The NSW Game Fish Tournament Monitoring Program 1994–2013: Data summary and assessment of program role and design

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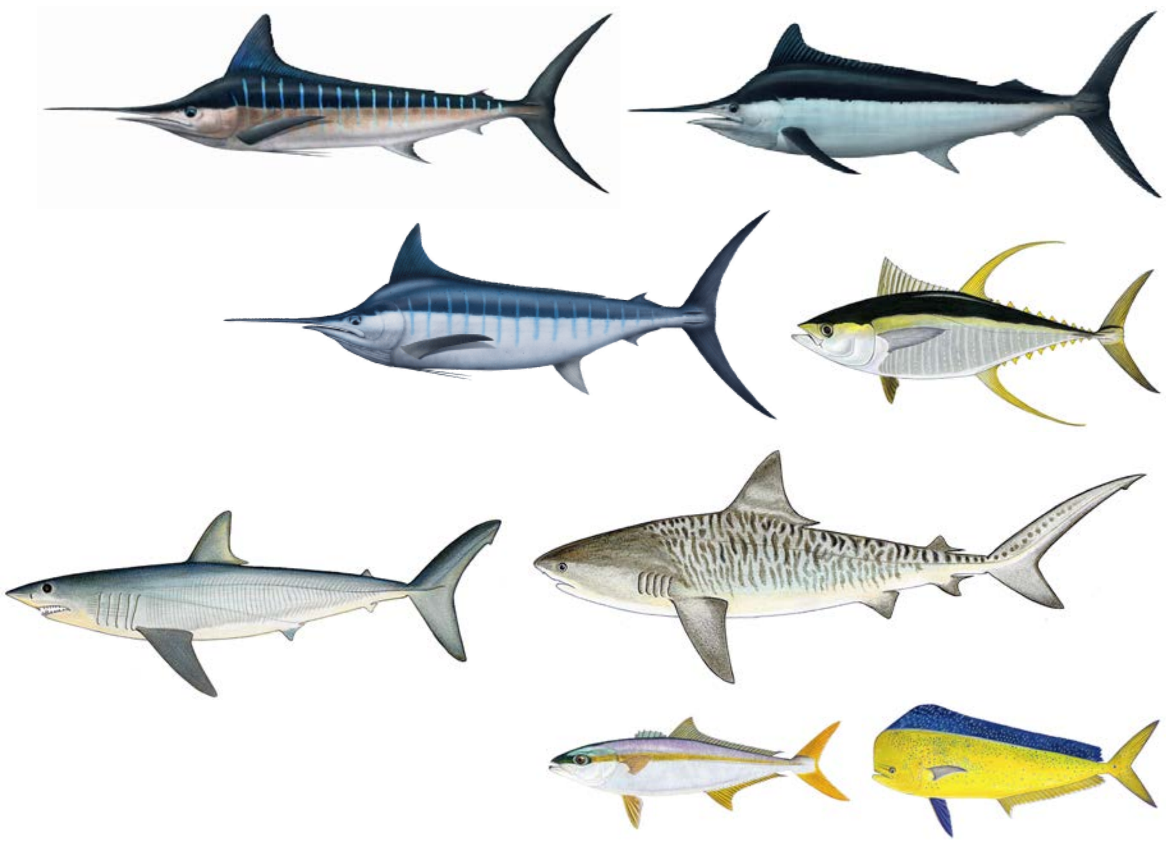

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ABBREVIATIONS

CPUE	catch per unit effort
EPBC Act	Environment Protection and Biodiversity Conservation Act
FAO	Food and Agriculture Organization of the United Nations
GFAA	Game Fishing Association of Australia
GTMP	NSW Game Fish Tournament Monitoring Program
IUCN	International Union for Conservation of Nature
NSW	New South Wales
NSW DPI	NSW Department of Primary Industries
NSW GFA	NSW Game Fishing Association
PSU	primary sampling unit
WCPO	Western and Central Pacific Ocean

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NON-TECHNICAL SUMMARY

NSW Game Fish Tournament Monitoring 1994–2013: Data summary and assessment of program role and design

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NON-TECHNICAL SUMMARY:

The New South Wales (NSW) Game Fish Tournament Monitoring Program has been in operation for 20 years, from 1994 to 2013. The program was funded by the NSW Saltwater Recreational Fishing Trust and the NSW Department of Primary Industries (NSW DPI). Over the 20-year monitoring period, 406 tournaments were monitored, including 955 tournament fishing days and 50451 fishing trips. Radio schedule ('sched') reporting data were obtained from 395 (97%) of the tournaments, and 14180 post-fishing interviews were conducted at 179 (44%) of the tournaments. Of this number, about 99.5% of fishing crews approached cooperated fully with interview staff.

A total of 39020 fish (35 taxa) were recorded from the scheds, with 98% recorded to species level. From the interview data, a total of 19048 fish and invertebrates (71 species) were recorded. Yellowfin tuna was the most common species recorded from scheds (21%), while skipjack (striped) tuna was the most common species recorded from interviews (20%). Striped marlin was the second most common species recorded from scheds (18%), followed by mahi mahi (15%), black marlin (12%), albacore (8%) and mako shark (6%). Yellowfin tuna was the second most common species recorded from interviews (18%), followed by mahi mahi (15%), striped marlin (14%), black marlin (8%) and albacore (5%).

Catch rate trends did not indicate any long-term decline in any of the game fish species populations or fishing quality since the inception of this monitoring program in 1994. Some species showed indications of an improvement in fishing quality over the monitoring period, with catch rates indicating a possible overall increasing trend for mako shark, mahi mahi, yellowtail kingfish, skipjack (striped) tuna and wahoo. All other species were either highly variable inter-annually (black marlin, shortbill spearfish and yellowfin tuna), or indicated no overall increasing or decreasing trend (striped marlin, blue marlin, blue shark, tiger shark, hammerhead sharks, whaler sharks and albacore). There was, however, a degree of uncertainty in these catch rates, due to large overlapping confidence intervals. Thus, caution has been used when interpreting trends.

These game fish tournament monitoring data have been vital in supporting assessments for the sustainability of the game fish fishery in NSW. The program

ensures that quality recreational fishing opportunities are maintained for participants. Data from the program have proven to be pivotal in the resolution of contentious fishery management issues affecting recreational game fishers. For example, negotiations assisted by program data led to an amendment to the *Australian Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), providing recognition of this fishery's importance and enabling the continuation of recreational fishing for mako sharks.

Despite the importance of these game fish data, the cost efficiency of this monitoring program has been a long-standing issue. This report provides the first comparison of data obtained from scheds versus more expensive post-fishing interviews in an effort to improve the cost efficiency of future monitoring. The differences between sched and interview data were used to determine which tournaments require post-fishing interviews to provide an adequate level of data accuracy and precision, and which can be accurately monitored using sched data. Based on the recommended reduction in post-fishing interviews, we estimate that at least 20% of costs could be saved. The overall costs could also be reduced by outsourcing the monitoring program to a non-government research provider, because they can negotiate fixed hourly pay rates (as long as they are above the legislated minimum wage).

If funding is critically limited and reduces the scope of further research, a viable option could be to cease collection of post-fishing interviews from the monitoring regime, at least in the short term. This would reduce costs by about 50%. The collection of sched and weigh station data only would ensure that the project is maintained, albeit at a lower level. In this study, we found that scheds and weigh station data provide a good measure of the catch of primary game fish species of billfish and shark. However, post-fishing interviews improved the quality of catch data for some other game fish species (especially tuna species and mahi mahi), and improved directed fishing effort data for all zones except North. Despite this, the inclusion of post-fishing interview data did not change catch rate trends significantly for any primary game fish species. Post-fishing interviews were not conducted throughout the entire 20-year monitoring period, covering only 44% of tournaments and 28% of fishing trips.

Our new, weighted catch rate approach provides further support for reducing or eliminating post-fishing interviews. This approach includes all fishing effort and catch data, thereby reducing biases that could be caused by mis-classification of the species group being targeted based on sched data.

The data summaries and catch rate analysis in this report met the primary objective of this monitoring program, which was to support the assessment of game fish species. However, some trends were identified that warrant further investigation to improve our understanding of the fishery and the accuracy of fishing effort, catch and catch rate estimates. Future work should be aimed at:

1. Investigating hyperstability in catch rate estimates by comparing the efficiency of each fishing method using interview data collected post-2007. This should be coupled with changes in the proportions of each fishing method used over time.

2. Investigating alternate measures of fishing quality with greater sensitivity to change and thus with greater power to identify smaller changes. This would provide further insights into changes in this fishery and species that require more detailed assessment.
3. Providing estimates of the total catch for all tournaments since 2008. During this period, data was missing for a number of tournament days. Estimating catches for these missing data cells will provide an estimate of the entire tournament game fish fishery over this period.
4. Improving catch rate estimates as indicators of fish abundance for all primary game fish species by standardising the catch per unit effort (CPUE), using similar methods to those applied to striped marlin.
5. Investigating habitat selection of key species using catch, catch rate and environmental data to improve our understanding of the relationship between fishing quality and the oceanographic conditions that favour the occurrence of game fish species.

Finally, by assessing the utility and design of the Game Fish Tournament Monitoring Program, we have demonstrated that our data have been vital in improving negotiations between government and stakeholders in recreational and commercial fisheries. These negotiations have led to long-term access to the fishery for recreational fishers and promoted sustainable, quality recreational fishing opportunities in NSW.

KEYWORDS:
Recreational fishing, catch rates, game fish, monitoring, resource assessment

1. INTRODUCTION AND OBJECTIVES

Catch and effort data on recreational game fishing are crucial in understanding game fish fishery dynamics and managing game fish resources and associated fisheries. However, game fish fisheries are difficult to monitor. Anglers who target these species represent a very small proportion of the general angling population, and hence are difficult to sample using traditional methods such as telephone-diary or access-point surveys (Pollock *et al.* 1994). The Australian Government recognised these difficulties, and consequently supported a study by West (1990) to investigate monitoring options. West (1990) identified a system used by game fishing clubs on the east coast of Australia as a potential source of catch and effort data. The clubs monitored their vessels while at sea during competitions using a mandatory radio schedule reporting system (hereafter referred to as 'scheds'). The scheds involved a marine radio base, usually situated on land, and a radio operator who contacted each participating vessel at regular intervals for information about the vessel's location, fishing activity (travelling, trolling, drifting or anchored) and a fishing report. The report included details of fish strikes, fish hooked, and fish captured (commonly referred to in other fisheries as harvest, kept fish or retained catch) or tagged and released.

The existence of this scheds system, combined with the investigations of West (1990), led to the launch of the Game Fish Tournament Monitoring Program (GTMP) in 1993. The GTMP formalised the collection of data using the existing fishing club structure (Pepperell and Henry 1999). Since the start of the program, data have been used to improve fisheries management for game fish species, and support negotiations between government, fishers and other interested groups. For example, information collected was used by the Game Fishing Association of Australia (GFAA) when negotiating with the Commonwealth regarding resource sharing between recreational and commercial fishers. It also allowed recreational fishers to continue to catch mako and porbeagle sharks following a ban on their capture. These species were listed under Appendix II of the Convention on Highly Migratory Species in 2009, which required their listing under the *Australian Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The GTMP has always focused on the collection of data to help manage the fishery. However, variations in funding levels have caused fluctuations in the quantity and quality of data collected. NSW Department of Primary Industries recognised that an assessment of the program's data quality was required to support future management of the fishery using cost-effective and robust data collection strategies. Hence, the past seven years of this program have focused on investigating potential biases in the data, to improve catch rate estimates for this fishery and to identify the most cost-effective solutions for future monitoring. To investigate these issues, an intensive data collection phase was required before we could discern any trends.

This report summarises the data from the 20 years of monitoring from 1994 to 2013, and provides recommendations for the future monitoring strategies. The role and design of the program are also discussed.

1.1. Objectives

The primary objectives of this report are to:

1) Describe the game fish tournament fishery for game fish species in NSW.
2) Summarise 20 years (1994–2013) of fishing effort and catch data from the GTMP.
3) Provide catch and catch rate estimates in support of resource assessments of billfish, shark, tuna and other game fish species.
4) Investigate potential biases in fishing effort and catch data to identify options to improve catch rate estimates.
5) Provide recommendations to improve the cost efficiency of the monitoring program.
6) Summarise the management outcomes for the recreational game fish fishery that benefited from the program’s data.

2. BACKGROUND

2.1. Fishery description

The history of game fishing in Australia has been extensively documented, and dates back to the early 20th century (Bromhead *et al.* 2003; Campbell *et al.* 2002; Goadby 1987; McIntyre 2007; McIntyre 2008). The first club to establish game fishing rules in Australia was the Angler's Casting Club of Australia, which formed in 1907 (McIntyre 2007). Spanish mackerel and tuna were the most common species caught by game fish anglers in these early days. In 1913, the first marlin (a black marlin) to be caught on rod and reel in Australasia was landed off Port Stephens in NSW (McIntyre 2007). Game fishing continued to gain popularity, with 18 NSW game fishing clubs formed and game fishing formalised by the establishment of the GFAA in 1938 (McIntyre 2007). GFAA (originally named the Big Game and Rod Fishers' Association of Australia) formalised game fishing by the introduction of a clear set of fishing rules and administration practices (McIntyre 2007). The GFAA is the world's longest-established national fishing association (Anon. 2013).

Current rules governed by the GFAA and the affiliated NSW Game Fishing Association (NSW GFA) include minimum size limits for obtaining capture point scores, and extensive fishing gear and method restrictions (Anon. 2013). There are categories for both the tag and release and the capture of game fish species. A point-score system for tag and release of game fish awards points based on the species and line class used to catch the fish. Point scores awarded for the capture of a game fish (i.e. a fish caught, killed and weighed on official competition scales; commonly referred to as harvest in other fisheries) are based on the weight of the fish and the line class used. The NSW GFA website has the up-to-date set of fishing rules and point-score system (www.nswgfa.com.au).

A total of 52 game fish species are recognised by GFAA, the national governing body for game fishing (Anon. 2013). Game fish include billfish, shark, tuna and other smaller pelagic species. Species that are most commonly targeted and caught in NSW are presented in Table 1.

The recreational fishery for game fish species in southeast Australia is comprised of fishers both affiliated and not affiliated with NSW GFA game fishing clubs, hereafter referred to as club and non-club fishers, respectively. The ratio of club to non-club fishers is currently unknown, and there is a lack of available data to represent the catch of non-club fishers, due to difficulties in monitoring game fish catches. Anglers who target these species represent a very small proportion of the general angling population, and hence are difficult to sample using traditional methods such as telephone-diary or access-point surveys (Pollock *et al.* 1994).

For example, the results of the National Recreational and Indigenous Fishing Survey in the year 2000 showed that of the 1.3 million persons recorded to have fished at least once in NSW, only 3% of fishers listed game fish (marlin, sharks and tunas) as their primary target (Jeff Murphy, NSWDPI, pers. comm.). Furthermore, the raw data of NSW game fish fishers from this national survey included only 16 records for marlin caught and kept, with the majority of the catch including tuna species (Jeff Murphy, NSW DPI, unpublished data).

These survey data indicate that direct targeting of large game fish species, such as marlin, probably represents an even smaller percentage of fishers than 3% of the general NSW recreational fishing population. This ‘needle in a haystack’ problem, along with game fish fisheries being episodic, means that the cost of any probability-based survey – with the spatial and temporal resolution required to effectively sample game fish catch and effort across the whole recreational fishery – is currently prohibitive. These difficulties in monitoring game fish fisheries using traditional survey methods led to the development of the GTMP in 1993, following recognition from fisheries managers and stakeholders of the importance of data relating to this high-profile, economically important fishery (Pepperell and Henry 1999; West 1990).

NSW has 24 game fishing clubs affiliated with the GFAA (Anon. 2013) and about 3500 members (Pat Jones, GFAA Secretary, pers. comm.). Game fishing tournaments that are run every year (weather pending) are hosted by 21 of these clubs, which operate out of major ports of NSW (Figure 1). The NSW GFA also runs a yearly statewide interclub tournament.

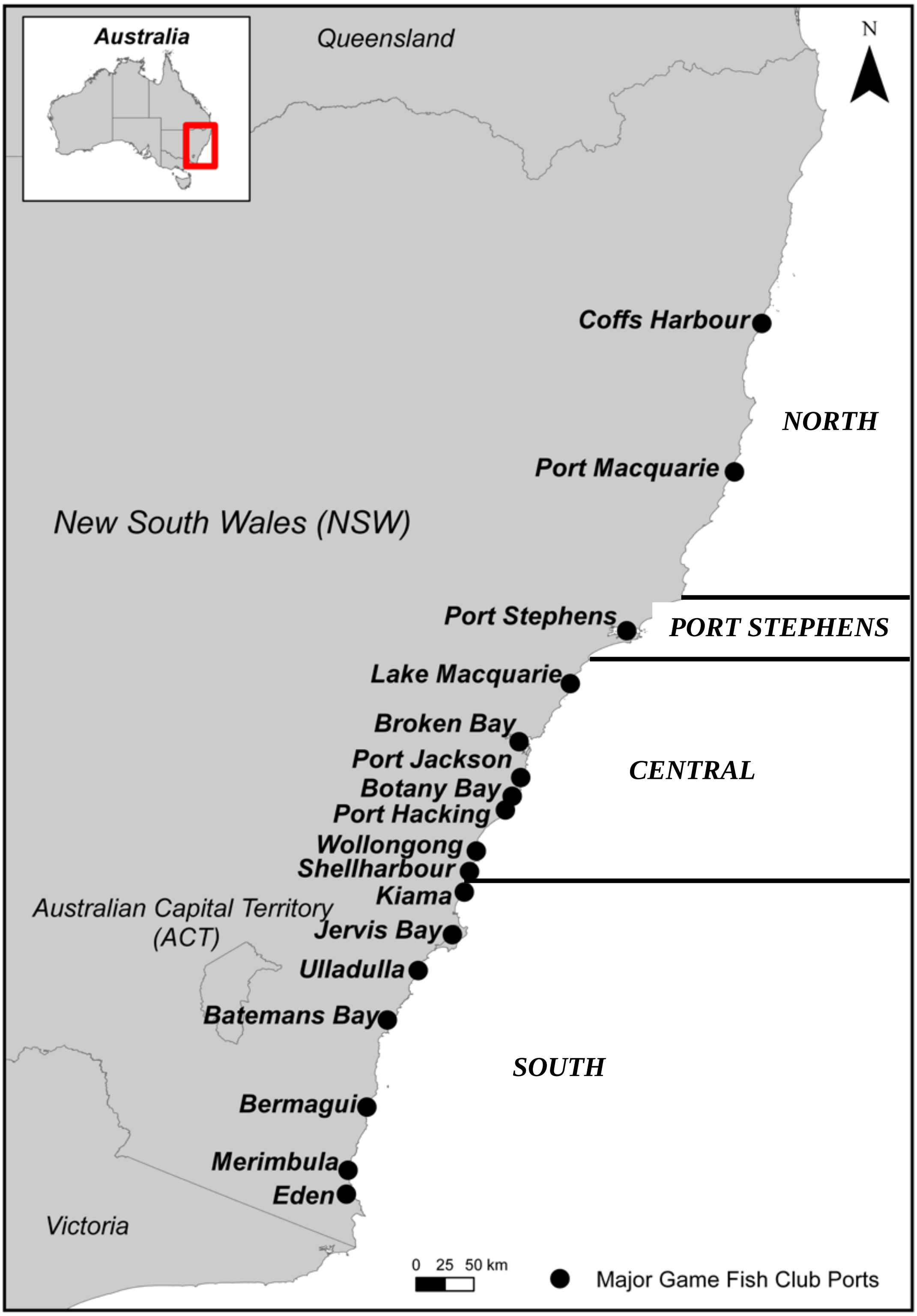
Tournaments, which are competitions between boats, anglers and clubs, mostly run for multiple years at the same time each year. For example, the ‘Port Stephens Interclub’ has been held annually by the NSW GFA over all 20 years of the program, while the Botany Bay Olympic Tournament was held only once, in the year 2000. Tournaments usually run over 1–4 consecutive days and usually include 15–150 participating fishing crews.

Table 1. Species most commonly caught in NSW and southern Queensland during game fishing activities, listed by generic species groups including their common and scientific names. The priority level of each species within the NSW Resource Assessment Framework (RAF) is also listed as either low, medium, high or either excluded from this process, or not listed as a recreational species for the purpose of the RAF (denoted by -). Details of the RAF can be found in Scandol (2004)

Species Group	**Common name**	**Scientific name**	**NSW RAF Priority**
Billfishes			
	Black marlin*	*Makaira indica*	Low
	Indo-Pacific blue marlin*	*Makaira mazara*	Low
	Striped marlin*	*Tetrapturus audax*	High
	Shortbill spearfish *	*Tetrapturus angustirostris*	Low
	Sailfish	*Istiophorus platypterus*	Low
	Broadbill swordfish	*Xiphias gladius*	-
Sharks			
	Blue shark*	*Prionace glauca*	Medium
	Hammerhead sharks*	*Sphyrna* spp.	Medium
	Shortfin mako*	*Isurus oxyrinchus*	Medium
	Tiger shark*	*Galeocerdo cuvier*	Medium
	Whaler sharks*	*Carcharinus* spp.	Medium
	Thresher shark	*Alopias* spp.	-
Large tunas			
	Albacore*	*Thunnus alalunga*	Low
	Yellowfin tuna*	*Thunnus albacares*	Medium
	Southern bluefin tuna	*Thunnus maccoyii*	-
	Longtail tuna	*Thunnus tonggol*	High
	Bigeye tuna	*Thunnus obesus*	-
Other game fish			
	Barracuda	*Sphyraena barracuda*	-
	Cobia	*Rachycentron canadum*	High
	Dolphin fish/Mahi mahi*	*Coryphaena hippurus*	High
	Yellowtail kingfish*	*Seriola lalandi*	High
	Wahoo*	*Acanthocybium solandri*	Low
	Spanish mackerel	*Scomberomorus commerson*	Medium
	Skipjack tuna**	*Katsuwonus pelamis*	-
Baitfish			
	Blue mackerel	*Scomber australasicus*	Medium
	Yellowtail and jackmackerel (Scads)	*Trachurus* spp.	Medium
	Australian bonito	*Sarda australis*	High
	Mackerel tuna	*Euthynnus affinis*	-

* Key species caught by GFAA-affiliated fishers in NSW, as indicated by Murphy *et al.* (2002), Park (2007), and catches recorded for the NSW GTMP since Park (2007) was published.
**This species is listed as eligible for point score only for junior anglers affiliated with the NSW GFA (Anon. 2013). A junior angler is any member under 16 years of age (Anon. 2013). Consequently, this species is both a target and baitfish species for the club-based game fish fishery in NSW. Baitfish species are only those that are commonly caught and used as bait by game fish tournament anglers.

Figure 1. Major game fish tournament ports and spatial zones used in the analysis of tournament data: North, Port Stephens, Central and South

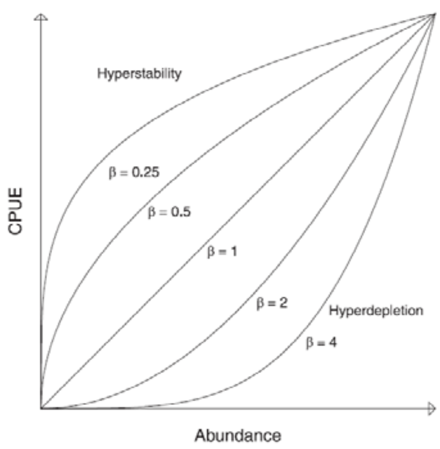


2.2. Data accuracy issues with recreational catch and effort data

Various potential biases are associated with catch and effort indices in estimating fish abundance, most commonly with catch rates being non-linearly related to stock size (Cooke and Beddington 1984; Harley *et al.* 2001; Hilborn and Walters 1992; Maunder *et al.* 2006; Walters and Maguire 1996; Ward 2008). However, fishery-dependent catch rates from commercial or recreational fisheries are most often the only available information that can be used to derive an index of abundance (Hilborn and Walters 1992; Walters 2003). The alternative is a long-term data set of fishery-independent catch rates, in which a survey is designed to monitor the catch of fish in a representative, random nature using standard gears over time (Hilborn and Walters 1992). However, fishery-independent surveys are rarely feasible, due to prohibitive survey costs: particularly for pelagic species (Hilborn and Walters 1992). The most common method to improve catch and fishing effort indices for the purpose of estimating fish abundance is to use regression modelling techniques. Such techniques incorporate environmental and fisheries variables, such as sea surface temperature and fishing location, to correct for extraneous sources of variation unrelated to population abundance. The techniques essentially 'standardise' catch and effort data, and are hereafter referred to as catch rate standardisation techniques.

Whether or not catch rate standardisation techniques are used to analyse catch and fishing effort data, there is still the potential for catastrophic impacts on fish populations due to the various scenarios of proportionality between catch rates and fish abundance. While catch rate standardisation can correct for some extraneous sources of variation, there still may not be a linear relationship between the standardised catch rate and stock abundance. This issue is well explained by the power curve of the shape *ß* as presented in Harley *et al.* (2001) (Figure 2). This demonstrates that abundance can be low (i.e. *ß* <1) while catch rates remain high (hyperstability); catch rates can be proportional to abundance (i.e. *ß* =1); or abundance can be increasing while catch rates are low (i.e. β >1, hyperdepletion; Harley *et al.* 2001; Hilborn and Walters 1992).

Figure 2. Relationships between catch per unit effort (CPUE) and abundance (Harley *et al.* 2001)



It is often difficult to interpret fishery-dependent sources of catch and effort data as indicators of fish abundance, due to uncertainty in the proportionality of abundance and catch rates. This can occur when fishing methods change over time, thereby changing the efficiency or gear selectivity of the fishery, and consequently increasing or decreasing catch rates. Altering catch rates leads to risks of hyperstability or hyperdepletion, with the former having more serious stock sustainability ramifications. The collapse of the Atlantic cod fisheries is a classic example of the ramifications of hyperstability (Hilborn and Walters 1992; Walters and Maguire 1996). In this case, the fishing fleets were able to maintain stable catch rates by their ability to find and catch fish with their modern fishing vessels, and by increasing their searching efforts while the cod populations declined (Hilborn and Walters 1992; Walters and Maguire 1996).

Biases caused by changes in fisher behaviour and fishing gears, such as that demonstrated by the Atlantic cod example, can also occur with recreational catch and effort data. Data from the GTMP, for example, indicate that tournament fishers have changed their targeting over the monitoring period towards striped marlin, and have altered their methods towards greater use of live baits (Park 2007), which may be a more efficient method than fishing with lures for this species. If this change in angler behaviour is not accounted for when estimating catch rates, then the observed increase in catch per unit effort (CPUE) indicate an increasing trend in fish abundance, while the true abundance has declined (i.e. these nominal catch rates may be hyperstable).

Other factors may also influence the catchability of a stock, and hence the resulting catch rate, leading to bias in the relationship between stock abundance and catch rate. For example, Knight *et al.* (2006) found evidence to suggest both longline catch in the same area and time period of a tournament, and in tournaments that had a larger number of participating vessels, led to about a 10% decrease in tournament catch rates for striped marlin. One potential reason may be the learning ability of striped marlin, particularly due to high tag-and-release activities of the recreational fishery. This learning ability therefore may influence the catchability of the stock when there are large concentrations of fishing effort within a small area over a short time.

Tag-and-release activities have become increasingly popular since the 1970s, with large, constituent-based tagging programs promoting this fishing technique worldwide (Ortiz *et al.* 2003). For many recreational fisheries, the percentage of fish tagged and released outweighs the number of fish landed (i.e. caught and kept), particularly for marlin species (Beardsley and Conser 1981; Campbell *et al.* 2003; Murphy *et al.* 2002; Park 2007). Due to catch and release fishing in the recreational fishery, marlin may ‘go off the bite’ after release (Knight *et al.* 2006) and avoid recreational or commercial fishing gear. Learned behaviour such as this would decrease the chance of catching a striped marlin, and consequently catch rates may decline while abundance remains high (i.e. hyperdepletion). Other studies have also demonstrated the learning ability of fish (Askey *et al.* 2006; Mathis *et al.* 1996). Mathis et al. (1996) showed that fish who live in groups may have the opportunity of learning to recognise the fright response of other individuals in the group, and subsequently learn to avoid the predator that caused the fright response in that individual. Striped marlin are thought to feed cooperatively in groups by corralling schools of bait (Ueyanagi and Wares 1975). This group feeding behaviour may provide opportunities for learning among individuals.

Other changes to fishing gears and methods may also influence catch rates over time, although some of the consequences on catch rates may not be quantifiable. A summary of fishery changes and how they may influence catch rates is provided in Table 2. To reduce – or at least, understand – the potential for bias in catch rates, it is important to incorporate as much available information about fishing methods as possible. Hence, over the past five years, the GTMP has focused on data quality and the collection of data on fishing methods and targeting practices. This focus was aimed at investigating fishery changes in fishing effort and catch, and the potential biases in catch rate estimates.

Table 2. Changes in the recreational fishery over time, including how these changes may affect methods and catches of the recreational fishery. Changes have been restricted to those documented for the period of the existing NSW Game Fish Tournament Monitoring Program (1994–current)

Change	Likely effect on methods	Likely effect on catch/catch rates
Increase in minimum sizes from 60 kg to 80 kg for marlin caught on line class 15 kg and above (Date: May 1997)[a]	Increase in use of heavier tackle	• Increase in no. fish tagged and released • Increase in average CPUE as result of shorter fight times and more intervening fishing time
Ethics and shift to more tag-and-release and routine fishing further offshore (mid 1980s to mid 1990s)[a]	Increase in use of heavier tackle	• Increase in the no. fish tagged and released • Increase in the size of fish that are tagged • Increase in average CPUE as result of shorter fight times and more intervening fishing time
Transition from lure fishing to a greater use of live baits (towards the end of the 1990s or early 2000s) [b]	Use of methods such as 'switch-baiting' and 'live baiting' increased	• Increase in CPUE for striped marlin • Catch rates more variable as fishing crews become accustomed to a new, more complex and 'difficult' method
More sophisticated electronic navigation and depth sounding equipment (mid 1990s onwards)	Easier for vessels to locate bathymetric features, such as seamounts, reefs and canyons	• Increase in CPUE • Shift in species composition from black marlin to blue and striped marlin
Access to up-to-date sea surface temperature data (2000s)	Fishing in more perceived favourable locations, such as near ocean fronts	• Increase in CPUE
Increase in the use of circle hooks with live and dead baits (since 1999)[a] Use of circle hooks when live baiting made mandatory by NSW GFA from 2006 onwards at the Port Stephens Interclub tournament, and from 2008/09 onwards for all club-based fishing (Pat Jones, pers. comm.)	Increase in the use of circle hooks; possible increase in the use of lures	• More variable catch rates and possibly a decrease in CPUE initially as fishing crews become accustomed to different gear • Decrease in the 'hook-up' rate likely to be equalled by more effective catch as a result of a decrease in the number of fish throwing the hooks during the fight

a Pepperell and Bromhead (2004)
b Park (2007)
NSW GFA = New South Wales Game Fishing Association; CPUE = catch per unit effort

3. METHODS

3.1. Temporal frame

The main game fishing tournament season in NSW starts in September (spring) each year and finishes at the end of June of the following year. There is one off-season shark tournament, held in early August. Hence, to coincide with the main game fishing tournament season, data were analysed by financial year (often referred to in this report as the fishing year). This report covers the fishing years from 1994 to 2013.

Each tournament was based out of the NSW fishing port of the game fishing club hosting the event. The major ports, listed north to south, were: Coffs Harbour, Port Macquarie, Port Stephens, Lake Macquarie, Broken Bay (including Brisbane Waters), Port Jackson, Botany Bay, Port Hacking, Wollongong, Shellharbour, Jervis Bay, Ulladulla, Batemans Bay, Bermagui, Merimbula and Eden (Figure 1). For the purpose of some analyses, these ports were stratified into four spatial zones: North, Central, Port Stephens and South (Figure 1). These spatial zones were based on the bioregions as per the Commonwealth marine regionalisation process, which are based on broad-scale patterns evident by a combination of biological and physical data (Commonwealth of Australia 2006). However, we combined the two most southern NSW bioregions into our south zone. We also assigned all tournaments held out of Port Stephens to a separate zone, because of the unique nature of this port hosting the NSW Interclub Tournament (organised by the NSW GFA) and various other tournaments before, during and after this interclub event. See Appendix 1 for a full list of tournaments monitored, including their port and zone.

3.2. Data collection

3.2.1. Tournaments monitored and their structure

Tournaments included in the monitoring program were those listed as sanctioned by the NSW GFA. An annual list of NSW GFA-sanctioned game fishing tournaments was used as the basis for the collection of catch and effort data. Sched data were obtained from as many sanctioned tournaments as possible. These data were provided on a voluntary basis by tournament organisers, and were not always available.

Each fishing tournament in this dataset involved an aggregation of participating boats fishing over successive days, with tournaments ranging from two to four days in length. Most tournaments included a rule that all boats need to leave from the host tournament port on either the first, second or all days of the event. Tournament days were often cancelled due to unsafe sea conditions, resulting in fishing occurring on fewer days or being postponed to an alternate weekend.

Each tournament fishing day has specified start and stop fishing times. These vary by tournament, but are most commonly within the range starting at around 7:00 am and finishing around 5:00 pm. However, the stop fishing time for the last day of most tournaments is usually earlier than the previous days, to allow for point scores to be finalised and prizes awarded that night. These specified fishing times result in a ‘rush hour’ in the afternoon, when the majority of boats return to the tournament port around the same time after the stop fishing time.

3.2.2. Radio schedule (sched) data

Sched data provided the core information for this monitoring program, and were available for most tournaments over the monitoring period. All sanctioned tournaments adopt the ‘Guidelines for Radio Scheds for Tournaments’, published by the NSW GFA, as the minimum radio procedure to be followed. These guidelines provide the basis for collection of data and have not changed over the 20-year monitoring period. Data provided for each of the scheds each tournament fishing day included:

- **Fishing location**, given as an alpha-numeric grid (in reference to a grid map provided by the host club of the tournament and approved by the NSW GFA).
- **Fishing method**, reported as either travelling, trolling, drifting or anchored. This information was not consistently recorded for all scheds on each fishing day of each tournament, and varied according to the experience of the radio operator.
- **Catch**, reported using the ‘000’ system, where the first number represents the number of fish strikes; the second number represents the number of fish hooked and fought; and the third number represents the number of fish caught. For all fish caught, the species, whether the fish was tagged and released (hereafter referred to as released fish) or harvested/kept and killed (hereafter referred to as captured fish) was recorded. Catch refers to the combination of released and captured fish.

Catch recorded from scheds were recorded to the species level in most cases. However, whaler and hammerhead sharks represent a composite of species that are grouped into two species groups – ‘whaler’ and ‘hammerhead’ sharks – for the purpose of this report. All mako sharks that were recorded were assumed for the purpose of this report to be shortfin mako shark (*Isurus oxyrinchus*), despite the possibility of some longfin mako (*Isurus paucus*) and porbeagle (*Lamna nasus*) sharks being caught. This assumption is based on research suggesting the occurrence and catches of longfin mako and porbeagle sharks in NSW are rare (Chan 2001).

To improve the quality of sched data, weigh station records were also collected when possible to validate the species and number recorded on the scheds and to collect weight data for captured fish. These were usually provided electronically by the tournament organisers after the event, as a list of fish caught for each boat by species and for both tagged and released and captured fish. Survey staff would record these data or photocopy tag cards and capture sheets if an electronic list was not expected to be available after the event, because some tournament point scorers recorded the point scores by hand.

3.2.3. Post-fishing interview data

Post-fishing interviews were used to investigate issues relating to data accuracy and changes in targeting behaviour. The coverage of post-fishing interviews is restricted to a subset of tournaments and fishing years. A summary table of the tournaments monitored, including data collected (sched, interview or both sched and interview), is provided in Appendix 1.

Post-fishing interviews provide a sample of the total catch; i.e., data reported during scheds and fish catches that were not reported. Information about the species group targeted, fishing methods used, bait fishing activities, point-score and nonpoint-score captures and fish size information was collected during these interviews.

All post-fishing interviews recorded the number of persons on board, fishing date, time that fishing started and stopped (i.e., lines in and lines out of water to target game fish, excluding fishing for baitfish), boat name and tournament registration number. We attempted to interview as many boats as possible on each tournament fishing day as they returned to the access point. When many boats returned at the same time, only every second or third boat could be interviewed. Survey staff would then return to those boats not interviewed if time permitted, and if the fishing crew were still available.

Post-fishing interviews undertaken in the 1999 and 2002–2007 fishing years recorded:

- The number of hours spent targeting each of the species groups: 1. Billfish and tunas, 2. Sharks or 3. Other.
- The methods used to target each of the above species groups, as either anchoring, trolling or drifting. More than one method could be recorded per species group; in these instances, the time spent using each method was not partitioned.
- The catch of all game fish by species, including the fate of each fish as either: 1. Tagged and released, 2. Captured and weighed or 3. Captured but not weighed.
- Fish size information, including the: 1. Estimated weight of tagged and released fish, 2. Weight of all fish captured and 3. Estimated weight or fork length, when possible, of fish captured but not weighed.

- Bait fishing activities including the amount of time spent and the catch by species categorised into either: 1. Released, 2. Kept and not used or 3. Used for bait during that fishing day.

Post-fishing interviews in the 2008–2013 fishing years recorded more detailed data, including:

- Maritime registration number, to uniquely identify boats. This will allow future investigation of vessel effects on catch rates using a subset of identifiable vessels.
- Species group, targeted as either: 1. Billfish only, 2. Billfish and tunas simultaneously, 3. Sharks only, 4. Sharks and billfish simultaneously, 5. Sharks and tunas simultaneously, 6. 'Other' game fish such as mahi mahi, or 7. None of the above (for example, tunas only, kingfish or billfish and mahi mahi simultaneously).
- The methods used to target each of the above species groups, as either: 1. Switch-baiting, 2. Anchoring, 3. Trolling, or 4. Drifting.
- The bait types used for each of the species group and fishing method combinations, as either: 1. Lure, 2. Live bait, or 3. Dead bait.
- Whether the interview was successful or refused, with notes recorded about the reason for any refusal.
- The catch of all game fish by species, including the fishing method and bait type used to catch each fish and the fate of each fish, as either: 1. Tagged and released, 2. Free released, 3. Captured and weighed at the tournament weigh station, or 3. Captured but not weighed (i.e. retained fish not weighed at the tournament weigh station; often fish kept for purposes other than point score, such as for food). Hence, for interview data, released fish includes a combination of tagged and released and free released fish, and captured fish includes a combination of captured and weighed plus captured but not weighed fish.
- Fish size information, including the: 1. Estimated weight (in kilograms; kg) of released fish, 2. Weight (kg) of fish captured and weighed, and 3. Fork length (cm) when possible of fish captured but not weighed. If a captured but not weighed fish was not available for measuring at the time of the interview, then no weight was recorded for that individual. Fork lengths were converted into weight (kg) using the most recent equations available from the literature (Appendix 2).
- Bait fishing activities, including the amount of time spent and the catch by species, categorised into either: 1. Released alive, 2. Kept or dead and not used for bait that fishing day, or 3. Used for bait during that fishing day. Records were also made of whether or not the bait fishing effort was done before or after the fishing party put their game fishing lines in the water, and whether the bait fishing was done inside or outside three nautical miles from shore (i.e. inside or outside of NSW waters). However, to reduce the time taken to record each interview, bait fishing catch data were not recorded during the 2012 or 2013 fishing years. The collection of bait fishing effort data continued, because this information is used to remove the time spent bait fishing from the targeting of game fish species.

Each combination of species group targeted, fishing methods and bait types used (i.e. those methods and bait types used simultaneously) were recorded separately with an associated number of hours spent. For example: a fishing party might have spent two hours trolling lures in the morning to target billfish and tuna, then drifted for the next five hours to target sharks using dead baits, and then spent the remaining three hours of their day trolling live baits to target billfish. Each of these three combinations of species group targeted (billfish and tunas, sharks and billfish only), fishing methods and bait types (trolling lures, drifting dead baits and trolling live baits) were recorded separately on the interview form with the associated number of hours spent on each activity.

Post-fishing interviews were held at a selection of tournaments each year from 2003 onwards. Post-fishing interviews were also held in the 1999 fishing year to provide estimates of baitfish and the unreported catch; i.e., fish not required to be reported during scheds (Murphy *et al.* 2002). Since 2003, tournaments have been selected for interviewing based on the feasibility of conducting interviews at the access points of the host ports, the amount of funding available and the characteristics of the tournament (such as the number of boats entered and the species groups targeted).

Tournaments were assessed for their feasibility for interviews and the amount of coverage possible at the access points used by tournament fishing crews. Tournaments chosen for interviews were expected to have at least 20 boats entered.

It was not feasible to hold interviews at some tournaments, such as those on the NSW south coast and all those hosted by Port Stephens (with the exception of the interclub tournament, discussed further on in this section). This was because less than 20 boats were expected to have entered, and because the fishing party boats were spread across large numbers of access points. In the south coast tournaments of greater than 20 expected boats entered, a large proportion of fishing parties use trailer boats that they retrieve at their local boat ramp, which may be some distance away from the tournament control base. Conducting interviews at these tournaments to cover all access points would require survey staff to be at more than three access points, spread over an area with long driving distances (of at least 20 minutes) in between, for a tournament of about 30 boats. The monitoring program did not have enough funding to cover all access points for these tournaments, and it is not feasible to travel between these locations (such as to undertake a bus route survey) due to the high concentration of boats returning from their fishing day within about a 3-hour time period. Hence, interviews at these tournaments were obtained from only two to three of the access points. Fishing parties who retrieved their boats at those access points covered by survey staff were assumed to be representative of the entire tournament's fishing fleet.

In some tournaments, such as the Port Stephens Interclub tournament coordinated by the NSW GFA, interviews have been held every year since 2002. Interviews were also held at this tournament in the financial year ending 1999. This event is the largest tournament held in NSW. It was not feasible to undertake interviews at any other tournaments held out of Port Stephens due to the large number of access points, including many inaccessible to survey staff (such as private moorings). The other Port Stephens events are also predominately billfish-only events; hence, minimal bias was expected in the scheds data regarding species group targeted or catch.

Over the past seven years, all other tournaments were assigned to the bioregions North, Central and South (Figure 1) to devise a monitoring program and select tournaments from the NSW GFA list for interviewing. Only two tournaments are held every year in the North zone; hence, both of these included interviews. The only other tournament at which interviews were held in the North zone was at Forster, which only occurred in one year.

Tournaments in both the Central and South zones were randomly selected for interviews separately for each fishing year. More tournaments are held in the South zone (greater than 10 each year) than the Central zone (about 10 each year). Hence, at least four Central zone and six South zone events were randomly selected for interviews each year from the full list of events provided by the NSW GFA.

In the financial year ending 2011, there was a need to focus on data entry, data checking and validation work following the previous three years of intensive interview data collection. Therefore, funding for interviews was instead used to employ a fisheries technician to assist with the data checking and validation work. Consequently, interviews were only undertaken at the Port Stephens Interclub in that year.

3.3. Primary sampling unit

The primary sampling unit (PSU) used for all analysis of monitoring data was tournament. This was because we monitored tournaments based on an *a priori* list of game fishing events as listed by the NSW GFA. Within tournament are different data elements, including the fishing days and then the boats/fishing crews.

3.4. Spatial mapping of fishing effort, fish strikes and catch

3.4.1. Spatial mapping of fishing effort

Fishing effort for spatial mapping is non-directed; i.e., it includes all effort recorded during scheds. However, the number of scheds varies between tournaments, so each sched for each fishing day of each tournament was apportioned effort equal to one divided by the number of scheds for that fishing day. This calculation was needed for each fishing day, because the number of scheds sometimes varies between days. For example, on the last day of most tournaments, there is an earlier stop fishing time in preparation for the tournament presentation.

During the scheds, tournament boats reported their location at the time of each sched. The location was reported as an alpha-numeric grid reference based on a map that was distributed by the tournament organisers. Maps vary between tournaments in their spatial extent, grid size and grid cell references, and some tournament maps have changed over the monitoring period. As part of the monitoring program, each tournament map grid was spatially referenced using ArcGIS software and standardised. To compare information between years, each map grid was standardised by proportional allocation of the fishing effort to a single 3 x 3 minute (3’ x 3’) equivalent to 3 x 3 nautical mile grids system.

3.4.1.1. Expansion of sampled data to account for tournaments not sampled

Over the period of the monitoring program, scheds data have not been obtained from every tournament held each year. Hence, to provide an estimated total measure of the fishing effort per spatial grid for all NSW GFA game fishing tournaments between 1994 and 2013, data for each sampled tournament were expanded by:

$$(1) \quad Fishing\ effort = E \times \frac{N_{years}}{N_{sampled}}$$

Where,
E = fishing effort in a grid cell in units of fishing days. This was a cumulative number of boat fishing days per map grid cell, summed for each tournament (PSU) and across monitoring years
N_{years} = the number of years the tournament is known to have been held
$N_{sampled}$ = the number of years that scheds data have been obtained.

3.4.2. Spatial maps of fish strikes and catch

The same methods used for the spatial fishing effort map were applied to fish strike and catch by species group data, where fishing effort (E) is replaced by the number of strikes or fish caught in Equation (1). Fish strikes were not recorded on scheds prior to the fishing year 1998; hence, the fish strikes map only represents the fish strikes from 1998–2013. Catches were grouped for the spatial maps into four species group categories: billfishes, sharks, large tunas, and other game fish, as per the species listed in Table 1.

3.5. Observed catch (released and captured fish)

3.5.1. Taxonomic composition

The total number of fish caught was recorded (i.e., total observed catch) by species or taxonomic group. Some species were able to be identified in data to species level, whereas others were only able to be identified to a taxonomic group; for example, 'hammerhead sharks'. The taxonomic composition were summarised as per the scheds and the interviews separately for all species over the monitoring period.

