recreational fishers is taken from waters confined to the south-eastern corner of the state.

The aim of this section of the research program was to gather information and data on the length, age and sex composition of recreational and commercial catches taken from the Queensland east coast. We collected information from, and determined gross characteristics of, commercial and recreational catches taken from the Queensland east coast between Lizard Island in the north and the Tweed River border in the south.

8.2 Methods

A. Length composition of catches

The length composition of recreational and commercial catches were collated and compared by log-linear analyses. Though information on the incidental capture of undersized Spanish mackerel were collected, only legal-sized mackerel (65cm fork length or 75cm total length) were considered in analyses. Two length descriptors were compared between commercial and recreational catches by single-factor analysis of variance. Both the average length of the catch as well as the average length of the largest 10% of captured mackerel was compared between the recreational and commercial sectors. An orthogonal single-factor analysis of variance

tested fishing sector (orthogonal factor) effect on the length measures with fish treated as random replicate units.

B. Age composition of catches
The age composition of recreational and commercial catches were collated and compared by log-linear analyses. Two age descriptors were compared between commercial and recreational catches by single-factor analysis of variance. Both the average age of the catch as well as the average age of the oldest 10% of fish captured was compared between fishing sectors. An orthogonal single-factor analysis of variance tested fishing sector (orthogonal factor) effect on the age measures (with fish as random replicate units).

C. Mortality estimates
Age-based catch curves described by Beverton and Holt (1957) were used to estimate instantaneous rates of total mortality (Z) for the two fishing sector. The natural log of fish numbers within each age class (*Nt*) were plotted against their corresponding age (*t*). Total mortality (Z) was estimated from the slope (*b*) of a fitted linear regression. The catch-curve method assumes relatively constant rates of mortality across all age-classes.

Mortality rates were estimated and compared between fishing sectors using a range of age-classes consistent to both samples. The age range used extended from year class one (modal class) to eleven (inclusive) with all other year classes excluded. The comparisons of mortality rates were made using analysis of covariance (ANCOVA).

D. Sex composition of catches
Sex ratios were compared against unity by goodness of fit chi-squared analyses. Log-linear analyses were used to compare the length and age compositions of male or female catches both within and between sectors. Average size and age of male and female fish were also compared between fishing sector and sex by two-factor analysis of variance. An orthogonal two-factor analysis of variance tested fishing sector and sex (orthogonal factors) effects on the age measures (with fish as random replicate units).

8.3 Results

Throughout the duration of the project, information was collected from a total of 5488 Spanish mackerel harvested from the east coast of Queensland. Sampling from the recreational sector was difficult at times due to logistical constraints of project time and staffing limitations. Nevertheless, relevant data was collected from 568 mackerel captured by recreational fishers (Table 8.1). Conversely, sampling from the commercial sector was less impeded by the project constraints as individual fishers within the commercial fishing sector were able to supply a considerably higher number of samples / fisher than the recreational sector. Data was amassed for a total of 4920 Spanish mackerel captured by the commercial fishing sector (Table 8.1).

Table 8.1 Samples for the project were collected through the voluntary participation of fishers from both the commercial and recreational fishing sectors. Wherever possible length, sex and age information was collected.

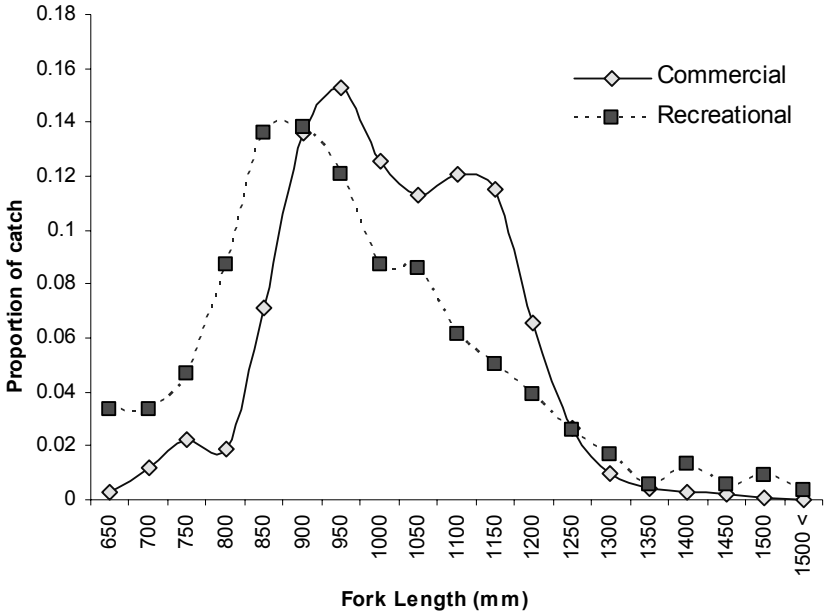
Fishing Sector	Total Sample	Length Data	Sex Data	Age Data
Commercial	4920	4828	3410	1560
Recreational	568	537	447	532

8.3.1 Length composition of catches

Length information was collected from a total of 4828 and 537 mackerel captured by commercial and recreational fishers respectively. Recreational fishers captured a greater length range (95cm) of mackerel with the smallest and largest fish sampled measuring 65 and 160 cm respectively. Commercial catches ranged between 65 and 152 cm (a range of 87cm).

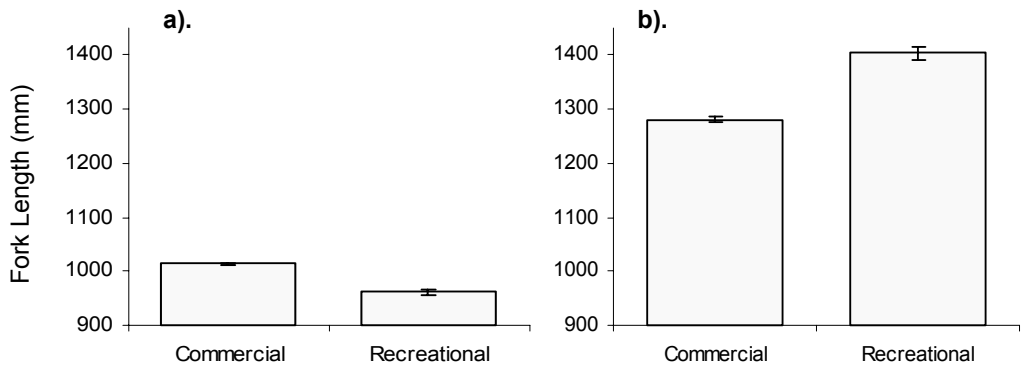
The length composition of commercial and recreational catches of Spanish mackerel varied significantly (Chi-square = 335.03, df = 18, $p < 0.0001$)(Figure 8.1). Recreational fishers tended to catch a greater proportion of smaller and larger mackerel than commercial fishers. The selectivity of the commercial harvest was more focused with 76.2% of mackerel landed measured in the 30cm length range between 87.5 and 117.5cm, while of the recreational catch 65.5% of mackerel harvested measured in the 30cm length range between 77.5 and 107.5 cm (Figure 8.1).

Figure 8.1 Length composition of Spanish mackerel collected from commercial (n = 4824) and recreational (n = 537) catches throughout Queensland between September 2001 and December 2002 (inclusive).



The average fork length of the commercial catch (101.5 cm) was significantly higher than the average fork length of the recreational catch (96.2 cm)($F = 72.8$, df = 1, 5363, $p < 0.0001$)(Figure 8.2a). However, the recreational sector harvested proportionally more larger mackerel than the commercial sector. The average fork length of the largest 10% of mackerel harvested by the recreational sector (140.4 cm) was significantly larger than the concomitant measure for the commercial harvest (128.1 cm)($F = 82.5$, df = 1, 267, $p < 0.0001$)(Figure 8.2b).

Figure 8.2 a). Average fork length of all fish sampled and b). average fork length of the largest 5% of fish sampled from both commercial and recreational fishers harvesting Spanish mackerel from the Queensland east coast. Error bars are standard errors.



8.3.2 Age composition of catches

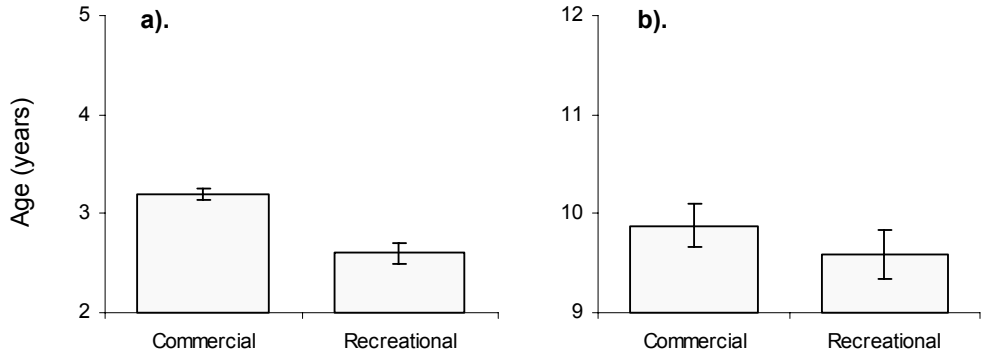
Age was determined for a total of 1560 and 532 mackerel captured by commercial and recreational fishers respectively. Commercial fishers captured a greater age range (18 years) of mackerel with the youngest and oldest fish sampled aged 0 and 17 years respectively. Recreational catches ranged between 0 and 13 years (a range of 14 years).

The age composition of commercial and recreational catches of Spanish mackerel varied significantly (Chi-square = 120.5, df = 12, $p < 0.0001$)(Figure 8.3). Though more than 75% of both the recreational and commercial catches consisted of mackerel in the 1 to 4 year age classes, the distribution of catch within these age classes was different between the sectors. Almost half of the recreational catch (46.6%) was made up of 1 year old mackerel while the same year class represented only 28.3% of the commercial harvest (Figure 8.3).

Figure 8.3 Age composition of Spanish mackerel collected from commercial (n = 1560) and recreational (n = 532) catches throughout Queensland between September 2001 and December 2002 (inclusive).

The average age of the commercial catch (3.2 years) was significantly higher than the average age of the recreational catch (2.6 years)(ANOVA, F = 30.5, df = 1, 2090, p < 0.0001)(Figure 8.4a). The average age of the oldest 5% of mackerel harvested by the recreational sector (9.6 years) was not significantly different to the concomitant measure for the commercial harvest (9.9 years)(F = 0.54; df = 1, 103; p = 0.47)(Figure 8.4b).

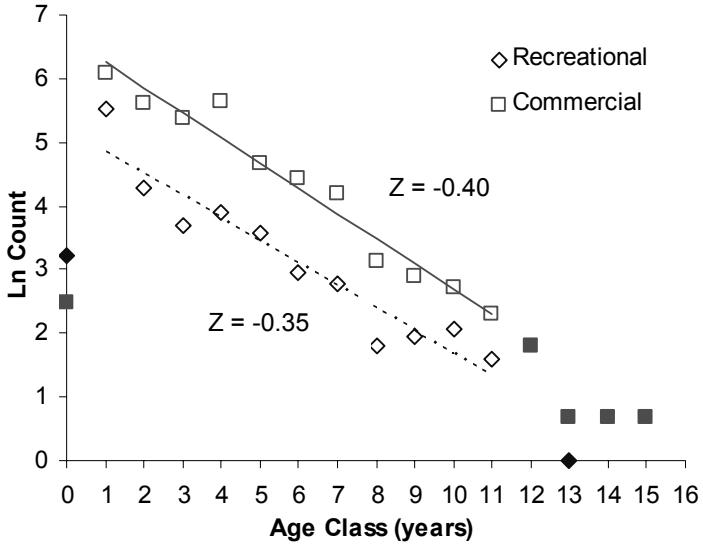
Figure 8.4 a). Average age of all fish sampled and b). average age of the oldest 5% of fish sampled from commercial and recreational fishers harvesting Spanish mackerel from the Queensland east coast. Error bars are standard errors.



8.3.3 Mortality rate estimates

Estimated mortality rates differed significantly between recreational and commercial harvests (ANCOVA df = 1, 19; F = 66.07; p < 0.001)(Figure 8.5). Mortality estimated from the recreational harvest (Z = -0.35) was significantly lower than the mortality estimated from the commercial harvest (Z = -0.40). Following this, higher survival rates were estimated from the recreational sample (S = 70.5%) over the commercial sample (S = 67.0%).

Figure 8.5 Age-based catch-curve estimates of total mortality rates for recreational and commercial harvests. Catch curves were fitted to a common range of age data (age classes 1 to 11 inclusive). Hollow data points indicate those data used.



8.3.4 Sex composition of catches

From the total sample collected sex was recorded for 3841 mackerel. The sex ratios of the total sample, the commercial sample and the recreational sample were not significantly different from unity (Table 8.2). In each case, sex ratios were slightly female biased.

Table 8.2 Total numbers of mackerel sampled by the program and from the recreational and commercial sectors. Sex ratio was calculated as the number of male mackerel to each female mackerel. Chi-squared analyses were used to test for significant departure of sex ratios from unity.

Sample	# Males	# Females	Sex Ratio	Chi	df	P
Total	1891	1966	0.96	1.42	1	0.233
Commercial	1665	1745	0.95	1.83	1	0.176
Recreational	221	226	0.98	0.04	1	0.850

In both the recreational and commercial sector samples, male mackerel dominated the smaller length classes while female fish predominated in the larger length classes. Sex had a significant effect on the length composition of catches within both the commercial (Chi-square = 234.9, df = 14, $p < 0.000$)(Figure 8.6a) and recreational (Chi-square = 40.2, df = 14, $p < 0.001$)(Figure 8.6b) samples. Conversely, sex had no effect on the age composition of catches within either the commercial (Chi-square = 10.33, df = 9, $p = 0.325$)(Figure 8.7a) or recreational (Chi-square = 16.09, df = 9, $p = 0.065$)(Figure 8.7b) samples.

Figure 8.6 The sex specific length compositions of Spanish mackerel collected from a). commercial and b). recreational fishers throughout Queensland between September 2001 and December 2002 (inclusive).

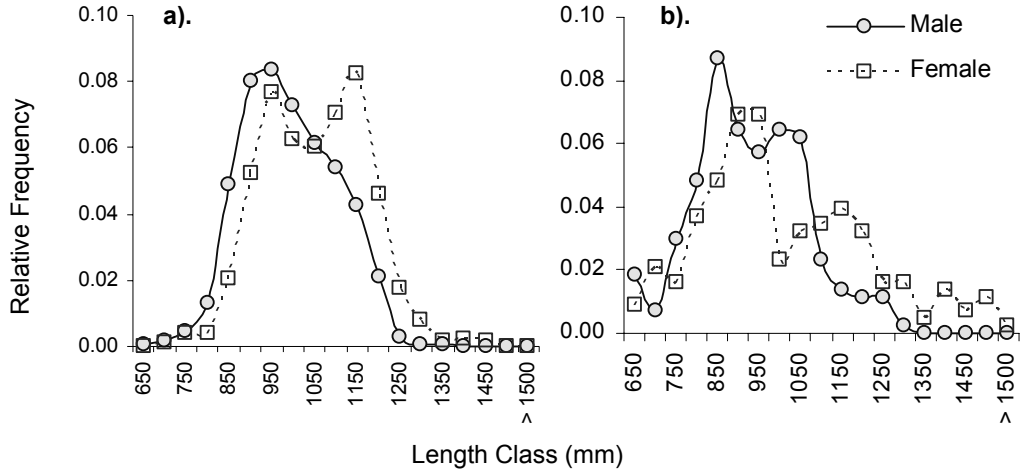
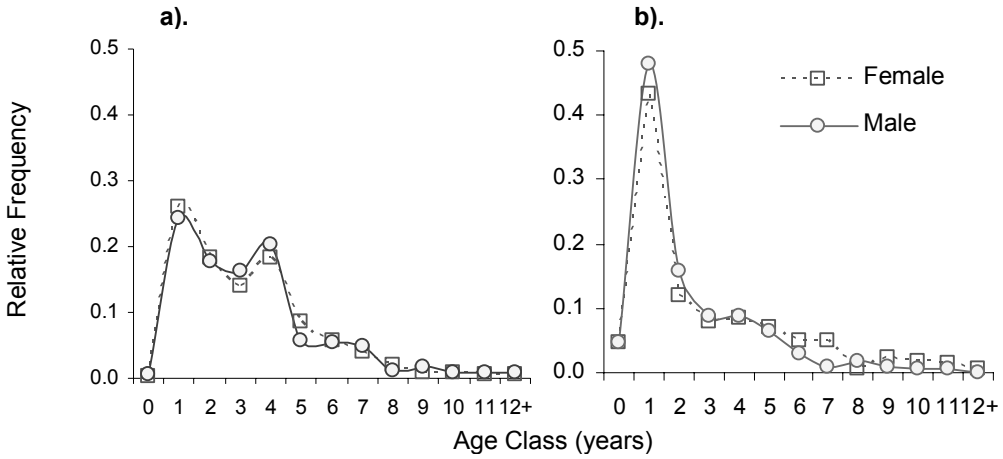


Figure 8.7 The sex specific age compositions of Spanish mackerel collected from a). commercial and b). recreational fishers throughout Queensland between September 2001 and December 2002 (inclusive).



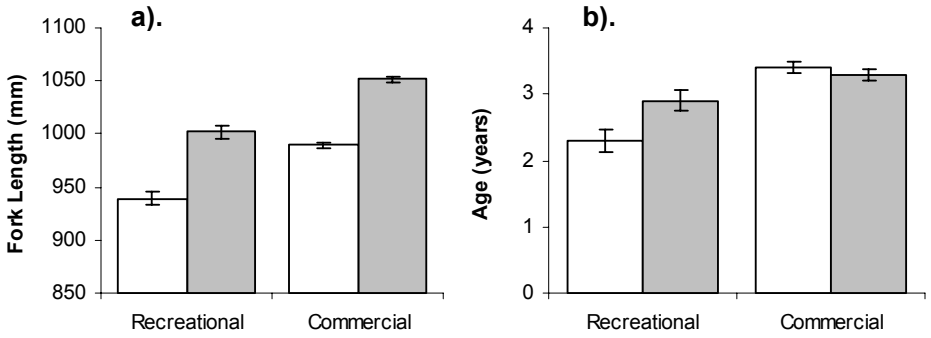
There was both pronounced sector and sex effects on the average length of mackerel harvested (Table 8.3). A consistent pattern existed between the sectors with male fish being smaller than female fish (Figure 8.8a). Further, the commercial sector consistently harvested larger mackerel than the recreational sector.

There was a significant interaction between sector and sex in the average age of harvested mackerel (Table 8.3). Though females were clearly older than males in the recreational harvest, this trend was reversed and differences less for the commercial harvest (Figure 8.8b).

Table 8.3 Two-factor analysis of variance was used to determine the effects of fishing sector and sex on the length and age of harvested mackerel. Sector and age were treated as fixed orthogonal factors with fish as random replicate units.

	Factor	df	F	p
Fork Length (mm)	**Sector**	1, 3831	63.7	**0.000**
	Sex	1, 3831	122.1	**0.000**
	Sector*Sex	1, 3831	2.3	0.130
Age (years)	Sector	1, 1786	32.1	0.000
	Sex	1, 1786	4.5	0.035
	Sector*Sex	1, 1786	6.8	**0.009**

Figure 8.8 The a). average length and b). average age of male (unshaded) and female (shaded) Spanish mackerel collected from commercial and recreational fishers throughout Queensland between September 2001 and December 2002 (inclusive). Error bars are standard errors.



8.4 Discussion

The data we collected indicate that the two main user groups of the east coast Spanish mackerel fishery, the commercial and recreational fishery sectors, tend to harvest different components of the resource. Further, previous to this research characteristics of the catch from the recreational sector where unknown and assumed. In addition, available catch descriptive information for the commercial sector was both out-dated and spatially limited.

We found that on average, recreational fishers harvested smaller and younger mackerel than their commercial fisher counterparts. Almost half (46.6%) of the recreational harvest was represented by a single cohort of mackerel (one year old fish) while the same cohort represented only 28.3% of the commercial sector harvest. Although the recreational harvest was dominated by these smaller younger mackerel, a small percentage of recreational fishers selectively target very large (> 15kg fish) Spanish mackerel. These fishers often go to great lengths modifying fishing gears and behaviours in order to maximise their chances of landing large fish. In accordance, we found that the recreational sector harvested proportionally more larger mackerel than the commercial sector.

Although the recreational sector was found to harvest proportionally more large mackerel, when we considered the age of harvested mackerel neither sector appeared to catch more older mackerel. In fact, at 17 years of age the oldest mackerel sampled was harvested by a commercial fisher.

The selective nature of the commercial fishery has been previously described by McPherson (2002) who reported that the traditional robust and heavy fishing gears used by commercial fishers select against large mackerel that are almost certainly present on the fishing grounds in higher numbers than they are represented in catches. In addition, it is a common anecdote that commercial fishers will actively move away from schools of small though legal sized mackerel due to poor economic returns per captured fish. In support of these assertions, we found that over three-quarters (76.2%) of the commercial harvest was represented by mackerel in a 30cm length range between 87.5 and 117.5cm fork length. In contrast, less than two-thirds (65.5%) of the recreational harvest was represented by mackerel in a slightly lower 30cm length range (77.5 to 107.5cm).

We estimated significantly different mortality rates for the commercial and recreational fishing sectors. Total mortality rates of 0.40 and 0.35 were estimated from the commercial and recreational fisheries respectively. Interestingly, recent stock assessment and management strategy evaluation work by Welch et al (2002) and Hoyle (2002) used a natural mortality rate of 0.34 in their assessment models. Using this natural mortality rate, estimates of fishing mortality would be very low at -0.05 and 0.01 respectively.

Further concerns about the derivation of the natural mortality estimate have been previously noted by both Welch *et al* (2002) and Hoyle (2002). Both these authors noted that even slight variations in the value of M introduce a large degree of uncertainty into the validity of fishery assessment model outputs. The value of total mortality rates we have determined here suggest that currently used natural mortality rate of 0.34 is of questionable validity.

The sex ratios we estimated from the two sector harvests were not significantly different from unity, and in each case were slightly female biased. We found that the

smaller size classes were dominated by male mackerel while the larger size classes tended to be female dominant. This pattern did not hold true for the age-based data with male and female fish captured in relatively even proportions throughout the age range. The dichotomous growth of the sexes of Spanish mackerel reported by McPherson (1992) is the likely driver of this scenario.

The distinct bi-modal peaks observed in the age-structures of both sector samples suggests that the success of annual harvests taken from the east coast Spanish mackerel fishery by both sectors is largely driven by years of good and bad recruitment. The high relative presence of 1 and 4 year old mackerel in both the recreational and commercial samples suggests that the spawning events and resulting recruitment from the years 2000 and 1997 were particularly successful.

Personal communication with fishers throughout the project indicated that the fishing activities and decisions of most recreational fishers are largely driven by opportunism. Recreational fishers target and capture Spanish mackerel for a wide diversity of purposes including sport, food and competition. Further, the recreational fishing sector is represented by a dynamic array of participants with individual fishers varying considerably in skill and experience levels and possessing varying qualities of fishing support infra-structure such as boats and fishing gears. Following this, it may have been hypothesised that the catch characteristics of the recreational fishing sector would be as diverse and varied as the individual participating fishers. Our findings certainly suggest this is the case.