3.5.2. Observed catch of key game fish species

For observed catch of the key game fish species (those marked with an * in Table 1), data were summarised by fishing year into: the total number of fish caught, the percentage tagged and released, the number of fish tagged and released, and the number captured as recorded on the scheds versus a combination of scheds and interviews. The combination of sched and interview data was assumed to provide the most accurate measure of the catch of each species. The observed catch using a combination of sched and interview data was used in the catch rate calculations. A more detailed description of how these data were summed is provided in Section 3.6.2.

3.5.2.1. Estimating total weight of captured fish from scheds data

Fish weights are not collected as part of the scheds system. However, weights can be obtained from tournament organisers based on their weigh station reports. Hence, all weights recorded in the scheds data are those that were obtained from tournament weigh station reports. A mean weight for each fishing day was calculated and then averaged across fishing days to derive a mean weight per tournament (PSU). These tournament mean weights were then averaged across tournaments within each fishing year. The overall mean fish weight was then multiplied by the number of captured fish to estimate the total weight of captured fish from scheds data.

3.5.2.2. Estimating total weight of captured fish from interview data

To estimate the total weight of captured fish from interview data, a combination of fish weights (for fish weighed at a tournament weigh station) and fork lengths (for fish kept but not weighed at the tournament weigh station) was used. Fork lengths were first converted to fish weights using available fish-weight conversion equations available in the literature (Appendix 2) before the mean weight for each fishing year was calculated. Calculations to derive a mean weight for each fishing year were performed as per the sched data.

3.6. Catch rates

Catch rates were calculated for all key game fish species marked with an * in Table 1. Numerous steps were required to prepare data for estimating the catch rates. First, directed fishing effort was estimated based on all available interview and scheds data. Second, observed catch was estimated based on all available data. Finally, catch rates were calculated. A detailed description of each of these three steps follows.

3.6.1. Directed fishing effort for catch rate estimation

All available data from interviews and scheds were used to provide the most accurate measure of the target species group category (billfish, billfish–shark, shark or other) for each boat of each fishing day (i.e., each fishing trip) of each tournament. First, the interview data were assumed to provide the most accurate measure of the species group being targeted during a fishing trip. Hence, the species group targeted for the majority of the fishing day as recorded by the interviews was used. Second, for fishing trips without interview data, the second-best set of data from the scheds was used to identify the most likely species group targeted for the majority of the fishing day. This was based on whether a boat was trolling, drifting or anchored. Third, fishing trips with no interview data and insufficient sched data to identify the targeted species group were initially assigned to an unknown category. Then, all data available from interviews and scheds were used to estimate targeting ratios for use as probability functions to randomly assign with replacement each of the unknown fishing trips into a target category (billfish, billfish–shark, shark or other). A more detailed description follows of each of these three steps used to provide final allocation of target category to each fishing trip expended in each tournament over the monitoring period. The final directed effort estimates as the number of fishing trips per fishing day per tournament was then used in the catch rate calculations.

3.6.1.1. Directed fishing effort categories for fishing trips based on post-fishing interviews

Targeting categories were reported by the fishing crews. When targeting of multiple species groups was reported, we assigned the targeting category to the species group that was targeted for the majority of the fishing day. The fishing time spent targeting each species group recorded during each interview was used to identify the primary target of the fishing trip and assign each boat to one of four directed effort (or target species) categories:

1. billfish (majority of the fishing day targeting billfish)
2. shark (majority of the fishing day targeting shark)
3. billfish–shark (boats that either spent an equal number of hours targeting billfish and sharks, or were recorded as targeting billfish and sharks simultaneously for the majority of their fishing day)
4. ‘other’ game fish (boats that were recorded to be targeting other game fish only for the majority of their fishing day).

No boats were categorised as ‘unknown’ based on the interviews, because interviews with missing data – or for those boats that refused to be interviewed – were discarded for the purpose of this analysis.

3.6.1.2. Directed fishing effort categories for fishing trips based on scheds

To partition the total fishing effort estimates from the scheds, each boat was assigned to one of the five directed fishing effort (or target species) categories: 1. billfish, 2. shark, 3. billfish–shark, 4. other game fish (‘other’) or 5. unknown. The total effort in these categories was partitioned using fishing method information reported on the scheds as trolling, drifting or anchored, and using known tournament rules for some events. Billfish are commonly targeted using trolling methods, although drifting methods may also be used. Shark species are generally targeted using drifting methods.

The billfish category was assigned on each tournament day to all boats who reported on the majority of the scheds as trolling. The billfish category was also assigned to all boats fishing in the Australian International Billfish Tournament, which was held at different ports each year (with the exception of Port Hacking, because this event was run simultaneously with a shark tournament). Boats fishing the Bermagui Alliance, Port Stephens Billfish Shootout and Port Stephens Bluewater tournaments, which are billfish-only tournaments, were also assigned to the billfish category.

The shark category was assigned on each tournament day to all boats who reported on the majority of the scheds as drifting. The billfish–shark category was assigned on each tournament day to all boats who reported on an equal number of scheds as drifting and trolling.

Other game fish are most often targeted simultaneously while fishing for primary species of billfish and shark. It is therefore difficult to identify the targeting of other game fish based on fishing method data from the scheds. Anchoring is the only fishing method most commonly used to specifically target other game fish species, such as yellowtail kingfish. However, given that billfish and shark species are usually the primary target species group in tournaments, anchoring to target other game fish species usually only occurs when weather conditions are poor and make it difficult to fish for billfish or sharks. Hence, boats that reported as anchoring for most of the day were assigned to the other game fish directed effort category. This category was also assigned to all boats fishing in the yellowfin tuna tournaments held out of Bermagui and Batemans Bay each year. Boats with missing fishing method information were assigned to the 'unknown' directed effort category.

3.6.1.3. Assigning directed fishing effort to fishing trips in the unknown target category

Available data were used to estimate targeting ratios for use in assigning target categories to fishing trips where target category was unknown. Targeting ratios were estimated for each tournament. Equal weighting was given to each fishing day within the tournament; i.e., a daily average. Targeting ratios within each fishing day were estimated by calculating the proportion of fishing trips in each target category. This was done in two ways:

1. Using interview data when these were available for the fishing day
2. Using sched data when no interview data were available for the fishing day.

When data were not available at the fishing day level, data were aggregated to the tournament level. This was done in two ways:

1. Using interview data available for the tournament
2. Using sched data when no interview data were available for the tournament.

When tournament specific data were not available, averaged data from tournaments with similar targeting profiles within that fishing year were used. This was done in two ways:

1. Using interview data averaged across similar tournaments within that fishing year
2. Using sched data when no interview data were available, averaged across similar tournaments within that fishing year.

Given the differences in the types of game fishing tournaments that occur in NSW, we thought it was important to use different targeting profiles. For example, we did not want to use targeting information from a mostly shark fishing tournament to assign targeting in tournaments where boats mostly targeted billfish.

Targeting ratios at the relevant level were then used as probability functions to randomly assign with replacement each of the unknown fishing trips into a target category (i.e., billfish, billfish–shark, shark or other).

3.6.2. Catch for catch rate estimation

Observed catch was estimated based on all available data. First, if interview data were available at the fishing trip level, then the catch data recorded for each species was used. Second, if there were no interview data, then the catch data from the scheds was used. The final observed catch for each fishing day of each tournament was then summed for use in estimating the catch rates.

3.6.3. Estimating weighted catch rates

Significant research was undertaken before applying the method of estimating weighted catch rates presented in this report. The weighted catch rate approach was taken because it was could reduce biases in our estimates caused by the mis-classification of fishing effort target categories based on scheds data, given that most of our data is derived from scheds over the 20 years of monitoring. This new method of weighting the catch rates was derived from an approach traditionally used in recreational fishing surveys when estimating annual estimates of catch or fishing effort from seasonal data (Pollock et al. 1994; Steffe et al. 2005). Previous methods used to estimate catch rates for game fish tournament monitoring data excluded fishing effort not directed at the target species; these are usually referred to as directed catch rates. This method is ideal if you can be certain about the species group that each boat was targeting. However, in the case of game fish tournaments, we needed to make assumptions about the species being targeted based on whether a boat was trolling, drifting or anchored, as reported on the scheds. As will be shown later in this report, the accuracy of this assumption has varied greatly.

For example, in more recent monitoring years, striped marlin were often being targeted using drifting methods. Boats that report on the scheds to be drifting for most of the day are traditionally thought to be targeting sharks. Hence, in cases when boats were targeting billfish for most of their day by drifting, they were mis-classified into the shark targeting category. All fishing effort and associated catch for these boats using previous methodology would have been excluded from the catch rate estimates for this species. However, the weighted catch rate approach allows for the inclusion of all striped marlin catches by calculating a separate catch rate for each target group (billfish, shark, billfish–shark and ‘other’ game fish). These separate catch rate estimates are then summed and weighted by the catch in each group. Hence, in the case of striped marlin, greater weighting can be given to the catch rate for the group of fishers assigned as targeting billfish, because the greatest amount of catch was recorded for this group. However, catches recorded for the other groups were also included, except with a lesser weighting in the final estimate. Thus, this new method reduces biases in the final catch rate estimates that are caused by incorrect classification of the species group being targeted based on radio sched data.

To estimate the weighted catch rate or CPUE, the total observed catch as the number of fish caught (by species) was first divided by the total number of fishing trips expended on each tournament fishing day by target fishing category (i.e., billfish, shark, billfish–shark or other). These catch rates by target category for each fishing day were then weighted by the catch for the day and target category in question against the total catch for each fishing day. In other words, for each target category, the total number of fish caught for boats in that category divided by the total number of fish caught for the fishing day across all target categories was calculated, and then multiplied by the catch rate for the target category and fishing day in question. Hence, for each fishing day, we had a catch rate for each fishing target category weighted by the catch for each species. These weighted catch rates (*wCPUE*) at the fishing day level were then summed to obtain the weighted catch rate for each species by fishing day for each tournament of each year:

(2) $$wCPUE = \sum_t \frac{C_t}{E_t} \times \frac{C_t}{\sum C_t}$$

Where,
wCPUE = Weighted catch per unit of effort (catch rate)
C_t = Total catch for target *t*
E_t = Total number of boats (fishing trips) per target *t*.

To estimate catch rates at the PSU level, the weighted catch rates at the fishing day level were then averaged across fishing days within tournament and year to derive the weighted catch rate for each tournament. Given that tournament is the PSU, the weighted tournament catch rates for each species and fishing year were then averaged to obtain independent annual CPUE estimates and their associated standard errors (as 95% confidence intervals that are 1.96 x standard error; i.e., 1.96 SE).

To assess the trends in the catch rates over the monitoring period, these 95% confidence intervals were used to indicate significant changes at the 5% significance level. A significant change in the catch rates is indicated by non-overlapping confidence intervals. To investigate potential causes of bias in the catch rates had we not used the weighted catch rate approach, the weighted catch rates by target category were estimated annually in the same way as the overall weighted catch rates, except that weighted catch rates across target categories were not summed. Instead, they were kept independent and averaged across fishing days and then across tournaments to obtain the annual CPUE and 95% confidence intervals by target category and species.

3.7. Future monitoring design

To identify future monitoring design requirements, the differences between data obtained from the scheds versus post-fishing interviews were compared for both fishing effort and catch. To identify potential consequences of future monitoring designs, we also investigated differences between catch rates that can be estimated based on scheds versus a combination of scheds and interview data.

3.7.1. Directed effort differences between sched and interview data

Data from directed effort target categories assigned using sched data were compared with data from the directed effort target categories identified from post-fishing interviews. The interview target category was assumed to be the most accurate measure of the target species group category for each fishing trip. The comparisons between sched and interview data were then used to estimate the proportion of fishing trips per tournament classified correctly into each of the target categories: billfish, shark, billfish–shark and other game fish. These proportions, and their variability within and between years, were used to determine the tournaments in which post-fishing interviews should be continued as part of a future monitoring regime.

If the variability of these proportions is low across years, then it may be possible to reduce the number of tournaments requiring interviews. However, if inter-annual variability in these proportions is large, then post-fishing interviews should be continued – if financially feasible – at current or increased levels. The variability in these proportions was assessed graphically for each spatial zone and fishing year.

3.7.2. Catch differences between sched and interview data

A linear model was fitted to catch data using R (Chambers 1992; R Development Core Team 2011; Wilkinson 1973) to compare the differences between the catch reported using scheds versus interview data as:

$$(3) \quad N_{sched} = a + b \times N_{int}$$

Where,

N_{sched} = Number of fish recorded per species per tournament and zone as recorded by the scheds

a = Intercept of the linear model

b = Slope of the linear model

N_{int} = Number of fish recorded per species per tournament and zone as recorded by post-fishing interviews.

For each species, the number of fish reported on the scheds was plotted against the number caught based on the post-fishing interviews for each tournament, and the linear model was then applied. To help interpret these catch differences and improve future monitoring regimes, a linear model was estimated for each species and spatial zone. Reasons for differences in the catch recorded from scheds versus the interviews can include: fish not reported during scheds if they were not kept for the purpose of point score (such as fish kept for food or bait), duplication of fish recorded during scheds, or species recorded differently during scheds compared with the species reported during interviews.

3.7.3. Catch rate differences using four different data scenarios

To investigate the potential biases of not using the weighted catch rate approach or not holding post-fishing interviews, we compared catch rates calculated under four different scenarios:

1. Non-directed CPUE using only scheds data
2. Directed CPUE using only scheds data
3. Weighted CPUE using only scheds data
4. Weighted CPUE using scheds and interview data (i.e., the approach used for this report).

Directed catch rates based on scheds data only (Scenario 2 above) were not estimated for large tunas or ‘other’ game fish species, due to the limited amount of directed fishing effort able to be identified using scheds data only.

4. RESULTS AND DISCUSSION

4.1. Radio scheds and post-fishing interview data

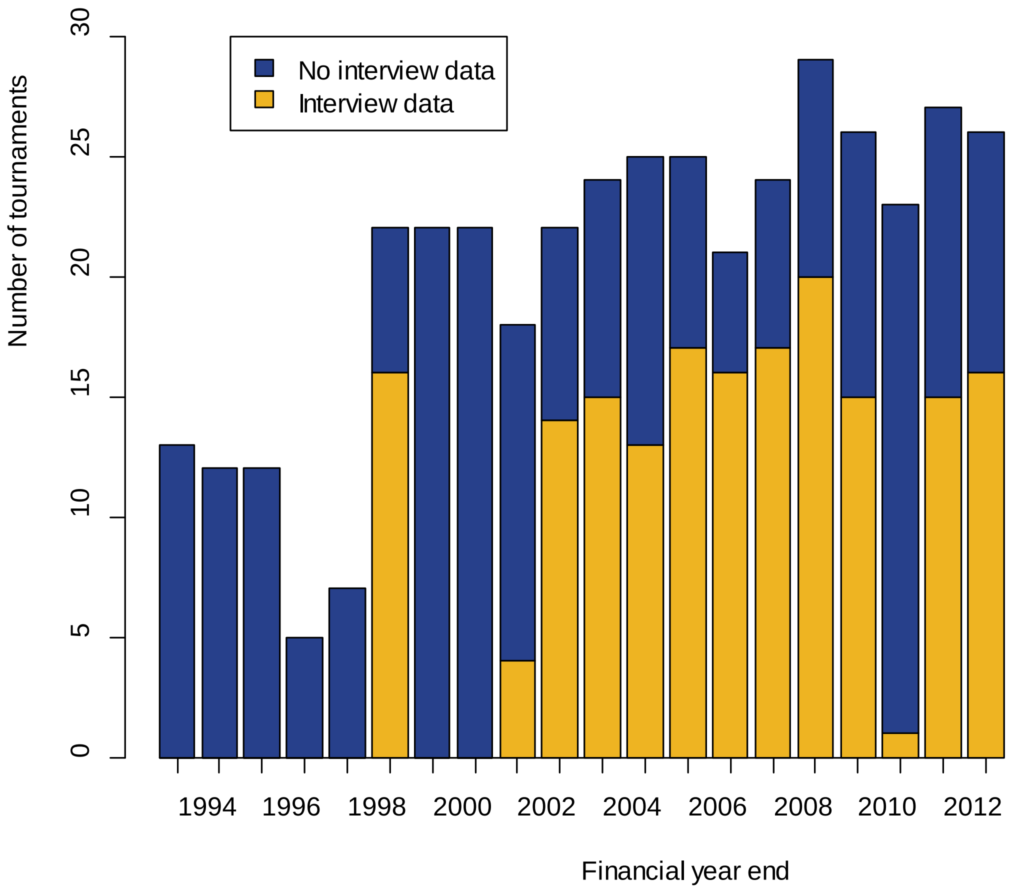
Over the duration of the program, 406 tournaments were monitored between the 1994 and 2013 fishing years. A total of 50451 fishing trips and 955 tournament fishing days were recorded. Radio scheds data were obtained from 395 (97%) of the total number of tournaments monitored. Post-fishing interviews were held at 179 (44%) of the 406 tournaments monitored, with a total of 14180 interviews completed. Since the start of recording interview refusals in 2008, 98.6% of fishing parties approached for interview cooperated fully with interview staff (Table 3). Low refusal rates were maintained over the monitoring period, despite many high-profile issues that could have affected cooperation between fishers and interview staff: e.g. the introduction of marine parks, bag and size limit changes, and resource-sharing conflicts between recreational and commercial fishers. Ongoing communication with fishers, tournament organisers, game fishing club officials and state and national association executives played a key role in maintaining a successful data collection program.

The number of tournaments in which data were obtained has been relatively consistent since 1999, with a slight overall increase over the monitoring period (Figure 3). The lowest numbers of tournaments were monitored in 1997 and 1998, while data were obtained from the greatest number of tournaments in 2009 and 2012.

Table 3. Post-fishing interview success and refusal rates from 2008 to 2013. Interview refusals were not recorded prior to 2008

	No. interviews				
Financial year end	**Refused**	**Success**	**Total**	**Refusal rate (%)**	**Success rate (%)**
2008	6	1289	1295	0.5	99.5
2009	16	1815	1831	0.9	99.1
2010	27	1658	1685	1.6	98.4
2011	8	332	340	2.4	97.6
2012	25	1291	1316	1.9	98.1
2013	11	838	849	1.3	98.7
Total no. and mean rate	**93**	**7223**	**7316**	**1.4**	**98.6**

Figure 3. Number of game fishing tournaments each financial (fishing) year monitored with scheds-only data (no interview data) and with scheds plus post-fishing interview data (interview data)



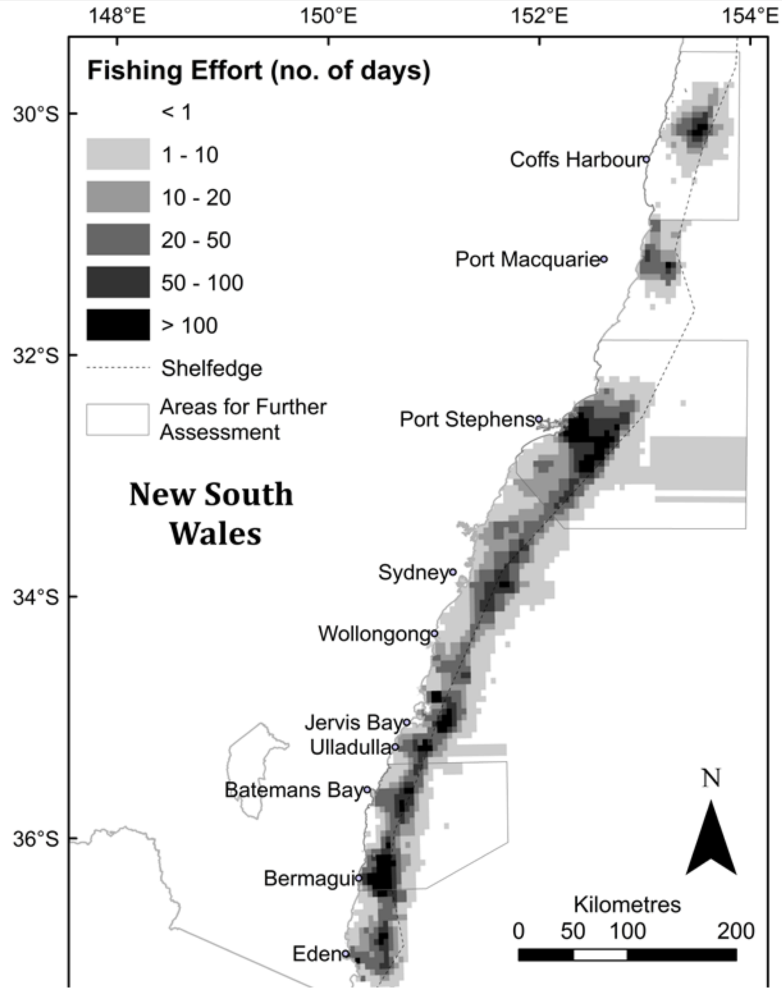
4.2. Spatial maps of fishing effort, fish strikes and catch

4.2.1. Spatial distribution of total fishing effort

Fishing effort was aggregated near ports where the game fishing tournaments were based, with the greatest effort occurring off the coast of Port Stephens in NSW, where the state’s largest tournament is held (Figure 4). Fishing effort was aggregated along the edge of the continental shelf slope, with some occurrences of high inshore effort (>100 days) near Bermagui, Ulladulla, Jervis Bay, Port Stephens and Port Macquarie (Figure 4).

Figure 4. Estimated fishing effort for each 3’ x 3’grid as the number of fishing days expended over the monitoring period from 1994 to 2013. The Areas for Further Assessment for the Commonwealth East Bioregional Planning Process and edge of the continental shelf slope are also displayed (refer to Section 7.3.1 for further details about the use of these data for the Bioregional Planning process)

[redacted]



4.2.2. Spatial distribution of fish strikes and catch

Fish strikes closely mirrored fishing effort, with a high number of strikes recorded for the waters further offshore just inside or along the edge of the continental shelf and adjacent to host game fish tournament ports (Figure 5). The number of billfish caught was highest out of the ports of Port Stephens and Bermagui (Figure 6). Shark catches were highest off Sydney, followed by Bermagui and Port Stephens (Figure 7). Large tunas were caught more often off the south coast between Jervis Bay and Bermagui, although there were also relatively high catches in the offshore waters adjacent to Coffs Harbour (Figure 8). Other game fish catches were highest off the port of Eden; however, there were also relatively high catches in the waters off Jervis Bay, Port Stephens, Port Macquarie and Coffs Harbour (Figure 9).

Figure 5. Number of fish strikes for each 3’ x 3’grid over the monitoring period from 1998 to 2013

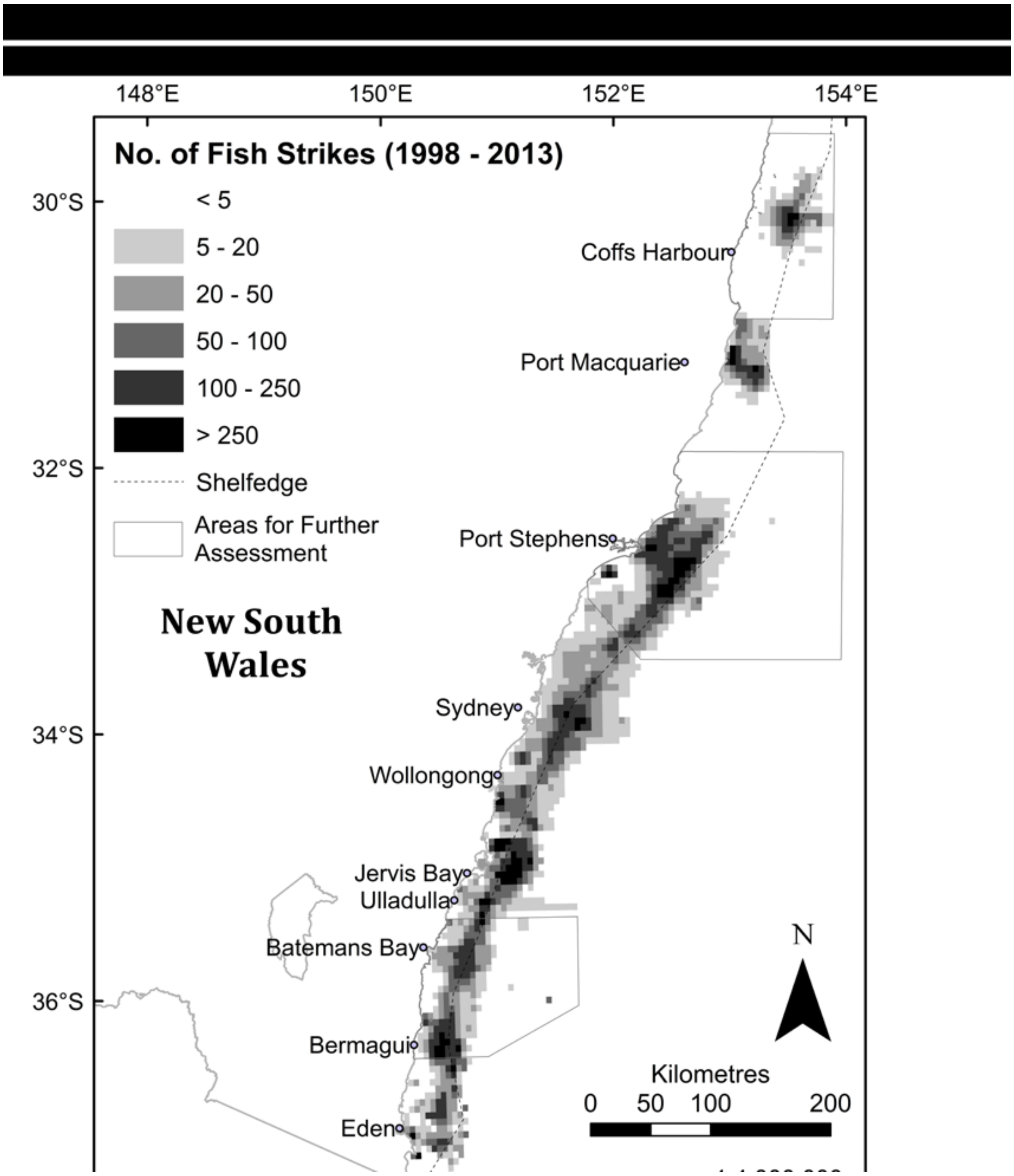


Figure 6. Number of billfish caught for each 3' x 3'grid over the monitoring period from 1994 to 2013

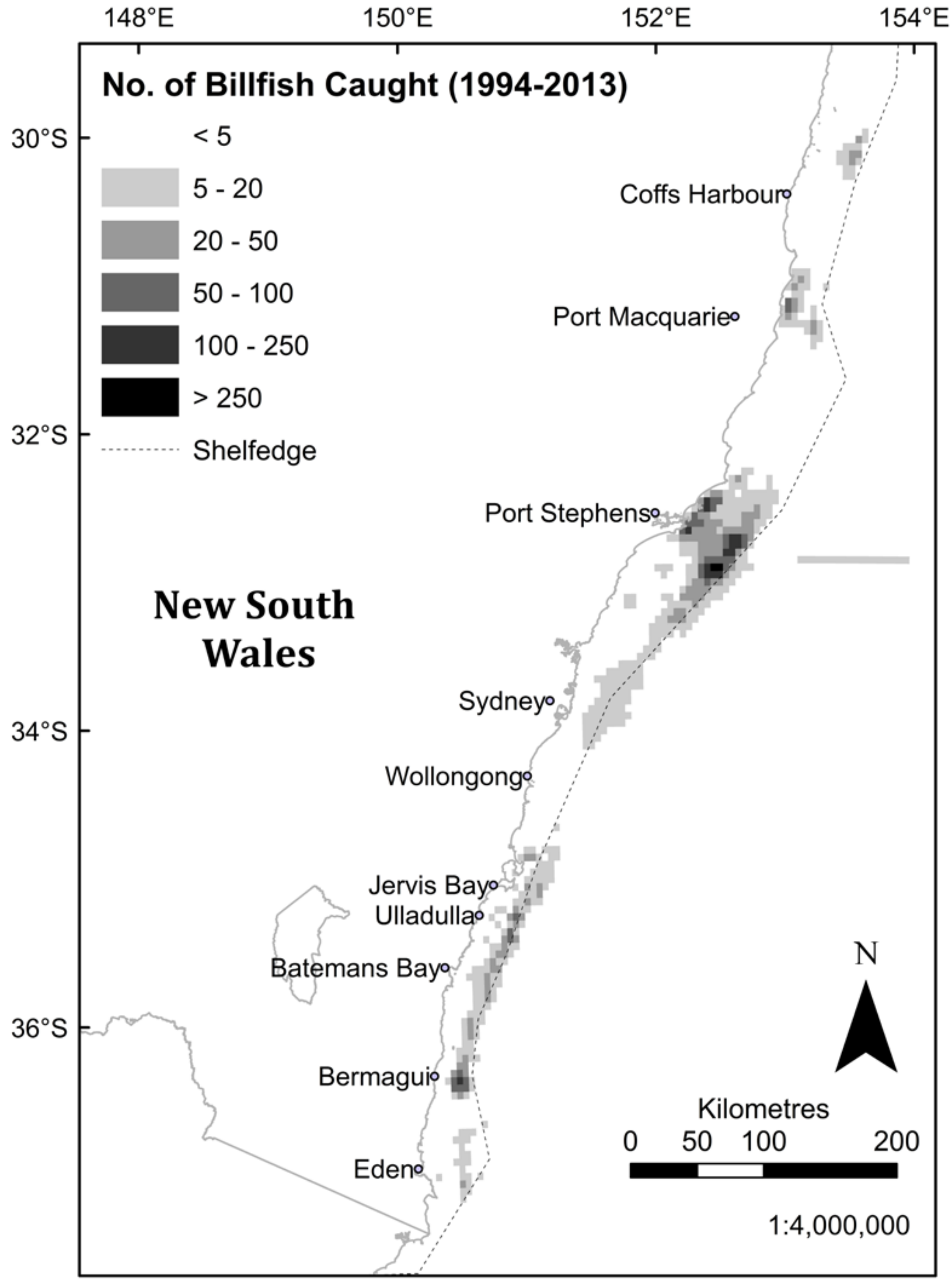


Figure 7. Number of sharks caught for each 3' x 3'grid over the monitoring period from 1994 to 2013

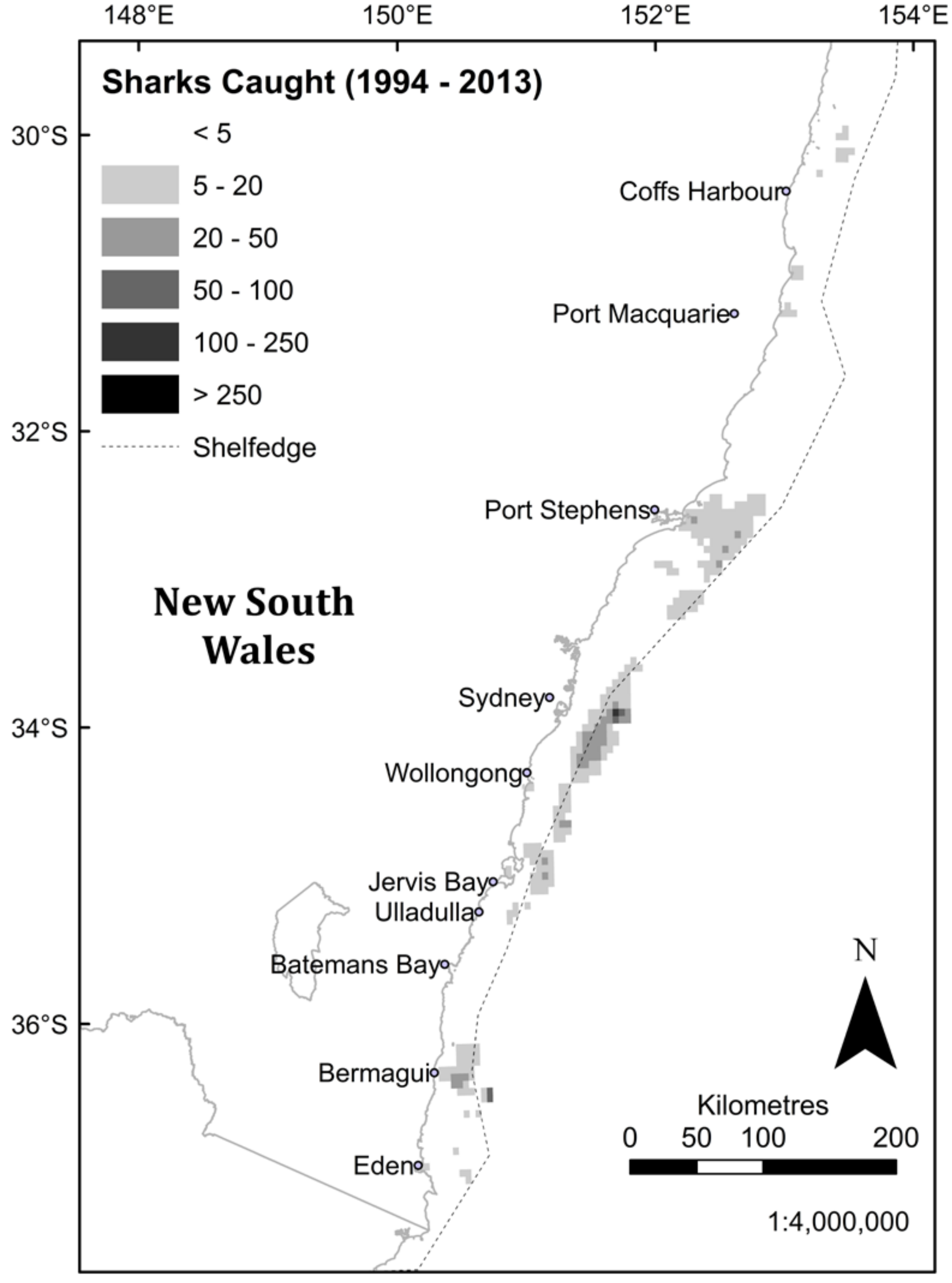


Figure 8. Number of large tunas caught for each 3' x 3'grid over the monitoring period from 1994 to 2013

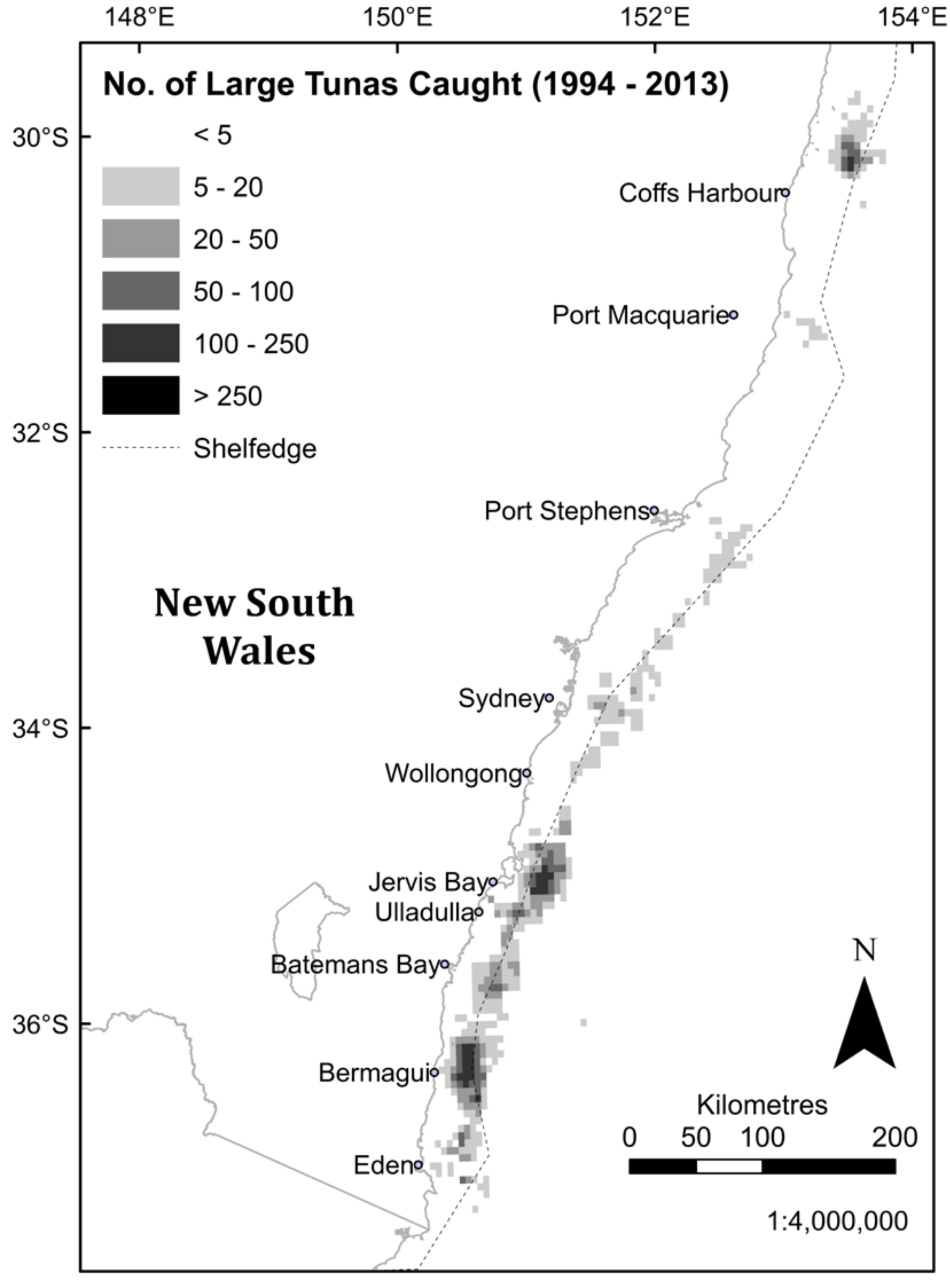
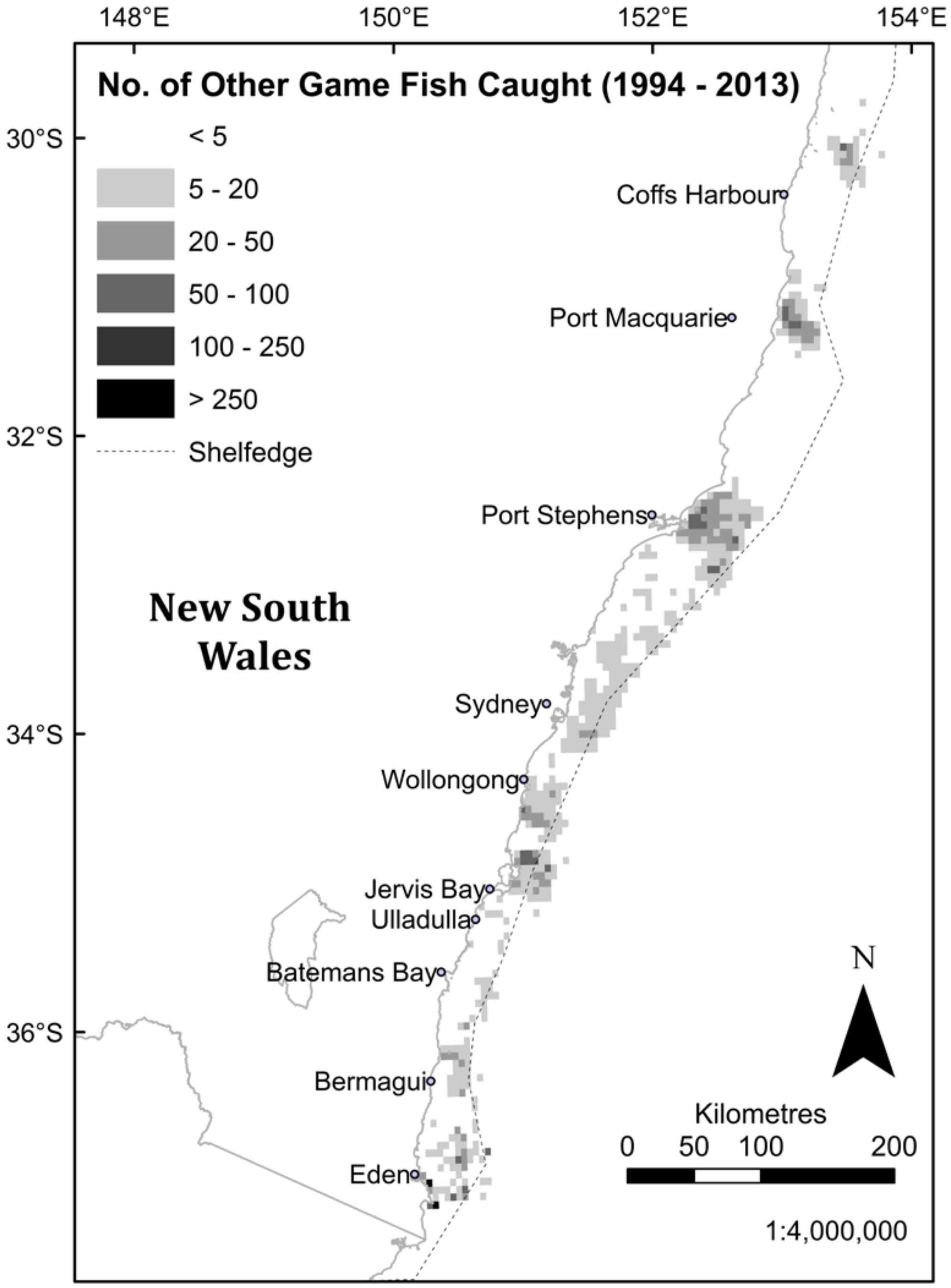


Figure 9. Number of other game fish caught for each 3’ x 3’grid over the monitoring period from 1994 to 2013



4.3. Observed catch

4.3.1. Taxonomic composition

A total of 39020 fish (35 taxa) were recorded from the scheds, with 98% of these recorded to species level (Table 4). From the interview data, a total of 19048 fish and invertebrates (71 species) were recorded (Table 4). The interview catch included both targeted game fish species and other non-game fish species. For example, bottom-dwelling fish (such as blue-eye cod) were often targeted simultaneously while fishers were drifting to target game fish species. Non-game fish species were not always able to be identified, due to fishers filleting their catch before the interview.

Yellowfin tuna was the most common species (21%) recorded from scheds, while skipjack (striped) tuna was the most common species (20%) recorded from interviews. Striped marlin was the second most common species (18%) recorded from scheds, followed by mahi mahi (15%), black marlin (12%), albacore (8%) and mako shark (6%; Table 4). Yellowfin tuna was the second most common species (18%) recorded from interviews, followed by mahi mahi (15%), striped marlin (145), black marlin (8%) and albacore (5%; Table 4).

Table 4. Taxonomic composition of the catch by game fish tournament anglers (excluding those recorded while bait fishing) as recorded from scheds and interviews over the monitoring period from 1994 to 2013. Catch fates are not specified in this table; hence, the total catch numbers include a combination of tagged and released, free released and captured individuals

	Sched		Interview	
Common name	**No. recorded**	**Composition (%)**	**No. recorded**	**Composition (%)**
Yellowfin tuna	8362	21.43	3434	18.03
Striped marlin	7102	18.20	2626	13.79
Mahi mahi	5678	14.55	2802	14.71
Black marlin	4502	11.54	1543	8.10
Albacore	3107	7.96	872	4.58
Shortfin mako shark	2154	5.52	749	3.93
Blue marlin	1533	3.93	512	2.69
Kingfish	1491	3.82	679	3.56
Skipjack	1311	3.36	3801	19.95
Tiger shark	856	2.19	224	1.18
Blue shark	769	1.97	217	1.14
Whaler sharks	633	1.62	131	0.69
Hammerhead shark	537	1.38	110	0.58
No identification	384	0.98	0	0.00
Wahoo	227	0.58	134	0.70
Shortbill spearfish	212	0.54	73	0.38
Southern bluefin tuna	32	0.08	23	0.12
Sailfish	29	0.07	9	0.05
Mackerel tuna	27	0.07	40	0.21
White pointer shark*	14	0.04	6	0.03
Bigeye tuna	9	0.02	1	0.01
Snapper	8	0.02	59	0.31
Thresher shark	8	0.02	0	0.00
Barracuda	7	0.02	0	0.00
Longtail tuna	5	0.01	1	0.01
Swordfish	4	0.01	0	0.00
Cobia	3	0.01	2	0.01
Salmon	3	0.01	7	0.04
Silver trevally	3	0.01	4	0.02
Australian bonito	2	0.01	126	0.66
Bluefish*	2	0.01	5	0.03
Narrow-barred spanish mackerel	2	0.01	0	0.00
Rainbow runner	2	0.01	0	0.00
Amberjack	1	0.00	2	0.01
Grey nurse shark*	1	0.00	0	0.00
Barracouta	0	0.00	4	0.02
Black cod	0	0.00	6	0.03
Blackspot pigfish	0	0.00	15	0.08
Blue groper	0	0.00	1	0.01
Blue morwong	0	0.00	8	0.04
Blue swimmer crab	0	0.00	9	0.05
Blue-throated wrasse	0	0.00	6	0.03

* released or recorded to be caught prior to fishing closures

Table 4 cont. Taxonomic composition of the catch by game fish tournament anglers (excluding those recorded while bait fishing) as recorded from scheds and interviews over the monitoring period from 1994 to 2013. Catch fates are not specified in this table; hence, the total catch numbers include a combination of tagged and released, free released and captured individuals

	Sched		Interview	
Common name	**No. recorded**	**Composition (%)**	**No. recorded**	**Composition (%)**
Chinaman leatherjacket	0	0.00	380	1.99
Common gurnard perch	0	0.00	1	0.01
Common squid	0	0.00	5	0.03
Deepsea trevalla (blue eye)	0	0.00	3	0.02
Deepwater seaperch	0	0.00	1	0.01
Dogfish	0	0.00	10	0.05
Draughtboard shark	0	0.00	1	0.01
Dusky flathead	0	0.00	30	0.16
Eastern blue-spotted flathead	0	0.00	35	0.18
Frigate mackerel	0	0.00	41	0.22
Gemfish	0	0.00	50	0.26
Grey-banded cod (bar-cod)	0	0.00	5	0.03
Gummy shark	0	0.00	1	0.01
Hapuka	0	0.00	5	0.03
Jack mackerel	0	0.00	8	0.04
Latchet	0	0.00	6	0.03
Leaping bonito	0	0.00	1	0.01
Longtom	0	0.00	1	0.01
Nannygai	0	0.00	21	0.11
Ocean perch	0	0.00	26	0.14
Pearl perch	0	0.00	9	0.05
Red scorpioncod	0	0.00	1	0.01
Sea garfish	0	0.00	25	0.13
Sergeant baker	0	0.00	2	0.01
Shark mackerel	0	0.00	1	0.01
Six-spined leatherjacket	0	0.00	3	0.02
Slimy mackerel	0	0.00	60	0.31
Southern blue-spot flathead	0	0.00	6	0.03
Southern calamari	0	0.00	15	0.08
Southern frostfish	0	0.00	1	0.01
Stingarees & black stingrays	0	0.00	1	0.01
Tailor	0	0.00	2	0.01
Teraglin	0	0.00	1	0.01
Tiger flathead	0	0.00	23	0.12
Yellowback seabream	0	0.00	4	0.02
Yellowtail	0	0.00	22	0.12
Total	**39020**	**100**	**19048**	**100**

4.3.2. Observed catch of key game fish species

The following subsections describe the observed catch of key game fish species by their broad taxonomic group, including numbers of released (tagged and released plus free released) and captured fish in numbers. Captured fish are also summarised by weight in kilograms.

4.3.2.1. Billfish catch (released and captured fish) by number

Striped marlin was the primary billfish species caught over the monitoring period, with a total recorded catch of 7224 fish (Table 5) followed by black marlin (4633; Table 6), blue marlin (1585; Table 7) and shortbill spearfish (212; Table 8). Sailfish and broadbill swordfish were also recorded during NSW game fishing tournaments; however, these catches were low, with only 29 sailfish and four swordfish recorded over the 20 years of monitoring (Table 4).

The highest annual catch of any billfish species over the monitoring period was recorded for black marlin in 1997 (890 fish; Table 6). Other high catches were recorded for black marlin in 1999 and in 2005 (668 and 685, respectively; Table 6). The highest catches of striped marlin were recorded in 2000, 2010 and 2012 (606, 648 and 645 fish respectively; Table 5). This indicates a shift in the catch of billfish from black marlin to striped marlin, with catches of black marlin being highest in the early part of the monitoring period and catches of striped marlin being highest in more recent years. Despite this trend, the catch of striped marlin in 2013 was relatively low (103 fish; Table 5), predominately as a result of bad weather experienced over the fishing season. For example, three out of four fishing days of the Port Stephens Interclub tournament were cancelled in 2013.

The shift in the catch from black to striped marlin may be related to an increase in the abundance of striped marlin off southeast Australia, and/or a change in fishing methods directed towards striped marlin, improved fish finding technology, and more affordable boats that can travel further offshore (Table 2; Knight *et al.* 2006; Park 2007; Pepperell and Bromhead 2004). Striped marlin may be more consistently available than black marlin, which tends to demonstrate higher inter-annual variability in occurrence (Bridge 2006; Pepperell 1990). Differences in the strength of each year class of black marlin have been demonstrated by their yearly southward migration with the Eastern Australian Current during late summer (Bridge 2006; Pepperell 1990). The spatial extent of black and striped marlin also differs, which may have influenced the shift in their catches during tournaments. Black marlin tend to be caught closer to shore, while striped marlin are more commonly targeted around the shelf region and shelf edge, where recreational fishers tended to expend most of their fishing effort in the latter half of the monitoring period (Bromhead *et al.* 2003; Pepperell 1990).

Blue marlin catches have remained relatively consistent over the monitoring period, with an overall average catch of 79 fish per year. The highest annual catch of blue marlin was recorded in 1999 (228 fish; Table 7). Blue marlin are most often caught further offshore than striped or black marlin. Catches of blue marlin are likely to be related to their availability during tournaments under favourable environmental conditions, with blue marlin most commonly targeted by trolling lures outside of the shelf edge (Kalish *et al.* 2000).

Shortbill spearfish catches have been sporadic and relatively low over the monitoring period, with the highest annual catch for this species in 2002 and 2009 (32 and 28 fish, respectively; Table 8). The catches of this species in some years were strong enough to estimate robust catch rates, and hence were included in the catch rate analysis. This is the first reported analysis of catch and fishing effort for this species in the history of the monitoring program.

4.3.2.2. Billfish captures by weight

Blue marlin captures by weight were about 70 tonne over the monitoring period, followed by about 60 tonne of striped marlin, about 25 tonne of black marlin and only 0.6 tonne of shortbill spearfish (Tables 5–8).

4.3.2.3. Sharks(released and captured fish) by number

Mako shark was the primary shark species caught over the monitoring period, with a catch of 2154 (Table 9). This was followed by blue shark (890; Table 10), tiger shark (862; Table 11), whaler sharks (647; Table 12) and hammerhead sharks (541; Table 13).

The highest annual catch of mako sharks (323 individuals) was recorded in 1999, followed by a catch of 300 sharks in 2013 (Table 9). There have been periods of high and low annual catches of mako sharks, with the highest catches occurring in 1999–2002, 2005 and 2008–2013 (Table 9).

The annual catch of blue sharks was highest in 1996 and 1999 (159 and 101, respectively) and lowest in 2007 (7; Table 10).
The number of tiger sharks caught annually has remained relatively stable over the monitoring period (Table 11), with the highest annual catch in 1999 (78 sharks) and the lowest annual catch in 2013 (12 sharks). An average of 43 individuals was recorded per fishing year (Table 11).

The highest annual catch of whaler sharks as a complex of species was in 1998 (76 individuals), and the lowest annual catch was in 2008 (11 individuals). An average of 32 individual whaler sharks was recorded per fishing year (Table 12).

The highest annual catch of hammerhead sharks as a complex of species was in 2000 (64 individuals) while the lowest annual catch was in 2008 (4 individuals). An average of 27 individual hammerhead sharks was recorded per fishing year (Table 13).

4.3.2.4. Shark captures by weight

About 143 tonne of tiger sharks were captures, followed by about 101 tonne of mako shark, about 27 tonne of blue shark, about 16 tonne of whaler sharks and about 6 tonne of hammerhead sharks recorded over the monitoring period (Tables 9–13).

4.3.2.5. Large tunas (released and captured fish combined) by number

Yellowfin tuna was the most common large tuna species caught over the monitoring period, with a catch of 9024 individuals (Table 14), followed by albacore (3344 fish; Table 15). Southern bluefin tuna, longtail tuna and bigeye tuna were also recorded, but in much smaller numbers (32, 5 and 9, respectively; Table 4).

The highest annual catches of yellowfin tuna were recorded in 1996 (1192 fish) and 2007 (1422 fish), while the lowest annual catch of only 67 individuals was recorded in 1998 (Table 14). The highest annual catch of albacore over the monitoring period was in 1994 (788 individuals), with catches since then being highly variable. They ranged from as low as two fish in 1997 and four fish in 2000 and 2003 to higher catches above 150 fish in 1996, 1998, 2001, 2007, 2009 and 2012–2013 (Table 15).

4.3.2.6. Large tuna captures by weight

The catch of yellowfin tuna and albacore by weight for captured fish was about 56 tonne of yellowfin tuna and 5 tonne of albacore (Tables 14–15).

4.3.2.7. Other game fish (released and captured fish combined) by number

Mahi mahi was the primary other game fish species caught over the monitoring period, with a recorded catch of 6689 fish (Table 16) followed by skipjack (striped) tuna (4430 fish, Table 17), yellowtail kingfish (1687; Table 18) and wahoo (262; Table 19).

The highest annual catch of mahi mahi was recorded in 2001 (1149 individuals), with the lowest annual catch recorded in 1996 (47; Table 16). The highest annual catches of skipjack tuna were recorded in 1999 (681) and 2009 (665; Table 16). There was a notable difference between the number of skipjack tuna recorded, with sched catch records being much lower than the combined sched and interview catch. Large numbers of skipjack caught incidentally by game fish tournament anglers are not eligible for point score. They may have been kept for use as bait, and hence were not reported during scheds. Skipjack tuna only became eligible for point score for junior anglers (aged under 16 years; Anon. 2013) in 2009, and would have been recorded during scheds in most instances under this rule. This rule change also explains the large increase in the reported sched catch of this species from 2009–2013 (Table 16).

Annual yellowtail kingfish catches over the monitoring period have been sporadic, ranging from lows of less than 10 fish in 1996–1998 to highs of more than 250 fish in 2001 and 2009 (Table 18).

Annual wahoo catches were also sporadic over the monitoring period, and were relatively low compared with the other game fish species. Catches ranged from zero to 54 fish, with an average of 13 fish per financial year (Table 19).

4.3.2.8. Other game fish captures by weight

Mahi mahi captures by weight were about 16 tonne (Table 16) followed by 8 tonne of skipjack (striped) tuna (Table 17), 1 tonne of wahoo (Table 18) and 0.3 tonne of yellowtail kingfish (Table 19).

Table 5. Summary of the total number of striped marlin recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Striped marlin	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	190	78.8	150	40	105.1	4227	190	78.8	150	40	105.1	4227
1995	156	87.2	136	20	98.8	1975	156	87.2	136	20	98.8	1975
1996	379	80.5	305	74	90.8	6718	379	80.5	305	74	90.8	6718
1997	175	93.7	164	11	-	-	175	93.7	164	11	-	-
1998	107	91.6	98	9	89.3	804	107	91.6	98	9	89.3	804
1999	380	90.8	345	35	94.0	3290	381	91.3	348	33	89.3	2979
2000	606	92.9	563	43	83.3	3583	606	92.9	563	43	83.3	3583
2001	326	89.9	293	33	90.3	2980	326	89.9	293	33	90.3	2980
2002	315	84.1	265	50	92.2	4605	322	82.8	267	55	96.2	5326
2003	294	94.9	279	15	98.7	1485	294	94.8	279	15	81.5	1244
2004	397	90.5	359	38	80.9	3039	435	88.7	386	49	90.3	4445
2005	398	94.6	377	21	109.2	2347	399	95.4	380	19	92.6	1714
2006	358	93.7	335	23	71.4	1612	390	94.0	366	24	84.7	1999
2007	277	90.9	252	25	83.2	2102	293	88.7	260	33	79.9	2655
2008	467	94.0	439	28	80.1	2262	512	93.5	479	33	90.3	3004
2009	361	89.7	324	37	88.1	3269	370	88.7	328	42	87.6	3679
2010	661	89.9	594	67	87.2	5817	648	89.2	578	70	89.3	6252
2011	498	93.3	465	33	94.5	3158	493	93.2	460	33	92.1	3076
2012	653	95.6	624	29	83.7	2427	645	96.0	619	26	83.7	2169
2013	104	88.5	92	12	82.0	985	103	87.5	90	13	92.5	1191
Total	**7102**		**6459**	**643**		**56685**	**7224**		**6549**	**675**		**60020**
Annual mean	**355**	**90.2**	**323**	**32**	**89.6**	**2983**	**361**	**89.9**	**327**	**34**	**89.9**	**3159**

- no data recorded

Table 6. Summary of the total number of black marlin recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Black marlin	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	112	83.9	94	18	135.7	2443	112	83.9	94	18	135.7	2443
1995	32	81.3	26	6	102.0	612	32	81.3	26	6	102.0	612
1996	156	82.1	128	28	105.5	2954	156	82.1	128	28	105.5	2954
1997	890	98.1	873	17	-	-	890	98.1	873	17	-	-
1998	168	94.6	159	9	93.0	837	168	94.6	159	9	93.0	837
1999	634	97.0	615	19	85.0	1610	668	96.9	647	21	85.0	1785
2000	272	90.2	245	27	103.7	2768	272	90.2	245	27	103.7	2768
2001	105	93.5	98	7	139.3	948	105	93.5	98	7	139.3	948
2002	81	78.8	64	17	104.0	1790	85	79.8	68	17	115.0	1978
2003	49	87.8	43	6	96.0	576	46	89.4	41	5	89.0	436
2004	116	87.1	101	15	106.5	1597	100	87.8	88	12	112.7	1380
2005	640	98.0	627	13	-	-	685	98.5	675	10	63.0	660
2006	297	93.9	279	18	86.5	1573	320	89.3	286	34	70.3	2415
2007	166	97.6	162	4	116.2	473	178	96.0	171	7	116.1	836
2008	138	92.8	128	10	104.6	1046	168	93.5	157	11	104.6	1151
2009	51	86.3	44	7	124.0	868	56	91.1	51	5	97.0	485
2010	217	91.2	198	19	102.4	1946	218	93.1	203	15	102.6	1547
2011	129	93.0	120	9	105.5	957	124	94.3	117	7	101.1	714
2012	96	90.6	87	9	101.2	910	94	92.6	87	7	94.6	662
2013	153	98.7	151	2	75.5	151	156	98.1	153	3	76.4	228
Total	**4502**		**4242**	**260**		**24059**	**4633**		**4367**	**266**		**24839**
Annual mean	**225**	**90.8**	**212**	**13**	**104.8**	**1337**	**232**	**91.2**	**218**	**13**	**100.3**	**1307**

- no data recorded

Table 7. Summary of the total number of blue marlin recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Blue marlin	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	66	73.5	49	17	161.9	2829	66	73.5	49	17	161.9	2829
1995	21	77.8	16	5	-	-	21	77.8	16	5	-	-
1996	44	65.9	29	15	133.8	2007	44	65.9	29	15	133.8	2007
1997	24	75.0	18	6	-	-	24	75.0	18	6	-	-
1998	131	86.3	113	18	123.5	2223	131	86.3	113	18	123.5	2223
1999	216	72.9	158	58	162.0	9468	228	72.3	165	63	149.7	9473
2000	98	78.6	77	21	161.8	3399	98	78.6	77	21	161.8	3399
2001	47	66.0	31	16	200.9	3214	47	66.0	31	16	200.9	3214
2002	138	65.2	90	48	162.4	7812	138	65.2	90	48	162.4	7812
2003	48	63.8	31	17	158.7	2755	50	63.8	32	18	156.5	2830
2004	25	72.0	18	7	127.7	894	44	67.4	30	14	163.2	2337
2005	33	75.8	25	8	-	-	37	74.3	27	10	128.0	1218
2006	88	73.6	65	23	129.9	3021	92	72.2	66	26	134.2	3429
2007	62	62.3	39	23	162.7	3802	70	60.3	42	28	157.8	4386
2008	77	59.7	46	31	177.7	5510	82	60.2	49	33	158.6	5171
2009	85	65.1	55	30	149.6	4444	83	62.7	52	31	150.3	4660
2010	91	72.5	66	25	154.0	3849	83	73.5	61	22	153.7	3381
2011	84	65.5	55	29	168.0	4873	92	68.5	63	29	168.0	4873
2012	98	72.7	71	27	161.5	4317	97	74.3	72	25	150.0	3746
2013	57	64.9	37	20	162.3	3246	58	63.8	37	21	162.2	3407
Total	**1533**		**1089**	**444**		**67663**	**1585**		**1119**	**466**		**70395**
Annual mean	**77**	**70.5**	**54**	**22**	**156.4**	**3980**	**79**	**70.1**	**56**	**23**	**154.3**	**3911**

- no data recorded

Table 8. Summary of the total number of shortbill spearfish recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Spearfish	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	9	55.6	5	4	22.0	88	9	55.6	5	4	22.0	88
1995	19	79.0	15	4	-	-	19	79.0	15	4	-	-
1996	4	75.0	3	1	-	-	4	75.0	3	1	-	-
1997	0	-	-	-	-	-	0	-	-	-	-	-
1998	12	100.0	12	0	-	-	12	100.0	12	0	-	-
1999	12	83.3	10	2	-	-	12	83.3	10	2	-	-
2000	5	100.0	5	0	-	-	5	100.0	5	0	-	-
2001	2	100.0	2	0	-	-	2	100.0	2	0	-	-
2002	32	84.4	27	5	27.5	138	32	84.4	27	5	27.5	138
2003	12	75.0	9	3	23.5	70	12	75.0	9	3	24.0	72
2004	3	100.0	3	0	-	-	3	100.0	3	0	-	-
2005	8	100.0	8	0	-	-	8	100.0	8	0	-	-
2006	13	69.2	9	4	18.0	72	12	33.3	4	8	8.0	64
2007	1	100.0	1	0	-	-	1	100.0	1	0	-	-
2008	13	84.6	11	2	-	-	14	85.7	12	2	28.0	56
2009	29	89.7	26	3	17.0	51	28	89.3	25	3	16.0	48
2010	6	83.3	5	1	33.1	33	7	85.7	6	1	33.1	33
2011	17	88.2	15	2	25.4	51	17	88.2	15	2	25.2	50
2012	3	100.0	3	0	-	-	3	100.0	3	0	-	-
2013	12	91.7	11	1	26.2	26	12	91.7	11	1	26.0	26
Total	**212**		**180**	**32**		**529**	**212**		**176**	**36**		**575**
Annual mean	**11**	**87.3**	**9**	**2**	**24.1**	**66**	**11**	**85.6**	**9**	**2**	**23.3**	**64**

- no data recorded

Table 9. Summary of the total number of mako shark recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Mako shark	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	54	63.0	34	20	139.5	2790	54	63.0	34	20	139.5	2790
1995	56	62.5	35	21	172.6	3624	56	62.5	35	21	172.6	3624
1996	99	69.7	69	30	103.7	3112	99	69.7	69	30	103.7	3112
1997	11	72.7	8	3	-	-	11	72.7	8	3	-	-
1998	30	76.7	23	7	-	-	30	76.7	23	7	-	-
1999	320	86.3	276	44	109.5	4817	323	85.5	276	47	143.3	6737
2000	153	75.2	115	38	143.0	5435	153	75.2	115	38	143.0	5435
2001	118	56.8	67	51	149.1	7605	118	56.8	67	51	149.1	7605
2002	122	71.4	87	35	154.1	5371	122	72.1	88	34	148.8	5071
2003	64	64.1	41	23	150.0	3451	74	64.9	48	26	133.7	3477
2004	58	61.4	36	22	181.4	4060	63	56.7	36	27	162.9	4448
2005	118	70.9	84	34	130.5	4475	120	69.6	83	37	152.3	5561
2006	31	45.2	14	17	193.7	3292	46	24.1	11	35	170.4	5947
2007	42	61.0	26	16	126.9	2078	49	39.1	19	30	125.7	3750
2008	82	61.7	51	31	144.1	4522	100	62.0	62	38	133.4	5069
2009	106	54.6	58	48	122.2	5878	113	53.2	60	53	155.0	8195
2010	190	65.4	124	66	149.2	9798	199	65.3	130	69	141.3	9751
2011	105	65.7	69	36	164.4	5918	105	65.7	69	36	166.2	5983
2012	182	67.4	123	59	140.2	8318	187	67.4	126	61	127.8	7796
2013	213	85.4	182	31	151.9	4730	300	82.3	247	53	127.3	6771
Total	**2154**		**1522**	**632**		**89274**	**2322**		**1606**	**716**		**101122**
Annual mean	**108**	**66.9**	**76**	**32**	**145.9**	**4960**	**116**	**64.2**	**80**	**36**	**144.2**	**5618**

- no data recorded

Table 10. Summary of the total number of blue shark recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Blue shark	Sched						Combination of sched and interview data					
Financial year	**No. caught**	**Released (%)**	**No. released**	**No. captured**	**Mean weight (kg)**	**Total captures (kg)**	**No. caught**	**Released (%)**	**No. released**	**No. captured**	**Mean weight (kg)**	**Total captures (kg)**
1994	19	42.1	8	11	113.1	1244	19	42.1	8	11	113.1	1244
1995	32	62.5	20	12	95.0	1140	32	62.5	20	12	95.0	1140
1996	156	59.6	93	63	105.3	6637	156	59.6	93	63	105.3	6637
1997	12	91.7	11	1	-	-	12	91.7	11	1	-	-
1998	22	95.5	21	1	-	-	22	95.5	21	1	-	-
1999	91	82.4	75	16	100.9	1614	96	77.3	74	22	89.2	1943
2000	30	86.7	26	4	74.0	296	30	86.7	26	4	74.0	296
2001	38	71.1	27	11	120.8	1328	38	71.1	27	11	120.8	1328
2002	32	75.0	24	8	110.8	886	33	72.7	24	9	110.8	997
2003	13	46.2	6	7	140.7	985	14	50.0	7	7	139.3	975
2004	4	50.0	2	2	93.0	186	5	60.0	3	2	93.0	186
2005	13	76.9	10	3	78.8	236	15	73.3	11	4	111.4	446
2006	11	63.6	7	4	88.5	354	13	53.9	7	6	120.8	724
2007	7	62.5	4	3	103.0	270	3	33.3	1	2	129.4	259
2008	48	61.7	30	18	114.1	2098	50	61.2	31	19	102.9	1996
2009	57	59.7	34	23	120.4	2770	64	62.5	40	24	91.7	2200
2010	65	64.6	42	23	116.0	2668	66	63.2	42	24	109.5	2657
2011	22	68.2	15	7	113.3	793	22	68.2	15	7	113.3	793
2012	41	80.5	33	8	81.4	652	42	83.3	35	7	82.1	575
2013	56	80.0	45	11	104.4	1169	75	76.0	57	18	117.8	2121
Total	**769**		**533**	**236**		**25326**	**807**		**553**	**254**		**26517**
Annual mean	**38**	**69.0**	**27**	**12**	**104.1**	**1407**	**40**	**67.2**	**28**	**13**	**106.6**	**1473**

- no data recorded

Table 11. Summary of the total number of tiger shark recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Tiger shark	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	67	19.4	13	54	187.9	10146	67	19.4	13	54	187.9	10146
1995	55	14.6	8	47	273.3	12846	55	14.6	8	47	310.0	14569
1996	68	19.1	13	55	215.9	11874	68	19.1	13	55	215.9	11874
1997	54	20.4	11	43	189.0	8127	54	20.4	11	43	189.0	8127
1998	31	16.1	5	26	183.0	4758	31	16.1	5	26	183.0	4758
1999	78	32.1	25	53	319.5	16934	78	30.8	24	54	235.5	12717
2000	57	45.6	26	31	226.9	7033	57	45.6	26	31	226.9	7033
2001	35	37.1	13	22	231.8	5100	35	37.1	13	22	231.8	5100
2002	49	39.6	19	30	208.1	6161	49	39.6	19	30	208.6	6175
2003	29	72.4	21	8	341.0	2728	29	73.3	21	8	341.0	2637
2004	33	15.2	5	28	230.3	6448	43	19.1	8	35	287.2	9996
2005	35	20.0	7	28	285.2	7986	32	21.9	7	25	290.3	7257
2006	48	39.6	19	29	240.2	6966	47	36.5	17	30	247.6	7385
2007	21	33.3	7	14	238.5	3339	23	30.4	7	16	186.6	2986
2008	37	17.1	6	31	243.2	7455	37	16.7	6	31	231.7	7145
2009	16	18.8	3	13	152.3	1979	16	12.5	2	14	200.9	2813
2010	45	35.6	16	29	203.9	5913	44	34.1	15	29	219.5	6366
2011	36	42.9	15	21	229.8	4728	36	42.9	15	21	217.3	4469
2012	50	32.0	16	34	279.4	9501	49	31.4	15	34	277.1	9318
2013	12	36.4	4	8	190.8	1457	12	33.3	4	8	208.5	1668
Total	**856**		**252**	**604**		**141479**	**862**		**249**	**613**		**142539**
Annual mean	**43**	**30.4**	**13**	**30**	**233.5**	**7074**	**43**	**29.7**	**12**	**31**	**234.8**	**7127**

- no data recorded

Table 12. Summary of the total number of whaler sharks recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Whaler sharks	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	48	56.3	27	21	116.9	2454	48	56.3	27	21	116.9	2454
1995	15	40.0	6	9	134.0	1206	15	40.0	6	9	134.0	1206
1996	42	78.6	33	9	191.5	1724	42	78.6	33	9	191.5	1724
1997	46	80.4	37	9	-	-	46	80.4	37	9	-	-
1998	76	89.5	68	8	-	-	76	89.5	68	8	-	-
1999	31	67.7	21	10	105.0	1050	32	65.6	21	11	105.0	1155
2000	56	73.2	41	15	173.4	2600	56	73.2	41	15	173.4	2600
2001	22	68.2	15	7	224.7	1573	22	68.2	15	7	224.7	1573
2002	14	71.4	10	4	162.0	648	14	71.4	10	4	162.0	648
2003	41	82.9	34	7	99.0	693	42	81.0	34	8	89.2	714
2004	19	76.5	15	4	209.0	934	18	68.8	12	6	169.7	954
2005	30	86.7	26	4	-	-	27	86.4	23	4	-	-
2006	10	90.0	9	1	-	-	12	91.7	11	1	58.0	58
2007	22	80.0	18	4	147.8	650	23	87.0	20	3	76.5	230
2008	10	70.0	7	3	115.2	346	11	63.6	7	4	116.3	465
2009	13	76.9	10	3	134.0	402	16	75.0	12	4	140.7	563
2010	60	96.7	58	2	156.6	313	61	95.1	58	3	126.4	379
2011	37	77.1	29	8	103.4	874	37	77.1	29	8	99.0	837
2012	17	88.2	15	2	136.1	272	21	86.4	18	3	108.9	312
2013	24	95.8	23	1	173.0	173	28	92.9	26	2	149.0	298
Total	**633**		**502**	**131**		**15912**	**647**		**508**	**139**		**16170**
Annual mean	**32**	**77.3**	**25**	**7**	**148.9**	**995**	**32**	**76.4**	**25**	**7**	**131.8**	**951**

- no data recorded

Table 13. Summary of the total number of hammerhead sharks recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Hammerhead sharks	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	59	83.1	49	10	93.0	930	59	83.1	49	10	93.0	930
1995	18	77.8	14	4	-	-	18	77.8	14	4	-	-
1996	29	89.7	26	3	126.0	378	29	89.7	26	3	126.0	378
1997	39	89.7	35	4	-	-	39	89.7	35	4	-	-
1998	23	100.0	23	0	-	-	23	100.0	23	0	-	-
1999	35	91.4	32	3	109.0	327	36	86.1	31	5	109.0	545
2000	64	90.6	58	6	90.8	544	64	90.6	58	6	90.8	544
2001	60	88.3	53	7	117.2	821	60	88.3	53	7	117.2	821
2002	42	71.4	30	12	109.3	1312	42	70.7	30	12	109.3	1344
2003	37	86.5	32	5	-	-	37	86.5	32	5	80.0	400
2004	20	95.2	19	1	-	-	19	100.0	19	0	-	-
2005	17	93.3	16	1	-	-	18	87.5	16	2	-	-
2006	16	87.5	14	2	-	-	17	88.2	15	2	-	-
2007	9	100.0	9	0	-	-	9	100.0	9	0	-	-
2008	4	100.0	4	0	-	-	4	100.0	4	0	-	-
2009	10	90.0	9	1	-	-	10	90.0	9	1	190.0	190
2010	11	90.9	10	1	77.0	77	12	91.7	11	1	77.0	77
2011	13	84.6	11	2	84.0	168	14	85.7	12	2	84.0	168
2012	21	95.2	20	1	81.1	81	21	95.2	20	1	81.0	81
2013	10	90.0	9	1	129.2	129	10	90.0	9	1	129.2	129
Total	**537**		**473**	**64**		**4767**	**541**		**475**	**66**		**5607**
Annual mean	**27**	**89.8**	**24**	**3**	**101.7**	**477**	**27**	**89.5**	**24**	**3**	**107.2**	**467**

- no data recorded

Table 14. Summary of the total number of yellowfin tuna recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Yellowfin tuna	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	257	72.2	185	72	31.7	2267	257	72.2	185	72	31.7	2267
1995	476	91.8	437	39	28.9	1129	476	91.8	437	39	28.9	1129
1996	1192	84.9	1012	180	36.6	6583	1192	84.9	1012	180	36.6	6583
1997	124	91.1	113	11	-	-	124	91.1	113	11	-	-
1998	67	88.1	59	8	29.8	238	67	88.1	59	8	29.8	238
1999	502	89.0	447	55	36.1	2000	540	85.6	462	78	40.8	3167
2000	197	78.2	154	43	43.1	1854	197	78.2	154	43	43.1	1854
2001	188	68.1	128	60	39.9	2395	188	68.1	128	60	39.9	2395
2002	788	86.5	682	106	27.3	2908	799	79.3	633	166	36.5	6037
2003	379	79.9	303	76	28.7	2189	428	74.9	320	108	26.0	2794
2004	113	53.6	61	52	32.8	1721	157	46.4	73	84	37.7	3168
2005	759	91.8	697	62	39.6	2461	772	88.5	684	88	33.4	2957
2006	344	80.3	276	68	48.2	3265	490	75.9	372	118	33.7	3977
2007	1281	89.7	1149	132	29.8	3921	1422	93.0	1322	100	28.9	2886
2008	646	91.5	591	55	28.6	1577	770	79.7	613	157	23.7	3707
2009	152	61.2	93	59	36.2	2134	182	55.3	101	81	28.6	2323
2010	325	72.8	237	88	45.2	3994	364	71.4	260	104	43.0	4489
2011	202	66.3	134	68	34.2	2323	203	66.5	135	68	33.8	2301
2012	170	75.3	128	42	46.3	1943	170	74.7	127	43	44.2	1902
2013	200	85.9	172	28	49.8	1401	226	82.7	187	39	40.9	1594
Total	**8362**		**7058**	**1304**		**46303**	**9024**		**7377**	**1647**		**55768**
Annual mean	**418**	**79.9**	**353**	**65**	**36.5**	**2437**	**451**	**77.4**	**369**	**82**	**34.8**	**2935**

\- no data recorded

Table 15. Summary of the total number of albacore recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Albacore	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	788	82.5	650	138	10.4	1432	788	82.5	650	138	10.4	1432
1995	94	91.0	86	8	8.5	72	94	91.0	86	8	8.5	72
1996	491	89.0	437	54	12.0	648	491	89.0	437	54	12.0	648
1997	2	100.0	2	0	-	-	2	100.0	2	0	-	-
1998	152	90.8	138	14	-	-	152	90.8	138	14	-	-
1999	95	84.4	80	15	9.8	145	98	82.7	81	17	9.8	166.6
2000	4	100.0	4	0	-	-	4	100.0	4	0	-	-
2001	239	87.5	209	30	8.3	250	239	87.5	209	30	8.3	250
2002	7	85.7	6	1	8.0	8	7	85.7	6	1	8.0	8
2003	0	-	-	-	-	-	4	50.0	2	2	-	-
2004	12	100.0	12	0	-	-	13	92.3	12	1	-	-
2005	30	96.7	29	1	8.2	8	38	81.1	31	7	7.4	53
2006	16	91.7	15	1	-	-	24	62.5	15	9	7.8	70
2007	150	96.0	144	6	6.0	36	197	82.8	163	34	6.0	204
2008	95	99.0	94	1	14.2	14	125	80.6	101	24	7.2	174
2009	344	93.8	323	21	20.8	441	444	75.3	335	109	8.6	937
2010	43	79.1	34	9	-	-	42	76.2	32	10	8.7	87
2011	47	95.6	45	2	-	-	47	95.6	45	2	-	-
2012	159	90.6	144	15	-	-	185	74.6	138	47	7.4	346
2013	339	72.6	246	93	9.5	880	350	69.1	242	108	9.0	972
Total	**3107**		**2698**	**409**		**3934**	**3344**		**2729**	**615**		**5419.6**
Annual mean	**155**	**90.8**	**142**	**22**	**10.5**	**358**	**167**	**82.5**	**136**	**31**	**8.5**	**387**

- no data recorded

Table 16. Summary of the total number of mahi mahi recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Mahi mahi	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	105	68.6	72	33	20.0	660	105	68.6	72	33	20.0	660
1995	94	98.9	93	1	-	-	94	98.9	93	1	-	-
1996	47	87.2	41	6	-	-	47	87.2	41	6	-	-
1997	66	100.0	66	0	-	-	66	100.0	66	0	-	-
1998	89	93.3	83	6	-	-	89	93.3	83	6	-	-
1999	255	92.1	235	20	14.0	282	392	62.2	244	148	14.0	2072
2000	76	89.5	68	8	9.2	73	76	89.5	68	8	9.2	73
2001	1149	99.0	1138	11	13.2	145	1149	99.0	1138	11	13.2	145
2002	509	81.2	413	96	9.5	910	550	75.2	414	136	10.0	1364
2003	135	92.6	125	10	13.0	130	173	70.9	123	50	12.8	645
2004	168	89.2	150	18	17.5	317	231	78.7	182	49	16.3	804
2005	307	89.3	274	33	17.6	578	375	78.2	293	82	13.7	1123
2006	551	94.1	519	32	16.3	527	729	75.9	553	176	14.0	2465
2007	60	88.3	53	7	22.0	154	135	55.0	74	61	16.8	1023
2008	432	91.6	396	36	14.4	521	557	82.0	457	100	7.6	762
2009	448	94.0	421	27	17.6	476	505	85.2	430	75	8.3	624
2010	503	88.1	443	60	17.1	1027	668	74.4	497	171	14.0	2400
2011	226	70.7	160	66	16.7	1108	241	67.8	163	78	16.5	1278
2012	240	95.4	229	11	11.3	126	252	90.9	229	23	9.2	210
2013	218	94.9	207	11	11.9	132	255	88.8	226	29	11.4	328
Total	**5678**		**5186**	**492**		**7166**	**6689**		**5446**	**1243**		**15976**
Annual mean	**284**	**89.9**	**259**	**25**	**15.1**	**448**	**334**	**81.1**	**272**	**62**	**12.9**	**999**

- no data recorded

Table 17. Summary of the total number of skipjack (striped) tuna recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Skipjack tuna	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	2	100.0	2	0	-	-	2	100.0	2	0	-	-
1995	0	100.0	0	0	-	-	0	-	-	-	-	-
1996	3	33.3	1	2	-	-	3	33.3	1	2	-	-
1997	0	-	-	-	-	-	0	-	-	-	-	-
1998	5	0.0	0	5	-	-	5	0.0	0	5	-	-
1999	17	5.9	1	16	-	-	681	3.7	25	656	-	-
2000	0	-	-	-	-	-	0	-	-	-	-	-
2001	0	-	-	-	-	-	0	-	-	-	-	-
2002	9	66.7	6	3	-	-	107	7.4	8	99	-	-
2003	44	95.5	42	2	-	-	342	29.3	100	242	10.0	2417
2004	32	90.3	29	3	-	-	126	18.8	24	102	-	-
2005	62	95.1	59	3	-	-	127	66.7	85	42	2.0	85
2006	53	98.1	52	1	-	-	212	40.5	86	126	-	-
2007	54	100.0	54	0	-	-	206	41.4	85	121	3.0	362
2008	50	98.0	49	1	3.8	4	415	32.8	136	279	2.8	775
2009	218	99.5	217	1	1.2	1	665	43.3	288	377	3.2	1210
2010	207	98.6	204	3	3.7	11	396	68.5	271	125	3.7	457
2011	170	98.2	167	3	-	-	228	27.0	62	166	5.1	854
2012	182	97.8	178	4	-	-	507	40.8	207	300	3.4	1032
2013	203	94.6	192	11	3.3	36	408	67.6	276	132	3.7	491
Total	**1311**		**1253**	**58**		**52**	**4430**		**1656**	**2774**		**7683**
Annual mean	**66**	**80.7**	**74**	**3**	**3.0**	**13**	**222**	**38.8**	**104**	**173**	**4.1**	**854**

- no data recorded

Table 18. Summary of the total number of yellowtail kingfish recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Yellowtail kingfish	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	15	100.0	15	0	-	-	15	100.0	15	0	-	-
1995	10	90.0	9	1	-	-	10	90.0	9	1	-	-
1996	7	100.0	7	0	-	-	7	100.0	7	0	-	-
1997	4	100.0	4	0	-	-	4	100.0	4	0	-	-
1998	2	100.0	2	0	-	-	2	100.0	2	0	-	-
1999	55	100.0	55	0	-	-	68	89.7	61	7	-	-
2000	50	100.0	50	0	-	-	50	100.0	50	0	-	-
2001	259	97.7	253	6	-	-	259	97.7	253	6	-	-
2002	85	95.1	81	4	-	-	88	94.1	83	5	-	-
2003	76	100.0	76	0	-	-	133	78.6	105	28	-	-
2004	104	96.2	100	4	8.0	32	101	96.0	97	4	8.0	32
2005	109	100.0	109	0	-	-	97	97.9	95	2	5.0	10
2006	72	100.0	72	0	-	-	68	85.9	58	10	-	-
2007	132	97.7	129	3	-	-	117	95.8	112	5	2.0	10
2008	36	100.0	36	0	-	-	78	91.0	71	7	-	-
2009	270	95.6	258	12	-	-	328	95.4	313	15	2.8	42
2010	41	97.6	40	1	-	-	67	65.7	44	23	7.2	166
2011	118	99.2	117	1	-	-	118	99.2	117	1	-	-
2012	31	100.0	31	0	-	-	55	81.5	45	10	4.4	45
2013	15	93.3	14	1	-	-	22	90.9	20	2	7.2	14
Total	**1491**		**1458**	**33**		**32**	**1687**		**1561**	**126**		**319**
Annual mean	**75**	**98.1**	**73**	**2**	**8.0**	**32**	**84**	**92.5**	**78**	**6**	**5.2**	**46**

- no data recorded

Table 19. Summary of the total number of wahoo recorded by game fish tournament anglers from scheds versus a combination from scheds and interviews for each financial year over the monitoring period from 1994 to 2013. Values presented are the percentage released (tagged and released plus free released individuals), number of fish released and captured, the mean fish weight in kilograms and the total captures by weight in kilograms. The annual mean released percentage and mean weight were estimated as the mean value average across financial years

Wahoo	Sched						Combination of sched and interview data					
Financial year	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)	No. caught	Released (%)	No. released	No. captured	Mean weight (kg)	Total captures (kg)
1994	1	0.0	0	1	-	-	1	0.0	0	1	-	-
1995	0	-	-	-	-	-	0	-	-	-	-	-
1996	1	0.0	0	1	-	-	1	0.0	0	1	-	-
1997	9	88.9	8	1	-	-	9	88.9	8	1	-	-
1998	2	100.0	2	0	-	-	2	100.0	2	0	-	-
1999	43	90.7	39	4	-	-	54	71.2	38	16	-	-
2000	10	60.0	6	4	20.5	82	10	60.0	6	4	20.5	82
2001	3	33.3	1	2	-	-	3	33.3	1	2	-	-
2002	17	70.6	12	5	-	-	18	66.7	12	6	-	-
2003	7	100.0	7	0	-	-	13	61.5	8	5	16.0	80
2004	0	-	-	-	-	-	0	-	-	-	-	-
2005	31	83.9	26	5	-	-	38	69.2	26	12	19.0	222
2006	15	92.9	14	1	-	-	15	92.9	14	1	-	-
2007	32	81.3	26	6	16.0	96	37	71.1	26	11	16.0	171
2008	12	66.7	8	4	17.4	70	13	61.5	8	5	20.8	104
2009	5	80.0	4	1	-	-	6	66.7	4	2	8.0	16
2010	2	50.0	1	1	-	-	3	0.0	0	3	12.0	36
2011	21	52.4	11	10	16.5	165	21	52.4	11	10	15.4	154
2012	8	37.5	3	5	18.6	93	8	37.5	3	5	18.4	92
2013	8	62.5	5	3	6.0	18	10	50.0	5	5	6.0	30
Total	**227**		**173**	**54**		**524**	**262**		**172**	**90**		**987**
Annual mean	**11**	**63.9**	**10**	**3**	**15.8**	**87**	**13**	**54.6**	**10**	**5**	**15.2**	**99**

- no data recorded

4.4. Catch and release ratios and size composition

4.4.1. Billfish

Of the total 13654 billfish (black marlin, blue marlin, striped marlin and shortbill spearfish) caught during tournaments, 89% were released (either tagged and released or free released) over the monitoring period. Of these, black marlin had the highest overall release ratio, with an average of 91% of fish caught and released over the monitoring period (Table 6). Annual release ratios for black marlin also increased over the monitoring period, from 84% in 1994 to 98% in 2013 (Table 6). Increasing interest by tournament anglers in the conservation of billfish resources and rules governed by the NSW GFA to increase the minimum capture weights (Table 2) may be two reasons for this high release-to-capture ratio for black marlin. Also, the black marlin available to the game fish fishery in NSW are commonly smaller than the increased minimum capture weights specified by the NSW GFA. The highest annual release ratios are also predominantly for years with the lowest mean weights (Table 6). Average black marlin capture weights and estimated weights for released fish was on average100 kg over all years of monitoring (Table 6). The average size of black marlin was significantly lower in 2005 and 2013 compared with the other years of monitoring (Figure 10). Black marlin capture weights and estimated weights of released black marlin rarely exceeded 200 kg (Figure 10).

The next highest overall average catch and release ratio (90%) for the entire monitoring period was recorded for striped marlin, with release ratios also increasing over time from 79% in 1994 to 88% in 2013 (Table 5). The highest annual release ratio for striped marlin of 96% was recorded in 2012 (Table 5). Mean weights of striped marlin were relatively consistent over the monitoring period, with an average of 90 kg (Table 5; Figure 11) and maximum weights rarely exceeding 150 kg (Figure 11).

The average catch and release ratio recorded for blue marlin for the entire monitoring period (70%; Table 7) was lower than for striped and black marlin, and remained similar over the monitoring period (Table 8; Figure 12). The highest annual release ratio (86%; Table 7) was recorded in 1998, which also coincided with the lowest mean annual weight over the monitoring period (123.5 kg; Table 7). Blue marlin caught by tournament game fishers averaged 154 kg, which is much larger than striped and black marlin. The larger sizes of blue marlin, with weights up to about 300 kg (Figure 12), provide the opportunity for tournament fishers to gain higher capture points. Their larger size may partly explain the lower release ratios and lack of an increasing trend in the percentage of released blue marlin over the monitoring period.

Release ratios for spearfish were variable over time, but an increasing trend is evident over the monitoring period, with the 56% released in 1994 rising to 92% in 2013 (Table 8). The lowest annual release ratio was in 2006, which coincided with the lowest mean weight of 8 kg. This contrasts with trends observed for the other billfish species. The average release ratio over the monitoring period was 86%, which is lower than striped and black marlin, but higher than blue marlin. Despite shortbill spearfish being a billfish species, it is categorised within the NSW GFA point-score system as ‘Other game fish’. This is because it reaches a smaller size than other billfish, with the Australian record catch being 33.5 kg (Anon. 2013) and maximum sizes observed in tournaments rarely exceeding 30 kg (Figure 13). The ‘Other game fish’ category only requires the fish to be equal to the line class being used to catch the fish before it is eligible for capture points. Given that shortbill spearfish are caught incidentally while tournament fishers are targeting billfish, many fish do not meet the minimum weight requirements to be eligible for capture, resulting in the higher release ratios for this species. Average weights of released spearfish were relatively stable over the entire monitoring period (about 20 kg per fishing year; Figure 13), which is similar to the average capture weights of 23 kg for the entire monitoring period (Table 8). Trends in the size of spearfish are difficult to ascertain, given the small sample size of weights for this species.