Alternately, commercial fishers share a common purpose with that being the capture of Spanish mackerel for commercial sale. The fishing behaviours, gears and methods utilised by commercial fishers are ultimately driven by the requirement that a certain amount of fish needs to be captured and sold to earn a wage. Further, wholesale markets generally have a strong preference for a particular size and quality of product. As such, the fishing behaviours of commercial fishers are likely then to be much more refined and targeted than those behaviours of recreational fishers. The sampling of the commercial fishers we have conducted indicated that fishers from this sector preferentially harvest a defined length and hence age range of Spanish mackerel.

We have been able to define the broad biological characteristics of the recreational and commercial harvests of Spanish mackerel. It is now pertinent that the effect of region on these characters be assessed.

Section 9: The effects of region on defining catch parameters of recreational and commercial fisheries.

9.1 Introduction

The current uncertainty surrounding the status of the east coast Spanish mackerel fishery (see Welch *et al* 2002; Holye, 2003) combined with a distinct lack of information about the biological characteristics of catches taken throughout many regions of the state identifies a mandatory need to define these parameters. Current biological catch information is available only for the commercial sector harvest taken from the Townsville region of the northern Queensland east coast. No representative information is available for commercial catches taken in more southerly regions and no information is available for recreational catches taken from any region.

Spanish mackerel are captured and harvested by commercial and recreational anglers operating within all waters off the east coast of Queensland. The concentration of commercial harvest is around the Townsville region where fishers harvest large volumes of Spanish mackerel (~ 200t per annum) within a short three month period that coincides with the annual spring-summer spawning period. Commercial landings of Spanish mackerel in more southerly regions of the state may not be as large on the regional scale (ranging between 30 and 100t per annum in each region), however total annual harvests from all of these regions combined usually equal the annual landings taken from the Townsville region.

Alternately, the concentration of recreational Spanish mackerel harvest is in the south-eastern Queensland region where recreational fishers harvest around 400t of Spanish mackerel per annum in this region alone. The high volume of harvest taken by recreational anglers within this region is due to the high concentration of fishers in this region, the ease of accessibility to suitable fishing grounds (generally close inshore reefs and shoals), and the coincident timing of the seasonal presence of Spanish mackerel within the south-eastern region with the popular summer and autumn fishing months. In combination, the landings taken by recreational fishers in more northern regions of the state equate to a further 300 to 400t of mackerel landed per annum.

Understanding the regional dynamics of the east coast Spanish mackerel fishery is important to ensure management arrangements and harvesting behaviours continue in a sustainable manner. This section of the research project defines the biological characters of recreational and commercial harvests of Spanish mackerel taken from four regions off the east coast of Queensland. The biological characteristics of catches from all regions of the state require identification to enable an assessment of the suitability of the state-wide management approach that is currently in place.

In this section we collate length, age and sex composition of catches taken by commercial and recreational fishers from four regions of the Queensland east coast. We determine biological characteristics and compare these between coastal regions and fishing sector. We also investigate the effect of different fishing gears and calendar month of the biological characters of captured mackerel.

9.2 Methods

A. Regional and Sector comparisons of length composition of catches
The length composition of recreational and commercial catches were collated for each region and compared within each region by log-linear analyses. The overall effect of region and fishing sector on the length composition of landed catches were assessed by two-factor analysis of variance. An orthogonal design was used with fishing sector and region as fixed factors and with fish treated as random replicates.

B. Regional and Sector comparisons of age composition of catches
The age composition of recreational and commercial catches were collated for each region and compared within each region by log-linear analyses. The overall effect of region and fishing sector on the age composition landed catches were also assessed by two-factor analysis of variance. An orthogonal design was used with fishing sector and region as fixed factors and fish treated as random replicates.

C. *Regional and Sector comparisons of age-based mortality estimates*
Age-based catch curves described by Beverton and Holt (1957) were used to estimate instantaneous rates of total mortality (Z) for the two fishing sectors within each of the four regions sampled. The natural log of fish numbers within each age class (*Nt*) were plotted against their corresponding age (*t*). Total mortality (Z) was estimated from the slope (*b*) of a fitted linear regression. The catch-curve method assumes relatively constant rates of morality across all age-classes.

Mortality rates were estimated and compared using a range of age-classes consistent to all samples (all eight combinations of region and fishing sector). The age range used extended from year class one (modal class of all samples) to year class eight (inclusive) with all other year classes excluded. The comparisons of mortality rates were made using analysis of covariance (ANCOVA).

D. Gear effects on the length and age composition of landed catches
The effect of different fishing gears on the length and age of catches landed by recreational fishers were investigated by single-factor analysis of variance. Five fishing gears were identified as used by recreational anglers to capture mackerel. The five categories were defined largely on the type and size of bait used and included:

- big bait (large sized baits including school and doggie mackerels, bonito and wolf herring),
- medium bait (medium sized baits including gar, pike, slimey mackerel, yellowtail)
- small bait (small bait including pilchards and poddy mullet),
- live bait (any live fish bait irregardless of size), and
- artificial lure (any artificial lure or fly).

The effect of different fishing gears and year on the length of catches landed by commercial fishers was investigated by two-factor analysis of variance. Two fishing gears were identified as used by commercial fishers to capture mackerel in November 2001 and November 2002 and included:

- Wire methods (traditional robust fishing methods)
- Rod and reel methods (more cryptic methods of rod and reel fishers)

An orthogonal ANOVA design was used with fishing sector and region as fixed factors and fish treated as random replicates.

The effect of the same fishing gears on the sex ratios of landed catches were also investigated by chi-squared contingency analyses.

E. Temporal effects on the length and sex structure of commercial catches
The effect of month on the length and sex structure of catches landed by commercial fishers throughout the spring-summer spawning period of 2002 was investigated. Landings of mackerel captured from within the recognised spawning area by fishers using rod and reel gears were sampled during September, October, November and December of 2002. Single factor analysis of variance was used to test the effects of month on the average length of landed mackerel. Chi-squared contingency analysis was used to test the effect of month on the sex ratios of landed catches.

9.3 Results

9.3.1 Regional and Sector comparisons of length composition of catches

Fishing sector had a significant effect on the length composition of landed catches within each of the four sampled regions (Table 9.1)(Figure 9.1). Analysis of variance indicated a significant fishing sector and regional interaction effect in the average size of landed mackerel (ANOVA; $F_{3, 5253} = 48.4$; $p < 0.001$). Differences between the average size of landed mackerel between fishing sectors was not consistent between regions. Further, the average size of mackerel landed by the commercial sector was more consistent between regions than the average size of mackerel landed by recreational fishers.

Table 9.1 Log-linear analyses tested the effect of fishing sector on the length composition of landed catches within each of the four regions sampled. Sample sizes of the recreational and commercial samples are given by Rec n and Com n respectively. Significant effects are shown in bold.

	Rec n	Com n	Chi-value	df	p
Townsville	245	3363	549.1	12	**0.000**
Mackay	87	154	26.2	12	**0.010**
Rockhampton	77	896	32.0	12	**0.001**
South-east Qld	128	311	28.6	12	**0.005**

9.3.2 Regional and Sector comparisons of age composition of catches

Fishing sector had a significant effect on the age composition of landed catches in all sampled regions with the exception of Rockhampton (Table 9.2)(Figure 9.2). Analysis of variance indicated a significant fishing sector and regional interaction effect on the average age of landed mackerel (MS = 97.8; $F_{3, 2084} = 18.1$; $p < 0.001$). Differences between the average ages of landed mackerel between fishing sectors was not consistent between regions (Figure 9.2). Further, the average age of mackerel landed by the commercial sector was more consistent between regions than the average age of mackerel landed by recreational fishers.

Table 9.2 Log-linear analyses were used to test the effect of sector on the age composition of landed catches within each of the four regions sampled. Sample sizes of the recreational and commercial samples are given by Rec n and Com n respectively. Significant effects are shown in bold.

	Rec n	Com n	Chi-value	df	p
Townsville	251	1291	150.2	7	**0.000**
Mackay	83	149	16.5	7	**0.021**
Rockhampton	75	41	6.3	4	0.176
South-east Qld	123	79	15.9	7	**0.026**

Figure 9.1 The length compositions of Spanish mackerel harvested by commercial and recreational fishers were collated and compared within regions using log-linear analyses. Samples sizes are given in Table 9.1.

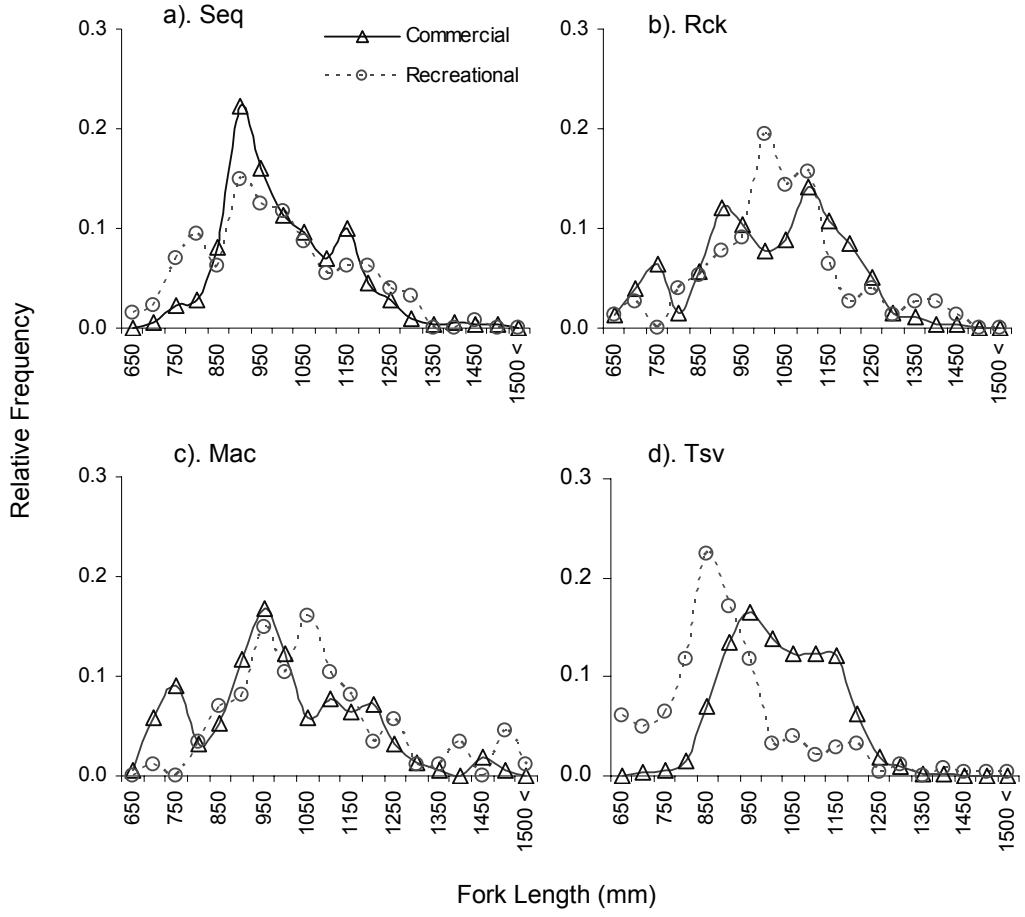


Figure 9.2 The effect of fishing sector and region on the length of harvested catches were assessed by two-factor analysis of variance. Error bars are standard errors.