Figure 10. Black marlin minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year of the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

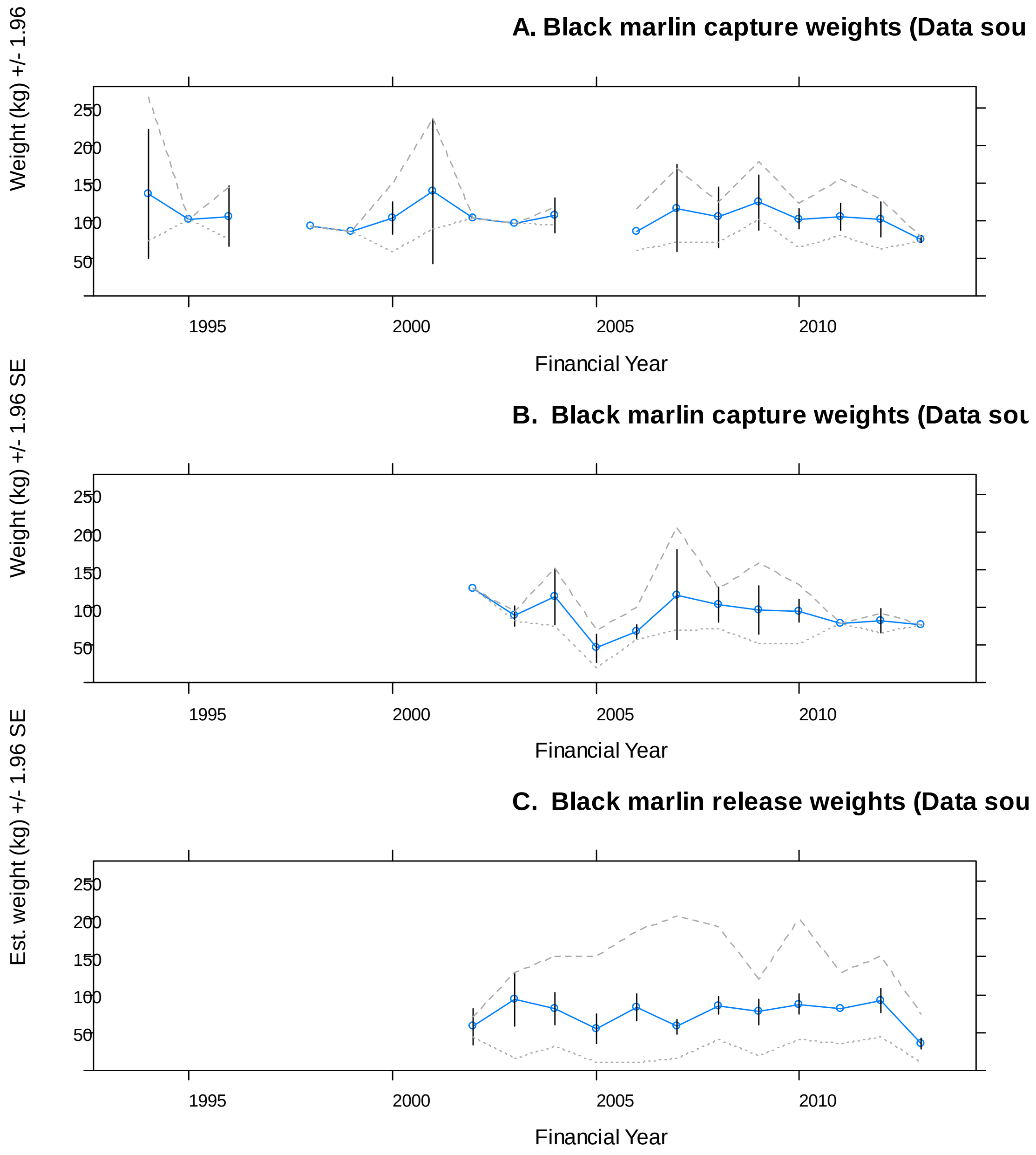


Figure 11. Striped marlin minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year of the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

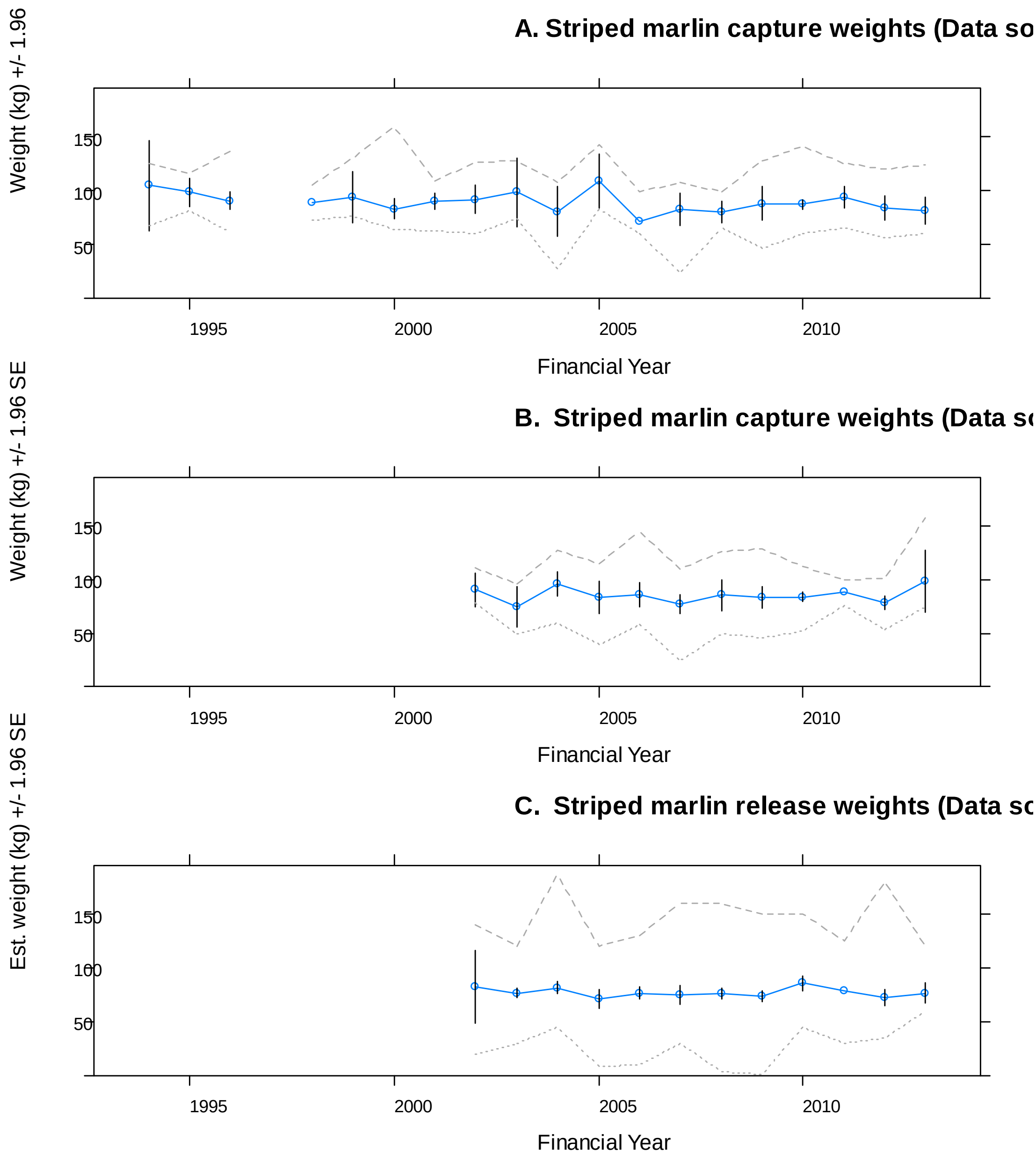


Figure 12. Blue marlin minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year of the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

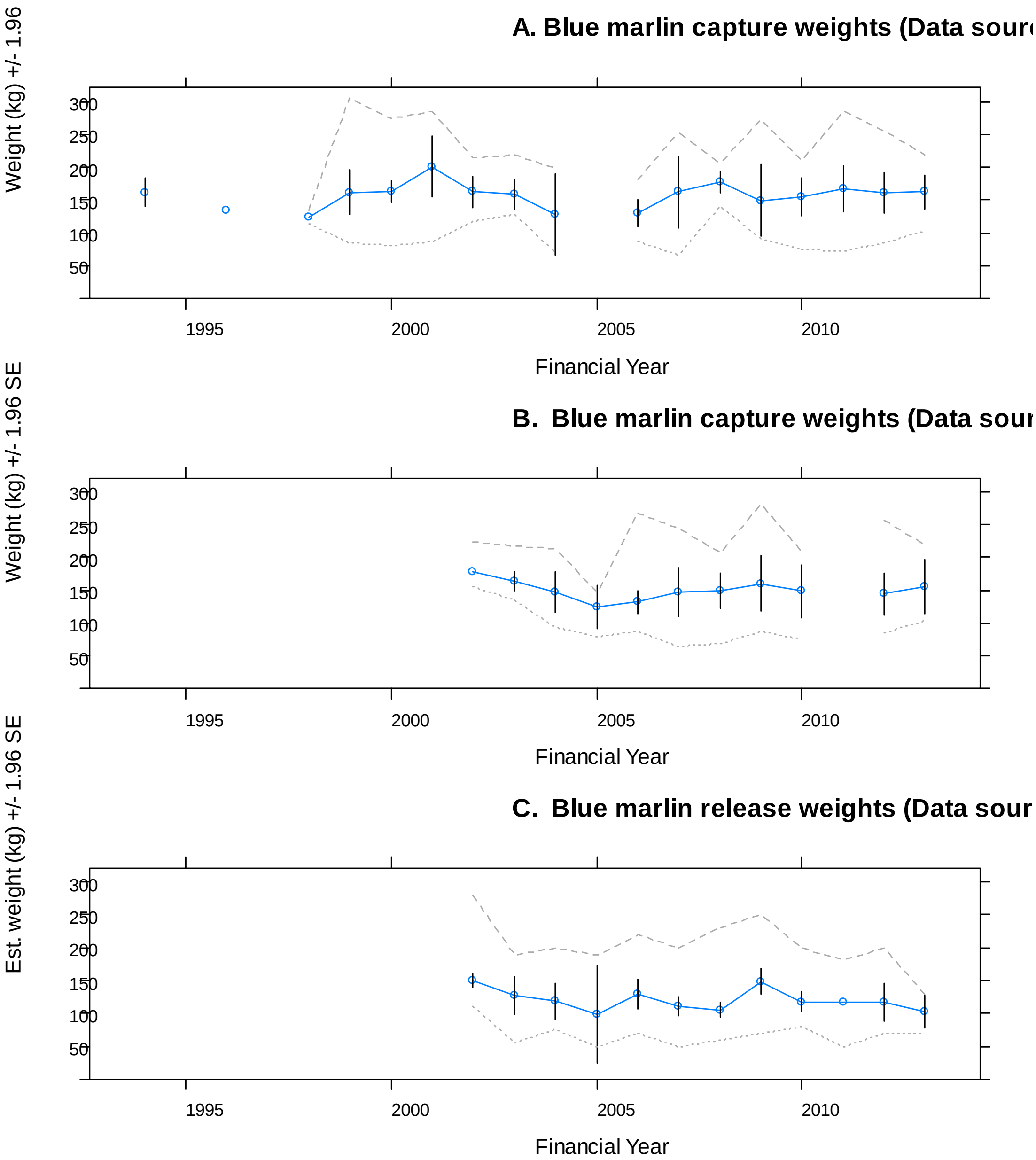
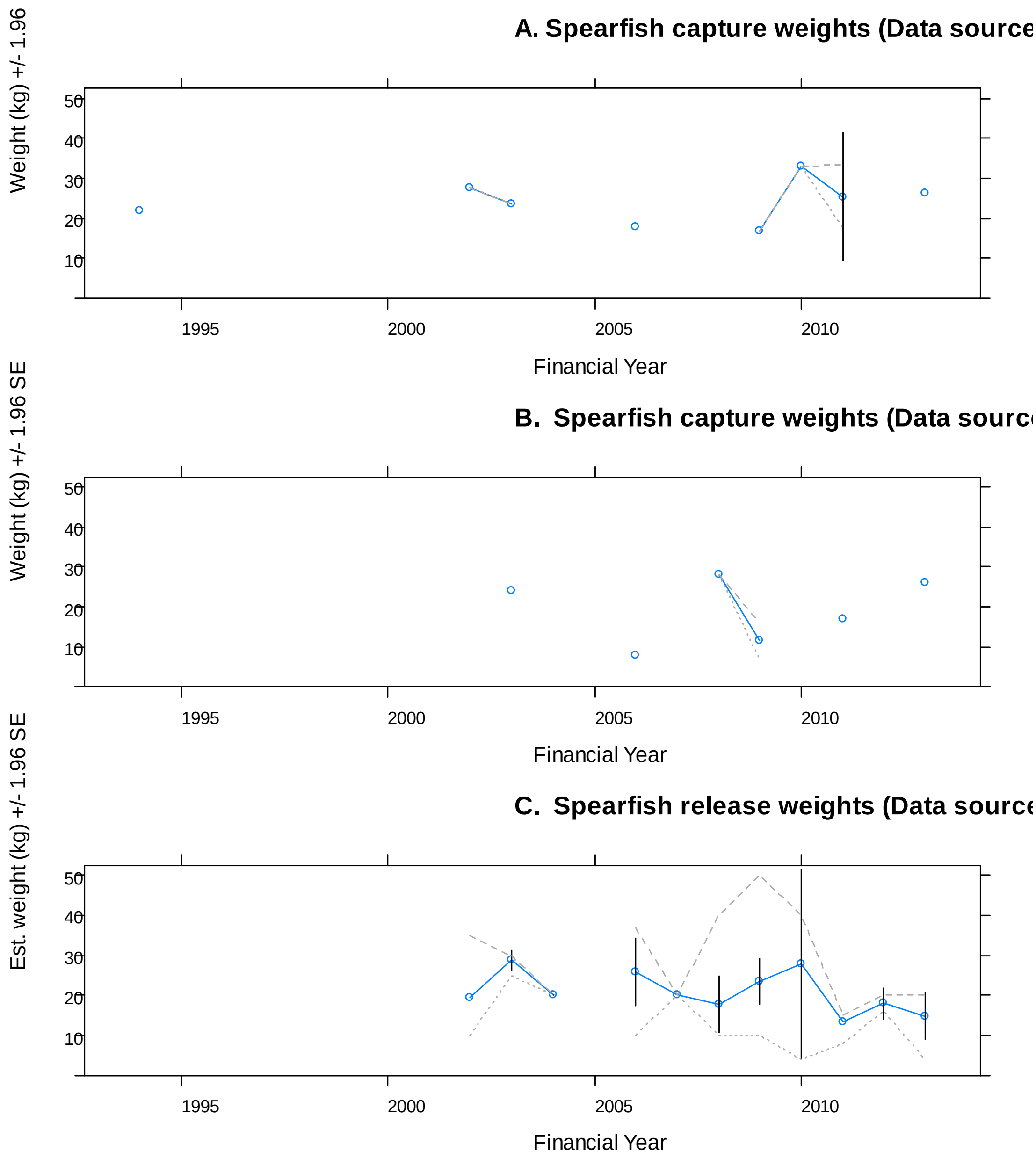


Figure 13. Shortbill spearfish minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year of the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)



4.4.2. Sharks

Of the total 5179 sharks (mako, blue, tiger, whalers and hammerheads) caught during tournaments, 65% were released (either tagged and released or free released) over the monitoring period. Of these, hammerhead sharks had the highest overall release ratio, with an average of about 90% being caught and released over the monitoring period (Table 13). Their weights did not exceed 150 kg and were predominantly less than 60 kg (Figure 14), which is less than the minimum size limit rules imposed by NSW GFA. Hence, the smaller size of hammerhead sharks adds to this species being predominately tagged and released over the monitoring period.

As for hammerhead sharks, blue sharks reach a smaller maximum size compared with common shark species targeted by game fish anglers (such as mako and tiger sharks), not exceeding 200 kg and averaging just over 100 kg for captures (Table 10; Figures 15A and B), and averaging around 70 kg estimated weight for released individuals (Figure 15C). Captured blue sharks receive only one-quarter of the points scored for other shark species (Anon. 2013), because their poorer fighting ability makes them an easier shark to catch. Their low point value makes blue sharks less likely to be captured, and they are predominately tagged and released (release ratio of 67%; Table 10).

The overall release ratio for mako sharks is only slightly lower than blue sharks, at 64% (Table 9). The highest release ratio for mako shark of 86% was recorded in 1999, followed by the most recent fishing year, 2013, with a release ratio of 82%. These years do not coincide with the lowest average weights of captured mako sharks (Table 9, Figure 15). The average size of captured mako sharks has not changed significantly over the monitoring period, although there was a reduced maximum size in the middle of the monitoring period, which increased over the last four years of monitoring to more than 300 kg (Figures 16A and B). In recent years, more fishing crews are choosing to tag and release mako sharks, even if they are larger than the minimum size for capture point score. For example, there has been an increase in the maximum weights of mako sharks released over the monitoring period (Figure 16C).

Tiger sharks are the largest of the shark species caught in game fish tournaments, with an average weight of 235 kg (Table 11). Maximum capture weights also exceed 400 kg in most years (Figures 17A and B). As a consequence of their large size, tiger sharks are most susceptible to capture by tournament anglers, who can obtain the maximum amount of points for their capture. This is reflected in the release ratios of this species being lowest of all shark species at 30% (Table 11). The highest annual release ratio for tiger sharks of 73% was recorded in 2003 (Table 11). However, it is notable that in the past two years of monitoring, there has been an increase in the average weight of tagged individuals, from around 50–70 kg to about 100 kg, as well as a spike in the maximum size of tagged and release sharks (Figure 17C). This may be indicating a shift in the nature of the capture of tiger sharks by game fish tournament anglers. However, caution should be taken with these results, given the uncertainty in the weight estimates – particularly for the last two years of monitoring, which have large overlapping confidence intervals for tagged and released sharks (Figure 17C).

The release ratio for whaler sharks was relatively high at 76% (Table 12). This is likely to be related to the size of the sharks available to the fishery, with most whaler sharks not exceeding the minimum weights required to obtain capture point score. Whaler sharks captured rarely exceeded 250 kg, and were on average around 130 kg (Table 12; Figures 18A and B). There was an influx of smaller whaler sharks averaging less than 50 kg in 2006 and 2007, while larger sharks were available in the most recent years of monitoring (Figure 18C).

Figure 14. Hammerhead sharks minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

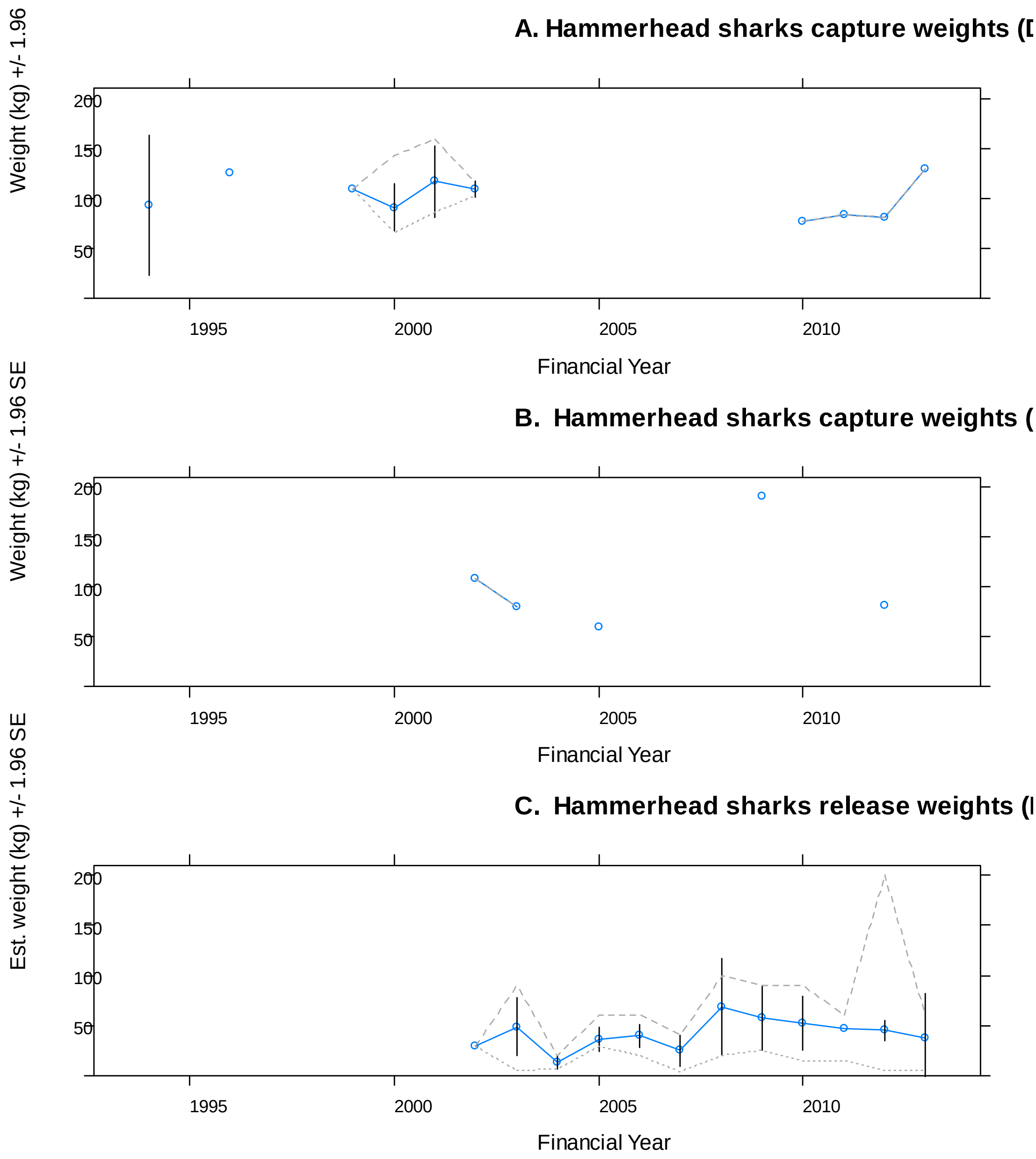


Figure 15. Blue shark minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

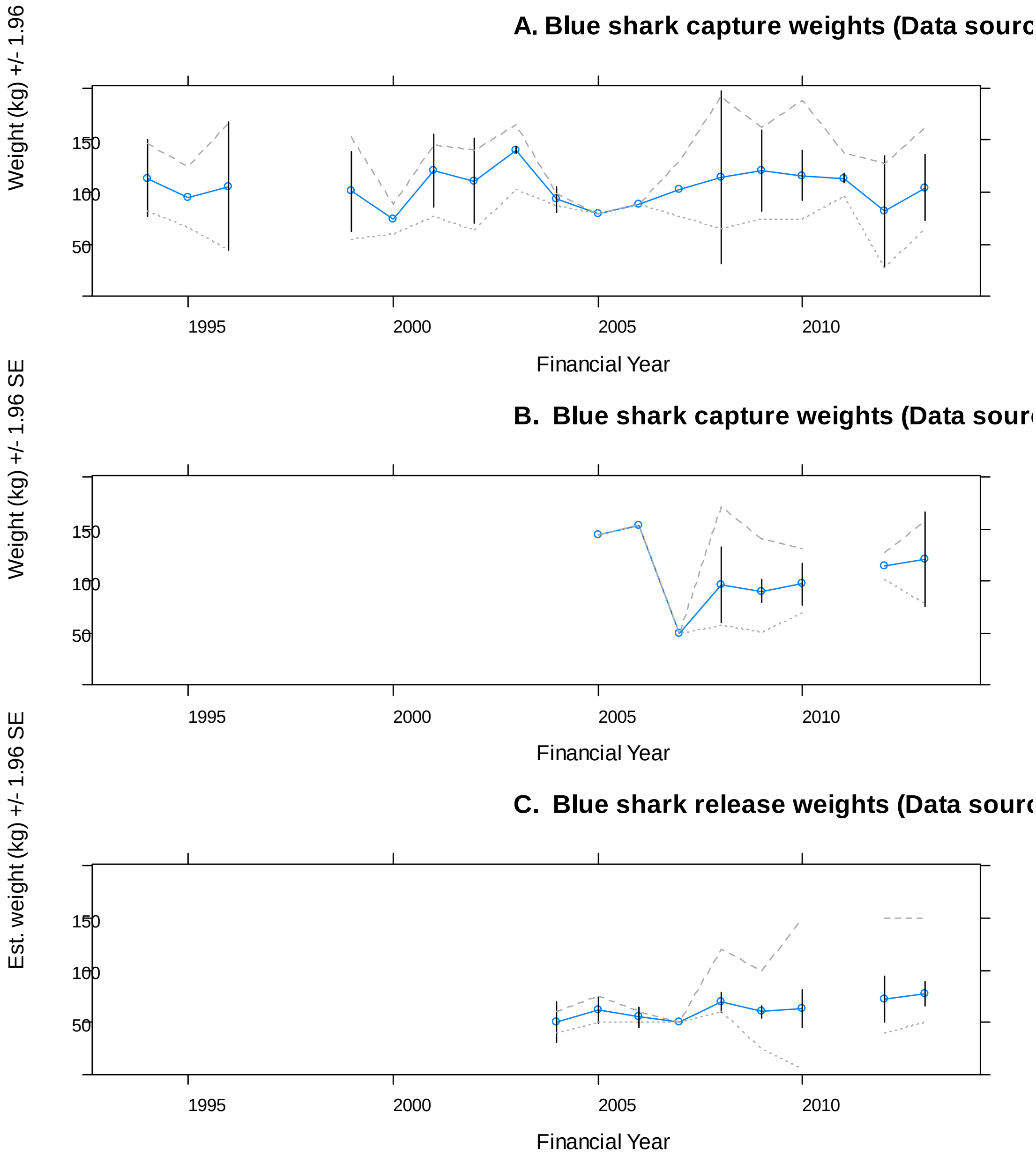


Figure 16. Mako shark minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

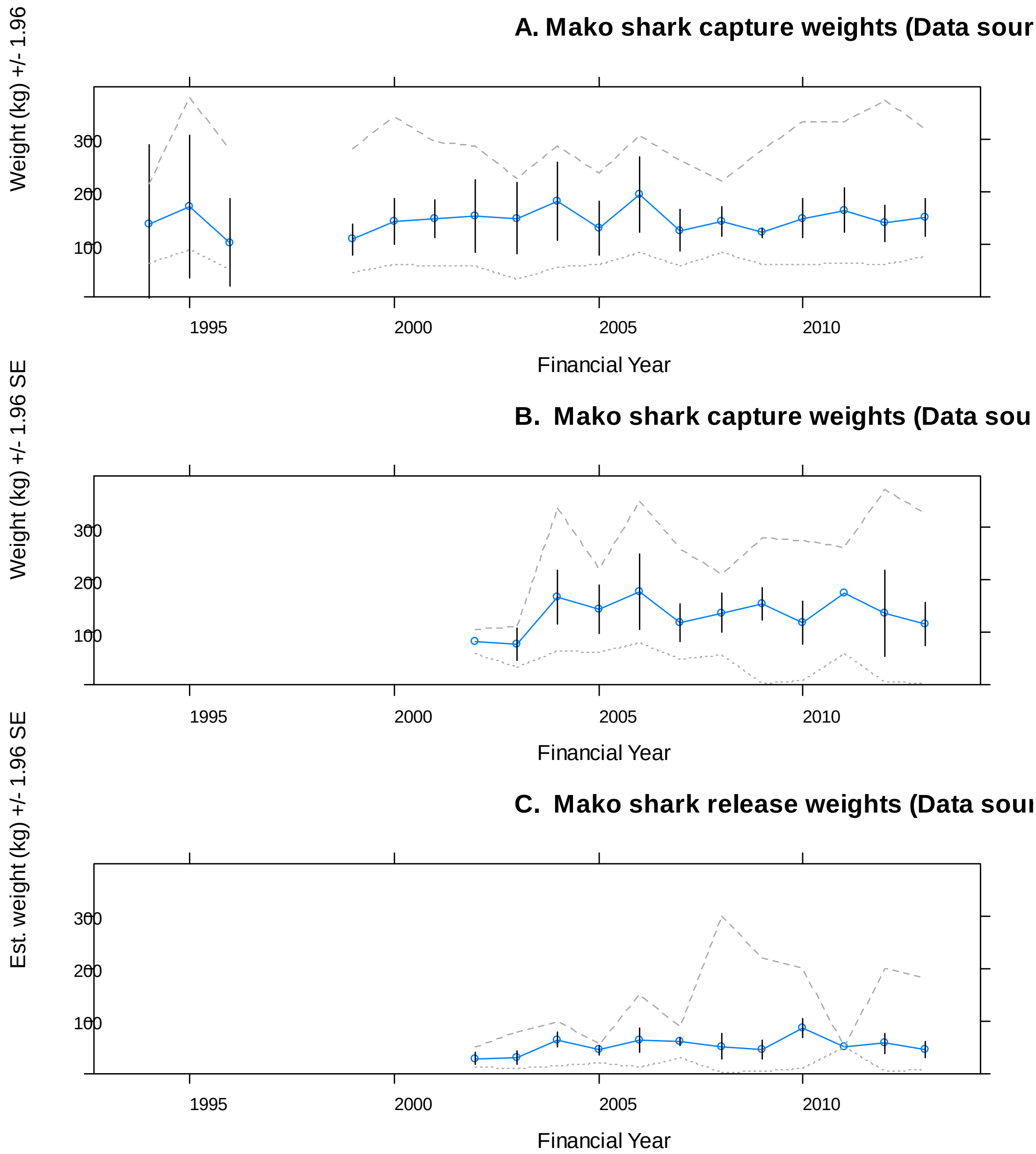


Figure 17. Tiger shark minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

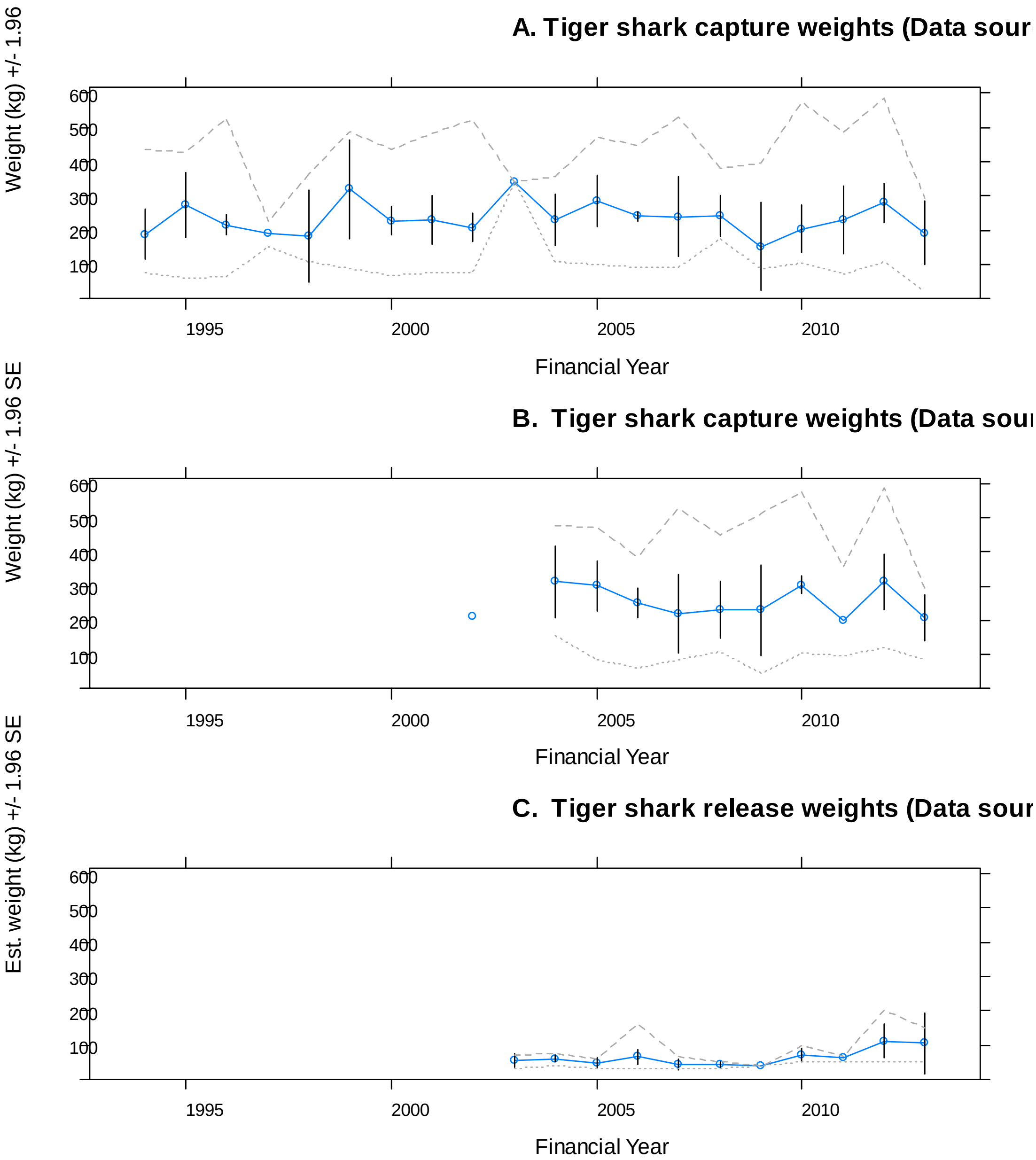
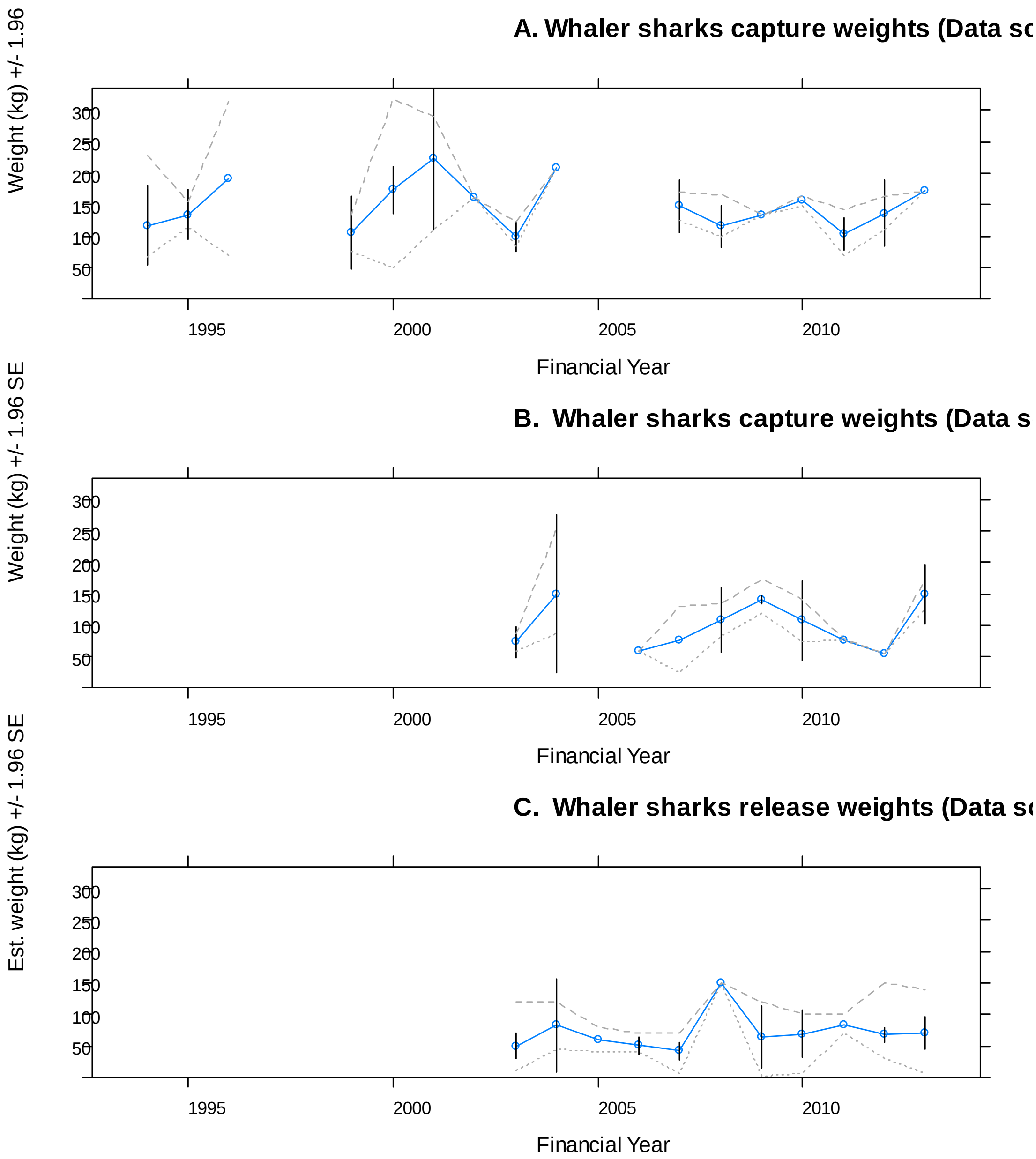


Figure 18. Whaler sharks minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)



4.4.3. Large tunas

Release ratios for yellowfin tuna were relatively high, with an average of 77% over the monitoring period (Table 14). The highest annual release ratio for yellowfin tuna of 93% in 2007 corresponded to the year of the highest recorded catch of this species, and a lower mean weight of fish caught compared with most other years of monitoring (Table 14).

The average annual size of captured and released yellowfin tuna over the monitoring period has been variable inter-annually, but with no significant increasing or declining trend over time (Figure 19). The largest yellowfin tuna, weighing 97 kg, was recorded in 2000 (Figure 19A). In most years, the maximum size has exceeded 60 kg (Figures 19A and B). There was an overall slight decrease in the maximum and mean weights of released yellowfin tuna over the monitoring period (Figure 19). While a decrease in fish size may be some cause for concern for the status of the yellowfin tuna population, the capture weights are not supporting this, with no significant decrease in mean capture weights evident over the monitoring period (Figure 19). These trends may simply be indicative of more large tunas available to the fishery and potential signs of a healthy yellowfin tuna population. Stock assessment models support the notion that current fishing practices are sustainable, with indications that yellowfin tuna in most regions of the Western and Central Pacific Ocean, including Australian waters, are under-exploited (Langley *et al.* 2009).

Albacore tuna release ratios were high at 83% (Table 15). This trend may be related to the maximum sizes attainable for albacore tuna of predominantly less than 20 kg (Figure 20). The largest albacore recorded for the monitoring program weighed 20.8 kg and was caught in 2009 (Figure 20A). The smaller size of albacore make this species difficult to meet minimum sizes for capture points equal to the line class used. Albacore are also highly prized for good eating, and hence many are kept for food instead of being released for tag-and-release point score. This is indicated by the 8% lower release ratio of this species on interview and sched data combined compared with sched data (Table 15). Estimated average weights of released albacore have not changed significantly over the monitoring period for the years that release weights were recorded as part of the interviews (Figure 20C).

Figure 19. Yellowfin tuna minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

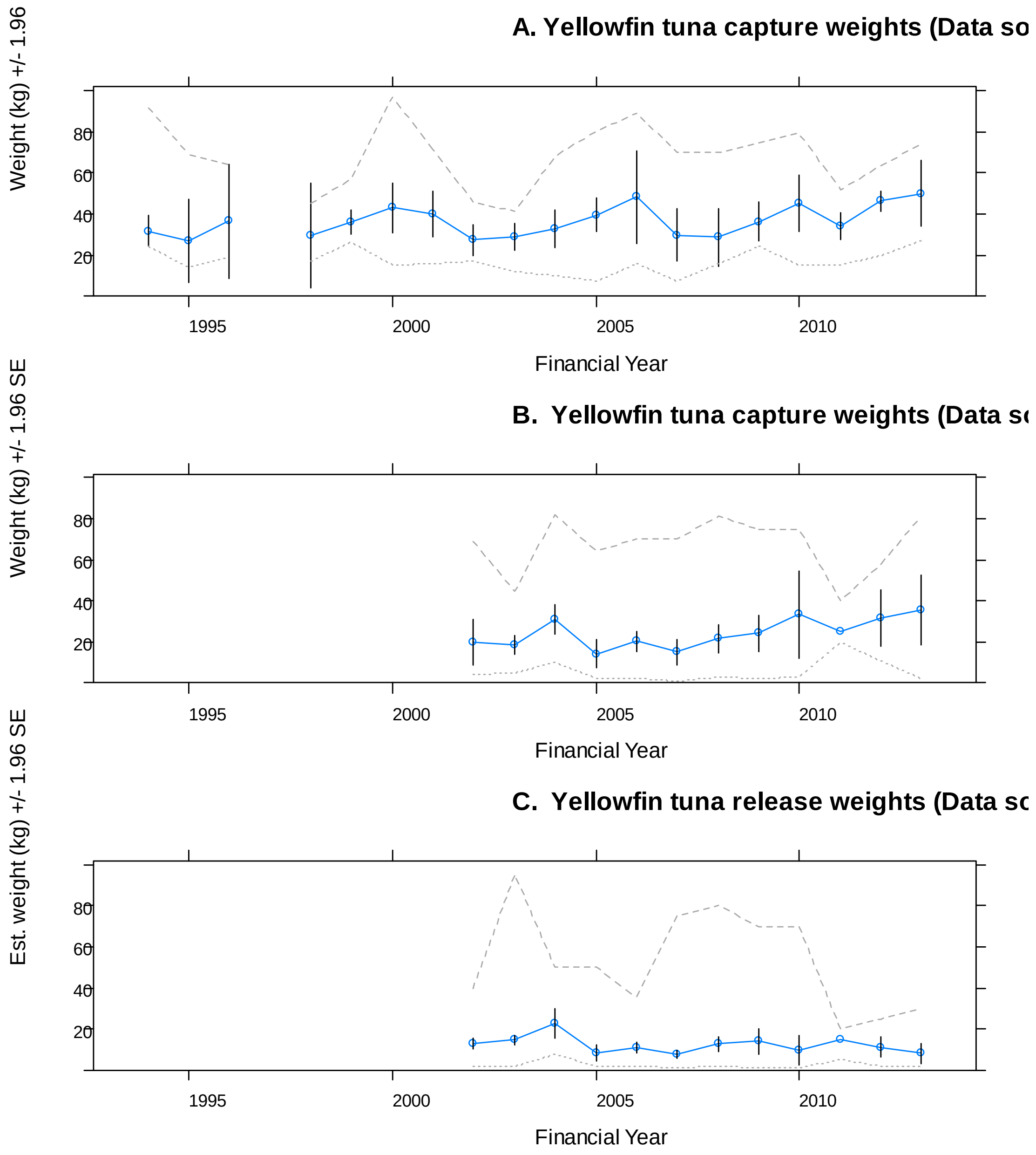
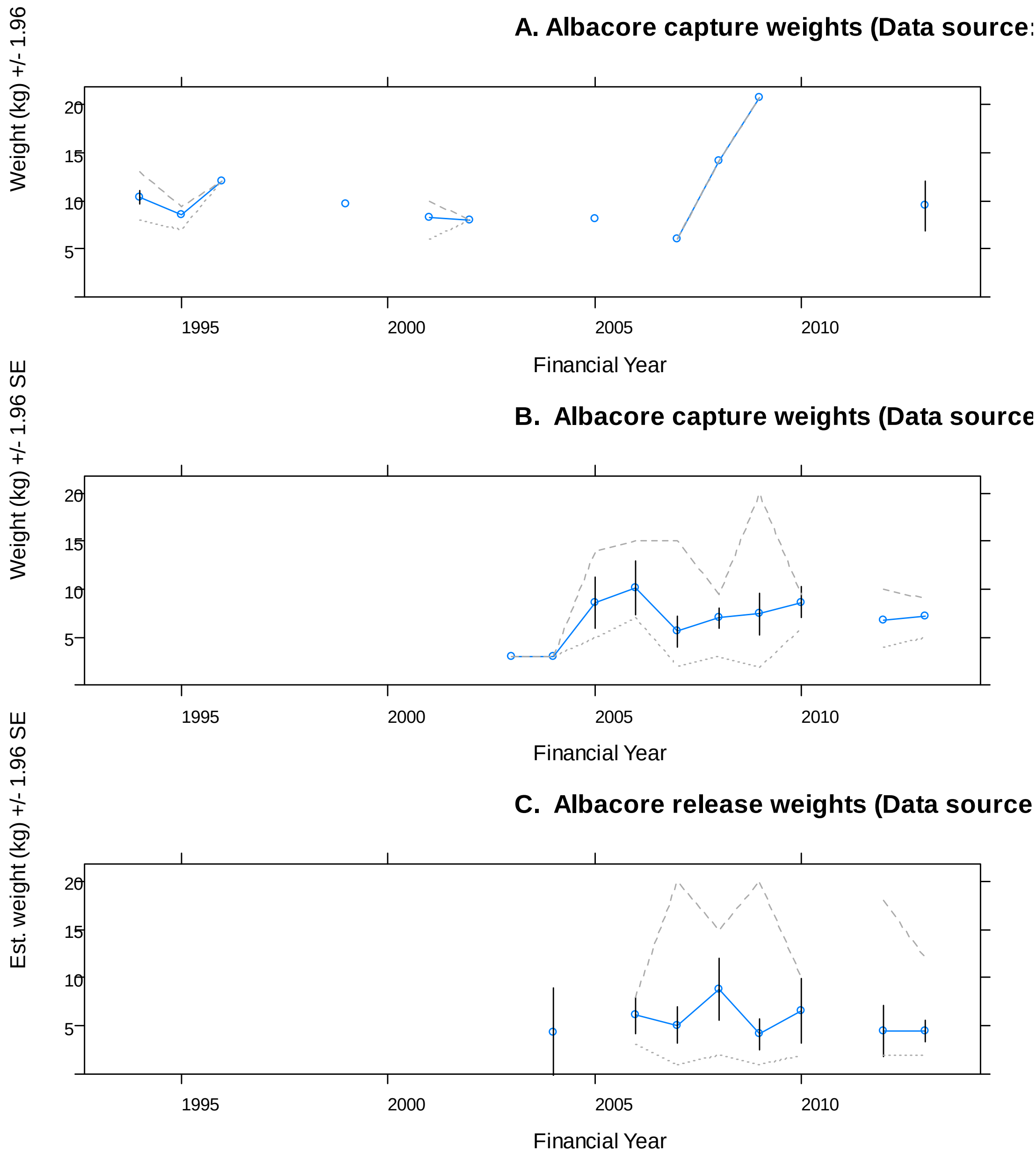


Figure 20. Albacore minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)



4.4.4. Other game fish

Release ratios for skipjack tuna compared with all other species had the greatest disparity between scheds versus interviews. While 81% of skipjack were released based on sched data, only 39% were released based on a combination of sched and interview data (Table 16). Skipjack tuna are only a point-score species in game fish tournaments for junior anglers. They are commonly caught incidentally while trolling for billfish, resulting in low records of this species from scheds, while low release ratios and significantly higher catches are recorded in interviews (Table 16). They are also a favourite bait fish species for game fish tournament fishers, and are often kept when incidentally caught, even when the fishing party were not specifically targeting them for bait collection.

There have been no notable significant changes to the size of skipjack tuna caught over the monitoring period, with mean weights for both captured and released fish at around 3 kg (Figure 21). There were a few notable captures of skipjack of more than 10 kg, such as one 12.8-kg fish being caught in 2013. This is close to the maximum attainable size for this species (Figure 21).

Mahi mahi release ratios were high at 81% (Table 16). This trend may be related to the maximum sizes attainable, with fish recorded being less than 30 kg (Figure 22). The largest mahi mahi recorded for the monitoring program weighed 29 kg and was caught in 2003 (Figure 22B). The smaller size of mahi mahi make this species difficult to meet minimum sizes for capture points of equal to the line class used. Mahi mahi are also known for their good eating qualities, and need to weigh equal to the line class to meet the minimum size for capture points. Hence, many mahi mahi are caught and keep for food rather than point score, explaining the disparity between release ratios recorded on the scheds versus the combination of scheds and interviews (9% lower from sched and interview data combined versus scheds; Table 16). This difference is also evident in the mean weights of captured mahi mahi from the tournament weigh station, at between about 10 to 20 kg (with line classes of 8, 10 and 15 kg most commonly used to catch smaller game fish), versus the interviews at between about 5 and 10 kg, which is less than the minimum weight required for capture point score dependent on the line class used (Figures 22A and B).

Weights of captured mahi mahi obtained from interviews indicate a slight decreasing trend in the maximum sizes of this species over the past ten years of monitoring (Figure 22B). This trend warrants detailed future investigation of all available data for this species to assess if current fishing practices are sustainable. Estimated average weights of released mahi mahi have not changed significantly over the monitoring period, although mean weights were significantly less in 2013 than in most previous years (Figure 22C).

Yellowtail kingfish had the highest release ratios of all game fish species at 93% (Table 20). Due to the low numbers of fish captured, there are no discernible differences in the capture weights available (Figures 23A and B). Mean estimated weights of released kingfish were about 2 to 3 kg each year, with a significant increase to around 5 kg evident only in 2010 compared with some other years (e.g. 2006, 2008, 2013; Figure 23C).

Finally, wahoo release ratios have varied over the monitoring period, with an average of 55% (Table 19). Similarly to yellowtail kingfish, not enough wahoo were caught to ascertain any trends in the size data for either captured or released fish (Figure 24).

Figure 21. Skipjack (striped) tuna minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

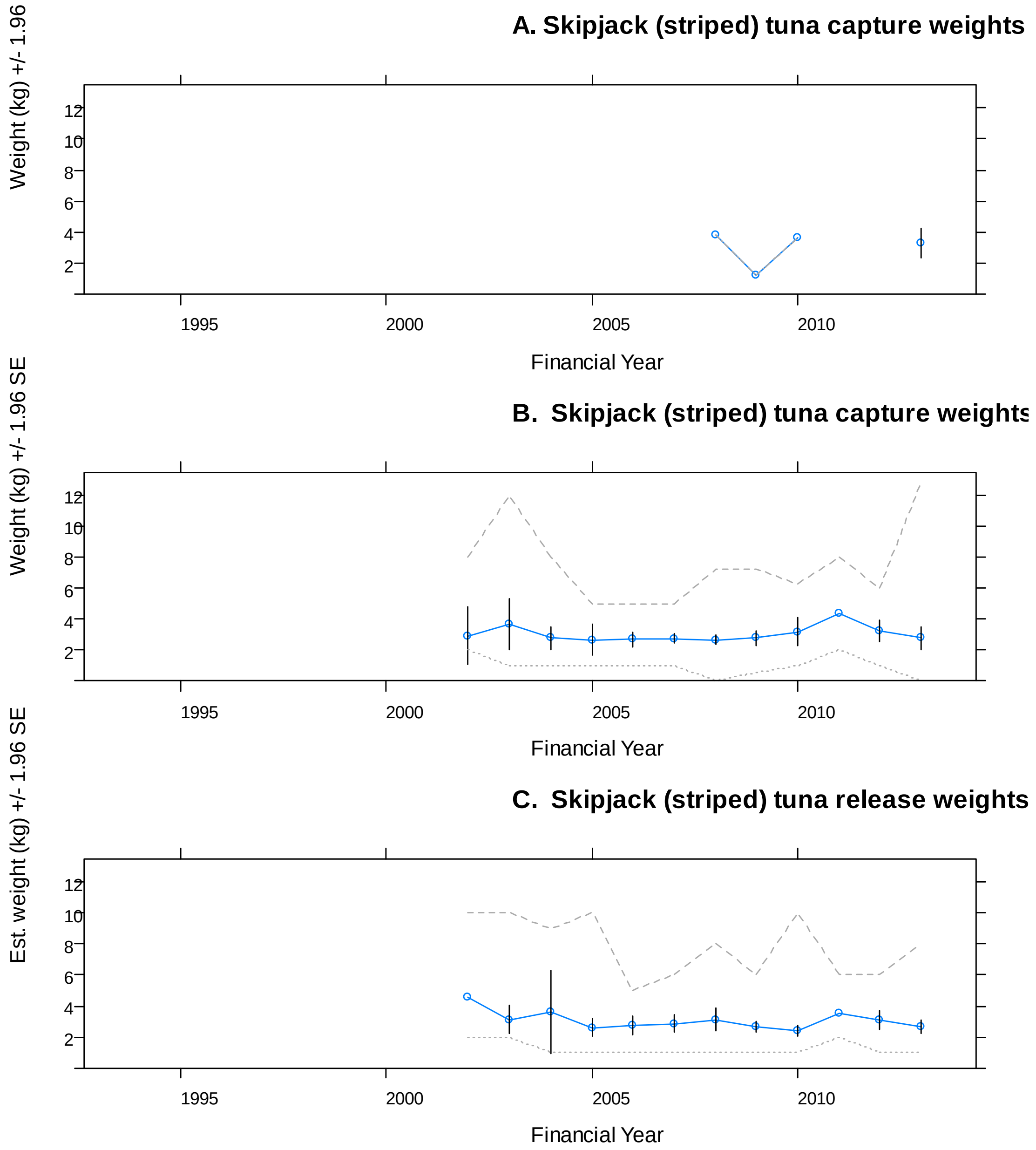


Figure 22. Mahi mahi minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

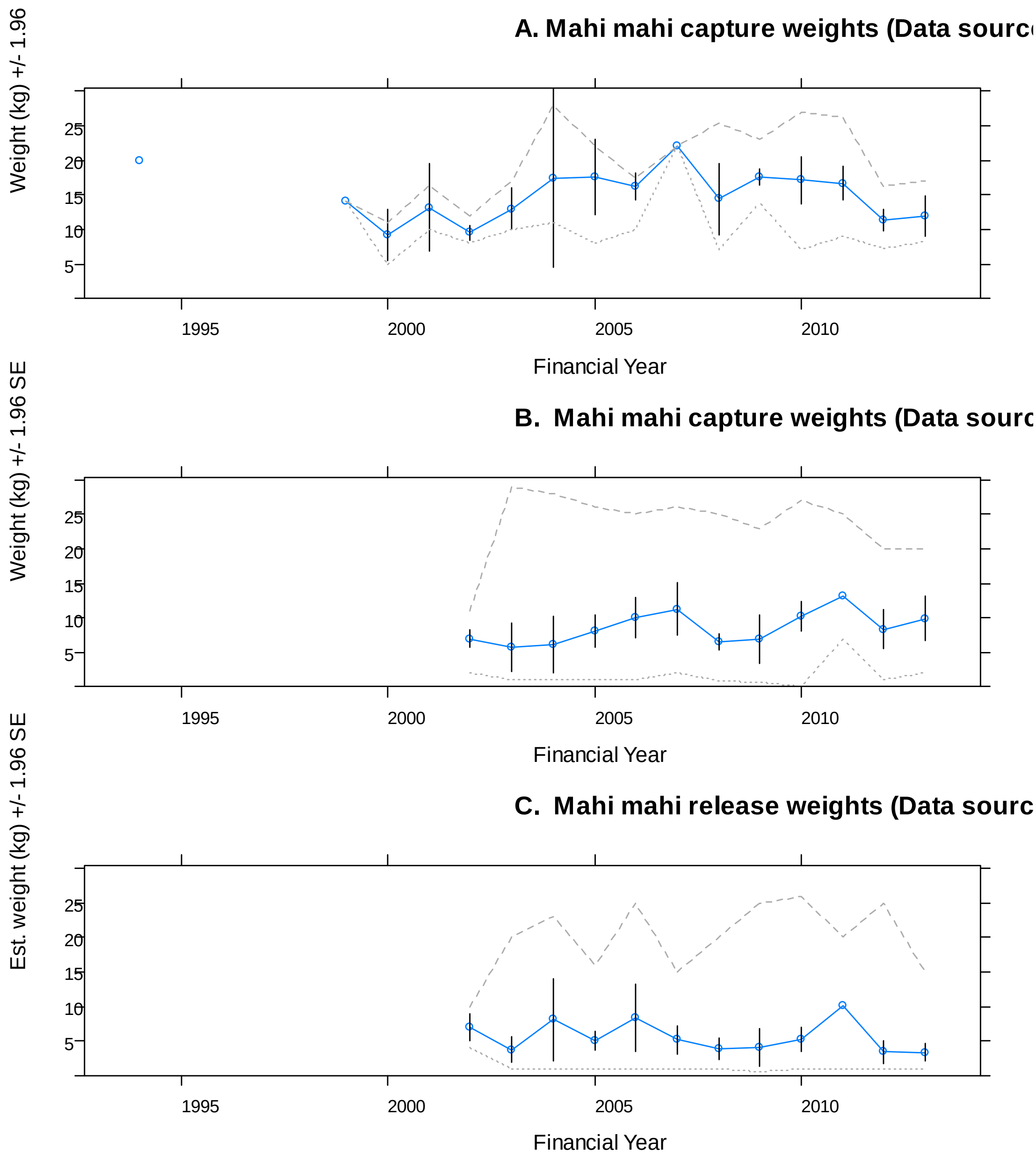


Figure 23. Yellowtail kingfish minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)

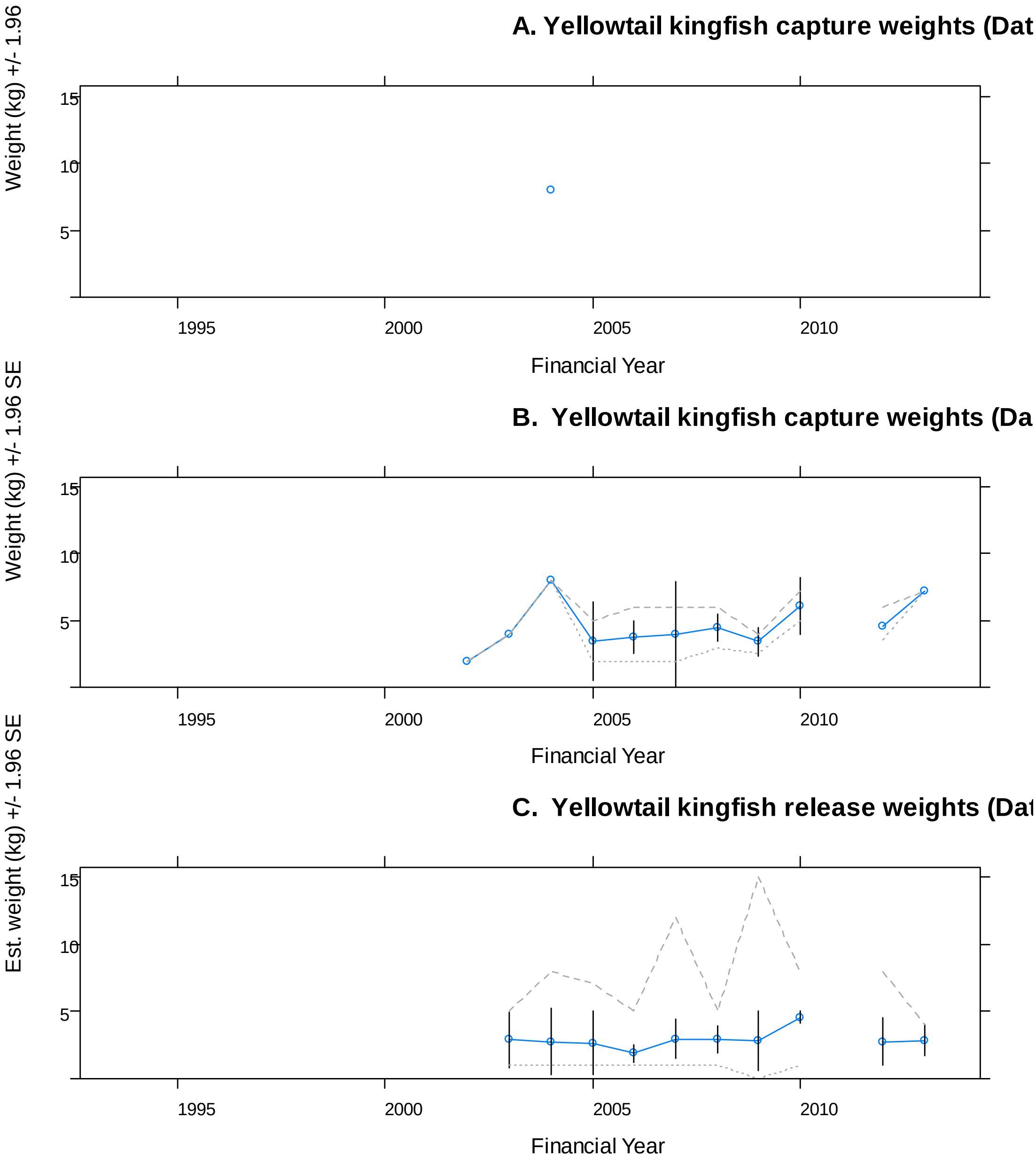
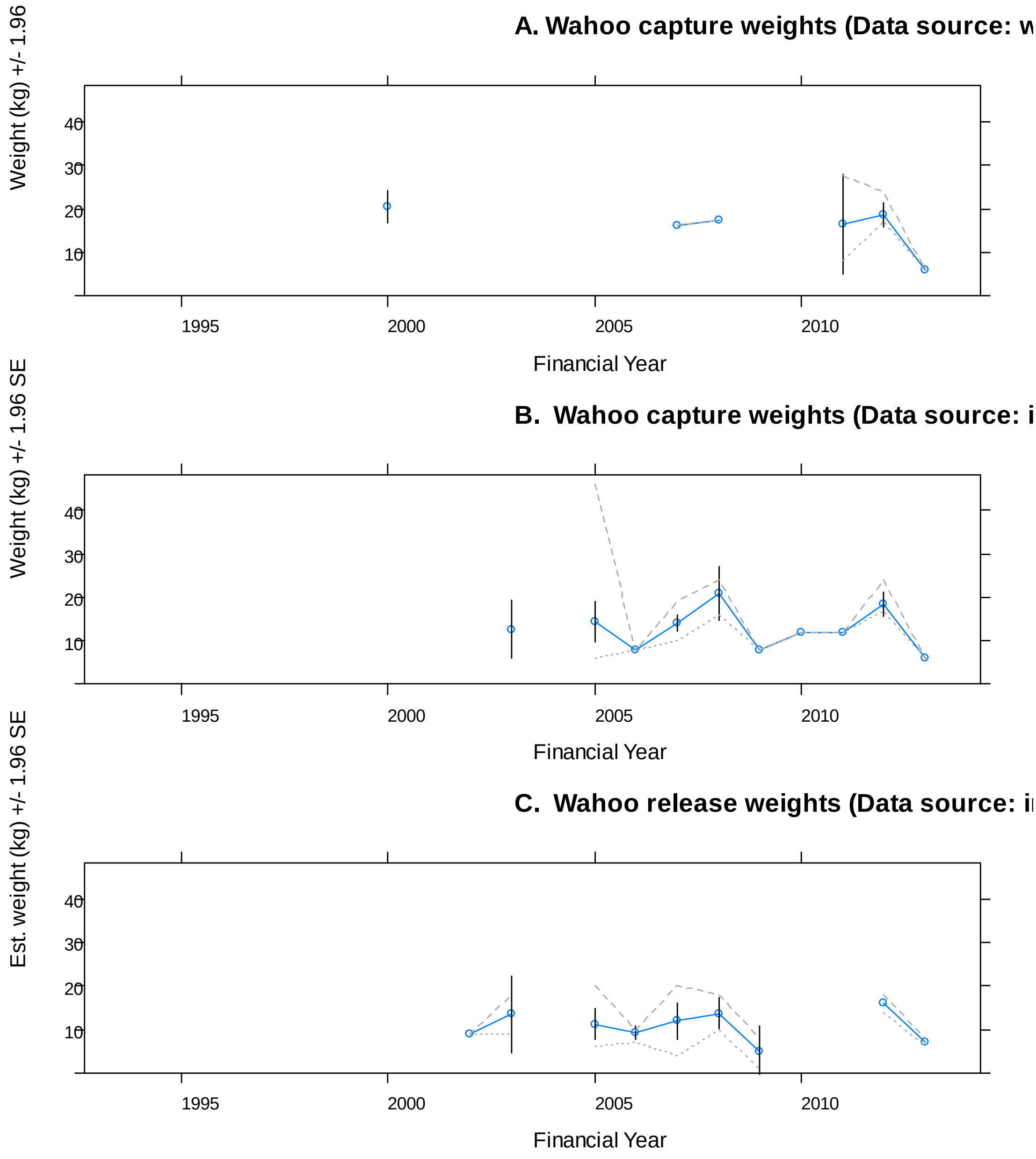


Figure 24. Wahoo minimum (dotted line), mean ± 1.96 standard error (SE, solid lines) and maximum (dashed line) fish weights in kilograms (kg) for each fishing year over the monitoring period from 1994 to 2013 for: A. Captured fish as actual weights as recorded via tournament weigh stations (scheds); B. Captured fish as actual weights as recorded via interviews; and C. Fish tagged and released or free released as estimated weights as recorded via interviews. Weights for years with no standard error are those with fish weights for only one tournament (i.e., N=1)



4.5. Directed fishing effort and catch rates

4.5.1. Directed fishing effort

Of the total 50451 fishing trips expended during monitored game fishing tournaments, the majority targeted billfish species (64% from scheds, 82% from interviews and 77% from final allocation; Table 20) followed by shark species (13% from scheds, 12% from interviews and 14% from final allocation; Table 20). This trend of billfish being the primary target category followed by shark species was evident for the North, Central and Port Stephens zones. In the South zone, the two primary target categories were billfish followed by other game fish (Table 20).

The billfish–shark category only represented about 3% of the directed fishing effort across all zones, while the ‘other’ target category was only able to be assigned to boats fishing in the two yellowfin tuna tournaments held in the South zone, representing 23% of that zone’s fishing trips (Table 20).

The targeting of other game fish as the primary target (i.e. most amount of time targeting other game fish species separately from billfish or sharks) was rare in the North, Central and Port Stephens zones (0.2%, <0.1% and 0.4%; Table 20). This is due to the low point scores obtainable by catching these species. These species were most commonly targeted for the majority of a day (while not targeting billfish or sharks at the same time) only when weather conditions were very poor and fishing parties needed additional point scores to increase their chances of winning the tournament.

The proportion of fishing trips classified as ‘unknown’ (due to insufficient information in the sched data to assign a target category) was highest in the North zone (20%), followed by the South zone (17%) and the Central and Port Stephens zones (both 6%; Table 20).

Table 20. Summary of the total number of fishing trips assigned to each of the directed fishing effort target categories using sched, interview data and the final assignment (which included allocation of unknowns based on probability distributions) for each zone (North, Port Stephens [PortS], Central and South) and across all zones (All). The percentage composition of each target category for each zone and across all zones (All) is also presented (Composition)

		Scheds		Interviews		Final	
Zone	**Target Category**	**No. fishing trips**	**Composition (%)**	**No. fishing trips**	**Composition (%)**	**No. fishing trips**	**Composition (%)**
North	billfish	3125	70.05	2028	91.47	4007	89.82
	shark	370	8.29	171	7.71	424	9.50
	billfshark	65	1.46	10	0.45	21	0.47
	other	0	0.00	8	0.36	9	0.20
	unknown	901	20.20	0	0.00	0	0.00
	Total	**4461**	**100.00**	**2217**	**100.00**	**4461**	**100.00**
PortS	billfish	14204	79.79	4186	89.31	15522	87.20
	shark	2099	11.79	404	8.62	2003	11.25
	billfshark	415	2.33	91	1.94	270	1.52
	other	0	0.00	6	0.13	6	0.03
	unknown	1083	6.08	0	0.00	0	0.00
	Total	**17801**	**100.00**	**4687**	**100.00**	**17801**	**100.00**
Central	billfish	5890	58.28	1367	60.01	6443	63.75
	shark	3187	31.54	798	35.03	3369	33.34
	billfshark	384	3.80	80	3.51	255	2.52
	other	0	0.00	33	1.45	39	0.39
	unknown	645	6.38	0	0.00	0	0.00
	Total	**10106**	**100.00**	**2278**	**100.00**	**10106**	**100.00**
South	billfish	9299	51.42	3948	80.18	12881	71.23
	other	4164	23.03	629	12.77	3629	20.07
	shark	1093	6.04	308	6.26	1392	7.70
	billfshark	438	2.42	39	0.79	181	1.00
	unknown	3089	17.08	0	0.00	0	0.00
	Total	**18083**	**100.00**	**4924**	**100.00**	**18083**	**100.00**
All	billfish	32518	64.45	11529	81.73	38853	77.01
	shark	6749	13.38	1681	11.92	7188	14.25
	other	4164	8.25	676	4.79	3683	7.30
	billfshark	1302	2.58	220	1.56	727	1.44
	unknown	5718	11.33	0	0.00	0	0.00
	Total	**50451**	**100.00**	**14106**	**100.00**	**50451**	**100.00**

billfshark=billfish-shark target category; other='other game fish' target category

4.5.2. Weighted catch rates

4.5.2.1. Billfish

Black marlin catch rates were indicative of the sporadic recruitment of black marlin to waters off NSW, with no overall upward or downward trend. Catch rates were highest in 1996–2000 and 2005–2006 (Figure 25A). This sporadic occurrence has been related to inter-annual changes in the sea surface temperature of waters arriving through the East Australian Current, which is driven by variations in the Southern Oscillation Index (Bridge 2006). High marlin abundance has been observed in sea surface temperatures of 25–27 °C (Bridge 2006).

Striped marlin annual catch rates indicate a relatively stable trend over the monitoring period, with 1994 being slightly lower than subsequent years and 1996 displaying the highest catch rate (Figure 25B). There is large uncertainty in these catch rates estimates, given the overlapping confidence intervals, so caution should be taken when interpreting these trends (Figure 25B). However, catch rates of striped marlin changed significantly from the mid to the late 1990s, which mirrors the change observed in commercial fisheries catch rates (Davies *et al.* 2012; Knight *et al.* 2006; Langley *et al.* 2006). Commercial fisheries catch rates after this change have declined rather than remained stable, as observed for the tournament catch rates. This may indicate the potential for hyperstability in the game fish tournament catch rates, whereby the abundance of the stock may be declining while recreational catch rates remain stable. The influence of environmental changes and how this affects the fishing methods used and the availability of marlin to the fishery is not well understood. Attempts to standardise the tournament catch rates, incorporating environmental and fisheries variables (such as fishing location presented in Ghosn *et al.* 2012), resulted in a down-weighting of the increased catch rates observed in the later part of the monitoring period. However, the standardised tournament catch rates still remained higher than the predictions in the 2012 stock assessment model for the recreational striped marlin fishery (Davies *et al.* 2012; Ghosn *et al.* 2012). A detailed analysis of changes to fishing methods used over time is required to investigate fishing power changes (i.e., fishing efficiency) of recreational tournament fishing for striped marlin. Detailed post-fishing interview data obtained over the recent monitoring period could be used to investigate this issue in the future.

Blue marlin catch rates were highest in 1998 and 1999, followed by a decrease in 2001. Since 2001, catch rates increased slightly, with a lower catch rate in 2013. However, there is uncertainty in these catch rates, given the overlapping 95% confidence intervals (Figure 25C). Hence, caution should be used when interpreting this trend.

The methods used to target blue marlin, such as trolling lures further offshore east of the continental shelf, have reportedly not changed over the monitoring period – unlike the fishing methods used to target striped marlin. It is therefore plausible that blue marlin catch rates have not been influenced by fishing efficiency changes over the monitoring period. Assuming there have been no significant changes in the fishing methods used to target blue marlin, this species' abundance has not changed significantly over the monitoring period, as indicated by the stability of the tournament catch rates (Figure 25C). The most recent stock status for the

Pacific Ocean blue marlin stock reflects this trend, indicating that the stock is not being subject to overfishing. However, the stock status is defined as nearly fully exploited, so as a precaution, current levels of fishing mortality should not increase (Billfish Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean 2013).

Shortbill spearfish catch rates were indicative of the sporadic occurrence of this species in waters off NSW, with large inter-annual variability over the monitoring period. The CPUE was zero or close to zero in seven out of the 20 years of monitoring. Catch rates for shortbill spearfish were highest in 2002 and 2011, but large overlapping confidence intervals indicate that no statistically significant difference was found (Figure 25D). Caution should therefore be used when interpreting this trend.

4.5.2.2. Sharks

Catch rates for all five of the main shark species were highly variable over the monitoring period, with large overlapping confidence intervals; i.e., no statistical difference could be detected between most years using 95% confidence intervals ($p>0.05$; Figures 26 and 27). There was no evidence to suggest any overall declines in shark abundance or fishing quality for any species over the monitoring period (Figures 26 and 27).

Mako shark catch rates were highest in 1999 and 2013 and lowest in 1998 and 2007 (Figure 26A). There was an overall slight increasing trend in these mako shark catch rates, but confidence intervals were overlapping; hence, no statistical difference ($p>0.05$) could be detected between years (Figure 26A).

Blue shark catch rates were significantly lower in 1994 and 2007 compared to most other years of monitoring, and highest – albeit with large uncertainty – in 1997, 1999 and from 2008–2010 (Figure 26B). Overall, blue shark catch rates from 2008 onwards have been relatively stable, after a declining trend from 1997–2007 (Figure 26B).

Tiger shark catch rates were variable and confidence intervals consistently high over the monitoring period, with no evidence of an increasing or decreasing trend (Figure 26C). However, the catch rate in 2009 was much lower than most other years, and statistically significantly lower ($p<0.05$) than five of the other 19 monitoring years (Figure 26C).

The catch rates for hammerhead sharks were highly variable over the monitoring period, and relatively low compared with the catch rates for the three primary shark species: mako, blue and tiger sharks (Figure 27A). Some years displayed higher catch rates (with very large confidence intervals), yet other years had very low catch rates close to zero, with 2008 being statistically significantly different to many of the previous monitoring years (Figure 27A). This indicates a potential decline in the catch rates of hammerhead sharks from the start of monitoring to 2008. Hammerhead catch rates peaked from 2009–2010, followed by a possible decline that was evident up to 2013. This is difficult to interpret, given the recent listing of scalloped and great hammerhead sharks as endangered and vulnerable species, respectively, and the large overlapping confidence intervals (Figure 27A). Caution should be taken with these catch rate trends given the large overlapping confidence intervals, and because this catch rate trend represents a mix of hammerhead shark species. This pattern is also indicative of a species that was not often specifically targeted by game fish tournament anglers, except in cases when weather conditions were poor and vessels would drift close to shore, targeting this species group for the purpose of tagging and releasing juvenile sharks. Hammerhead sharks are often caught incidentally while targeting primary shark species, such as mako and tiger sharks, or while drifting and targeting billfish with live baits.

Whaler shark catch rates were also variable over the monitoring period, with no evidence of an upward or downward trend and with large overlapping confidence intervals between monitoring years. Years that displayed very low catch rates, and all years with high catch rates, had very large confidence intervals around the catch rate estimates (Figure 27B). Again, these trends are indicative of a species that was not specifically targeted by game fish tournament anglers. The whaler sharks category represents a mix of species caught incidentally while targeting the primary shark species. As per hammerhead sharks, caution should be taken when interpreting these catch rate trends, given the large overlapping confidence intervals and because this catch rate trend represents a mix of whaler shark species.

4.5.2.3. Large tunas

Albacore catch rates were relatively low over the monitoring period (<0.1 per boat per day per tournament in 15 out of the 20 years; Figure 28A). There was no evidence of an increasing or declining trend in catch rates for albacore, with the highest catch rates in 1994, 1998 and 2009 (Figure 28A). The highest catch rate in 2009 was characterised by most tournaments with a zero catch rate, five tournaments with positive yet low catch rates (<0.3 fish per boat per day) and two tournaments with very high catch rates (one held out of Greenwell Point with a catch rate of 15.3 fish per boat per day, and another held out of Wollongong with a catch rate of 8.7 fish per boat per day). These catch rates are indicative of a schooling species – once a school of fish is encountered, high catch rates are attainable. However, given the large overlapping confidence intervals of the albacore catch rates, caution should be used when interpreting this trend.

Yellowfin tuna catch rates fluctuated over the monitoring period, with some significant changes over time when catch rates are compared each year, but with large overlapping confidence intervals in most years (Figure 28B). The catch rates for yellowfin tuna in 2002, 2007 and 2008 were significantly higher than the catch rates in 2001, 2004, 2011 and 2012 (Figure 28B). This inter-annual variability is likely to be related to environmental variables, such as eddy formations, chlorophyll *a* concentrations, depth of the mixed layer, sea surface temperatures and the distribution of yellowfin tuna prey in relation to these variables (Dell *et al.* 2011; Young *et al.* 2001). Given the evidence from these studies about the relationships between the environment and yellowfin tuna abundance, modelling to investigate the relationship between environmental variables and game fish tournament catch rates would be invaluable for future assessments. This would greatly improve our understanding of the availability of yellowfin tuna in relation to the recreational fishery in NSW. Given the expected influence of environmental variables on the catch rates for this fishery, it is likely that these weighted catches are not providing a good measure of stock abundance. This also highlights the importance of catch rate standardisation to reduce the influence of environmental variables on catch rate estimates.

4.5.2.4. Other game fish

Catch rates for the two main other game fish species (skipjack tuna and mahi mahi) indicate an increasing trend over the monitoring period (Figures 29A and B). However, confidence intervals are large and overlapping, and there have been changes in the targeting of these species; hence, caution should be used when interpreting these trends (Figures 29A and B). The increase in skipjack tuna catch rates in the later years of monitoring is thought to be indicative of a shift in targeting preferences, with the introduction of point score for junior anglers for this species in 2009. Hence, it is difficult to attribute the increasing trend in catch rates for skipjack tuna to fish abundance (Figure 29A). Catch rates derived from the targeting of this species for bait collection from interview data may provide a better measure of the abundance of this species over the monitoring period. However, interview data of this nature are not available in all monitoring years.

Similarly to skipjack tuna, mahi mahi catch rates indicate an overall increasing trend in fishing quality (Figure 29B). There is uncertainty in this trend, due to the larger overlapping confidence intervals and the potential for changes in the reporting of this species on the radio scheds (Figure 29B). The CPUE for mahi mahi was lowest in the first four years of monitoring (1994–1997), followed by higher and more variable annual CPUE in subsequent fishing years (Figure 29B). The lower catch rates observed for the earlier years of monitoring may be a result of non-reporting of mahi mahi catches on the scheds. Given that interview data are not available for these earlier years, catch rates may have been high for mahi mahi caught and kept for food, as opposed to those caught for the purpose of tournament point score (and thus more likely to be reported on the scheds).

Catch rates of yellowtail kingfish and wahoo were also notably lower in the earlier years of monitoring, suggesting the potential for non-reporting of these species on the radio scheds in those years (Figures 29C and D). Yellowtail kingfish catch rates were highest in 2001, 2003, 2008 and 2009, although these higher catch rates were not significantly different to those in the surrounding fishing years, given the large overlapping confidence intervals (Figure 29C).

Wahoo CPUE was highest in 1999, 2005, 2007, 2011 and 2013. However, these catch rates were not significantly different to most of the surrounding fishing years, with large overlapping confidence intervals (Figure 29D).

Figure 25. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) for: A. black marlin, B. striped marlin, C. blue marlin and D. shortbill spearfish

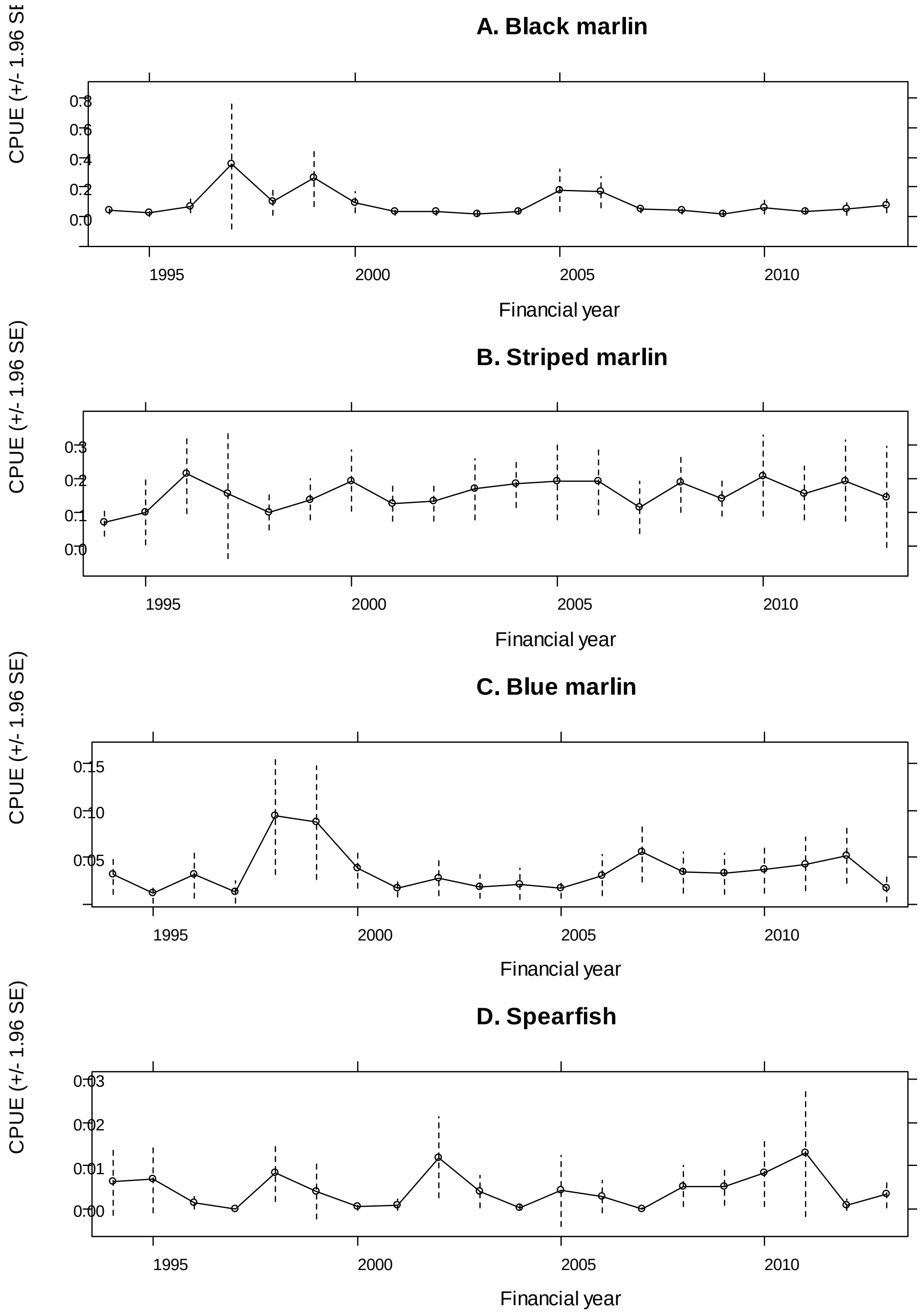


Figure 26. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for the three main shark species recorded to be caught in game fishing tournaments: A. mako shark, B. blue shark and C. tiger shark

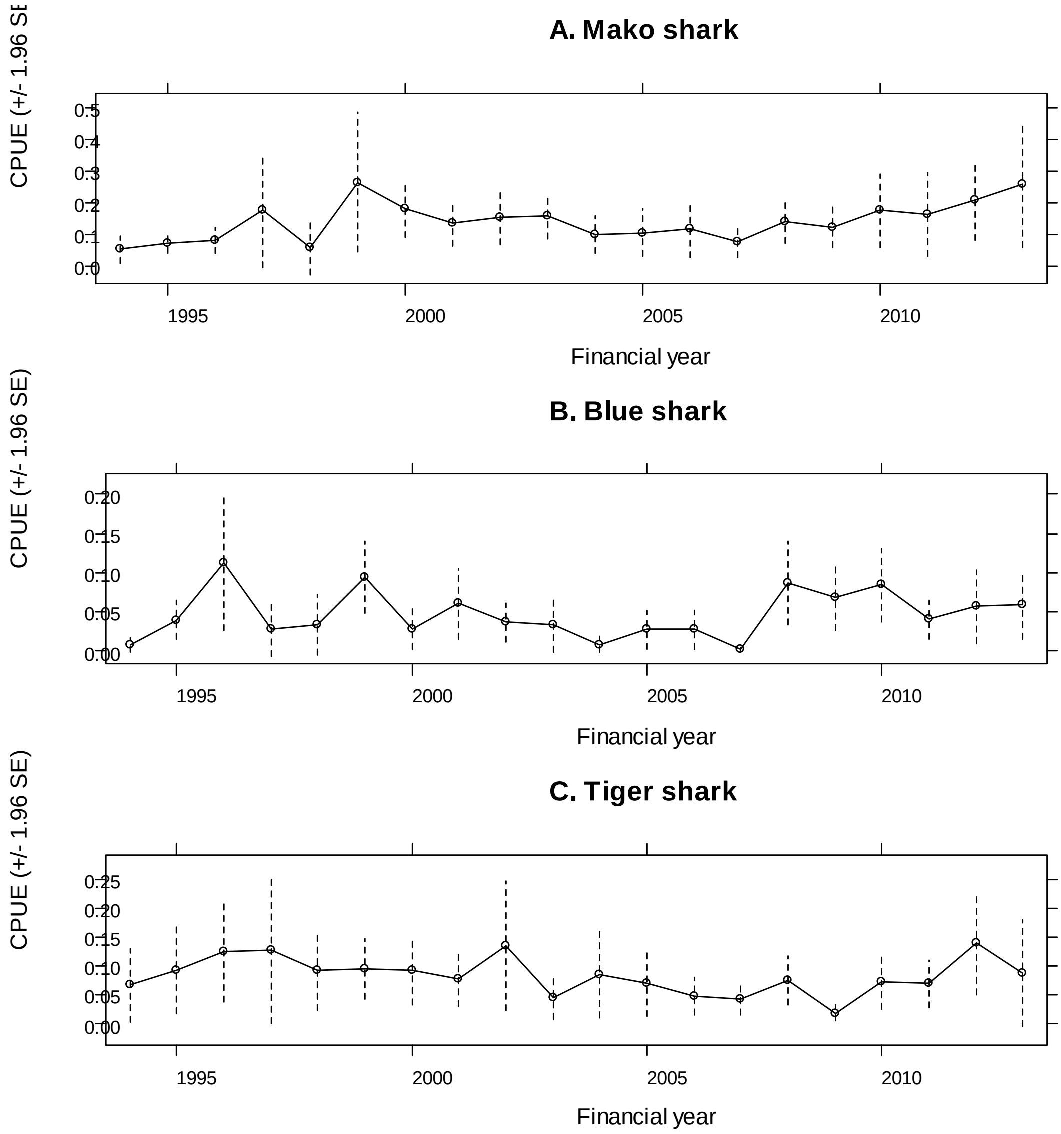


Figure 27. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for composite shark species groups: A. hammerhead sharks and B. whaler sharks

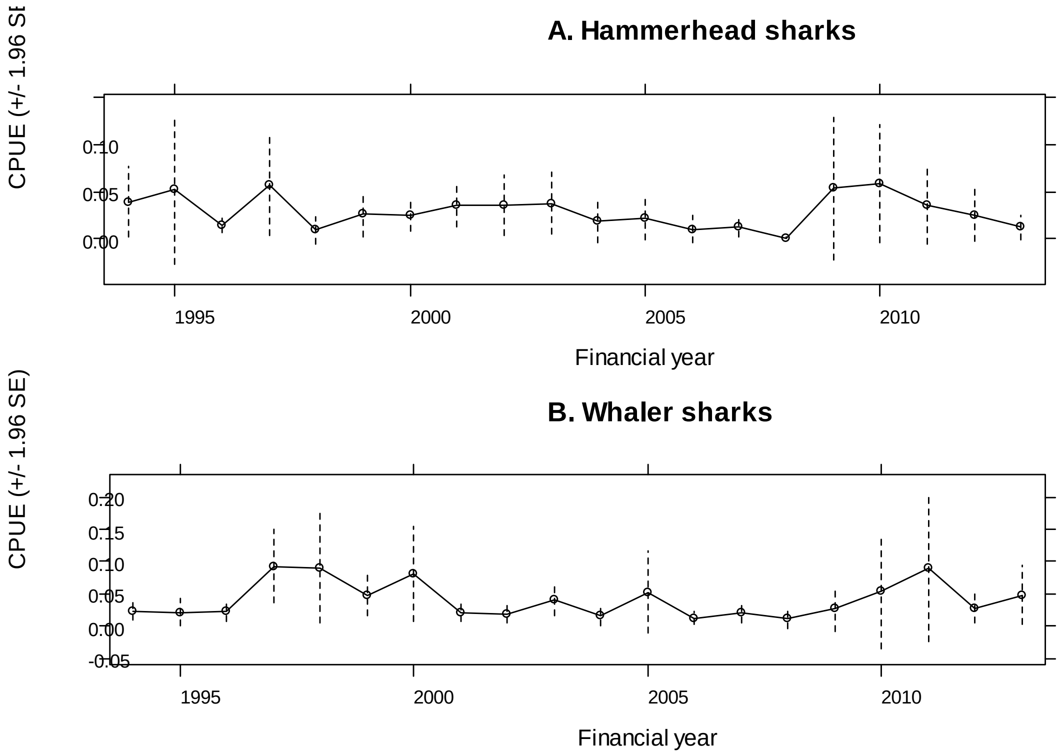


Figure 28. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for large tuna species: A. albacore tuna and B. yellowfin tuna

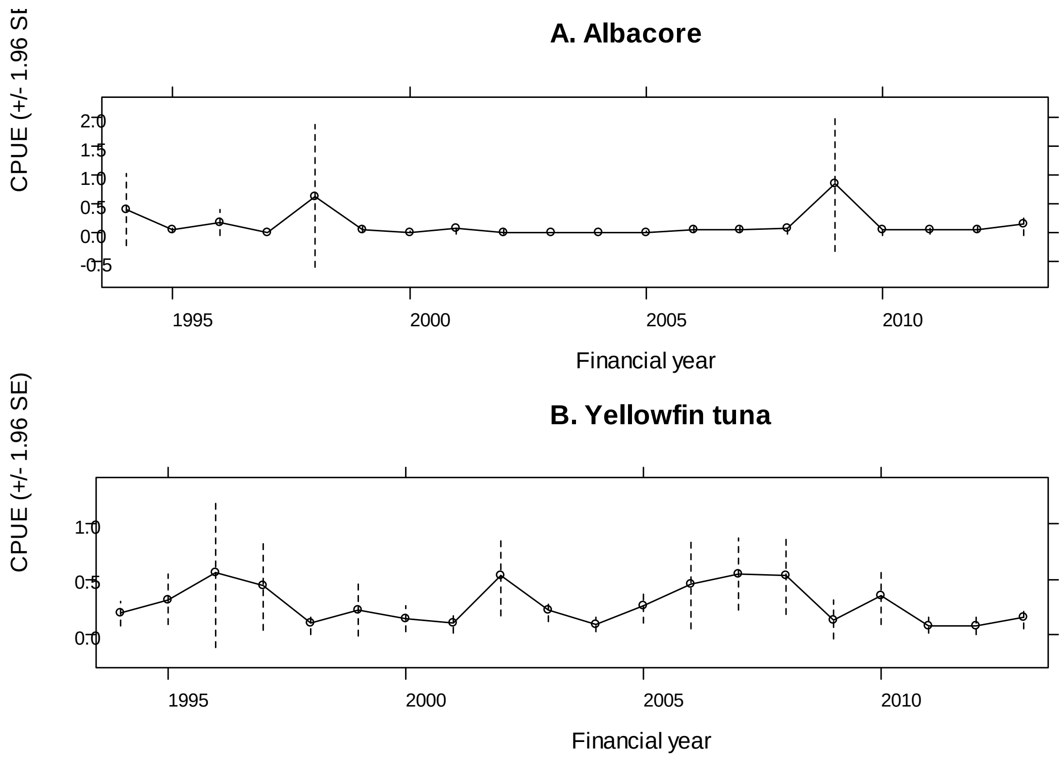
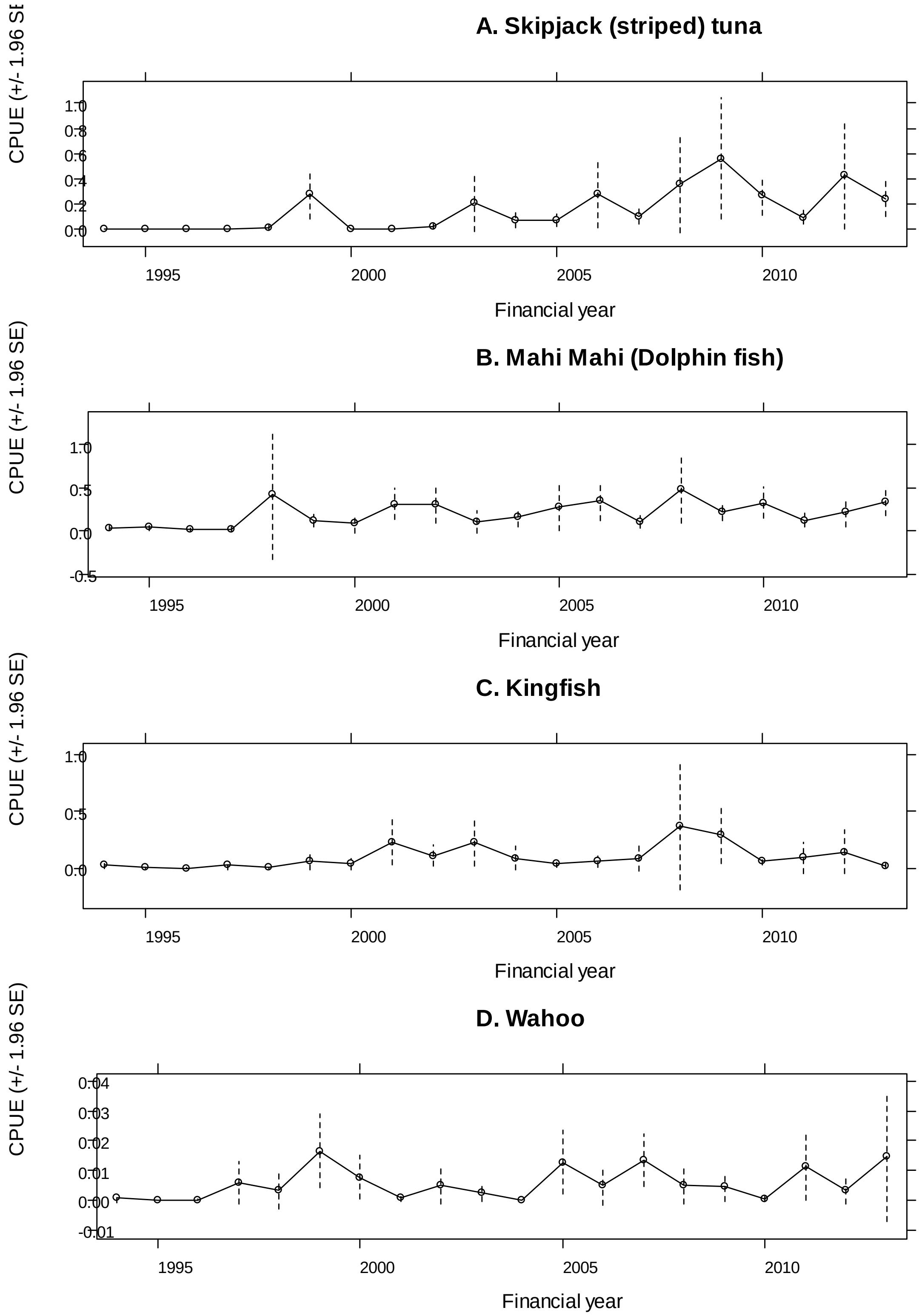


Figure 29. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for other game fish species: A. skipjack (striped) tuna; B. mahi mahi (dolphin fish), C. yellowtail kingfish and D. wahoo



4.5.3. Weighted catch rates by target category

4.5.3.1. Billfish

For all billfish species, catch rates were highest for boats that were categorised as targeting billfish (Figure 30). One exception to this trend was evident for striped marlin in 2013, when the catch rate for boats categorised as billfish–shark was higher than for boats identified as targeting just billfish (Figure 30B). This trend supports the use of weighted catch rates. If we only used the data for boats that were categorised as targeting billfish only (as per previous methods used; Murphy *et al.* 2002; Park 2007; Pepperell and Henry 1999) then we would have observed that the catch rates of striped marlin had declined compared with previous years. Rather, the catch rates for striped marlin have remained stable, as indicated by the weighted catch rates (Figure 25B).