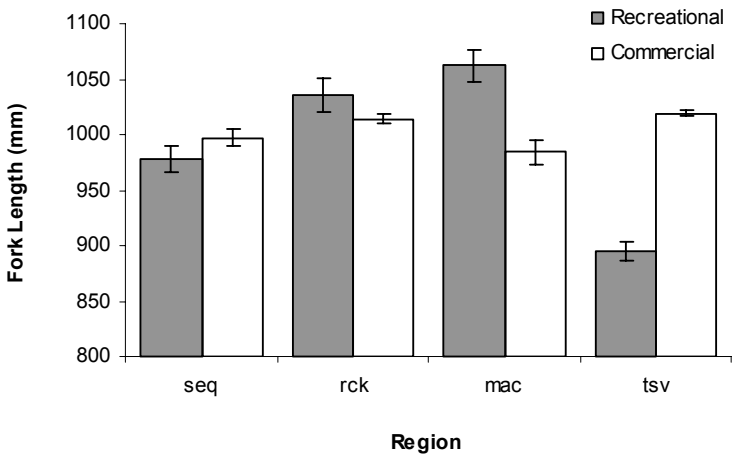


Figure 9.3 The age compositions of Spanish mackerel harvested by commercial and recreational fishers were collated and compared within regions using log-linear analyses. Samples sizes are given in Table 9.2.

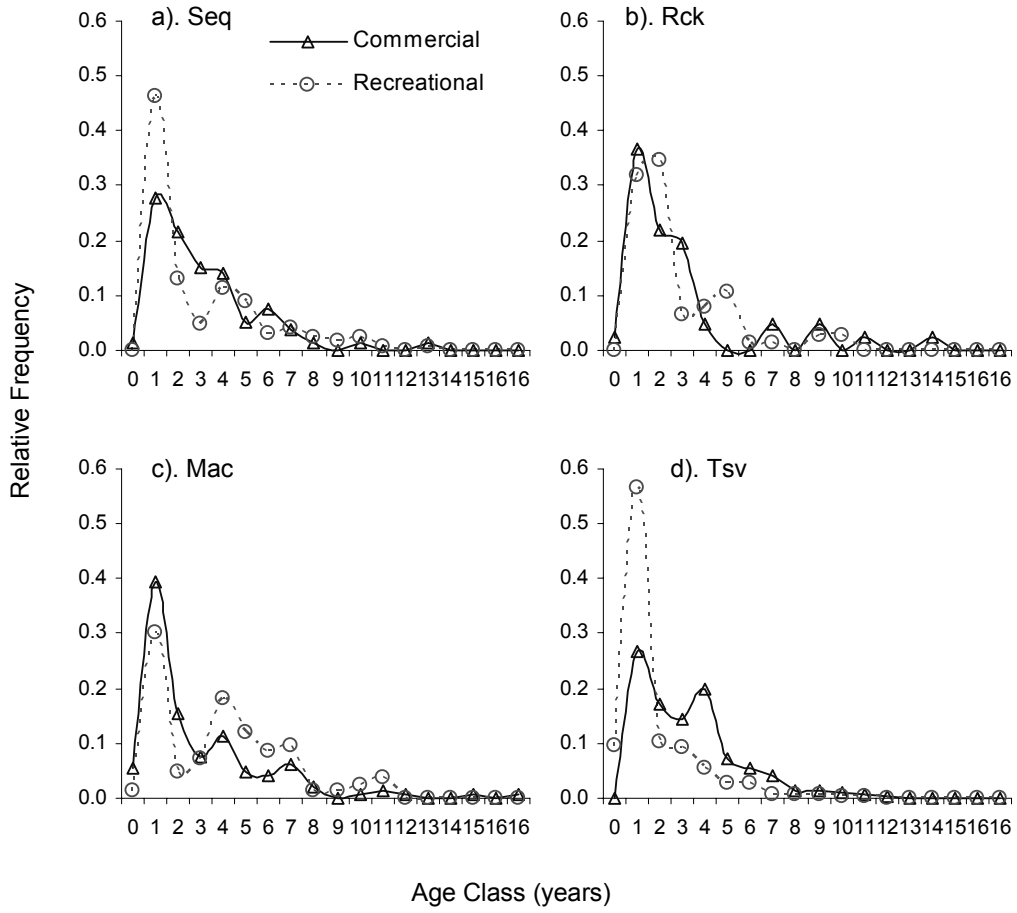
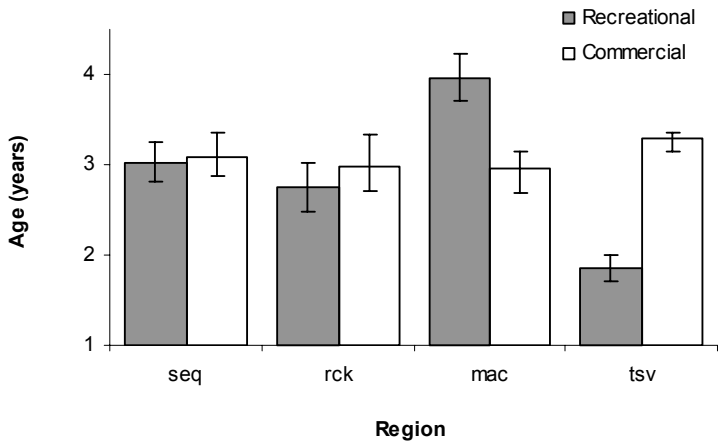


Figure 9.4 The effect of fishing sector and region on the length of harvested catches were assessed by two-factor analysis of variance. Error bars are standard errors.



9.3.3 Mortality rate estimates

The comparison of mortality rates estimated for each fishing sector in each region identified a significant interactive effect of region and fishing sector (ANCOVA df = 8, 44; F = 21.62; p < 0.001). Mortality rates estimated from commercial sector samples varied slightly (18%) between regions with the maximum rate of 0.40 recorded for south-east Queensland and the minimum rate of 0.34 recorded for Mackay (Figure 9.5). Conversely, mortality rates estimated from recreational sector samples varied by up to 240% with a low rate of 0.23 recorded for Mackay and a high rate of 0.56 recorded for both Rockhampton and Townsville (Figure 9.5).

9.3.4 Gear effects on the length and age composition of landed catches

The effect of 5 different fishing gears on the length, age and sex ratio of catches landed by recreational fishers was significant in all cases. Fishing gear had a significant effect on the average length of landed mackerel (ANOVA; $F_{4, 376} = 23.04$; $p < 0.001$) with larger baits landing larger mackerel and artificial lures landing the smallest mackerel (Figure 9.6a). Similarly, fishing gear significantly effected the average age of landed mackerel (ANOVA; $F_{4, 373} = 13.95$; $p < 0.001$) with larger baits landing older mackerel and artificial lures landing the youngest mackerel (Figures 9.6b). The sex ratio of landed catches varied significantly between the different gear types (chi-square contingency = 18.98; df = 4; p = 0.0008) with live bait gear landing the highest proportion of female mackerel (62.3%) and artificial lure landing the highest proportion of male mackerel (67.2%)(Figure 9.6c).

The type of commercial fishing gear used and year had a significant interaction effect (Two-factor ANOVA; $F_{1, 1462} = 31.67$; $p < 0.001$) on the length of landed mackerel. In 2001 wire gear captured slightly larger mackerel than rod and reel gear, though in 2002 the situation was reversed with wire gear capturing noticeably smaller mackerel than rod and reel gear (Figure 9.7). The sex ratio of landed catches did not vary significantly between the different fishing gear types for either the 2001 (chi-square contingency = 0.077; df = 1; p = 0.782) or 2002 (chi-square contingency = 1.273; df = 1; p = 0.259). Interestingly, while the sex ratios recorded by the two gear types in 2001 were close to unity, the sex ratios of both gear types in 2002 were largely female dominated (Figure 9.8).

Figure 9.5 Age-based catch-curve estimates of total mortality rates for recreational and commercial harvests taken from four regions of the Queensland east coast. Mortality curves were fitted to each group of data using a consistent range of age classes (age classes 1 to 8 inclusive indicated by hollow data points) to enable valid statistical comparisons to be conducted.

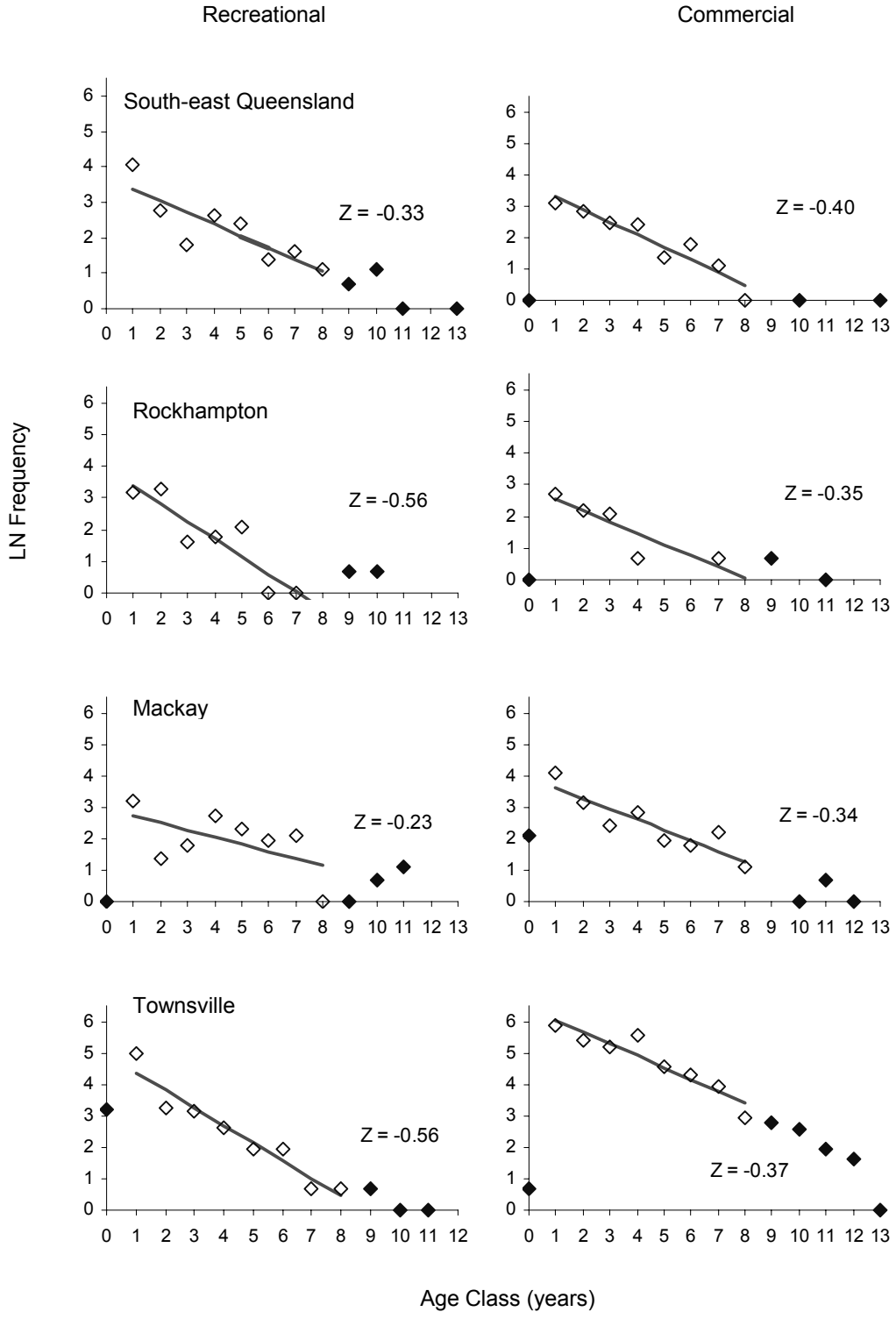


Figure 9.6 The effect of recreational fishing gear type on the a). average length, b). average age, and sex ratio of landed catches. Error bars on the length and age figures are standard errors. The sex ratio figures show the proportion of male (shaded) and female (unshaded) mackerel captured.