4.5.3.2. Sharks

Catch rates for shark species were highest for boats that were categorised as targeting sharks (Figures 31 and 32). However, in several years, catch rates for boats categorised as billfish–shark were equivalent or higher than the catch rates for boats categorised as targeting sharks (Figures 31 and 32).

4.5.3.3. Large tunas

Albacore catch rates were highest for boats categorised as targeting billfish, indicating that albacore was primarily caught incidentally while targeting billfish species (Figure 33A). However, in some years, catch rates for albacore were higher for boats categorised as ‘other’, indicating the years when albacore occurrence was higher during the yellowfin tuna tournaments held out of Bermagui and Batemans Bay (Figure 33A).

Catch rates for yellowfin tuna were also highest in most years for boats categorised as targeting billfish (Figure 33B). However, catch rates were higher (although not significantly) in 1996, 2008 and 2009 for boats categorised as targeting ‘other’ game fish (Figure 33B).

4.5.3.4. Other game fish

Catch rates by target category for all other game fish species, including skipjack (striped) tuna, mahi mahi and yellowtail kingfish, were not dominated by one particular target category (Figures 34A, B and C). Wahoo catch rates were highest in most years for boats categorised as targeting billfish (Figure 34D). These trends reflect the incidental catch of these species by game fish tournament fishers, because they return low point scores during tournaments.

Figure 30. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) for each target category (billfish, billfish–shark [bilfshark], other and shark) and billfish species: A. black marlin, B. striped marlin, C. blue marlin and D. shortbill spearfish

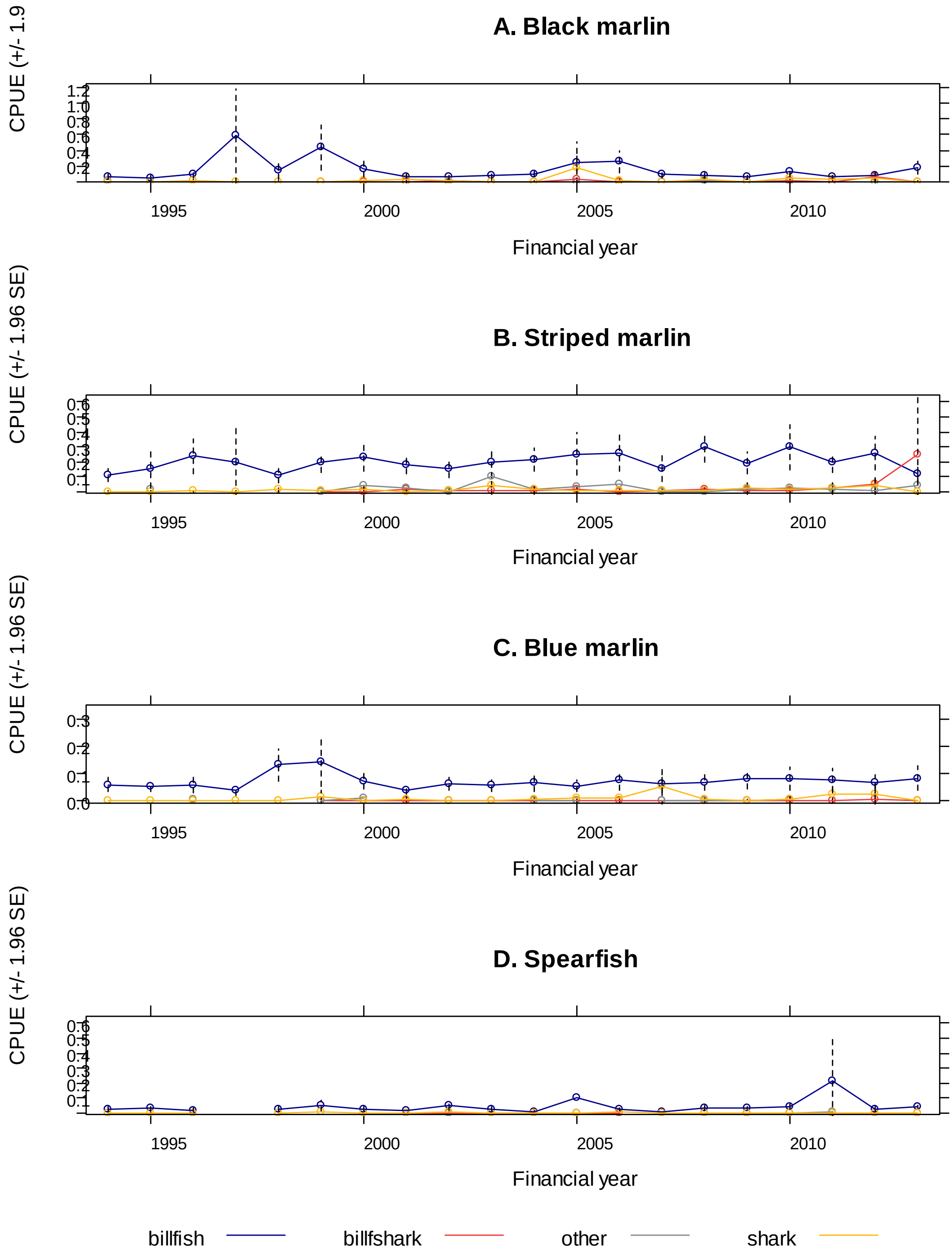


Figure 31. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for each target category (billfish, billfish–shark [bilfshark], other and shark) and shark species: A. mako shark, B. blue shark and C. tiger shark

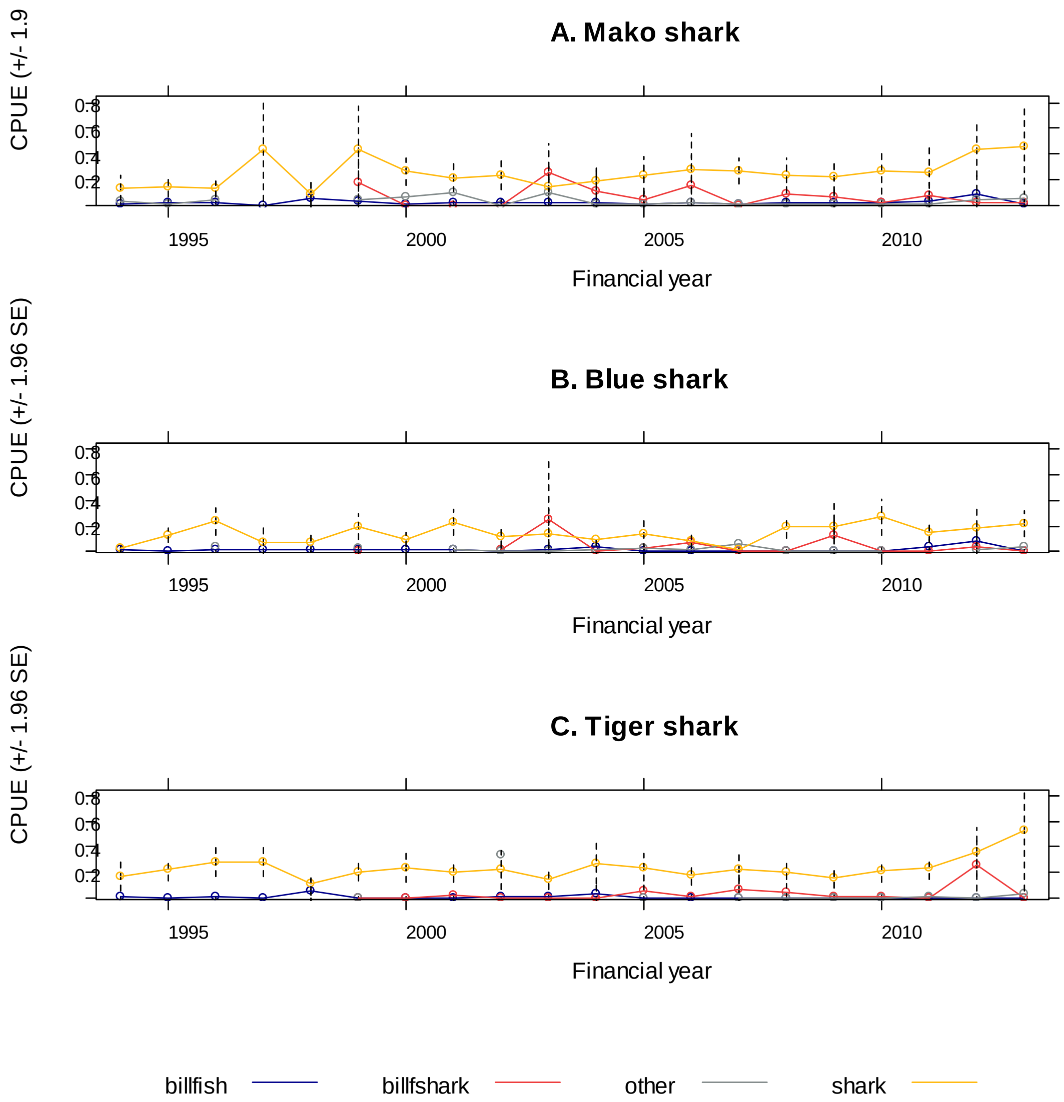


Figure 32. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for each target category (billfish, billfish–shark [bilfshark], other and shark) and shark species: A. hammerhead sharks and B. whaler sharks

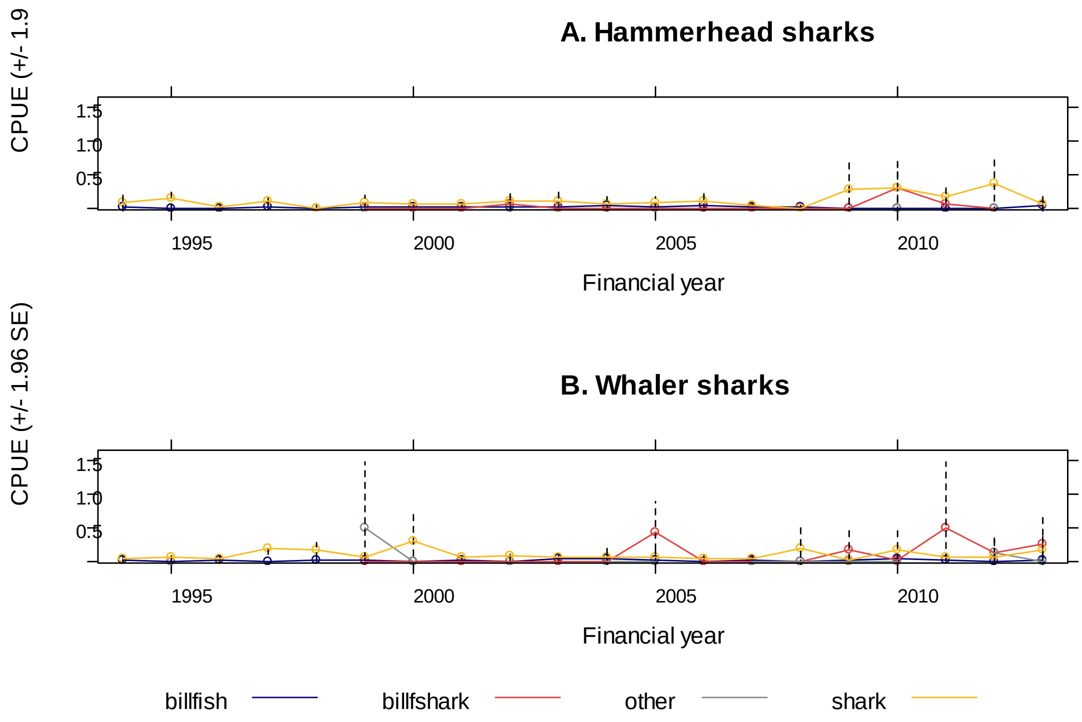


Figure 33. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for each target category (billfish, billfish–shark [bilfshark], other and shark) and for large tuna species: A. albacore and B. yellowfin tuna

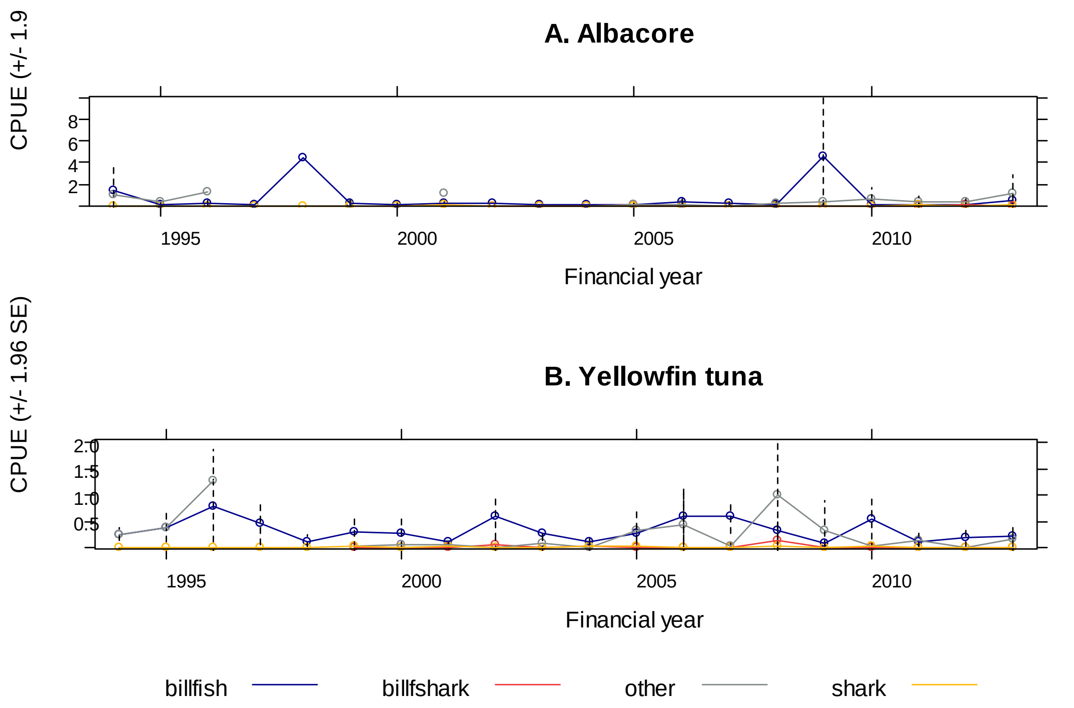
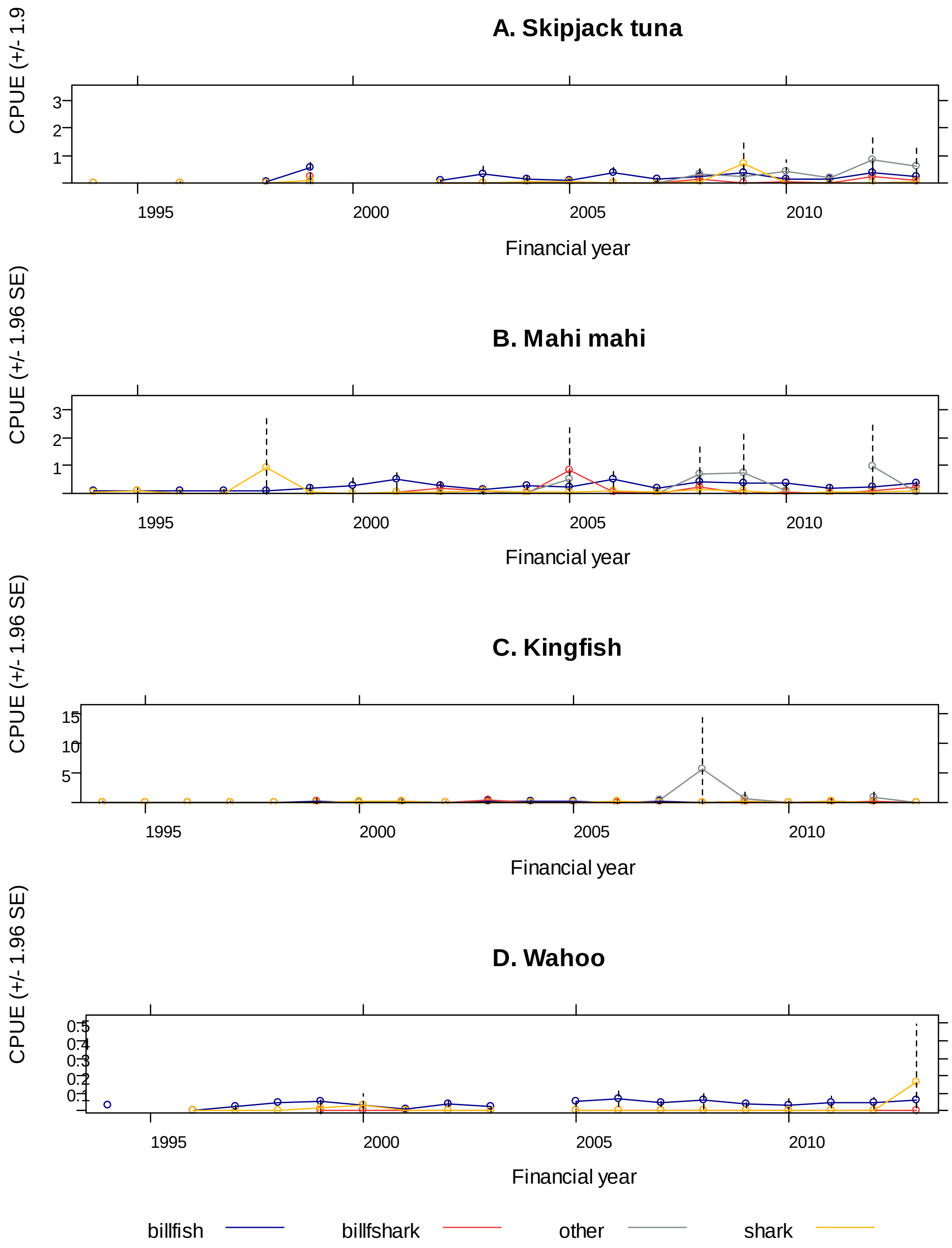


Figure 34. Weighted catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for each target category (billfish, billfish–shark [bilfshark], other and shark) and for other game fish species: A. skipjack (striped) tuna; B. mahi mahi (dolphin fish), C. yellowtail kingfish and D. wahoo



4.6. Future monitoring design

4.6.1. Differences between sched and interview fishing effort target categories

4.6.1.1. North zone

Interview and sched data both demonstrate the North zone as a predominantly billfish fishery. Thus, for the purpose of collecting accurate fishing effort target data, post-fishing interview data were not able to provide improvements for this zone. However, large numbers of boats were unable to be assigned to a target category based on sched data, and hence were assigned to the ‘unknown’ category (Figure 35). The proportion of boats assigned to the same target category based on scheds and interview data was close to one for all target categories except billfish–shark. This category was not influential because it represents only a small proportion of the fishing effort (Figure 35). On the basis of these results, post-fishing interviews in the North zone could be reduced in the future, because we are confident that close to 100% of boats are targeting billfish. We could use targeting ratios as probability functions as an average of the past 5 years to assign those boats in the ‘unknown’ category to one of the four target categories (billfish, billfish–shark, shark or other game fish). As a precautionary measure, post-fishing interviews should be held at least every three years for each of the two North zone tournaments to identify any changes in this directed fishing effort trend. An increase in the amount of fishing method data recorded on the scheds – i.e., whether boats are trolling, drifting or anchored per sched – would reduce the proportion of boats that need to be assigned to a target category (due to lack of method data on the scheds) based on targeting ratios. This would improve the accuracy of directed fishing effort data for this zone.

4.6.1.2. Port Stephens zone

The differences between sched and interview fishing effort target categories for the Port Stephens zone (based on the interclub tournament only) were highly variable over the monitoring period relative to the other zones (Figure 36). Since around the early 2000s, Port Stephens has been renowned for striped marlin fishing, with fishing methods shifting towards the direct targeting of this species. The number of boats targeting both marlin and sharks within the same day has increased. Fishing parties that would traditionally target shark are taking advantage of the marlin availability by trolling en route to the shark fishing grounds. Boats targeting sharks are also floating live baits to target billfish while drifting for sharks. These factors, along with variables such as weather conditions, may explain the variability in the targeting proportions evident for the Port Stephens zone. Consequently, this zone should ideally be monitored more closely by undertaking post-fishing interviews every year, which will provide accurate classification of directed fishing effort target categories at the year and zone level for the Port Stephens Interclub tournament. Changes could then be reassessed in another few years to identify whether the trend has stabilised. Thus, we could identify whether targeting ratios used to assign ‘unknown’ boats to a target category could be based on an average of the past three years, or whether interviews need to be continued.

4.6.1.3. Central zone

The Central zone has a greater mix of fishing parties targeting billfish and sharks. However, differences between sched and interview target categories were low in this zone in most years, and not significantly different over the past five years of monitoring (Figure 37). With the proportions close to one and not changing significantly in recent monitoring years, this zone does not require intensive post-fishing interviews for the purpose of improving fishing effort data for tournaments. For precautionary reasons, we recommend holding post-fishing interviews at least once every three years for each of the Central zone tournaments to identify any shifts in targeting behaviours. These interviews could be undertaken on a rotating basis, with all ongoing tournaments randomly selected for interview without replacement over a three-year period, as opposed to the previous method of yearly interviews.

4.6.1.4. South zone

Mis-classification of fishing target categories using sched data was more variable for the South zone than the Central zone (Figure 38). The higher proportion of boats targeting tunas and the high proportion of missing fishing effort data recorded from scheds for this zone influenced the observed variability. Boats in some fishing grounds may also commonly target striped marlin using drifting methods, as used in the Port Stephens zone; such boats would be identified as targeting sharks based on scheds data alone. Consequently, mis-classification of the shark target category on the scheds has been highly variable.

A similar approach is recommended for the South zone to that of the Central zone. However, the tournament held out of Jervis Bay should ideally include post-fishing interviews each year for the next three years, because it had the greatest disparity between scheds and interviews and was highly influential on the differences in the proportions in 2006–2008. Hence, the Jervis Bay tournament will require closer attention to investigate the mis-classification of shark fishing boats. The remaining tournaments from the South zone should be selected at random for interviews without replacement over a three-year period. Survey staff should also work closely with radio operators in this zone to increase the quality of fishing method data recorded on the scheds, thereby reducing the proportion of boats requiring assignment from the ‘unknown’ target category based on targeting ratios.

Figure 35. The average proportion of boats per tournament by financial year end (game fishing season) for the North zone with 95% confidence intervals (CI) (±1.96 standard error, SE) assigned to each target category based on interviews within each target category assigned using scheds data: billfish, billfish–shark (bilfshark), shark and unknown. The top line of numbers is the total number of boats assigned to each of the sched method categories based on the scheds fishing methods data. The bottom line of numbers is the total number of boats interviewed in each of the assigned sched method categories

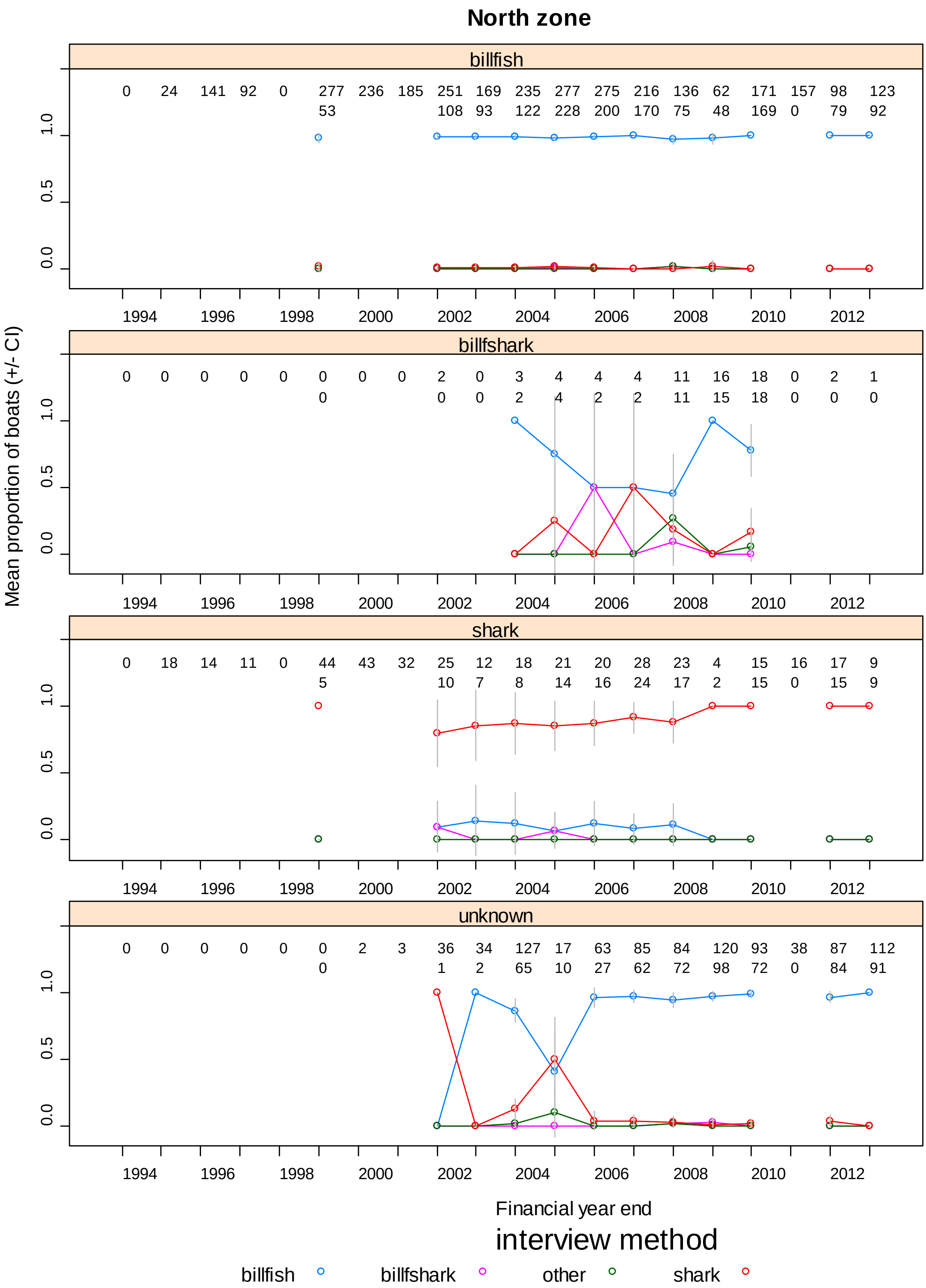


Figure 36. The average proportion of boats per tournament by financial year end (game fishing season) for the Port Stephens zone with 95% confidence intervals (±1.96 standard error, SE) assigned to each target category based on interviews within each target category assigned using scheds data: billfish, billfish–shark (bilfshark), shark and unknown. The top line of numbers is the total number of boats assigned to each of the sched method categories based on the scheds fishing methods data. The bottom line of numbers is the total number of boats interviewed in each of the assigned sched method categories

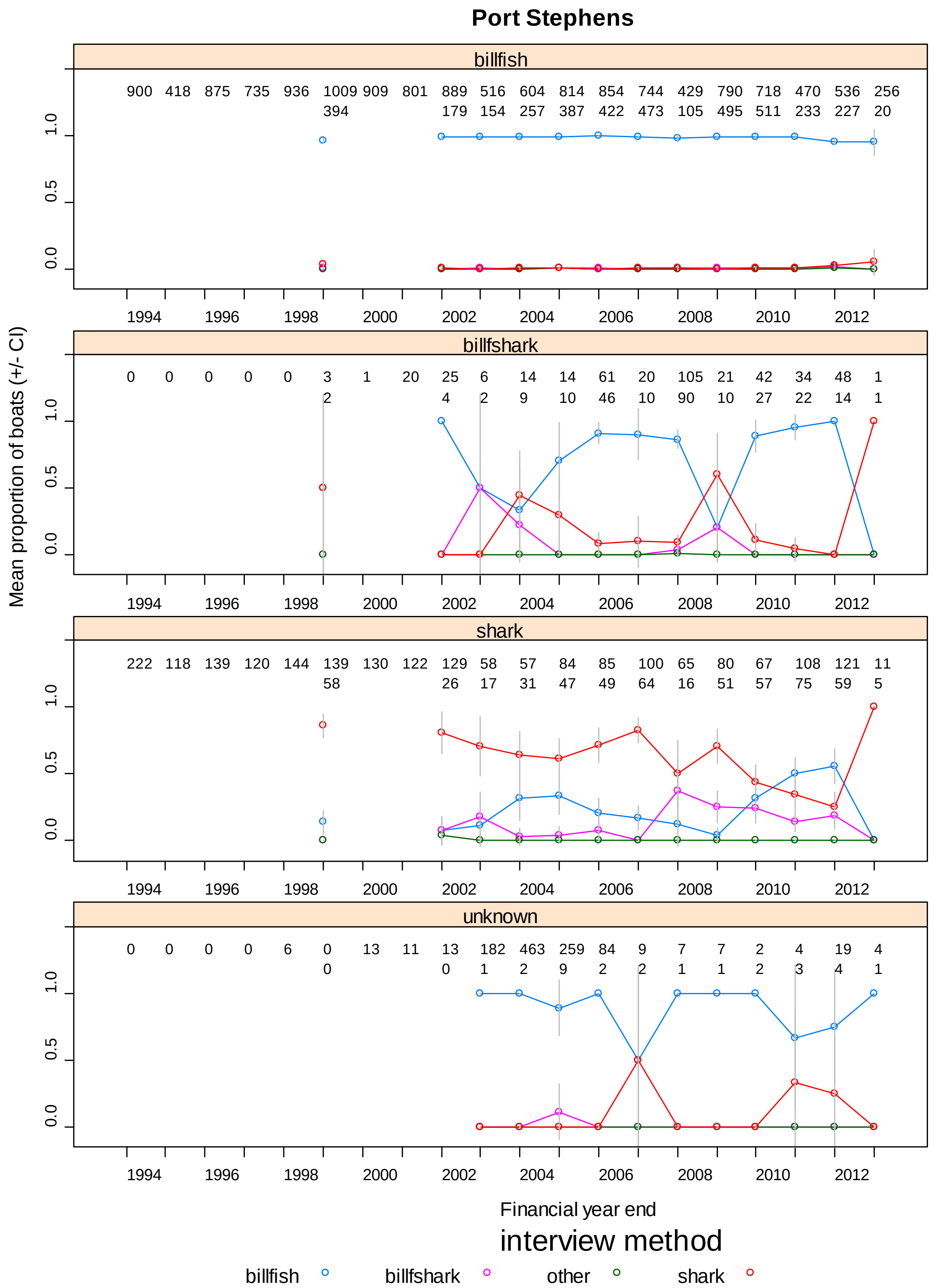


Figure 37. The average proportion of boats per tournament by financial year end (game fishing season) for the Central zone with 95% confidence intervals (±1.96 standard error, SE) assigned to each target category based on interviews within each target category assigned using scheds data: billfish, billfish–shark (bilfshark), shark and unknown. The top line of numbers is the total number of boats assigned to each of the sched method categories based on the scheds fishing methods data. The bottom line of numbers is the total number of boats interviewed in each of the assigned sched method categories

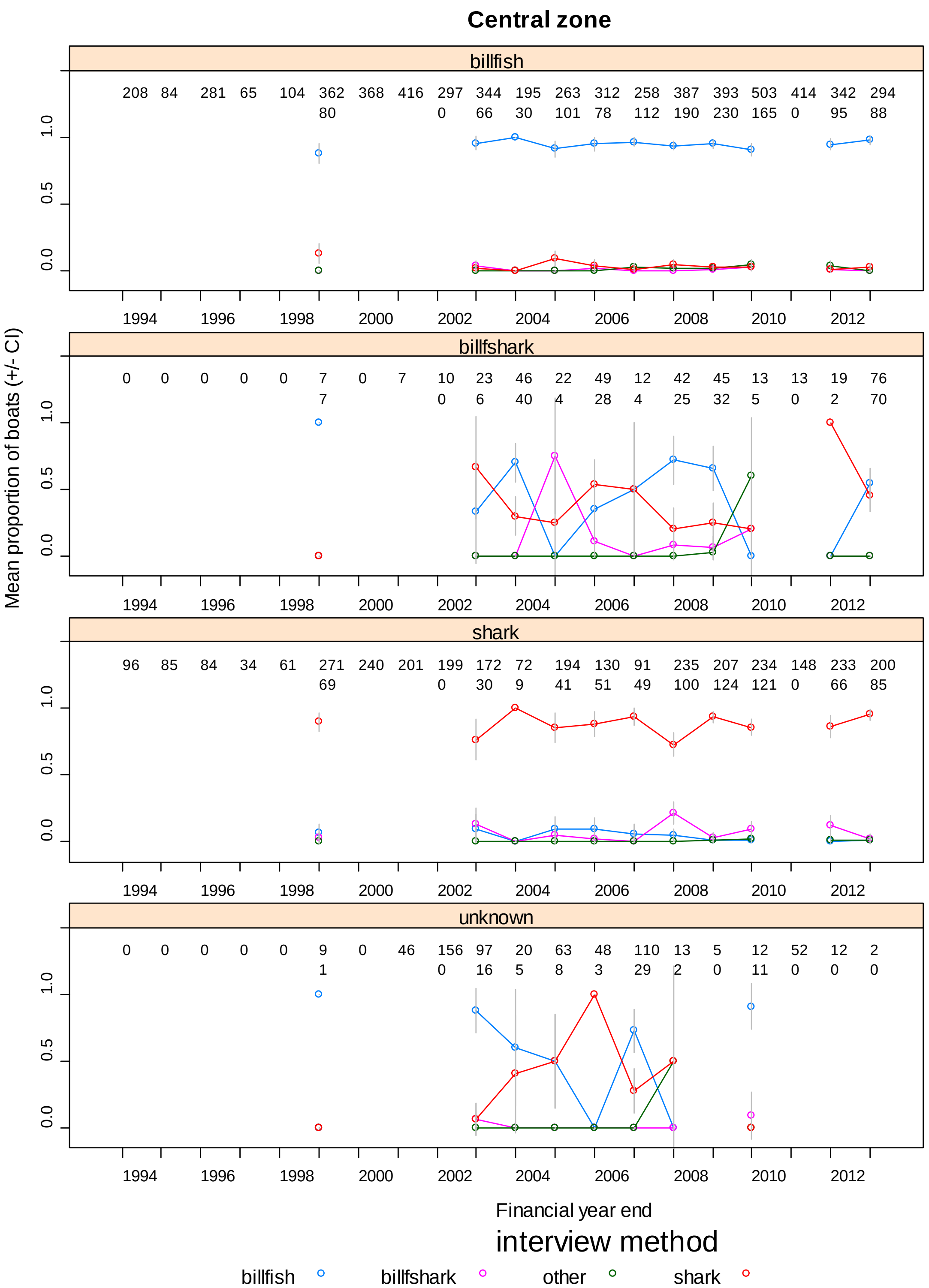
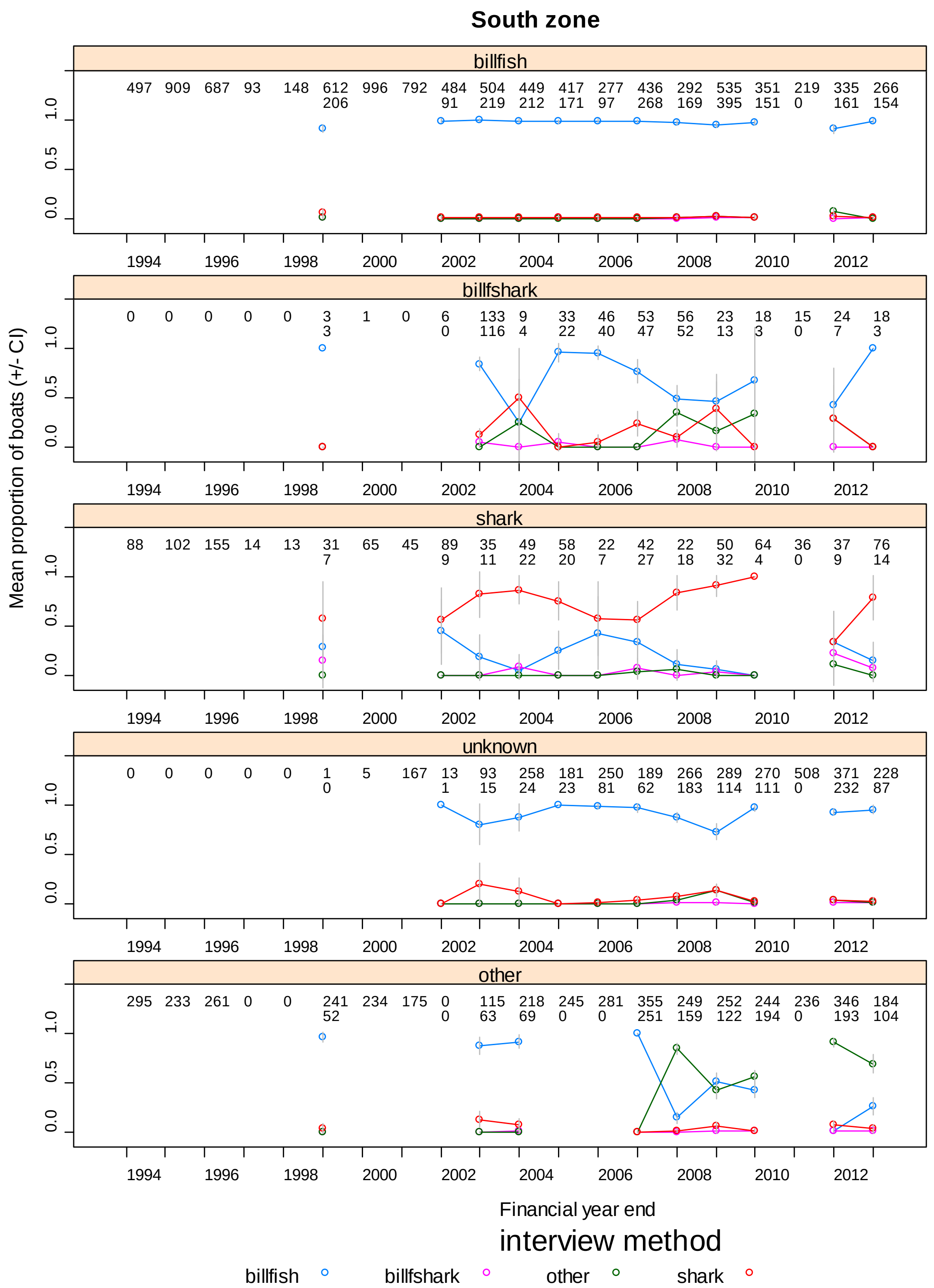


Figure 38. The average proportion of boats per tournament by financial year end (game fishing season) for the South zone with 95% confidence intervals (±1.96 standard error, SE) assigned to each target category based on interviews within each target category assigned using scheds data: billfish, billfish–shark (bilfshark), shark and unknown. The top line of numbers is the total number of boats assigned to each of the sched method categories based on the scheds fishing methods data. The bottom line of numbers is the total number of boats interviewed in each of the assigned sched method categories



4.6.2. *Differences between sched and interview catch*

4.6.2.1. Billfish

The comparison of catch from scheds versus the interviews indicated that all billfish species had a slope close to one, and an intercept close to zero, for most zones (Figures 39–42). The largest departure from this trend was for black and blue marlin in the South zone, with the number caught for each of these marlin species at tournaments being most commonly underestimated on the scheds (b=0.53; Figure 39D and b=0.67; Figure 41D, respectively). This may be due to confusion over which species (blue or black marlin) was being recorded on the scheds, given that both of these species may be recorded in short hand as ‘b marlin’. Survey staff should work closely with radio sched operators to ensure that the scheds are clear on which species are being reported by the fishers. This result also highlights the importance of collecting weigh station records to validate the species being recorded on the scheds against the tag card returns and captures reported at the end of each tournament fishing day.

4.6.2.2. Sharks

For shark species, the largest differences between catch numbers recorded on the scheds versus the interviews was for mako and blue sharks, with the numbers for both species most commonly underestimated on the scheds (Figures 43 and 44). There were some exceptions to this trend for these species; for example, mako shark numbers in the North were slightly overestimated on the scheds, but fairly accurate, with the intercept close to zero (a=–0.07) and slope close to one (b=1.09; Figure 43A). For mako shark, the greatest catch differences between the scheds and interviews were found for the Central zone (Figure 43C), followed by the South zone (Figure 43D). The number of mako shark caught per tournament was highest for the Central zone, with the Sydney Game Fishing Club tournament held out of Port Jackson, Sydney in July–August each year being the most influential on this trend. These differences may be related to the high numbers recorded and the difficulties of keeping accurate tallies of sharks caught from one sched to the next. This may be related to the anecdotal grouping behaviour of mako sharks, with numerous reported observations of several sharks swimming simultaneously around drifting vessels that have been burleying to attract sharks. This has historically also been observed for blue sharks in the years when their abundance is apparently higher.

To ensure we have accurate catch numbers for mako shark, post-fishing interviews should be undertaken each year for the tournaments held in the Central and South zone in the earlier part of the fishing season (including the Sydney, Wollongong and Jervis Bay tournaments), given these observed differences and the importance of the mako shark fishery and associated management issues. These tournaments were also most influential on the trends for blue sharks. Therefore, increasing post-fishing interviews will also improve the accuracy of catch numbers for blue shark.

Differences in the catch numbers per tournament for tiger shark were low for the North and Port Stephens zones, with the intercept close to zero and the slope close to one (Figures 45A and B). Tiger shark catch numbers per tournament were slightly underestimated on the scheds for the Central and South zone (Figures 45C and D). However, only a small number of tournaments caused these differences, which were not highly influential on the overall catch rate trend for tiger shark.

Differences in the catch numbers per tournament for hammerhead and whaler sharks were low, with the intercept close to zero and slope close to one for all zones (Figures 46 and 47). One exception to this trend was for whaler sharks in the South zone, where the numbers of whaler sharks was underestimated on the scheds for six tournaments over the monitoring period (Figure 47D).

4.6.2.3. Tunas and other game fish

All of the tuna and other game fish species for most zones were underestimated on the scheds (Figures 48 to 53). This is expected, given that these species are often kept for purposes other than point score (such as for food or bait) and are observed during interviews aboard the boats, but not reported on the scheds. One exception to this trend was for kingfish, where it was difficult to identify why numerous boats had kingfish catches reported on the scheds, but zero reported catches in interviews (Figure 52). Some evidence of this is apparent for the North zone, with three tournaments having much higher kingfish catches reported on the scheds than in interviews (Figure 52A). The low point score of this perhaps less memorable species for game fish tournament fishers, combined with the high proportion caught and released, may have resulted in recall bias in the interview data.

The largest differences between the catch numbers recorded on the scheds versus interviews was for skipjack (striped) tuna (Figure 50), followed by mahi mahi (Figure 51). This can be expected for skipjack tuna, given that point score for this species is only obtainable for junior anglers and that it was ineligible for point score for any anglers before 2009. This trend is also expected for mahi mahi, given their low point score and good eating quality. Mahi mahi are commonly kept for food instead of for tournament point score, and thus are not always reported on the scheds.

To obtain accurate catch estimates for tuna and other game fish species from game fish tournaments, maintaining good coverage of post-fishing interviews is therefore required. However, given funding constraints, high coverage of tournaments for post-fishing interviews at all spatial and time scales may not be possible. Hence, extra caution should be used when interpreting the catch rate estimates for tuna and other game fish species, and post-fishing interviews should be undertaken for the greatest proportion of tournaments as possible given the funding available. Alternatively, if accurate data on the catch of these species is not a priority for research, then post-fishing interviews can be further reduced. However, given that mahi mahi and yellowtail kingfish are both listed as high-priority species under the NSW Resource Assessment Framework (Table 1), accurate data on these other game fish species is of particular interest and should warrant further research.

To adjust future overall catch estimates, catch correction factors can be estimated based on the differences found between sched and interview data. However, we found that the catch rates cannot be adjusted. As part of our statistical analyses, we estimated catch correction factors with the aim of adjusting catch (and fishing effort) before using the factors in catch rate calculations. However, this work was not able to be completed, because we found conceptual issues with using the correction factors to adjust catch at the fishing day level. These conceptual issues were due to the varying levels of data obtainable, given the complexities of the tournament fishery. For example, numerous tournaments only occurred in one place at one time only, and interviews were unobtainable for some tournaments or for the last day of some tournaments. Consequently, we often lacked enough representative data at the fishing day level to estimate correction factors. In these cases, we needed to estimate the correction factors at a higher level, such as at the species, tournament or fishing year by zone levels, and apply these factors back to the fishing day level. This made it statistically impossible to estimate the error around our estimates, which results in inaccuracies and further uncertainty in our results.

Figure 39. The relationship between the number of black marlin recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

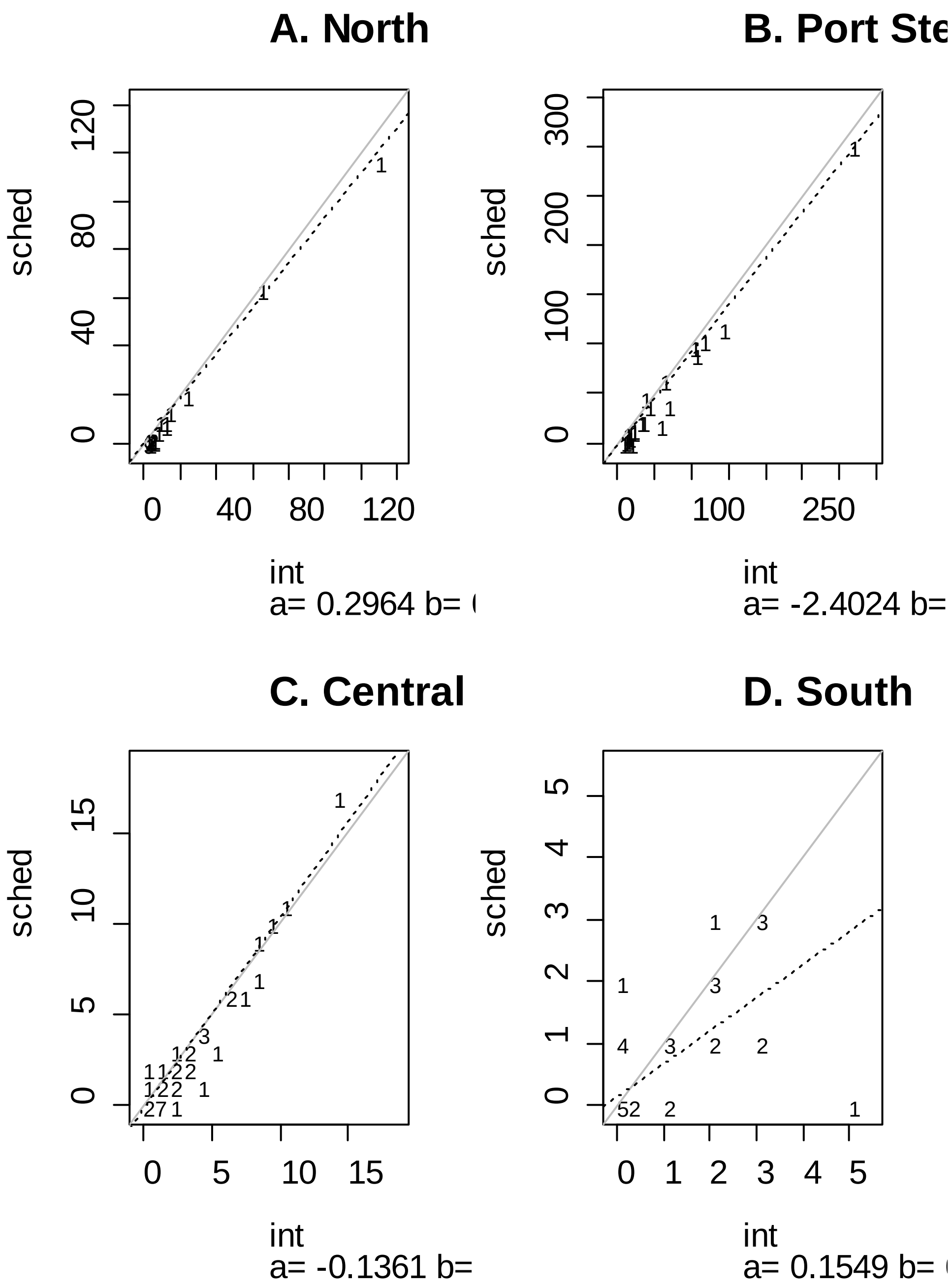


Figure 40. The relationship between the number of striped marlin recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

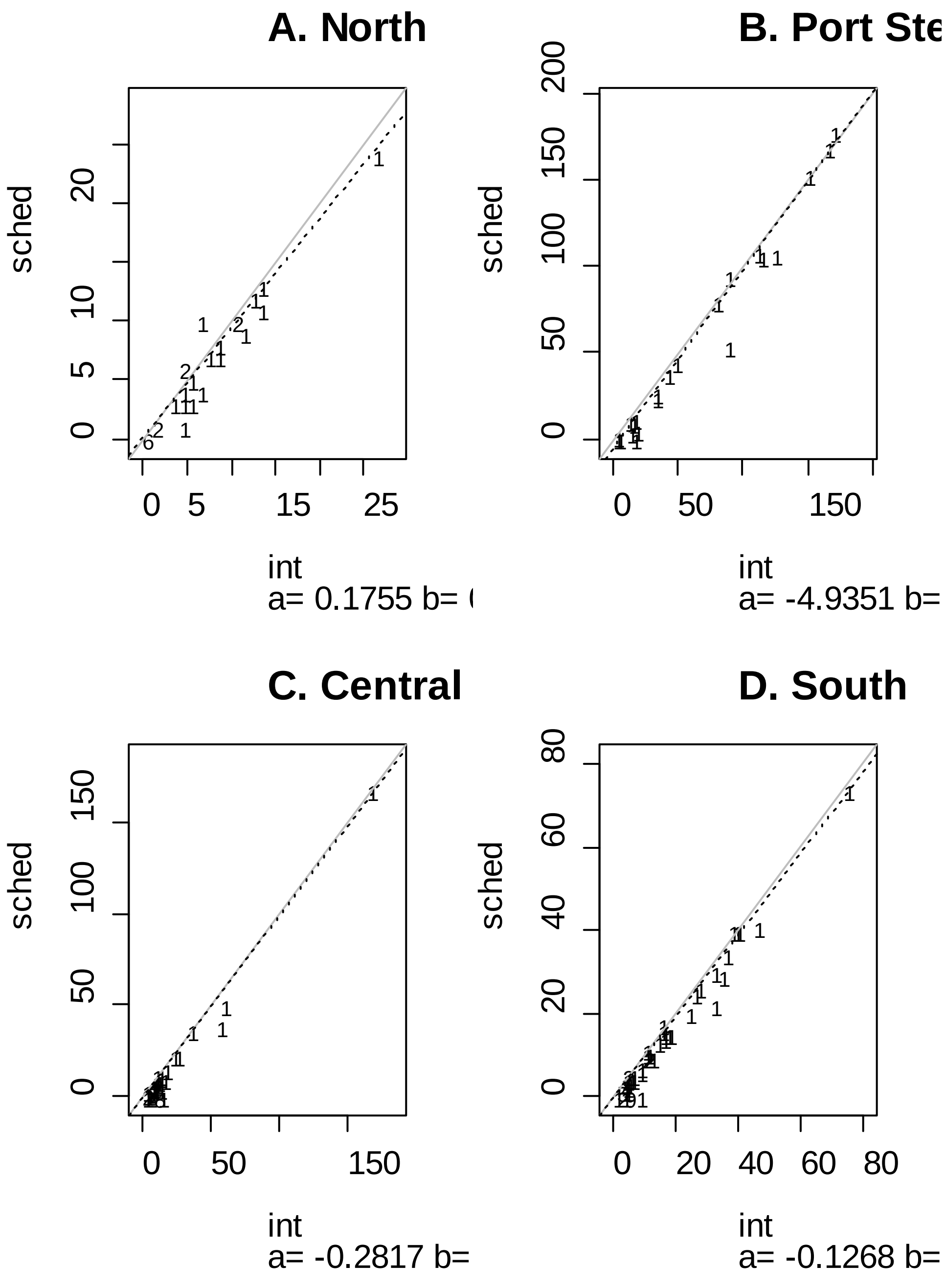


Figure 41. The relationship between the number of blue marlin recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

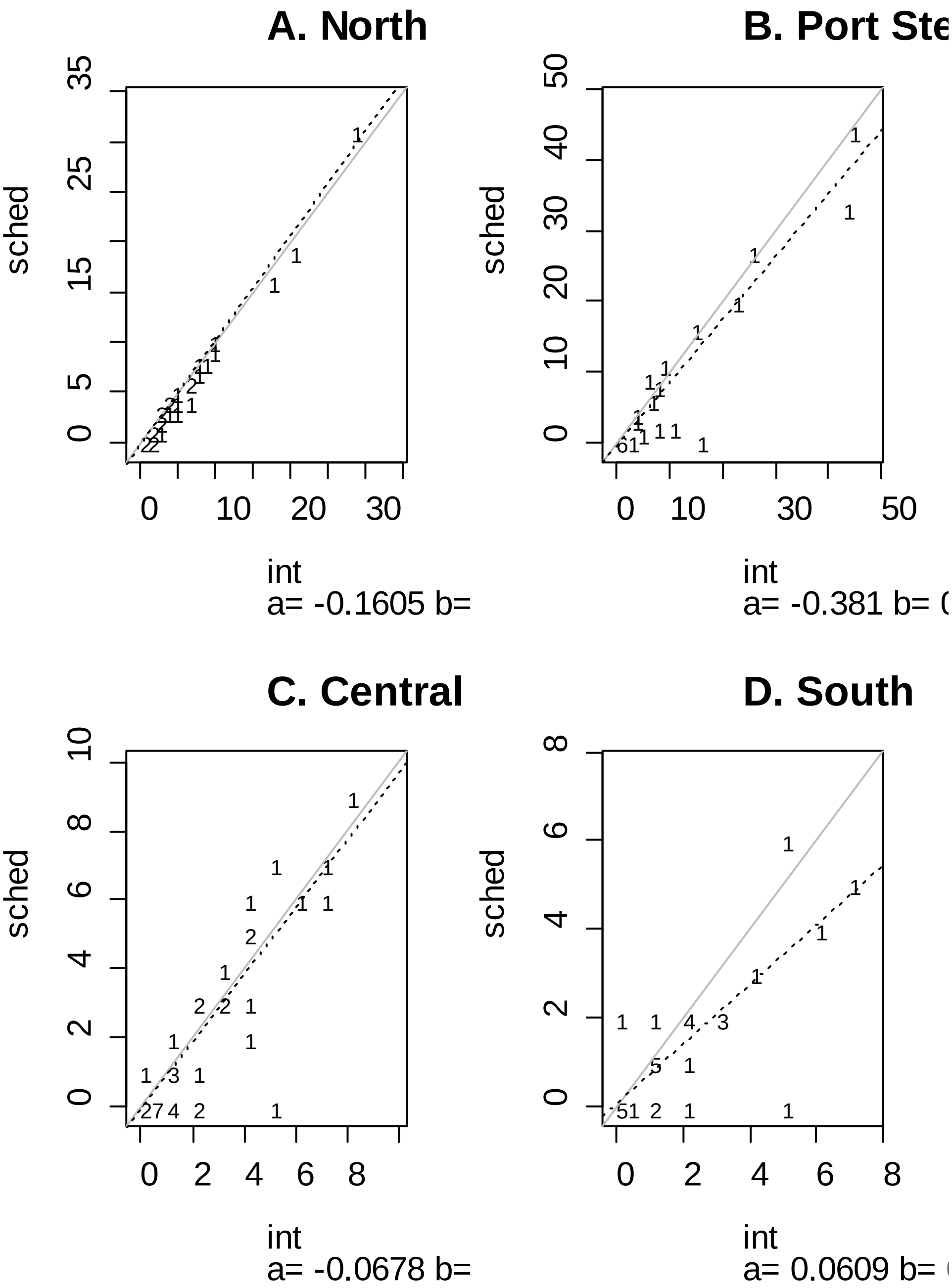


Figure 42. The relationship between the number of shortbill spearfish recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

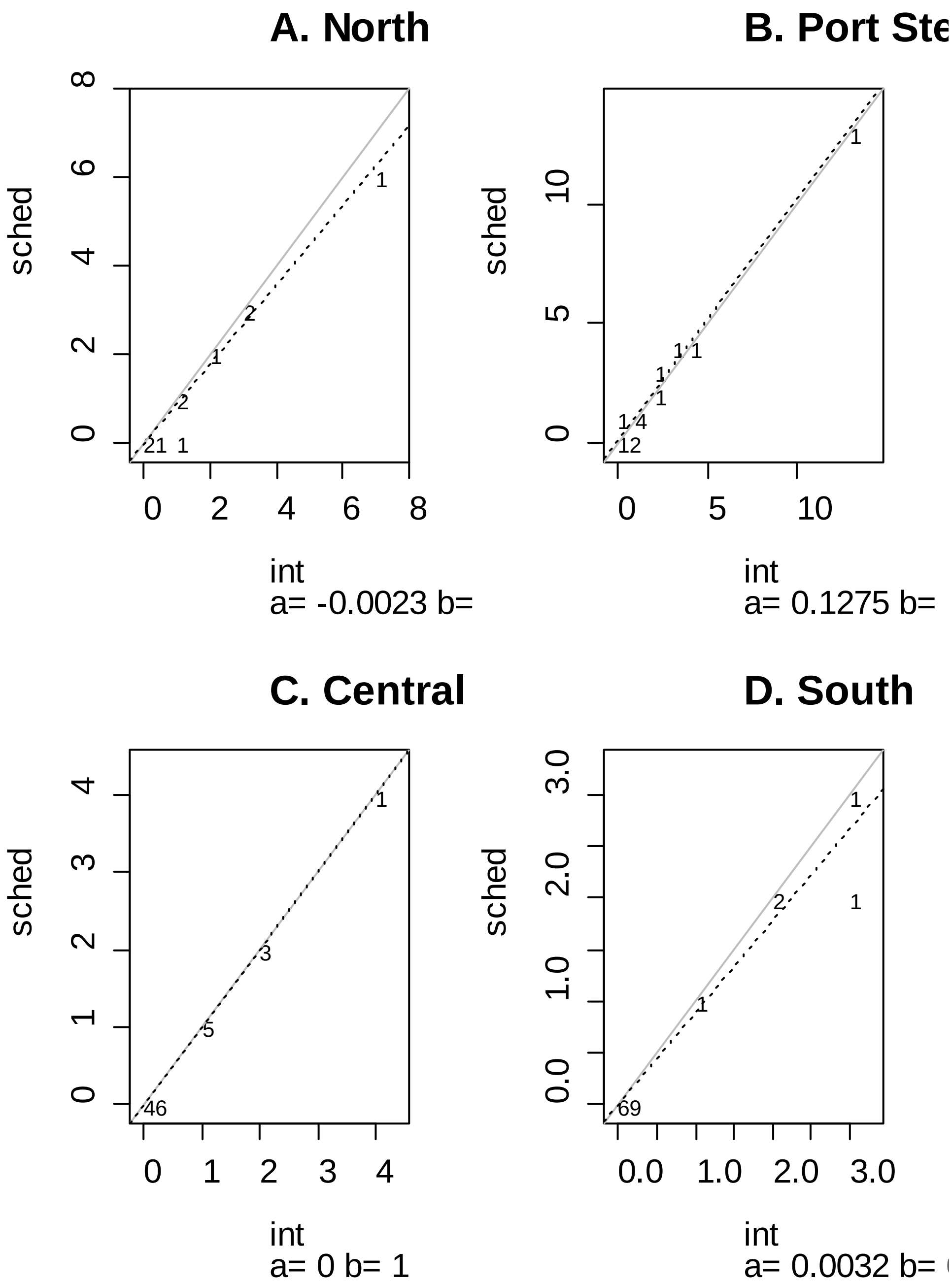


Figure 43. The relationship between the number of mako shark recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

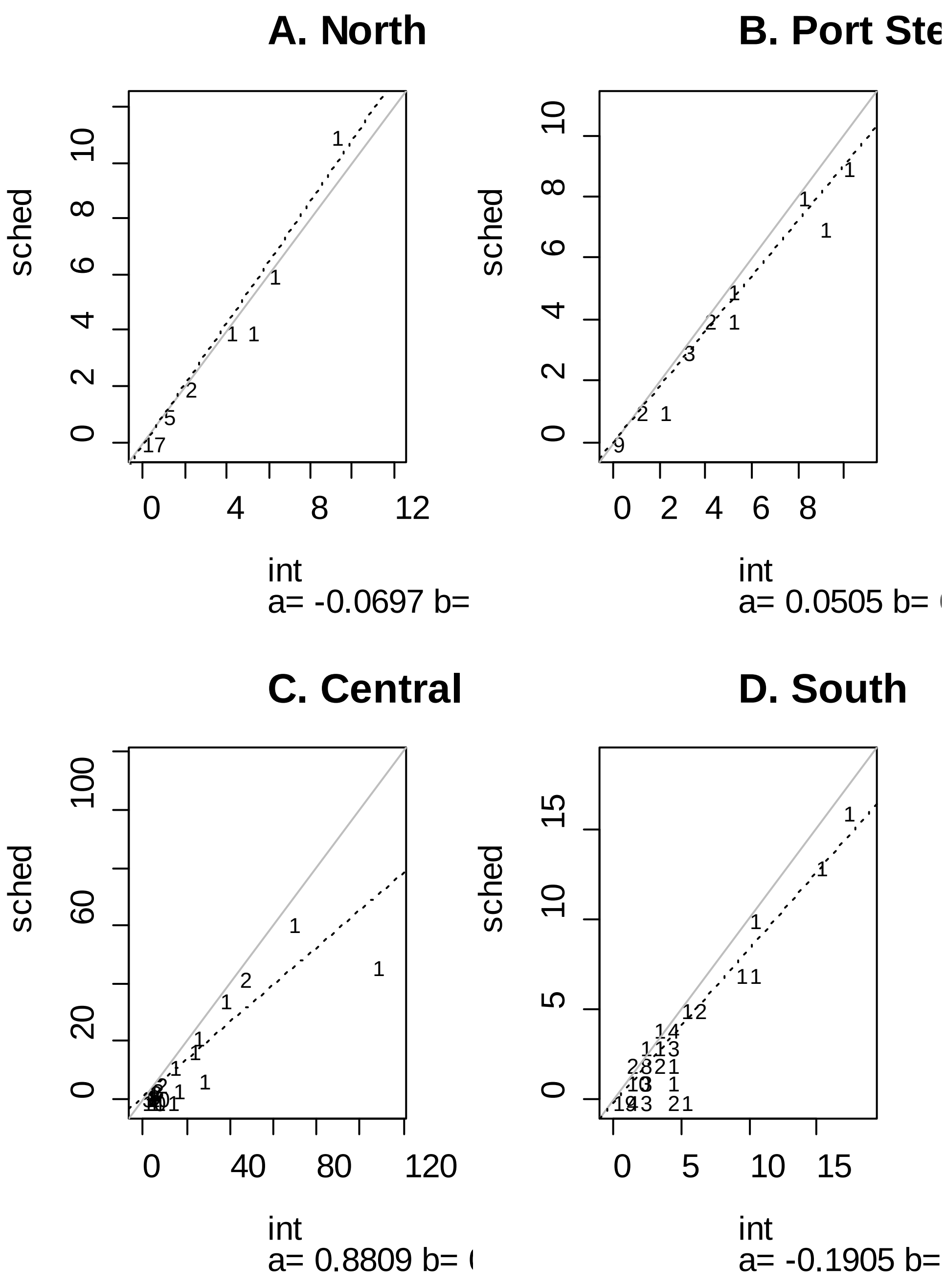


Figure 44. The relationship between the number of blue shark recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

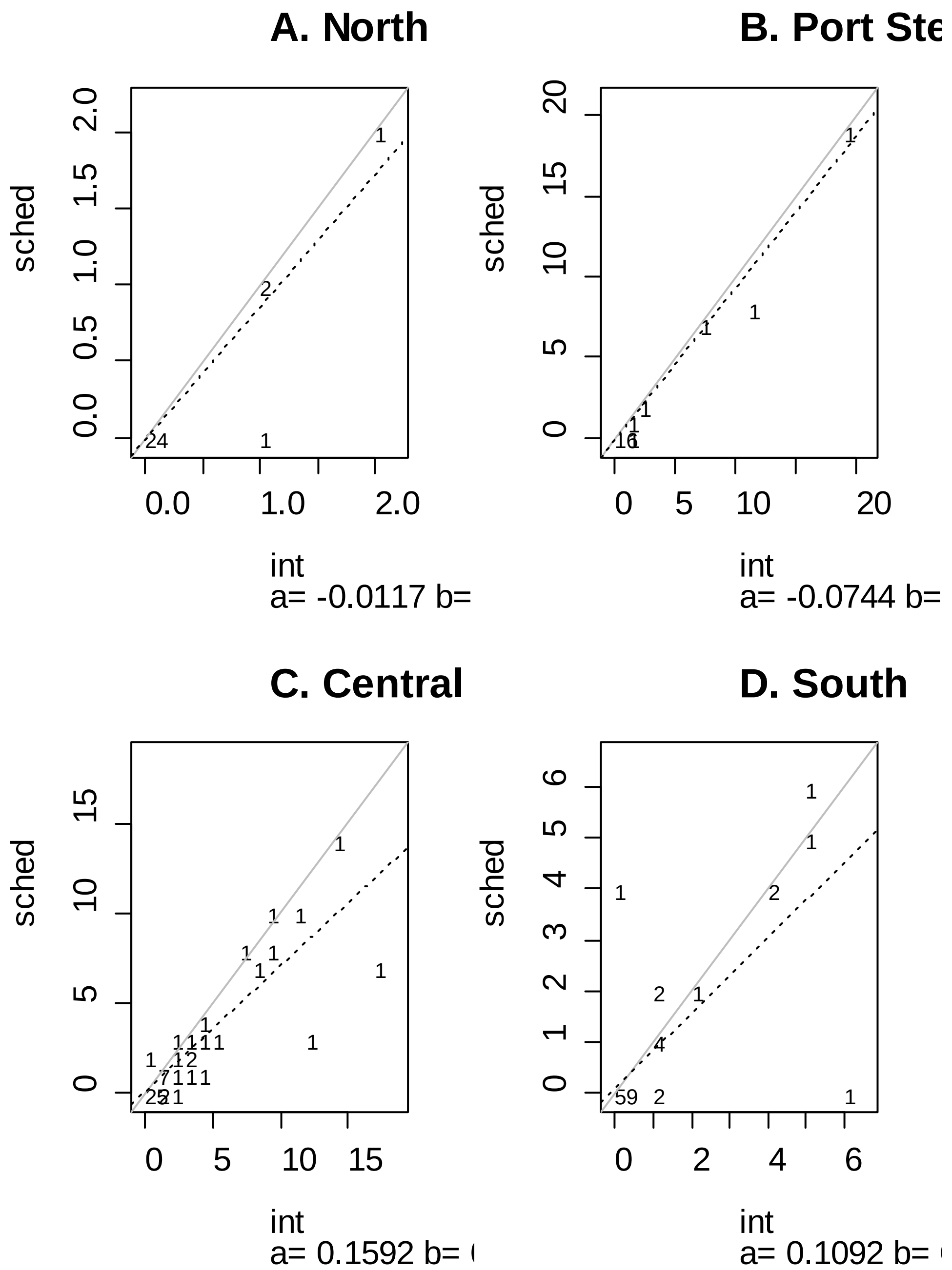


Figure 45. The relationship between the number of tiger shark recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

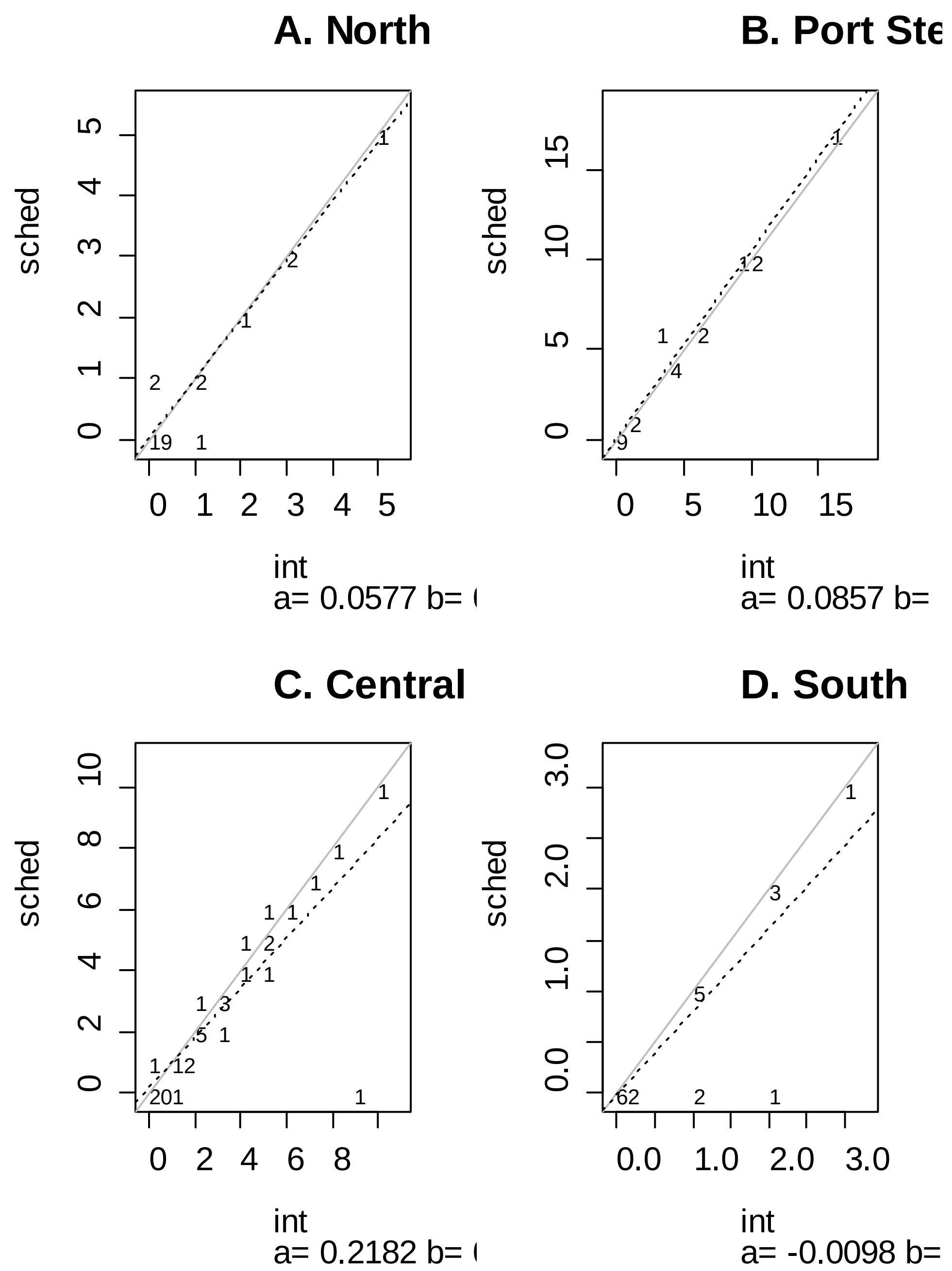


Figure 46. The relationship between the number of hammerhead sharks recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

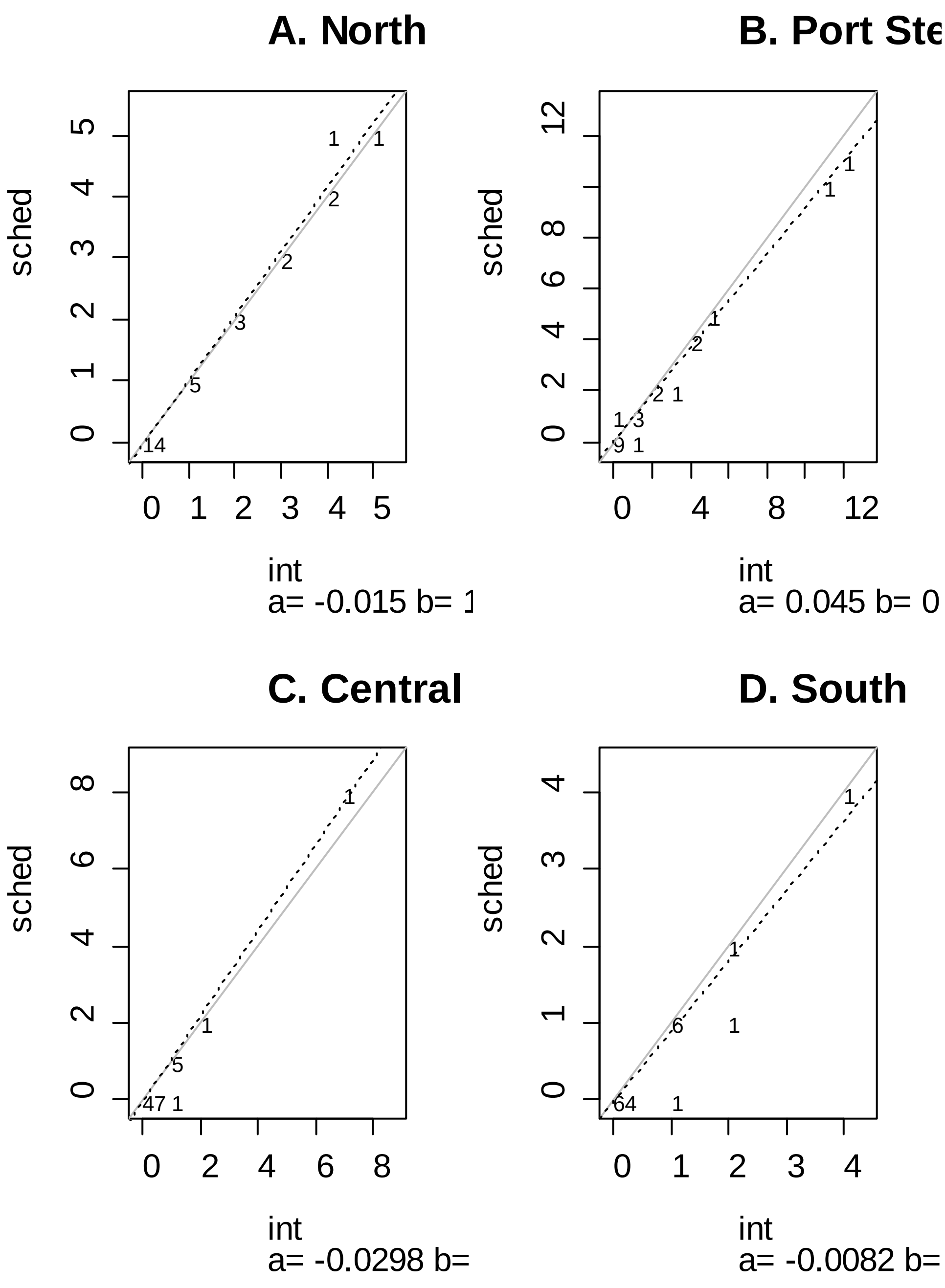


Figure 47. The relationship between the number of whaler sharks recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

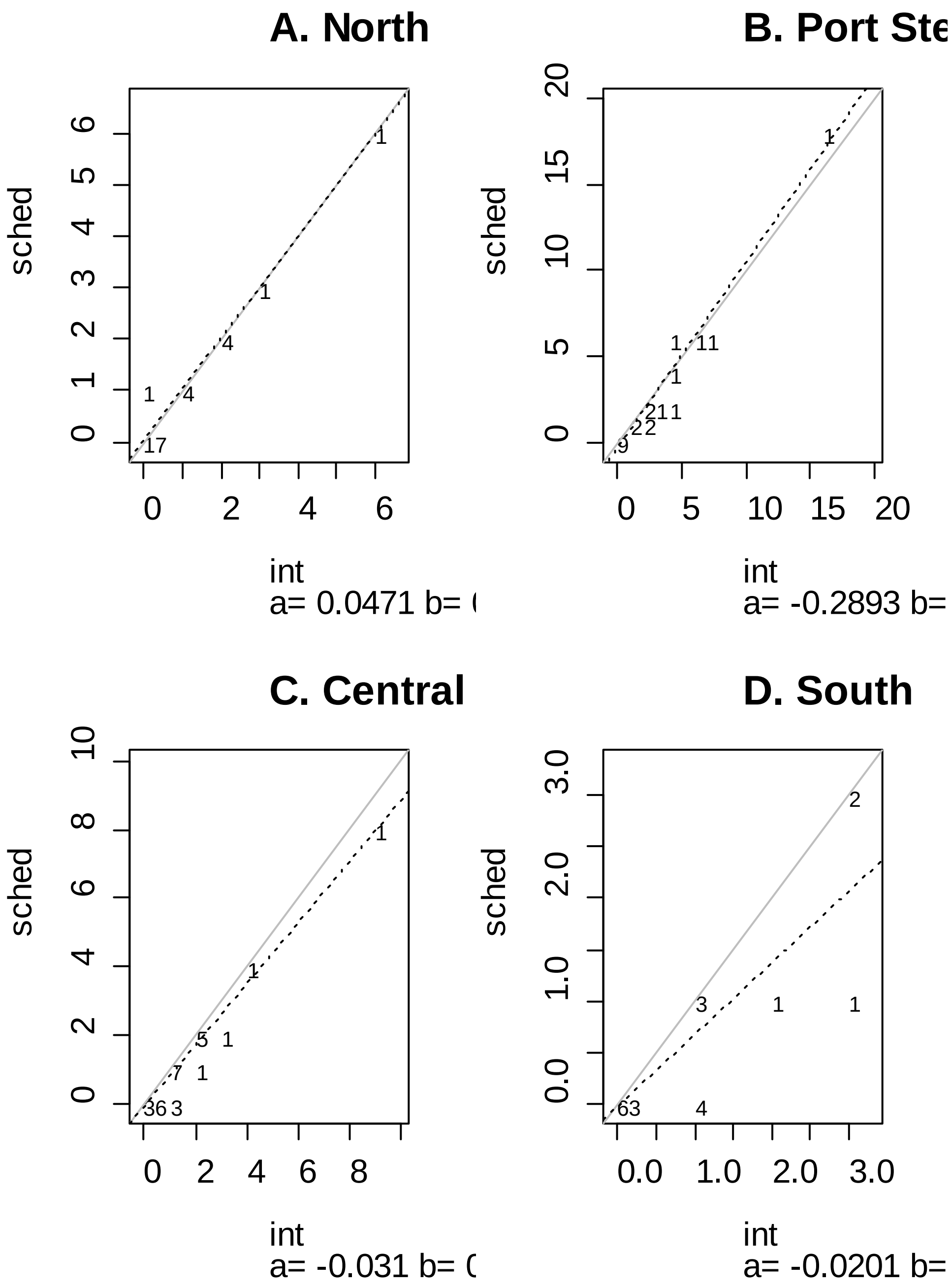


Figure 48. The relationship between the number of albacore recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

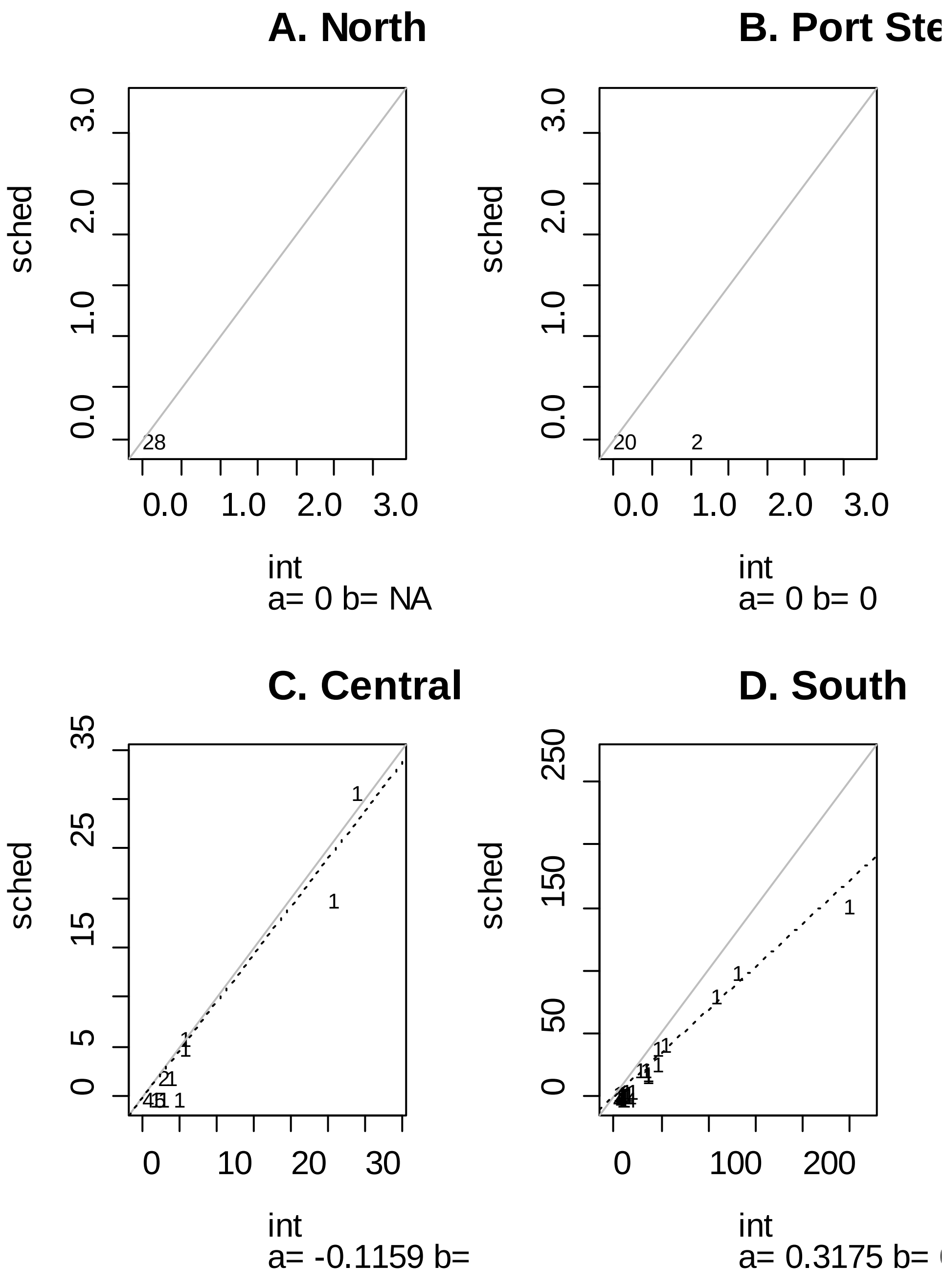


Figure 49. The relationship between the number of yellowfin tuna recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

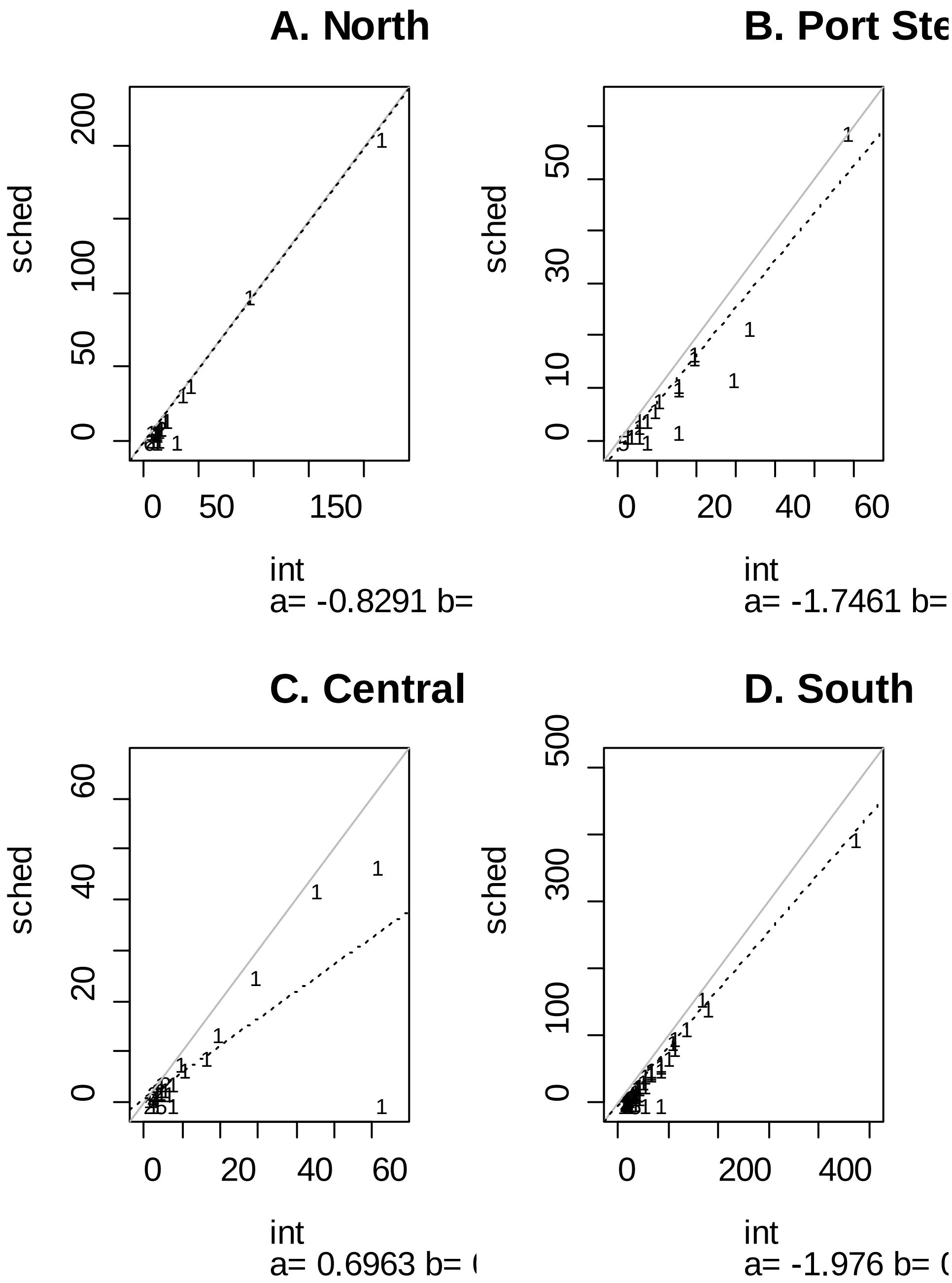


Figure 50. The relationship between the number of skipjack (striped) tuna recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

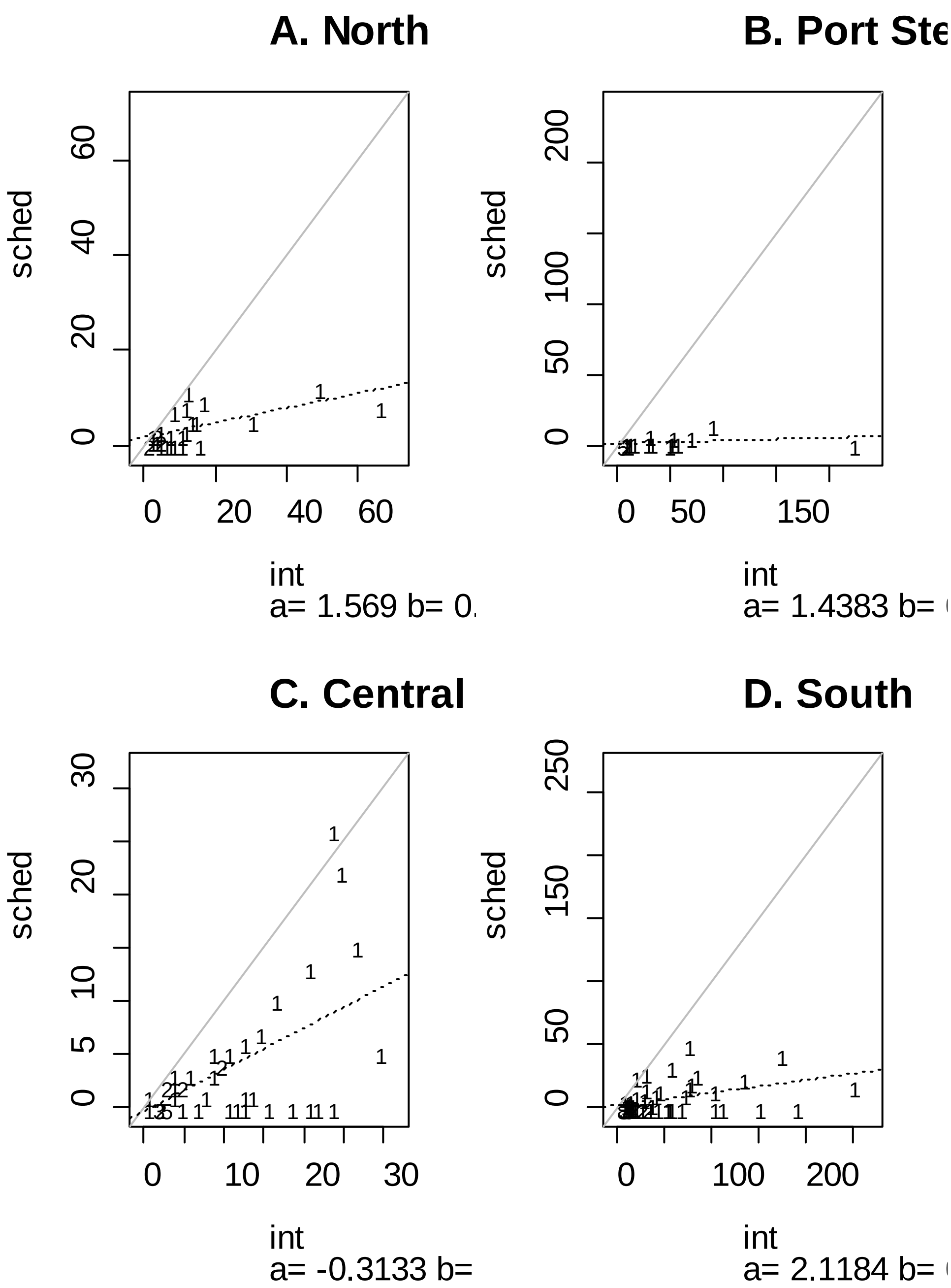


Figure 51. The relationship between the number of mahi mahi recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