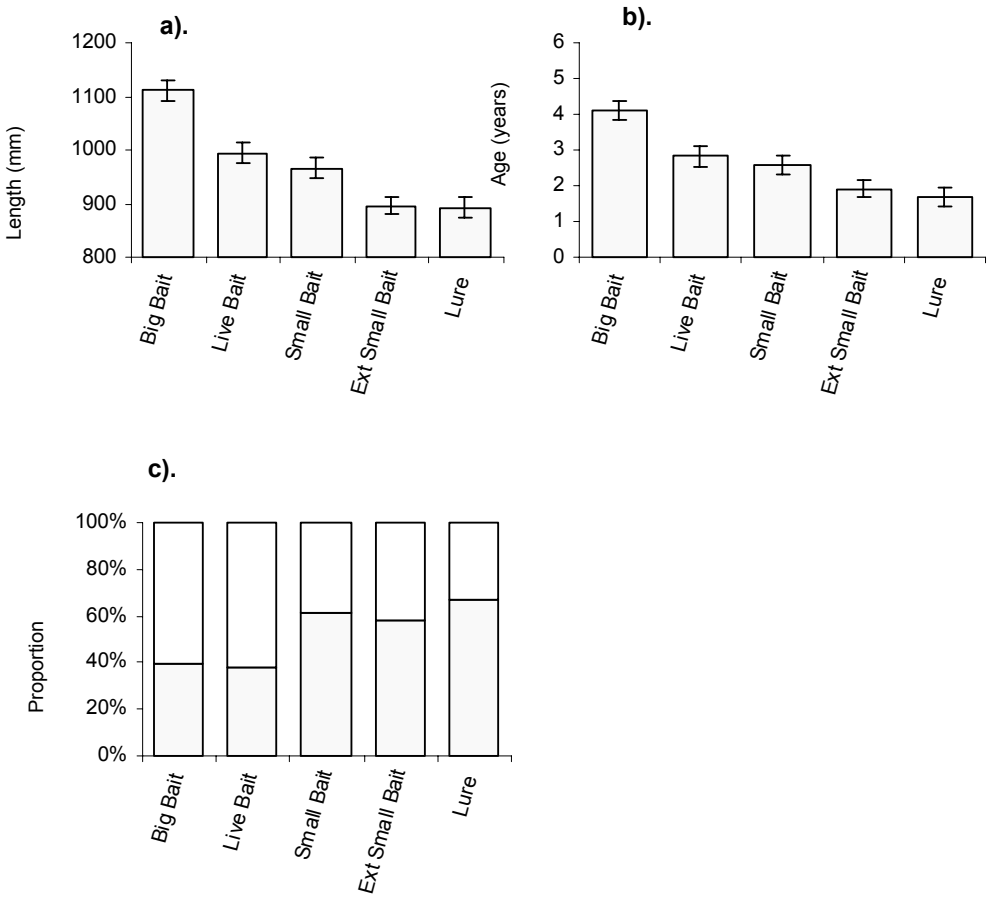


Figure 9.7 The effect of commercial fishing gear type and year on the average length of landed catches. Error bars are standard errors.

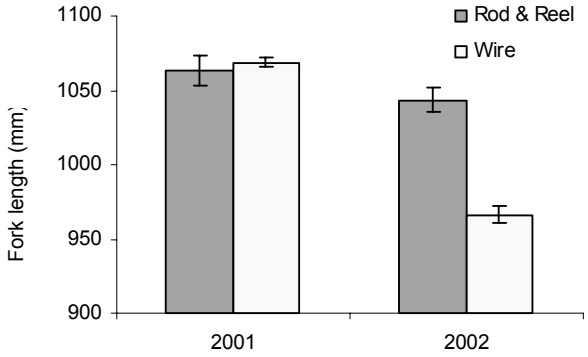
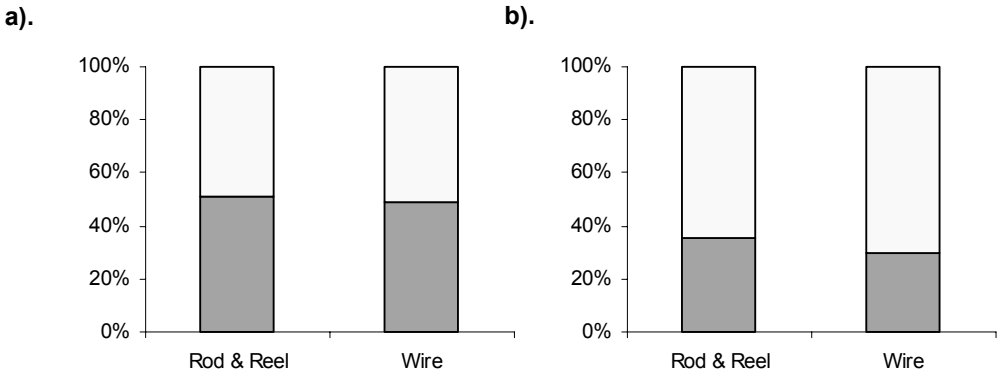


Figure 9.8 The effect of commercial fishing gear type on the sex ratio of landed catches in a) 2001 and b) 2002. The sex ratio graphs show the proportion of male (shaded) and female (unshaded) mackerel captured.



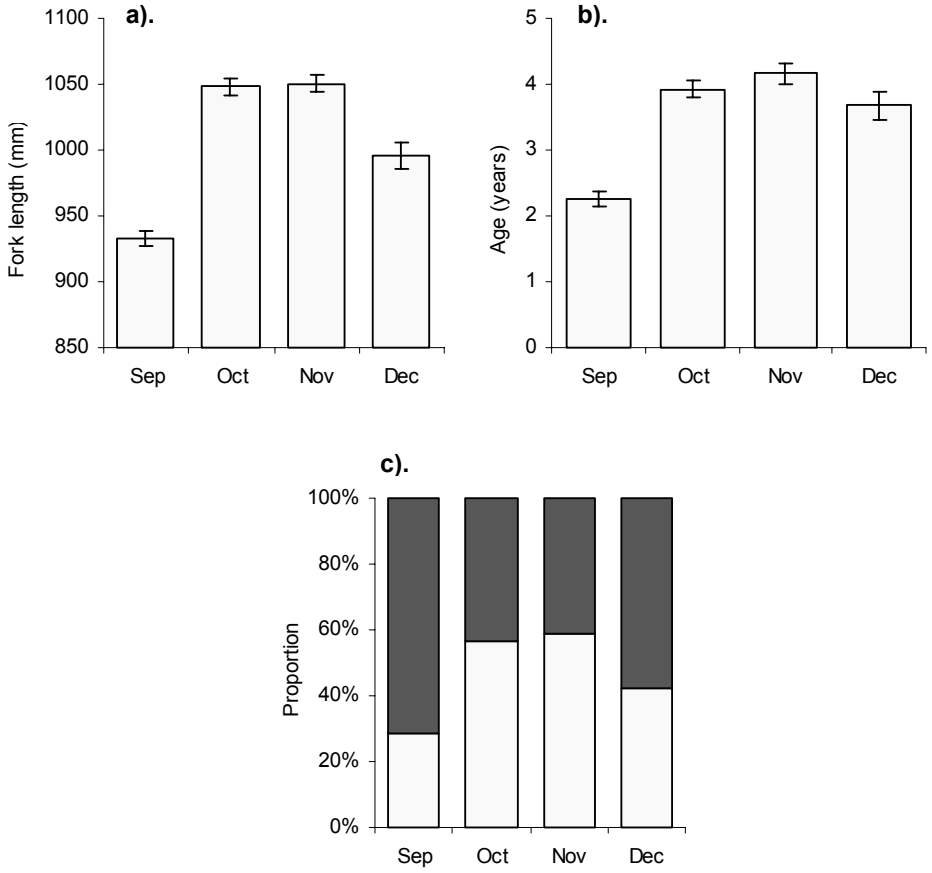
9.3.5 Seasonal effects on the length and sex structure of commercial catches

Month had a significant effect on the average length of mackerel landed by commercial fishers (ANOVA; $F_{3, 1137} = 87.50$; $p < 0.001$). Average length of landed mackerel was smallest in the pre-spawning month of September, largest in the prime spawning months of October and November, and at an intermediary of these during the post-spawning month of December (Figure 9.9a). Post hoc analysis indicated significant differences were present between September and all other months and December and all other months, while no difference was detectable between October and November.

Month had a similarly significant effect on the average age of landed mackerel (ANOVA; $F_{3, 1034} = 49.94$; $p < 0.001$). Average age of landed mackerel was youngest in the pre-spawning month of October and oldest in the prime spawning months of October and November and post-spawning month of December (Figure 9.9b). Post hoc analysis indicated significant differences were present between September and all other months, while no difference was detectable between the prime spawning months of October and November and the post-spawning month of December.

The sex ratios of landed catches were significantly effected by month (contingency chi-square = 77.19; df =3; p , 0.001). Catches in pre-spawning September were largely male biased; catches in prime-spawning October and November were slightly female biased; with catches in post-spawning December reverting to a male biased state (Figure 9.9c).

Figure 9.9 The effect of month on the a). average length, b). average age and c). sex ratio of landed commercial catches. Error bars are standard errors. Sex is indicated by shaded portions (male) and unshaded portions (female).



9.4 Discussion

Both fishing sector and coastal region were found to significantly affect most of the biological characteristics we measured from landed Spanish mackerel catches. Most notable however, was the relative consistency among regions of some of the characters measured from commercial sector catches relative to the variable nature of the same characters measured from recreational catches between the same coastal regions.

The length composition of commercial catches was relatively stable between regions with most landed mackerel measuring between 87.5 and 117.5cm. Conversely, the length composition of regional recreational catches varied considerably. Though the average length of commercially captured mackerel was relatively stable between regions (variation of 4.5cm between all regions), the average length of recreationally captured mackerel varied (variation of 17cm between all regions) markedly between regions.

The sometimes contrasting characteristics of catches taken by commercial and recreational fishing sectors are best demonstrated in the Townsville region. The largest regional average length of commercial harvested mackerel (102cm) and the smallest regional average length of recreational harvested mackerel (89cm) were recorded in this region. Similarly, the Townsville region recorded the oldest regional average age for the commercial sector as well as the youngest regional average age for the recreational sector. Clearly, in some regions large differences exist between the catch characteristics of the two fishing sectors.

The regional age data collected mirrored the regional patterns described for the length data. Commercial catches were less variable in their regional age characteristics than the recreational catches. Importantly, the strong one year-old age class dominated all regional samples with the exception of the Rockhampton recreational sample. However, this finding is likely to be somewhat circumspect due to the small size of the sample collected from Rockhampton.

The estimated mortality rates continued the trend of regional consistency for commercial catches and regional variability for recreational catches. Total mortality rates estimated for the regional commercial catches demonstrated little variation with the highest and lowest rates estimated at 0.40 and 0,.34 respectively. In contrast regional estimates for the recreational sector ranged from 0.56 to 0.23.

As anecdote popularly reports, large baits fished in certain locations at specific times of year catch large mackerel. We collected some data from recreational fishers that specialise in catching very large Spanish mackerel by using big bait fish and robust gears. Invariably these fishers catch on average larger and older mackerel than other less robust rigs and smaller bait types. Although some concern has been raised about the targeted removal of very large Spanish mackerel for the stock, it appears that only a very small minority of fishers undertake this practice and at current levels of harvest is not likely to be detrimental to the health of the fishery. Rather, the relative persistence of these older mackerel within landed catches maybe a useful future diagnostic, in combination with other methods, to the state of the fishery. Confident estimates of growth rates and natural mortality rates are reliant on sampling the older fish in a population.

The effect of different commercial fishing gears on the characteristics of landed mackerel has been debated previously within industry. Claims have been made that the more cryptic monofilament line fishing gears used by some fishers catch proportionally more larger, older and female mackerel than the traditional robust wire fishing methods. Our data does not entirely support this assertion. Analysing data collected only from the Townsville spawning aggregation during the months of October and November we found little difference between the length and sex structure of catches taken by the two gears in 2001, though a marked difference in 2002. Similar average lengths (around 106cm fork length) of mackerel were landed by the two gears in 2001, while in 2002 wire fishing gears captured mackerel averaging 96cm and rod and reel gears captured mackerel averaging 104cm.

We detected a marked effect of fishing month on the average size and age and sex ratio of mackerel landed by commercial fishers off the commercially important Townsville region. In the Townsville region although the average size and age of mackerel and sex ratios of catches did not vary significantly between the two main spawning months of October and November, mackerel harvested in the pre-spawning month of September were significantly smaller and younger, and catches were significantly male dominated. Further, fishers in more southerly regions also report experiencing similar seasonal changes in the size of mackerel captured. Although we were unable to collect replicate monthly data for more southerly regions, fishers report a predominance of smaller mackerel within early season catches with larger mackerel more common in late season catches.

Given the effect of month on mackerel catches we have demonstrated, there are some serious considerations that accompany recent suggestions of implementing spawning closures to this fishery. If spawning closures were to be introduced into this fishery, fishing effort would likely be displaced to times immediately pre- and post-spawning season. From the data we have collected, effort displaced to pre-spawning times may be detrimental to the status of the fishery as targeted aggregations of Spanish mackerel largely consist of mackerel significantly smaller and younger than those captured during the prime spawning months. The potential for recruitment overfishing exists. Throughout the spawning period the contribution of young mackerel to the landed catch falls significantly. In the months of September, October, November and December the proportion of largely immature one year-old mackerel in the landed commercial catch was 46%, 17%, 11% and 9% respectively.

The data we have presented and patterns we have described highlight the inappropriateness of the premise that underlies the current fisheries monitoring program in place for the east coast Spanish mackerel fishery. The program is limited by budgetary and other logistic constraints and monitors the status of the east coast fishery by sampling mackerel captured by commercial fishers from a small number of reefs off Townsville each November. As we have demonstrated here, the characteristics of the catch taken during this period by this sector can not be assumed to be representative of the total annual harvest (commercial and recreational fisheries combined) of Spanish mackerel taken from the Queensland east coast.

Fisheries monitoring programs will be best designed with a comprehensive understanding of the variable nature of fishing activities and harvest taken from the nominated resource. A multi-user group resource introduces problems to representative fishery sampling programs particularly where different user groups are

targeting and harvesting different components of a resource. To ensure future fishery monitoring methodology and assessment program proceed with the greatest certainty possible, the data collected here should be consulted and utilised where possible. The identification and description of fishing sector and coastal regional effects on the biological characteristics of landed catches presented here will allow future fishery monitoring and assessment exercises to be conducted with greater certainty than previously available.

Section 10: Assess the status of the current size and bag limits.

10.1 Introduction

The current management arrangements for the east coast Spanish mackerel fishery include a minimum legal size limit of 75cm total length that applies to all fishing sectors, and a maximum in possession limit of 10 mackerel per angler that applies to recreational fishers. Questions about the suitability and sustainability of these two output controls have been raised in recent years.

Firstly, the current minimum size limit (75cm TL) is set at a length below the minimum size of female maturity (89cm total length, McPherson 1993). This is in contrast to the usual paradigm where size limits are conventionally set at a length that ensures individuals have spawned at least once before recruiting to the fishery.

Recent reproductive research on Spanish mackerel in Western Australia (FRDC Project 1999/181) has defined reproductive maturity at a similar size (90cm TL) to east coast Queensland Spanish mackerel. In response, Western Australia Fisheries management increased the minimum legal size limit for Spanish mackerel from 75 to 90cm TL. Contrasting this, Northern Territory Fisheries has no minimum size limit for Spanish mackerel in recognition that post-release mortality rates of Spanish mackerel are likely to be very high.

Additionally, recent concerns about ciguatera poisoning arising from eating ciguatoxic Spanish mackerel has some stakeholders suggesting the introduction of a maximum size limit into the east coast Queensland fishery may be appropriate. Maximum size limits would prevent the landing of very large Spanish mackerel considered to be at greater risk of carrying ciguatera due to the bioaccumulation properties of this disease. Suggestions of enforcing a maximum size limit become all the more pertinent when it is considered that the Sydney Fish Markets acted to not accept or market any Spanish mackerel greater than 10kg of weight during 2002 in response to a ciguatera poisoning episode arising from two Spanish mackerel captured off Brunswick Heads (northern NSW).

Secondly, the current in possession limit enforced for Queensland east coast recreational anglers (10 mackerel per angler) is considered by most stakeholders to be excessively generous. Hoyle (2003) suggested that the average weight of a recreationally captured Spanish mackerel (average weight of Spanish mackerel captured by recreational anglers - 9kg, Tobin and Mapleston, *unpublished data*) would provide 56 standard meals of 100g, and also suggested that the average mackerel could be worth between $82 and $95 if sold on the black market. Bag limits in Western Australia and Northern Territory are currently set at 2 fish and 5 fish respectively.

Based upon the data collected by project staff and some data provided by the RFISH program conducted by the Queensland Fisheries Service (QFS), we have run some scenarios that predict the impact of changing these output controls on the harvest of Spanish mackerel.

10.2 The effect of changes on size limit output control

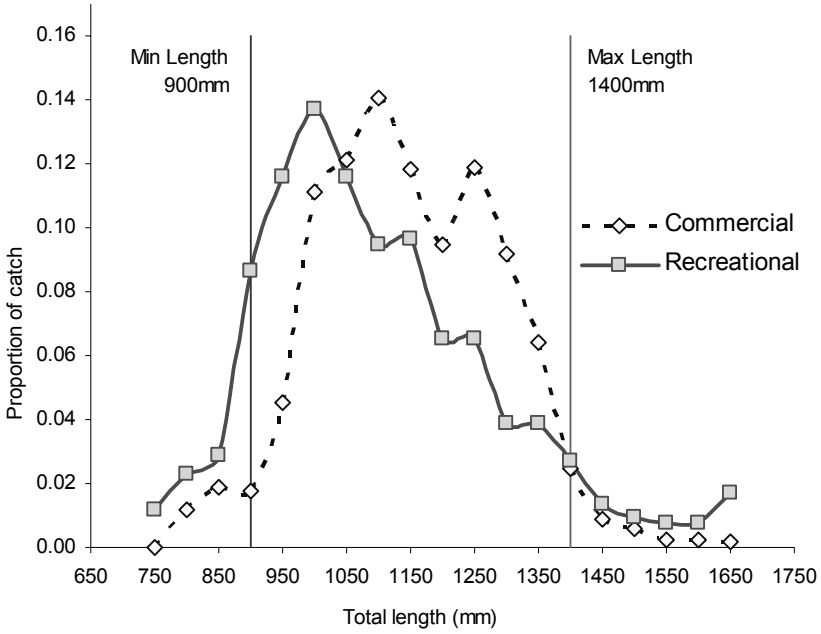
Some stakeholders have argued that the current minimum size limit of 75cm total length be raised to 90cm total length to abide with the conventional purpose of minimum size limits; that is, ensure most individual mackerel have attained maturity and spawned at least once before recruiting to the fishery. Using the length-

composition data we collated for both the recreational and commercial fishing sectors, the effect of raising the minimum legal size to 90cm total length on the harvested catch was estimated. Additionally, in response to calls from some stakeholder members for the implementation of a maximum size limit to protect large spawning females and protect against possible ciguatera poisoning, we examined the effect of a hypothetical maximum size limit of 140cm total length on the harvests of Spanish mackerel taken by both fishing sectors. A Spanish mackerel with a total length of 140cm would weigh about 14kg whole weight.

Raising the minimum size limit to 90cm total length would affect the recreational harvest greater than the commercial harvest. Around 15% of the recreational catch would have had to have been released under a minimum size limit of 90cm total length (Figure 10.1). In contrast to this only 4.9% of the commercial catch would have had to been released (Figure 10.1).

The imposition of a maximum size limit of 140cm total length would have much less of an impact on the harvests of mackerel taken by commercial and recreational fishing sectors. A maximum size limit of 140cm total length would have reduced the commercial and recreational harvests we observed by 2.1% and 5.6% respectively (Figure 10.1).

Figure 10.1 The effect of changes to the current minimum size limit (75cm TL) is demonstrated on the length-frequency distributions of catches landed by commercial and recreational fishing sectors as defined by this research. Increasing the minimum size limit to 90cm TL will exclude 15% of the current recreational sector harvest and 4.9% of the current commercial sector harvest. The implementation of a hypothetical maximum size limit of 140cm total length would exclude 2.1% and 5.6% of commercial and recreational sector harvests respectively.



Any consideration of changing the current 75cm total length minimum size limit for Spanish mackerel should also consider the fate of captured and released fish. Though no research has specifically addressed the issue, Spanish mackerel are considered notoriously difficult to catch and release in good condition. Firstly,

mackerel struggle and fight hard during the period of capture often completely exhausting themselves; and secondly, mackerel can suffer significant tissue damage during capture as the multiple hook rigs used by most fishers often lodge in areas of the head other than the jaw including the eyes, the cheek area and the gills.

Further, the success with which mackerel can be released is likely to be strongly negatively correlated to mackerel size. Appropriate handling of mackerel becomes more difficult with increasing size. Capture-tag-release data collected for Spanish mackerel by INFOFISH Services (Suntag data provided by Bill Sawynok) show that 85% of Spanish mackerel successfully captured-tagged-and-released on the Queensland east coast as part of the Suntag program are below the minimum legal size of 75cm. Further, very few mackerel larger than 100cm in length have been successfully tagged and released in this program.

Recent yield-per-recruit (YPR) calculations have indicated that the optimum size for harvesting Spanish mackerel is actually below the current minimum legal size at 70cm total length (Welch *et al*., 2002). Hoyle (2003) predicted that higher minimum size limits of 75, 80, 85 and 90cm total length would contribute to a loss of 1%, 2%, 4% and 8% of YPR respectively and suggested that these negative losses would be further compounded by the high mortality that would certainly be imposed through the capture and release process.

Introducing a maximum size limit for Spanish mackerel has been suggested by some stakeholder members for two reasons. Firstly, to lower the risk of ciguatera poisoning assumed to be more prevalent in larger mackerel; and secondly, as a means for protecting large female mackerel considered dis-proportionately more valuable to the reproductive potential of the stock relative to smaller female mackerel. Based on the length-structured data collected by the project, the introduction of a hypothetical maximum size limit of 140cm would have minimal impacts reducing the commercial and recreational harvests by 2.1% and 5.6% respectively. Importantly though, it should be considered that the likelihood of post-release survival of mackerel larger than 140cm total length would be very low.

Further, the likelihood of an individual Spanish mackerel carrying ciguatera is popularly linked to the size of individual fish, with bigger mackerel considered more prone to carrying ciguatoxin than smaller mackerel. However, given ciguatera occurs through the bioaccumulation of ciguatoxin within individual fish, we suggest fish age rather than fish length may be a better correlate with incidents of ciguatera poisoning. Due to the sexual dimorphic growth of Spanish mackerel where males grow significantly more slowly than females (see McPherson, 1992), the largest fish in the stock are not necessarily the oldest. Old male Spanish mackerel are generally quite small and rarely exceed 140cm total length. The bioaccumulation properties of ciguatera would indicate older fish rather than larger fish are more prone to accumulation of ciguatoxin. In this case, implementing a maximum size limit may only be partially successful, limiting the capture of large females but not limiting the capture of large males.

In concluding, any contemplation given to raising the current minimum size limit should consider that the survival rate of captured and released Spanish mackerel is likely to be low for almost all length ranges. The post-release survival rate of mackerel smaller than the current minimum size limit may be expected to be higher than that of larger mackerel due to factors including relatively shorter capture times combined with the relative ease of handling smaller fish. However, it should also be noted that the large majority of terminal fishing gears used to capture Spanish mackerel generally inflict serious injuries to the captured fish. Ganged hooks and

multiple treble hook rigs often lodge in areas around the head of the fish including eyes, cheek and gill areas. In a considerable number of cases it is probable that wounds inflicted from hook lodgement and removal will ultimately be fatal.

10.3 The effect of changes in bag limits

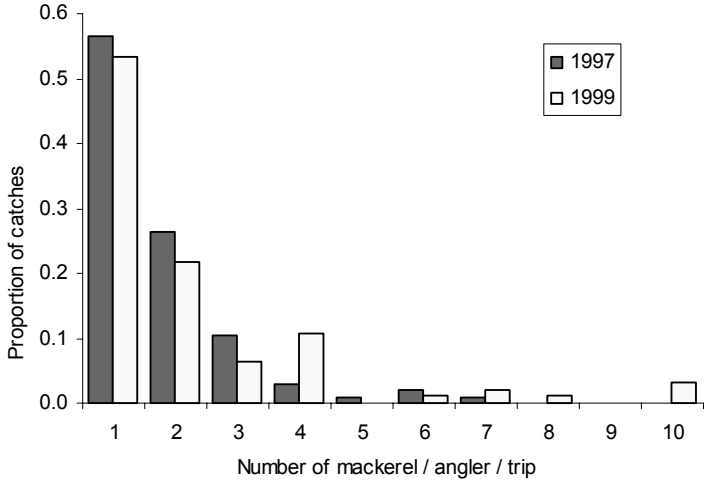
The current recreational in possession limit of 10 Spanish mackerel per angler is considered by most stakeholder representatives to be excessively generous. The QFS has recently proposed a reduction in the recreational in possession limit of Spanish mackerel from 10 fish per person to 3 fish per person.

We used data provided by Jim Higgs of the Queensland Fisheries Service to predict the effect of reductions in the mackerel bag limit on recreational catches. The data provided was supplied from the RFISH program which has collected individual angler catch records in 1997 and 1999. The data represent individual angler catches per fishing trip and has been reported on previously by Hoyle (2003).

The current in possession limit offers very little control over the harvest of Spanish mackerel taken by recreational anglers. Hoyle (2003) reported none out of 99 anglers achieved the bag limit of 10 Spanish mackerel during 1997, and only a single angler out of 95 achieved the bag limit in 1999.

The RFISH data demonstrates that over 80% of recreational angler catches of Spanish mackerel consist of 3 fish or less (Figure 10.2). Only 7.6% and 18.5% of recreational catches taken in 1997 and 1999 respectively reported landings of more than 3 Spanish mackerel per angler (Figure 10.2).

Figure 10.2 The relative frequency of catches of Spanish mackerel taken by anglers participating in the Queensland Fisheries Service RFISH program conducted in 1997 (99 anglers) and 1999 (95 anglers).



Given the annual recreational catch taken from the east coast of Queensland in recent years has equalled and in some cases exceeded the annual commercial landings, combined with the current uncertainty surrounding the status of the east coast stock (see Welch *et al*, 2002; Hoyle 2003), the harvesting capabilities of both sectors should be capped. The QFS is in the process of introducing an annual quota system to the commercial sector and has concomitantly proposed the recreational in possession limit be reduced from the current level of 10 mackerel per angler to three

mackerel per angler. Considering in possession limits are used as an output control for the specific purpose of limiting the harvest rates of individual anglers, limits should be set at levels that control the number of fish taken. Given the uncertain status of the fishery, we suggest a reduced in possession limit of three mackerel per angler for the recreational sector and a total allowable catch and quota system for the commercial sector appears appropriate at this time.

11. Benefits

The project:

- Collected data that allowed catch estimates for the recreational and commercial fisheries to be re-calculated with greater certainty than previously available.

- Re-defined the catch characteristics of the commercial fishing sector and provided a regional description of the catch characteristics of both the commercial and recreational fishing sectors, information that was not previously available. This data will be invaluable to ensuring future stock assessment and monitoring exercises can be undertaken with greater certainty and with clearer interpretation than currently available.

- Demonstrated age- and length-structure sampling protocols need to be carefully designed to ensure valid representation of actual fishery harvests. The variable effect of fishing sector and coastal region on the size and age composition of landed catches identified by the project will allow age- and length-structuring sampling protocols to be better designed and targeted than the current processes in place achieve.

- Collected age structured data that provides strong evidence that the fishery is largely supported by years of above-average recruitment that are dispersed with years of poor recruitment. The demonstration that these processes occur will ensure future interpretations of annual fluctuations in both harvest levels and CPUE indices are interpreted with greater certainty than currently available.

- Provided data to discuss the validity of current minimum size limits and recreational angler in possession limits currently enforced in the fishery.

12. Intellectual property and valuable information

No patentable inventions or processes have been developed during this study.

13. Further development

No further development is proposed at this time.

14. Planned Outcomes

The project has provided data and identified trends essential for future assessments of the Queensland east coast Spanish mackerel fishery to proceed with certainty. A number of recent fishery assessments have produced inconclusive outputs due to the depurate nature of available biological and regional fishery information. This project has collected and provided relevant biological and regional information that will ensure future fishery assessments are conducted with greater certainty than have been previously available.

The historical management of the fishery has largely relied upon input controls; however fishers in the Queensland east coast fishery will soon be subject to individual catch quotas (as of February 2004). The overall catch quota initially set for the fishery was based upon an average catch taken over the last 10 years. The appropriateness of this fishery quota will be assessed bi-yearly and will be dependent upon current fishery information. The project data collected and trends we have identified will also assist future assessment procedures by allowing targeting of future biological sampling from the fishery.

The projects' addressing and discussion of the pros and cons of reduced recreational bag limits and increasing the minimum size limit was timely. The Queensland Fishery Service recently amended fishery management to reduce the recreational bag limit from 10 to 3 mackerel per person. The minimum legal size limit was retained at 75cm fork length.

15. Staff

Andrew Tobin (50%)	Principal Investigator	CRC Reef, Fishing & Fisheries Project	1 Sept 2001 to 28 February 2003
Amos Mapleston (100%)	Fisheries Technician	CRC Reef, Fishing & Fisheries Project	1 Sept 2001 to 25 April 2003

16. Literature

Anon. (1973). Spanish mackerel. *Fisheries of Australia* (Australian Government Publishing Service, Canberra.)

Begg, G.A., Cameron D.S., & W. Sawynok. (1997). Movements and stock structure of school mackerel (*Scomberomorus queenslandicus*) and spotted mackerel *(S. munroi*) in Australian east-coast waters. Marine and Freshwater Research 48, 295-301.

Begg, G. A. and Sellin M. J. 1998. Age and growth of school mackerel (Scomberomorus queenslandicus) and spotted mackerel (S. munroi) in Queensland east-coast waters with implication for stock structure. Australian Journal of Marine and Freshwater Research 49, 109-120.

Buckworth, R.C. 1998. Age structure of the commercial catch of the Northern Territory narrow-barred Spanish mackerel. Final Report to the Fisheries Research and Development Corporation 42pp.

Buckworth et al 2003

Cameron, D and Begg, G 2003. Fisheries biology and interaction in the northern Australian small mackerel fishery. Final Report to the Fisheries Research and Development Corporation 235pp.

Collette, B.B. & Nauen, C.E. (1983). FAO Species Catalogue. Volume 2 Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fisheries Symposium 125, Vol. 2, 137p.

Collette, B.B. & Russo, J.L. (1984). Morphology, systematics, and biology of the Spanish mackerels (*Scomberomorus*, Scombridae). *Fishery Bulletin* **82**(4), 545-689.

Donohue, K., Edsall, P., Robins, J., Tregonning, R. 1982. Exploratory fishing for Spanish mackerel in waters off Western Australia during the period June 16 to October 16 1981. Report No 57, 46pp, Department of Fisheries and Wildlife Western Australia.

Hoyle, S (2003). Management strategy evaluation for the Queensland east coast Spanish mackerel fishery. Brisbane, Department of Primary Industries: 56p.

Lewis, P. and Mackie, M. 2002. Fisheries research report No. 143, Methods used in the collection, preparation and interpretation of narrow-barred Spanish mackerel (Scomberomorus commerson) otoliths for a study of age and growth in Western Australia. Department of Fisheries, Government of Western Australia

Ludescher, C.M. (1997). Fisheries resources between Bowen and Tully – an inventory. Queensland Fish Management Authority.

Kailola, PJ, MJ Williams, PC Stewart, RE Reichelt, A McNee and C. Grieve (1993). Australian Fisheries Resources. Bureau of Resource Sciences, Department of Primary Industries and Energy, Fisheries Research and Development Corporation, Canberra, Australia.

Mackie, M. and Lewis, P. 2001. Fisheries research report No. 136, Assessment of gonad staging systems and other methods used in study of the reproductive biology of narrow-barred Spanish mackerel, Scomberomorus commerson, in Western Australia. Department of Fisheries, Government of Western Australia

Mapstone, B.D., McKinlay, J.P. & C.R. Davies. (1996). A description of commercial reef line fishery logbook data held by the Queensland Fisheries Management Authority. Report to the Queensland Fisheries Management Authority.

Mc Pherson, G. R. 2002.

McPherson, GR and Williams, LE. 2002. Narrow-barred Spanish mackerel, pp. 88-93 in Williams, LE (ed)(2002) Queensland's fisheries resources: Current condition and recent trends 1988-2000. QI02012. Department of Primary Industries. Brisbane.

McPherson, G. 2001. Fisheries Long Term Monitoring Program: Summary of east coast Spanish mackerel sampling. Unpublished Newsletter, Queensland Fisheries Service, Department of Primary Industries, 2 pp.

McPherson, G.R. (1993). Reproductive biology of the Narrow Barred Spanish mackerel (*Scomberomorus commerson* Lacepede, 1800) in Queensland waters. Asian Fisheries Science 6, 169-82.
Mc Pherson, G. R. 1992. Age and growth of the narrow–barred Spanish mackerel, Scomberomorus commerson Lacepede, 1800) in north-eastern Queensland waters. Australian Journal of Marine and Freshwater Research 43, 1269 – 1282

McPherson, G.R. (1989). North-eastern Australian mackerel (*Scomberomorus*) fishery. Proceedings of the workshop Australia – Mexico on Marine Sciences (Ed: Ernesto A. Chavez), Mexico. 1989.

McPherson, G.R. (1987a). Food of narrow barred Spanish mackerel in north Queensland waters, the their relevance to the commercial troll fishery. Queensland Journal of Agricultural and Animal Sciences 44(1), 69-73.

McPherson, G.R. (1987b). Search for Spanish mackerel stocks. Australian Fisheries 47(6), 34-35.

McPherson, G.R. (1985a). Northern line fishery for mackerels still important. Australian Fisheries 44(8), 12-14.

McPherson, G.R. (1985b). Development of the northern Queensland mackerel fishery. Australian Fisheries 44(8), 15-17.

McPherson, G.R. (1982). Narrow barred Spanish mackerel migrations – a relationship with temperature (Abstract). Australian Society for Fisheries Biology, 9th Annu8al Conference, Hobart, Tasmania pp 6-7.

McPherson, G.R. (1981a). Research helps track Spanish mackerel. Australian Fisheries 40(6) 9-11.

McPherson, G.R. (1981b). Preliminary report: investigations of spanish mackerel *Scomberomorus commerson* in queensland waters. In `Northern Pelagic Seminar'. (Eds C.J. Grant and D.G. Walter.) pp. 51-58. (Australian Government Publishing Service, Canberra.)

McPherson, G.R. (1978a). North Queensland Spanish mackerel fishery. Northern Fisheries Committee Research Session, Townsville, 11-13 July, 1978.

McPherson, G.R. (1978b). Major Queensland bid to track Spanish mackerel. Australian Fisheries 37(3) 18-19.

O'Brien, V. (1994). Torres Strait Spanish Mackerel 1994, Stock Assessment Report, Torres Strait Fisheries Assessment Group. Australian Fisheries Management Authority, Canberra.

O'Neill, M and McPherson, G. 2001. A review of stock assessment requirements for Spanish mackerel; a model for Queensland based on available data. Unpublished report, QDPI, 11pp.

Quinn, R.H. (1993). Fisheries resources of the Moreton Bay region. Report to the Queensland Fisheries Management Authority.

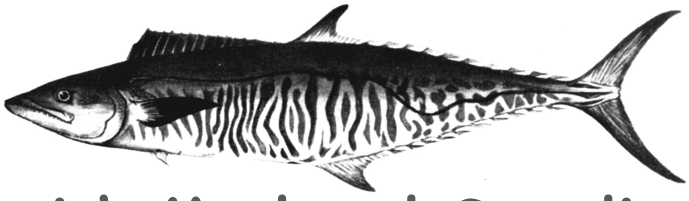
Shaklee, J.B., Phelps, S.R. & J. Salini. (1990). Analysis of fish stock structure and mixed-stock fisheries by the electrophoretic characterisation of allelic isozymes. In `Applications of Electrophoresis and Isoelectric focusing techniques in Fisheries Management'. Pp 173-96. (CRC Press: Boca Raton.)

Tobin, AJ. 2000. Review of Spanish mackerel, *Scomberomorus commerson* in Queensland waters: life history and biology, historical catch and effort, and recent trends. Unpublished report, QDPI, 33pp.

Welch, D, Hoyle, S., Gribble, N, and McPherson, G (2002). Preliminary assessment of the east coast Spanish mackerel fishery in Queensland. Brisbane, Department of Primary Industries: 34p.

Williams & O'Brien (1998). Torres Strait mackerel fishery 1998. Fishery Assessment Report.

17. Appendix 1 Sample kit issued to participating fishers



Spanish Mackerel Sampling Kit

YOU HAVE BEEN SUPPLIED WITH:

Tape measure – used to measure **fork length** (tip of the nose to fork of the tail) of fish.

Pencil - 1 HB pencil has been provided to record information on data labels (pens will also write on labels).

Data Labels – to record capture and fish information. These labels are waterproof (they can be wet) so they can be placed in bags with fish head and guts.

"Lip-Loc" bags – The head and gut of each fish should be placed into a single bag together with a completed data label.

HOW TO COMPLETE DATA LABELS:

All individual information provided will be kept strictly confidential.

Location - record location as closest reef, bay or headland followed by closest regional centre (eg: Cape Cleveland, Townsville).

Date - record date of capture.

Length - record fork length (tip of the nose to the fork of the tail) to the nearest 5mm.

Bait - circle the appropriate categories: Lure / Live (bait) / Dead (bait) : Pilchard / Gar / Other **Method** – circle the appropriate fishing method: Troll / Float / Other.
Line (kg) - Circle the appropriate line class on which the fish was captured.

An example of a completed data label:

LOCATION: Rib Reef, Lucinda

DATE: 17/9/01

LENGTH: 930 mm

BAIT: LURE / LIVE / (DEAD)

(GAR) PILCHARD OTHER:_____

METHOD: (TROLL) / FLOAT OTHER:_____

LINE, KG: 6/ 8 /(10)/ 15 / 20/ 24 OTHER:_____

HOW TO COLLECT SAMPLES:

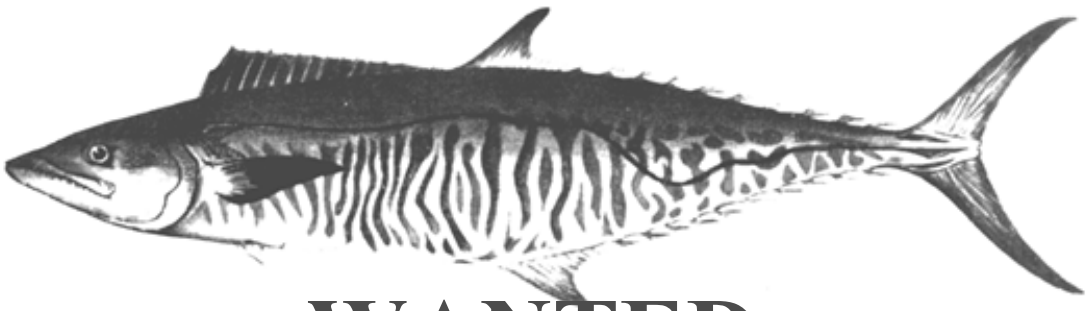
To help this important research, fishers who capture Spanish mackerel can do the following:

1. **As soon as possible after capture, complete / fill-in a data label including a fork length measurement from the fish.**
2. **Collect the head and complete gut (including gonad) of the fish and place in a single "lip loc" bag together with the completed data label. Whenever possible, put on ice or freeze as soon as possible.**
3. **At your convenience. Contact either Andrew or Amos (contacts below) to arrange collection.**

***** IMPORTANT NOTE:**

The gonads of each fish are very important for this research. Successful dissection of the gut and gonad is best achieved shortly after capture before any breakdown of the gut begins.

During the spawning season they are very large and easy to locate. During the non-spawning season the gonad can be very small and much harder to locate. The gonad consists of a pair of lobes (sausage-shape organs) that lie at the very top of the gut cavity and usually in the back half of the gut cavity. As the gut is removed, the gonads are the very last organs you will see before the bloodline along the backbone is exposed.



WANTED

SPANISH MACKEREL

IF YOU TARGET OR CATCH SPANISH MACKEREL, YOU CAN HELP AN IMPORTANT NEW RESEARCH PROJECT. CRC REEF RESEARCHERS, FUNDED BY THE FISHERIES RESEARCH AND DEVELOPMENT CORPORATION (FRDC), ARE ASSESSING HOW THE VALUABLE EAST COAST SPANISH MACKEREL RESOURCE IS HARVESTED BY RECREATIONAL, COMMERCIAL AND CHARTER FISHERS.

HOW YOU CAN HELP:

YOU CAN HELP RESEARCHERS BY COLLECTING FISH FRAMES WITH THE HEAD AND GUT INTACT. FROM FISH FRAMES, RESEARCHERS CAN DETERMINE THE LENGTH, AGE AND SEX OF EACH FISH. COLLECTING THIS INFORMATION FROM MANY FISHERS THROUGHOUT QUEENSLAND WILL HELP TO DEFINE THE CHARACTERISTICS OF THE IMPORTANT EAST COAST SPANISH MACKEREL FISHERY. IF YOU HAVE (OR CAN COLLECT) FISH FRAMES, WE WILL ORGANISE COLLECTION OR DIRECT YOU TO LOCAL DROP SITES.

RESEARCH AIMS:

SPANISH MACKEREL ARE AN IMPORTANT TARGET SPECIES FOR RECREATIONAL, COMMERCIAL, CHARTER AND INDIGENOUS FISHERS ALONG THE ENTIRE QUEENSLAND COAST. HOWEVER, LITTLE INFORMATION IS AVAILABLE ON HOW THE RESOURCE IS USED (WHAT GEARS AND METHODS FISHERS USE), WHAT THE BIOLOGICAL CHARACTERISTICS (SUCH AS LENGTH, AGE AND SEX INFORMATION) ARE OF THE FISH TAKEN AND HOW THESE CHARACTERISTICS MAY VARY BETWEEN REGIONAL CENTRES OR BETWEEN THE DIFFERENT FISHERY SECTORS. THE RESEARCH WILL DETERMINE HOW THE EAST COAST MACKEREL RESOURCE IS USED BY ALL FISHERY SECTORS AND PROVIDE INFORMATION VITAL FOR THE FUTURE SUSTAINABLE MANAGEMENT OF THIS IMPORTANT RESOURCE.

FOR FURTHER INFORMATION CONTACT:

ANDREW TOBIN 4781 5114 **OR AMOS MAPLESTON 4781 5247**

EMAIL: ANDREW.TOBIN@JCU.EDU.AU EMAIL: AMOS.MAPLESTON@JCU.EDU.AU

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JAMES COOK UNIVERSITY
TOWNSVILLE QLD 4811

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

18. Appendix 2 Response of two beneficiaries to the final report.

Queensland Government

Department of
Primary Industries

Enquiries: Mark Elmer
Telephone: **+61 7 3225 1844**

27 January 2004

Mr Peter Dundas-Smith
Executive Director
Fisheries Research and Development Corporation
PO Box 222
Deakin West ACT 2600

Dear Mr Dundas-Smith

Beneficiary Statement for the project Exploitation Dynamics and Biological Characteristics of the Queensland East Coast Spanish Mackerel (*Scomberomorus commerson*) Fishery (FRDC 2001/019)

Mr Amos Mapleston, one of the authors of the report for the above project, has requested a beneficiary statement from the Queensland Fisheries Service (QFS).

Overall, the results arising from this project have been invaluable in the development of new management arrangements for this fishery to ensure future sustainability. In particular, commercial/ recreational catch information and biological data have been used to develop a new quota management system for the commercial sector and revise the recreational bag limit. Information was also used to review the minimum legal size. As you may be aware, the new management arrangements were gazetted on 12 September 2003.

Preliminary age data from this project was also used as an input in the Management Strategy Evaluation (MSE) for this fishery. The MSE model was developed by the Queensland Department of Primary Industries in response to a request for advice from the Reef Management Advisory Committee (Reef MAC) on the likely effects of alternative management arrangements on fishery sustainability.

This research has also contributed significantly to informed fisheries management and on-going tasks associated with the management of this fishery. Estimates of parameters for assessment models can now be estimated with greater certainty than with previous existing data and the project has provided a regional description of the catch characteristics of both the commercial and recreational fishing sectors. The age structure data collected from this project provide a better understanding of the recruitment processes in the fishery, which will facilitate the interpretation of annual catch and catch related indices.

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Should you have any further queries on the benefits of this project to the Queensland Fisheries Service, I would be happy to elaborate further.

Yours sincerely

Mark Elmer
Manager, Reef, Line and Harvest Fisheries
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cc. Mr Amos Mapleston

Catching Fish for Everyone!

QSIA

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17 December 2003

Mr Peter Dundas-Smith
Executive Director
Fisheries Research and Development Corporation
PO Box 222
Deakin West ACT 2600

Dear Peter,

I have been asked by Amos Mapleston to provide a beneficiary statement on the project Exploitation Dynamics and Biological Characteristics of the Queensland East Coast Spanish Mackerel (*Scomberomorus commerson*) Fishery (FRDC 2001/019).

QSIA strongly supported the establishment of this project and have already found tangible use for its results.

In particular, the results have been useful to improve the accuracy of stock assessments underpinning the introduction of landmark new management arrangements for Spanish mackerel in Queensland earlier this year. These arrangements include, amongst other things, the introduction of a commercial individual transferable quota system and a long overdue correction of recreational bag limits.

Moreover the results will also assist in the development of an accurate method to determine the appropriate position for Spanish mackerel quota in future years.

The use of these results already in landmark new fisheries arrangements highlights the importance of having strong linkages between fisheries research and management processes such that research results can be delivered "as they happen", rather than waiting for final reports to be published.

Whilst the objective of the research was primarily to assess exploitation dynamics of Spanish mackerel to inform better fisheries management, we have also found it useful to better target future communication messages in relation to ciguatera risks amongst the various fishing sectors.

For example, the results demonstrated that whilst commercial fishers largely target a "medium" sized fish based on market constraints, recreational fishers opportunistically target smaller and larger fish and are at greater risk of being exposed to ciguatera if larger fish are eaten.

Finally, it is my understating that cooperation between the researchers and commercial fishers was good, and that there is a genuine grass roots interest in the results of the research.

I am happy to discuss the results of the research further at your convenience.

Yours sincerely,

Duncan Souter
CHIEF EXECUTIVE OFFICER

CC: Amos Mapleston