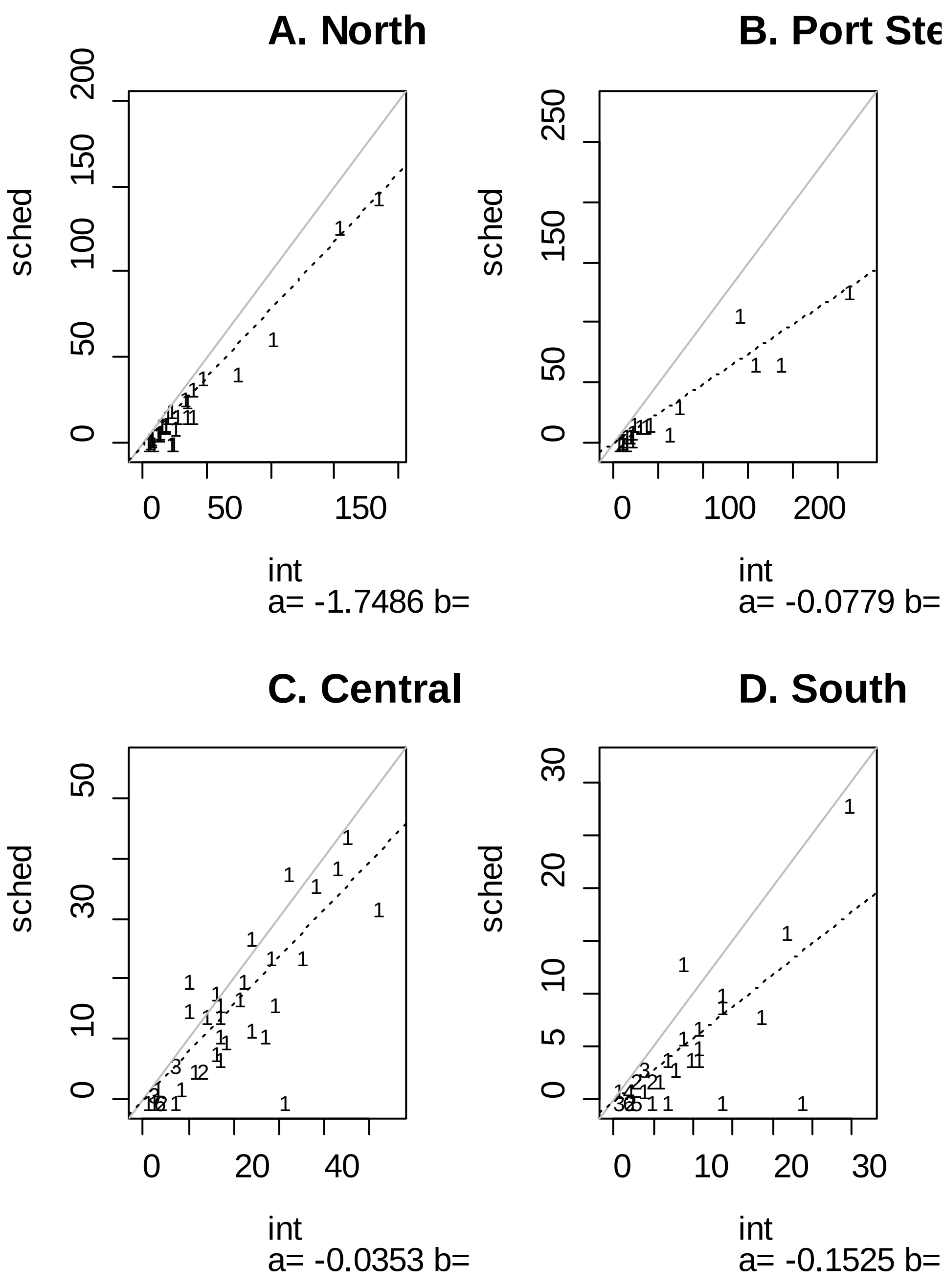


Figure 52. The relationship between the number of yellowtail kingfish recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1

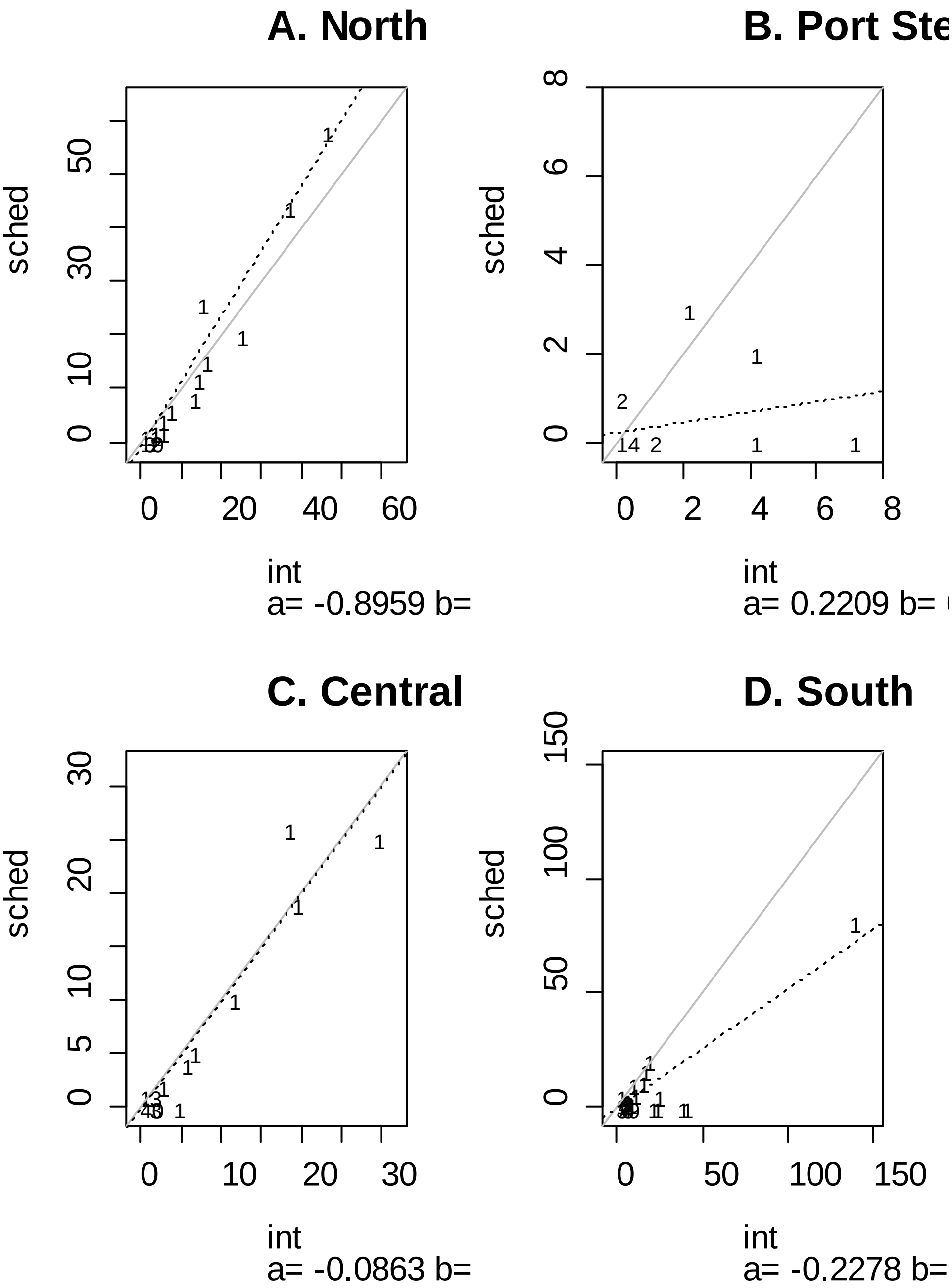
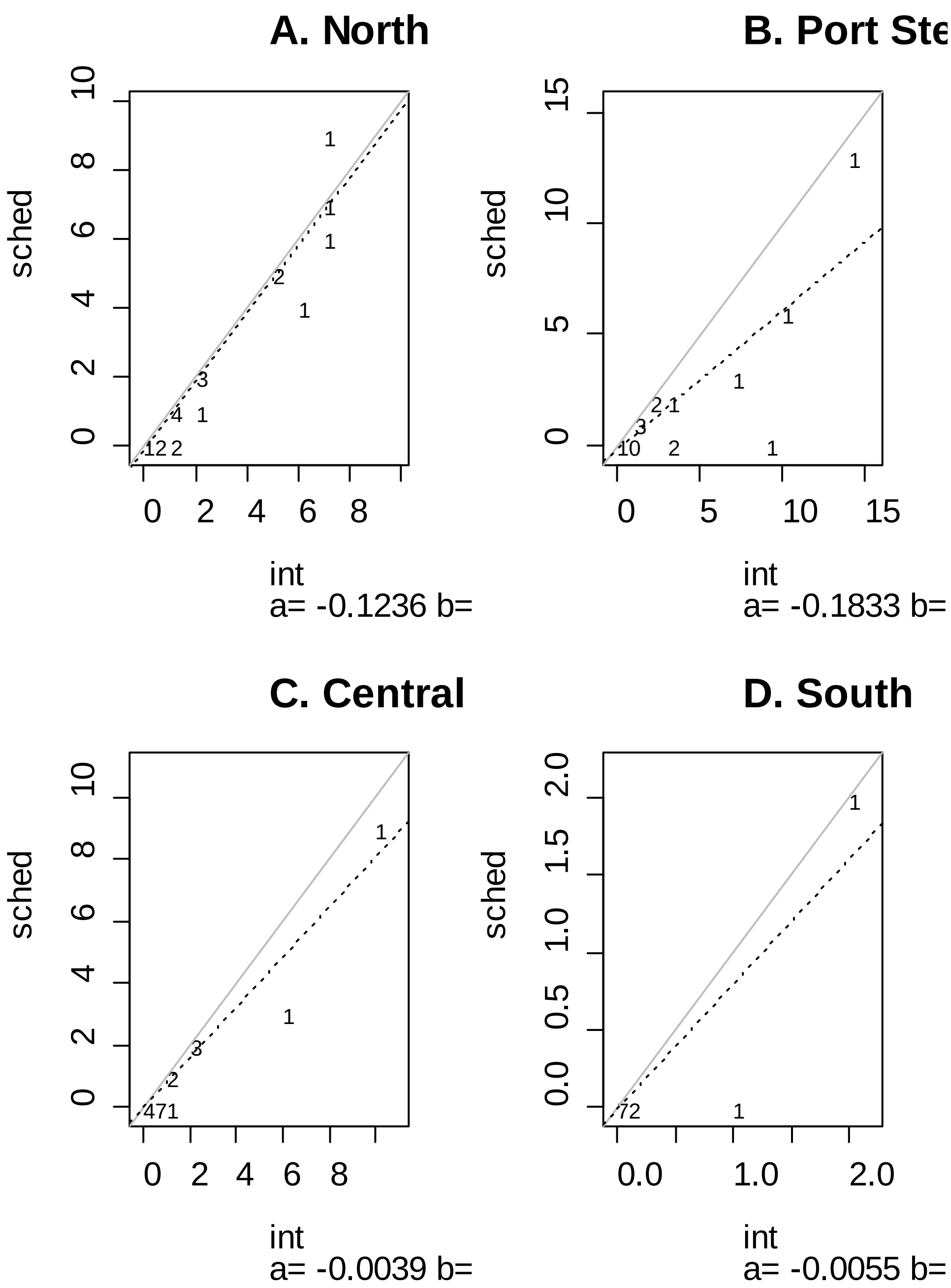


Figure 53. The relationship between the number of wahoo recorded on the scheds (sched) versus the interviews (int) represented by a dotted line (with the intercept [a] and slope [b] of the line given underneath each plot) with each point (as a number) representing the number of tournaments by zone: A. North, B. Port Stephens, C. Central and D. South. The solid line is a one-to-one line where the intercept a=0 and slope of the line b=1



4.6.3. Catch rate comparison under four scenarios

The results for this section are only presented for striped marlin (the most commonly caught billfish species for this fishery) and mako shark (the most commonly caught shark species). These species provide good case studies to investigate differences among the four scenarios. Results for all 15 species are available on request.

Comparisons between the catch rates under each of the four scenarios indicated that non-directed catch rates are underestimated, because they include all fishing effort regardless of targeting (Figures 54A and 55A). Non-directed catch rates were underestimated more for mako shark (Figure 55A) than for striped marlin (Figure 54A), because the targeting of sharks represents a small proportion of the total fishing effort (14%; Table 20).

Despite the non-directed catch rates being underestimated and there being some differences between the catch rates of the four scenarios in some years, there were no statistically significant differences (based on the 95% confidence intervals) in the catch rates for any of the four scenarios for any of the key game fish species. This finding provides support for the future reduction or cessation of post-fishing interviews, because the inclusion of post-fishing interview data did not significantly change the catch rate trends.

Thus, if future funding for this research is limited, then the project could be reduced to include the collection of sched and weigh station data only. Furthermore, the weighted catch rate approach enables all catch and fishing effort data to be included in the final catch rate estimates. Thus, mis-classification of the species group being targeted to estimate directed catch rates (as has been done previously using monitoring data) is not as important in obtaining an accurate catch rate measure. However, the main risk of discontinuing the interview component is lacking the data needed to investigate changes in fishing methods that may influence the catchability of stocks and to identify data issues, such as hyperstability.

Figure 54. Striped marlin catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for: A. non-directed CPUE using raw sched data only; B. directed CPUE using sched data only; C. weighted CPUE using sched data only; and D. weighted CPUE using sched and interview data combined

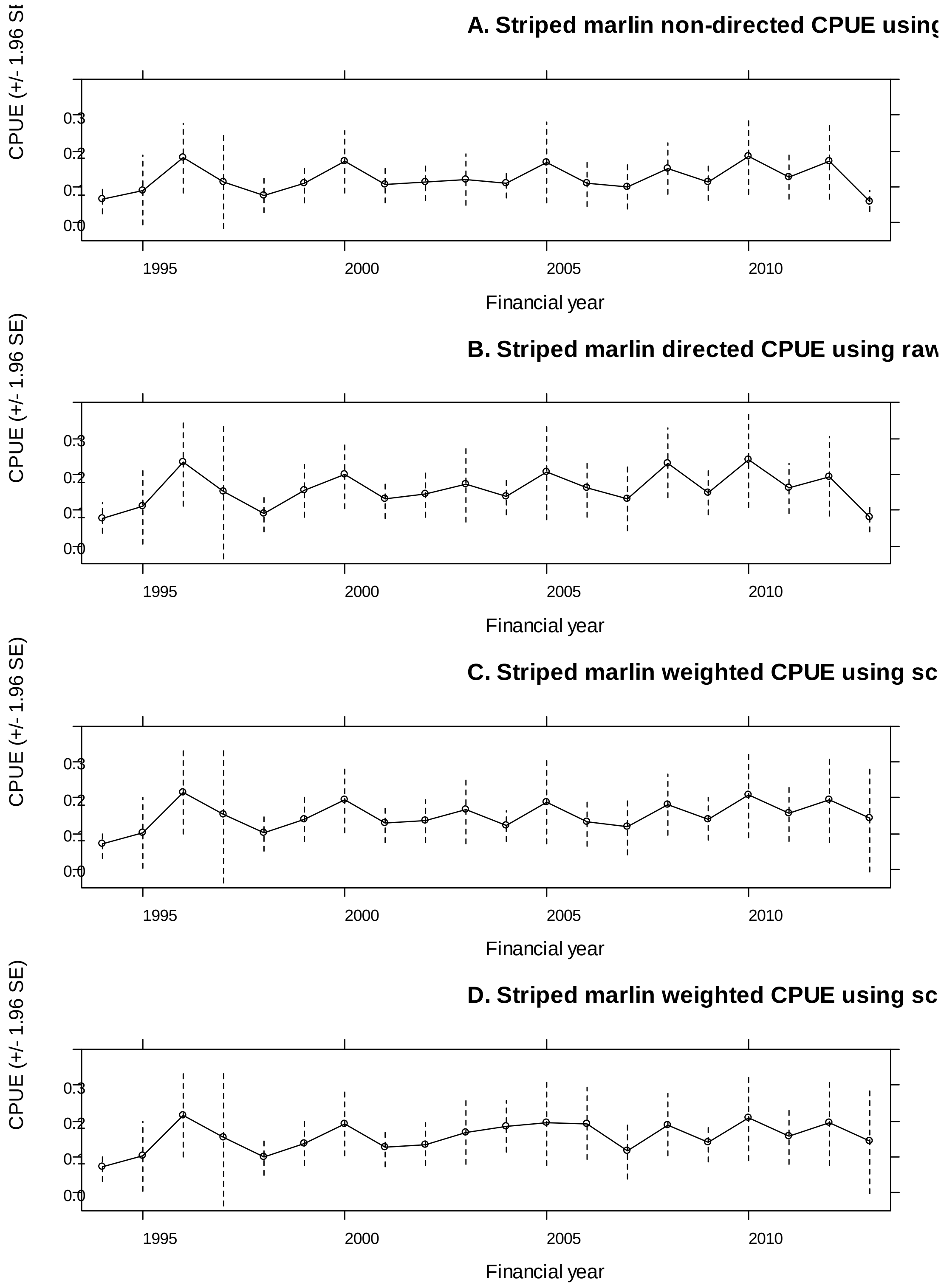
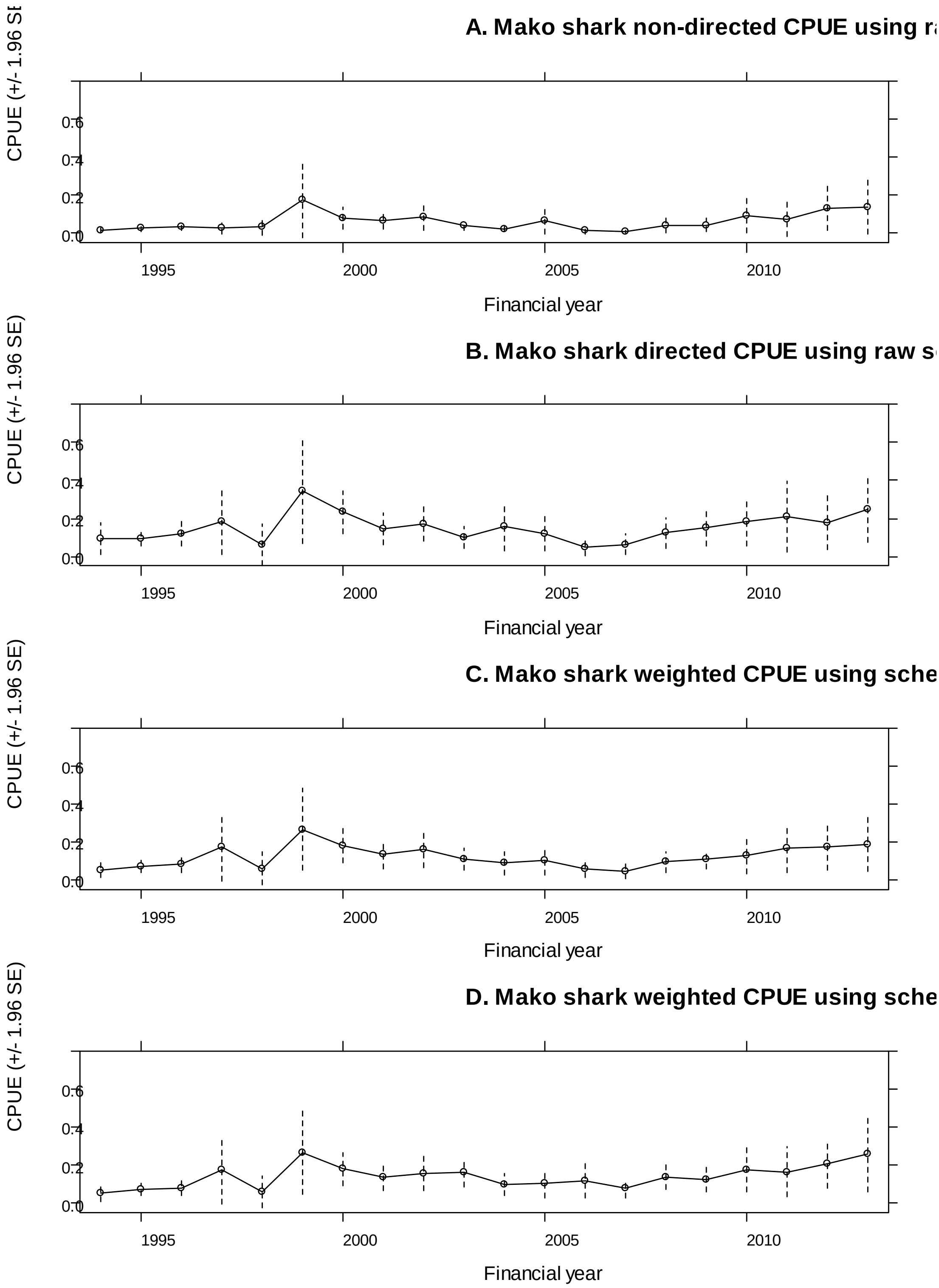


Figure 55. Mako shark catch per unit of effort (CPUE) with 95% confidence intervals (±1.96 standard error, SE) by financial year end (game fishing season) for: A. non-directed CPUE using raw sched data only; B. directed CPUE using sched data only; C. weighted CPUE using sched data only; and D. weighted CPUE using sched and interview data combined



5. OVERVIEW OF THE USEFULNESS OF GAME FISH CATCH AND FISHING EFFORT DATA

5.1. Supporting stock assessments

Hilborn and Walters (1992) describe the intent of a good stock assessment as a tool for understanding the dynamics of fisheries. Understanding fisheries dynamics requires knowledge of fishing effort, catch, and the behaviour of fishers in response to factors such as management policies and extraneous variables (Hilborn and Walters 1992). Understanding recreational fishing effort and catch improves our understanding of fishery dynamics, and is therefore important in stock assessment.

Stock assessments – such as for the Western and Central Pacific Ocean (WCPO) striped marlin – have demonstrated that recreational data are important, because they provide an additional independent source of information about the fish population (Langley *et al.* 2006). The stock assessment model by Langley *et al.* (2006) had a poor fit to the New Zealand recreational size data, with the model unable to predict mortality estimates that matched the observed catch of large striped marlin in the New Zealand recreational fishery. This provided evidence to support possible gear selectivity differences between recreational and commercial fisheries (Langley *et al.* 2006). It also highlights the importance of incorporating recreational data sources, as independent information, to help fine-tune stock assessment models and account for total fishing mortality on the population. The latest striped marlin stock assessment included the addition of CPUE and size frequency data for the recreational fisheries of both southeast Australia and New Zealand. This increased the current biomass estimated in the stock assessment by 27%, due to the different trends from those in the longline fishery (Davies *et al.* 2012). The inclusion of size data for the Australian recreational fishery, and estimating a separate selectivity curve to account for the differences in gear selectivity, also reduced the overall biomass of striped marlin stock by around 11%. However, given the differences in the trends observed between recreational and commercial fisheries for striped marlin, these model runs were not used in the final assessment model (Davies *et al.* 2012). Future work needs to identify variables that may be masking trends in striped marlin abundance from catch rates estimated using recreational fishery data, such as gear and fishing method changes over time.

The importance of recreational catch and effort data in stock assessments may be of higher significance for game fish species of billfish and shark than for tuna species. Billfish (with the exception of striped marlin) and shark species are not primarily targeted by commercial fishing operations, but rather are bycatch or byproduct species (Bailey *et al.* 1996). There are also commercial exclusions, such as the blue and black marlin commercial fishing bans in Australia (Findlay *et al.* 2003), and a commercial fishing ban on the take of all marlin species in New Zealand (Bromhead *et al.* 2004). Consequently, the quality of information from commercial logbooks for these species is highly variable across the various fishing fleets and spatial zones of the WCPO (Bailey *et al.* 1996).

The need for other data sources, such as that from recreational fisheries, becomes increasingly important in situations where the quality of commercial fisheries data may be poor. This may occur in either part or all of the spatial regions defined in the stock assessment model, or if the recreational fishery catches fish from a different life history stage of the population, such as large adult fish (Campbell *et al.* 2003; Kleiber *et al.* 2003; Langley *et al.* 2006; Squire 1987). Recreational fisheries data can be compared to commercial fisheries data from the same spatial and temporal frame, or be included as an additional source of fishing mortality to improve estimates of stock biomass from assessment models to predict population trends and determine stock status (Boyce *et al.* 2008; Diamond 2003; Langley *et al.* 2006).

A study by Manning et al. (2003) concerning the feasibility of conducting quantitative stock assessments for key shark species of the WCPO, combined with data from Murphy *et al.* (2002) and Park (2007), indicated that game fish tournament catch and effort indices may provide information for a spatial area (Region 9 of the WCPO) that lacks commercial observer data. Manning et al. (2003) also listed shortfin mako shark as an important candidate for quantitative assessment. This species is well represented in tournament monitoring data (Murphy *et al.* 2002; Park 2007), and thus may provide additional evidence to support future stock assessment models. Stock assessments for species such as mako shark are particularly important, because this species is listed as vulnerable on the International Union for Conservation of Nature (IUCN) Red List, is associated with contentious management issues (Arreguín-Sánchez 1996; Pullin and Knight 2009; Roughan *et al.* 2009; van Turnhout *et al.* 2008) and has a low reproductive potential (Musick 1999).

In contrast, it could be argued that stock assessments do not require recreational game fish catch and fishing effort information, particularly for highly migratory species. Stock assessments for most highly migratory species, in particular for tunas, are commonly undertaken without the inclusion of recreational fisheries data (Butterworth *et al.* 2003; Chang and Liu 2009; Hoyle and Davies 2009; Kleiber *et al.* 2003; Langley *et al.* 2009). Currently, it is not clear from the stock assessment literature if exclusion of recreational fisheries data from stock assessments, particularly for tunas, is due to: i) the lack of available information on recreational catches, or ii) the assumption made by stock assessment scientists that recreational data are not required to improve the outcomes of the assessment. Investigations into available recreational datasets for WCPO species found that very few sources of data are available on recreational fishing, supporting the idea that recreational data are unavailable.

Commercial fisheries data for game fish species span large spatial and long temporal scales, providing much more extensive information than recreational fisheries data for assessments at the necessary scale to understand the dynamics of the fish population. For example, the WCPO commercial tuna fisheries are the largest in the world, with annual catches of about one million tonnes (Bailey *et al.* 1996). Recreational catch is likely to be less than 1% of the total WCPO tuna catch, based on broad assumptions about the potential recreational catch levels in proportion to the commercial catch (Bailey *et al.* 1996; Scandol *et al.* 2008). Thus, recreational catch of tuna species is most likely to be well within the estimated errors of existing tuna stock assessments (Harley *et al.* 2009; Hoyle *et al.* 2008; Langley *et al.* 2009), making the inclusion of recreational catch into stock assessments less essential for assessing stock status. It is likely that both potential reasons for exclusion of recreational fisheries data in stock assessments (i.e., i and ii above) are true for most game fish species, although the exact circumstances will vary by species.

In summary, an annual estimate of total recreational effort and catch should be incorporated into stock assessment models at the least as a source of fishing mortality: particularly for fisheries that are data-poor, such as for billfish and shark species (Boyce *et al.* 2008; Diamond 2003; Langley *et al.* 2006). However, total recreational harvest estimates are seldom available for inclusion for these species (Boyce *et al.* 2008; Diamond 2003; Langley *et al.* 2006; Whitelaw 2003; Williams and Whitelaw 2000). In the case of the GTMP, estimated harvest will be of limited use in stock assessment models, because harvest from this component of the game fish fishery is not likely to be representative of the recreational harvest overall. On the other hand, catch rates and size composition data derived from the GTMP can be useful as an independent source of information about relative changes in fish abundance and gear selectivity, and subsequently the size of fish that are caught by recreational fisheries, as demonstrated by the recent striped marlin stock assessment (Davies et al. 2012).

The Australian Government recognises that all sources of mortality should be incorporated into stock assessments, and this is stated as a requirement of the *Fisheries Management Act 1991*. Furthermore, objects of the *Fisheries Management Act 1991* oblige that the Australian Government pursue cost-effective and efficient management, maximise the net economic benefit to the community, and ensure ecological sustainability of stocks. However, the responsibility for management of recreational fisheries is currently ceded to state and territory jurisdictions of Australia, hereafter referred to as the ‘states’, because no federal management plan for recreational fisheries is in place. This ceded responsibility does not distinguish between fisheries that are occurring in state (inside three nautical miles from shore) or Commonwealth waters (outside three nautical miles from shore). Until the management of recreational fisheries is written into an official federal fisheries management plan, the states (including NSW) are responsible for obtaining information about recreational effort and catch for stock assessments and fisheries management, and will need to provide this data whenever possible.

5.2. Management issues and outcomes

Data collected on the recreational game fish fishery helps fishery managers promote quality recreational fishing opportunities, while ensuring that fishing activities are sustainable. Without reliable and high quality data, fishery managers are unable to achieve these goals. To highlight the importance of monitoring game fish catch and effort for improving management outcomes, a summary of the management issues that relate to recreational game fish fisheries in NSW follows, along with examples of how data have been used.

5.2.1. General management arrangements in NSW

General management arrangements in NSW for recreational game fish species include bag and size limits (NSW Department of Primary Industries 2013). For example, there is a bag limit of one fish per person per day for each of the three marlin species and for each of the large shark species (with a maximum number of five sharks, species combined, allowed). There is also a bag limit of seven tuna (in any combination of yellowfin, albacore, bigeye, longtail or southern bluefin) with only two tuna over 90 cm and five tuna under 90 cm allowed (NSW Department of Primary Industries 2013). These bag and size limits are administered by the NSW State Government and are in place under the *NSW Fisheries Management Act 1994*. Data from the monitoring program were used to improve the outcomes of the most recent NSW bag and size limit review, indicating that there was no need to change the bag limits currently imposed for game fish species.

5.2.2. The challenges of managing game fish fisheries

Game fish species are challenging to manage. They are highly migratory, with the ability to travel large distances over relatively short periods of time, and have wide distributions (Ortiz *et al.* 2003). For example, tagged and released black marlin and blue marlin make trans-Pacific and trans-oceanic movements, respectively, greater than 6000 km in less than six months at liberty (Ortiz *et al.* 2003).

Management challenges for these species and their associated fisheries are caused by the need to implement fishing controls that straddle different countries and cultures. This requires the cooperation of people from many different jurisdictions. For example, annual updates of the stock assessment model for yellowfin tuna in the WCPO requires the cooperation of all nations responsible for fishers who target this species in the WCPO region, including Japan, China, Taiwan, Australia, the United States and Pacific Island nations (Langley *et al.* 2009). This requires all parties to provide up-to-date data on their fishing operations for incorporation into the stock assessment model (Langley *et al.* 2009; Western and Central Pacific Fisheries Commission 2000).

Various cross-jurisdictional agreements help in the management of highly migratory game fish species, with the aim of ensuring sustainable fishing practices over wide spatial and long temporal scales. The overarching international agreements are the *United Nations Convention on the Law of the Sea 1984* and the *United Nations Fish Stocks Agreement*. These are aimed at ensuring that conservation and management of fish stocks are established, are based on the best available scientific information, and follow a precautionary approach. As stated by the Food and Agriculture Organization of the United Nations (FAO,2003):

> *'Management according to the precautionary approach exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values.'*

Numerous treaties and conventions exist for highly migratory species on more local scales. The most relevant to Australia is the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (hereafter referred to as the WCPO Convention). The WCPO Convention provides guidelines for precautionary management based on formal stock assessment models of key species. Signatory countries of the WCPO Convention and cooperating non-member countries are encouraged to provide relevant data for inclusion in stock assessment models. They are also expected to implement appropriate management measures to ensure sustainable fishing practices are maintained, based on the recommendations derived from stock assessment results (Western and Central Pacific Fisheries Commission 2000).

Aside from the international management issues and signatory responsibilities, there are also more local management issues. For example, the eastern seaboard of Australia has historically seen considerable conflict between fishers of the NSW state-managed recreational game fish fishery and the Commonwealth-managed commercial Eastern Tuna and Billfish Fishery. These conflicts result from competition over primary resources of importance to both stakeholder groups: in particular, striped marlin and yellowfin tuna. To alleviate these conflicts in Australia, a resource-sharing agreement between recreational and commercial fishers was investigated and trialled in 2006 (Ridge Partners Consultants and Advisers 2006).

The initial development of this resource-sharing agreement included analysis of commercial and recreational game fish fisheries catch and effort data. Available data were used to assess the interactions between recreational and commercial fisheries to derive preliminary resource shares (Bromhead *et al.* 2003; Bromhead *et al.* 2004; Knight *et al.* 2006; Ridge Partners Consultants and Advisers 2006). Recreational catch estimates to devise proposed resource shares were based on broad assumptions, due to the lack of data on the recreational fishery as a whole (i.e. non-club and club fishers combined). As such, the estimates were regarded as uncertain. However, the negotiated recreational shares – based on the estimates derived from the club-based fishery, and broad assumptions regarding the non-club fishery – ranged from 2.5% for albacore tuna and 4.6% for yellowfin tuna to 33.7% for striped marlin (Ridge Partners Consultants and Advisers 2006).

Australian Government funding to manage the resource-sharing agreement was withdrawn following a change in government in 2007, and the proposed measures were subsequently put on hold. However, negotiations between commercial and recreational fishers and governing agencies are ongoing in an attempt to alleviate these conflicts. A gentlemen’s agreement is currently in place, whereby commercial longline fishers are not to expend fishing effort in the spatial areas and temporal periods surrounding game fishing tournaments. Since this agreement has been put in place, reports of conflict between recreational and commercial fishers have apparently reduced.

The difficulties of managing a formal resource-sharing agreement between commercial and recreational fishers, if reinstated in the future, is the lack of information on the total recreational harvest and post-release mortality of game fish species caught by the recreational fishing sector (Bromhead *et al.* 2003; Bromhead *et al.* 2004; Ridge Partners Consultants and Advisers 2006). One possible way of estimating total fishing effort and catch in NSW for game fish species would be to use the recreational fishing licence fee database as a sampling frame for an off-site recreational fishing survey. The licence fee database would provide a list of recreational fishers and their phone numbers and home addresses. However, the use of this database on its own as a sampling frame may underestimate fishing effort and catch due to fishing licence exemptions (for example, a person under the age of 18, an Aboriginal person or the holder of a Pensioner Concession card are not required to pay the NSW recreational fishing fee). While the majority of fishers who participate in game fishing are not likely to fall within one of the exemption categories, a recreational licensing system should ideally include all recreational fishers, with current exempt categories obtaining a licence without charge. This would provide a comprehensive list to undertake fishing surveys at a greatly reduced cost compared with present methods. When purchasing a licence, fishers should also nominate which fisheries they mostly participate in (for example, freshwater, estuarine, game fish). This would further reduce survey costs and enable reliable surveys of hard-to-reach fisheries, such as the game fish and mulloway fisheries.

5.2.3. Outcomes of other game fish management issues

A number of other management issues associated with key game fish species highlight the importance of monitoring fishing effort and catch to help resolve those issues. This report has described the importance of game fish fisheries data for supporting fisheries stock assessments and for resource-sharing negotiations between recreational and commercial fisheries. To further demonstrate the importance of these data, three more examples follow showing how the use of data from the game fish fishery can improve outcomes for the recreational fishery and the management of game fish stocks.

5.2.4. The recreational-only status of blue and black marlin

The conflict between recreational and commercial fishers over the capture of blue and black marlin generated considerable media attention in 1997 (Findlay *et al.* 2003). Following negotiations between the Australian Government and the competing fishery sectors, commercial fishing for these species was banned in a number of areas. The status of blue and black marlin as a recreational-only species was due in part to data generated by the monitoring program that assessed the importance of these species to the recreational sector (Kalish *et al.* 2000).

Recreational data on these species will remain particularly important, because this ban reduced the reliability of commercial logbook data for these species (Findlay *et al.* 2003; Kalish *et al.* 2000). The agreement resulted in commercial fishers having to release any caught blue or black marlin and report them on their logbooks. However, quality control issues are an ongoing problem with commercial logbook data, particularly for species that are caught as bycatch (such as blue and black marlin, once the ban was put in place), because fishers often lack the motivation to record accurate data for these species. This then causes issues when estimating stock abundance (Bigelow *et al.* 1999; Findlay *et al.* 2003).

5.2.5. Shark fisheries management

Shark fisheries face many management issues worldwide, such as the low reproductive potential of most shark species, which makes them highly vulnerable to overfishing. Australia's National Plan of Action for the Conservation and Management of Sharks (Shark-plan) was implemented in response to the FAO International Plan of Action for the Conservation and Management of Sharks (Shark Advisory Group and Lack 2004). Shark-plan, which has now been updated (Shark-plan 2), provides guidelines to ensure that catches of sharks are sustainable – with special attention given to vulnerable or threatened species (DAFF 2012). Both versions of Shark-plan identified the need to review the effectiveness of management measures for the recreational sector, including the management of game fish fisheries. The need to fill gaps in information systems related to shark species, such as existing monitoring and data collection programs, was considered important for recreational, charter and indigenous fisheries (DAFF 2012; Shark Advisory Group and Lack 2004).

Some species directly targeted by game fish anglers, including tiger shark and shortfin mako shark, are listed on the IUCN Red List of Threatened Species as near threatened and vulnerable, respectively. Mako and porbeagle sharks were also listed under Appendix II of the Convention on Highly Migratory Species in 2009, and were consequently required to be listed under the EPBC Act. The provisions of the EPBC Act prohibited the killing, injuring, taking, trading, keeping or moving of these species once listed (Australian Government Department of the Environment 2010). However, game fishing representatives and the government used available catch and effort data to strengthen negotiations and demonstrate the importance of mako sharks to recreational fishers. No evidence was found from available data to suggest a decline in the mako shark population in Australian waters. This led to an amendment to the Act, allowing the continuation of recreational fishing for these species (Australian Government Department of the Environment 2010).

5.2.6. Commonwealth Marine Bioregional Planning

The spatially mapped fish strike and fishing effort data from NSW game fish tournaments (similar to that in Figures 3 and 4 of this report) were pivotal during the Commonwealth Marine Bioregional Planning process. These data, which were used to strengthened negotiations regarding the zoning of the Commonwealth offshore marine parks, were provided to the Australian Government in collaboration with the GFAA, NSW GFA and NSW DPI. As a result of the negotiations, the Australian Government did not impose any green ‘Sanctuary’ zones within the Areas for Further Assessment. Instead, they implemented multiple-use zones, which allowed recreational game fishers to continue to operate as previously in the offshore waters of NSW.

6. CONCLUSIONS

Our research has shown that catch rates do not indicate any long-term decline in any of the game fish species populations or fishing quality since the inception of this monitoring program in 1994. Some species showed indications of an improvement in fishing quality over the monitoring period, with catch rates indicating a possible overall increasing trend for mako shark, mahi mahi, yellowtail kingfish, skipjack (striped) tuna and wahoo. All other species were either highly variable inter-annually (black marlin, shortbill spearfish and yellowfin tuna) or had no overall increasing or decreasing trend (striped marlin, blue marlin, blue shark, tiger shark, hammerhead sharks, whaler sharks and albacore). There was a degree of uncertainty in the catch rate trends for all species, due to large overlapping confidence intervals. Thus, caution should be taken when interpreting these trends.

Alternate measures of fishing quality should be investigated to identify indices with greater sensitivity to change and thus with greater power to identify smaller changes in species abundance and fishing quality. These investigations coupled with identifying changes in fishing methods and the potential for hyperstability in catch rates that may be masking fishing quality declines would provide further insights into changes in this fishery and species that require greater attention.

The data summaries and catch rate analysis in this report meet the primary objective of this monitoring program, which is to support the assessment of game fish species. However, the cost efficiency of this monitoring program is a long-standing issue that needed investigating to ensure the project's future. Our results provide the first assessment of differences between data that were obtained from radio schedules ('scheds') versus the more expensive post-fishing interviews. The differences between sched and interview data were used to determine which tournaments require post-fishing interviews to provide an adequate level of data accuracy and precision, and which can be accurately monitored using sched data. Based on the recommended reduction in post-fishing interviews, we estimate that at least 20% of costs could be saved. The overall costs could also be reduced by outsourcing the monitoring program to a non-government research provider, because they can negotiate fixed hourly pay rates (as long as they are above the legislated minimum wage).

Further long-term savings may be possible once the methods recommended in this report are finalised, and catch rate standardisations are incorporated into the project for all primary game fish species. Once this work is complete, a full set of R scripts (with each being a written program with a set of steps to run all statistical analyses and produce all graphs for this project using the R statistical computing environment; R Development Core Team, 2011) will be available for all monitoring and reporting, which will increase program efficiency and reduce the time required for a Scientific Officer to run the project. So far, more than 50 R scripts have been written for the catch rate standardisation of striped marlin that was completed in 2012, and for all analyses and data summaries completed for this report. These scripts form the basis of the complete set of scripts needed for the future of the monitoring program – they simply need to be refined and expanded to cater for all main species requiring catch rate standardisations. R scripts will also be written and used for all future analysis.

By assessing the usefullness and design of the GTMP, which has now been in operation for 20 years, we have demonstrated that the data obtained are vital in improving negotiations between government and recreational and commercial fishing stakeholders. Data have strengthened the basis for long-term access to the fishery and promoted quality, sustainable recreational fishing opportunities in NSW.

7. FUTURE WORK

During our research, we have identified several trends that warrant thorough investigation to further improve our understanding of fishing quality and the accuracy of fishing effort, catch and catch rate estimates. Future work should be aimed at:

1. Investigating hyperstability in catch rate estimates. This could be investigated by comparing the differences in the efficiency of each fishing method: for example, fishing for billfish trolling lures versus drifting with live baits versus trolling with dead or live baits. These comparisons should be coupled with changes to the proportion of each fishing method used over time. Interview data since 2008 would provide the level of information required for this analysis. However, any shifts in the proportion of the different methods used may have changed before 2008. Therefore, we may only be able to identify fishing power differences between fishing methods, and not be able to standardise catch rate estimates before 2008 based on the results.
2. Investigating alternate measures of fishing quality to identify indices with greater sensitivity to change, and thus with the power to identify smaller changes in species abundance and fishing quality. These investigations, coupled with identifying changes in fishing methods and the potential for hyperstability in catch rates that may be masking catch rate declines, would provide further insights into changes in this fishery and species that require greater attention.
3. Providing estimates of the total catch for all tournaments since 2008. During this period, data for a number of tournament days is missing. Calculating the estimated catch for these missing data cells would provide an estimate of the entire tournament game fish fishery over this period. Furthermore, catch correction factors that have been developed over the past two years (which are not presented in this report, but are based on linear regressions similar to those in Figures 39–53) could be used to adjust these estimates. This would be particularly important for species with large differences between the catch on the scheds versus interviews (e.g. tunas and other game fish species).
4. Improving catch rate estimates as indicators of fish abundance for all primary game fish species by standardising the CPUE, using similar methods to that applied to striped marlin (Ghosn *et al.* 2012).
5. Investigating habitat selection of key species using catch, catch rate and environmental data to improve our understanding of the relationship between fishing quality of the recreational fishery and the oceanographic conditions that favour the occurrence of game fish species.

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9. APPENDICES

Appendix 1. Tournaments monitored each game fishing season (financial year) with the number of fishing days per tournament that sched and/or interview data were obtained

Number of fishing days sched and interview data were obtained each game fishing season (financial year)

Game fishing (financial) year	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
Zone Port-Tournament Code	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**
north CH-AIBT																				
north CH-HOTC					4		3				4		4		4		4	4	4	4
north FT-BLUE																				
north PM-GOLD			2								4	4	3		4		4			
north PM-GOLDL&J											1		1							
north PM-SHOO																				
PortS PS-AIBT	2				2				2		2									
PortS PS-ANIV											2	2								
PortS PS-BESO													2							
PortS PS-BFSO	3		3		3						3	3								
PortS PS-BILL																				
PortS PS-BLUE															1		1		1	
PortS PS-FISH																				
PortS PS-INTC	4		2		4		4		4		4	4	4		4		4	4	2	2
PortS PS-LADY	1				1				1		1		1		2		1		1	
PortS PS-SHOO																				
PortS PS-SHOR																				
PortS PS-SHOT																				
central BB-ANNI	2				3															
central BB-BHEY											2	1	2		2		2		2	1
central BB-CLUB											1									
central BB-OLYM															3					
central BB-SHOT																				
central BK-CZON			2		2						2	1	2		2		2		2	1
central BK-SIGT	3																			
central BW-BLUE																				
central LM-BFBZ	2		2		2		2		2		2	2	2		2		2		2	
central LM-SHRK											2		2							
central PH-AIBT															2					
central PH-ANIV																				
central PH-BHEY																				
central PH-CZON											2	1	2		2		2		2	1
central PH-MACI																				
central PJ-CZON											2	2	2		2		1			
central PJ-MAKO																	1			
central PJ-SIGT									1											
central SL-OPEN															2				2	2
central WG-CZON																				
central WG-OPEN											1	1	2		2		2		2	
central WG-SHOT																				

Game fishing (financial) year	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total Sum	Total Sum
Zone Port-Tournament Code	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**Sched**	**Int**	**of Sched**	**of Int**
north CH-AIBT					2	2	2	2													**4**	4
north CH-HOTC	4	4	4	4	4	4	4	4	3	2	1	1	4	4	4		4	4	3	3	**62**	38
north FT-BLUE									1	1											**1**	1
north PM-GOLD	4	2	4	4	4	4	4	4	5	5	4	5	4	4	2		3	3	2	4	**53**	39
north PM-GOLDL&J	1		1		1	1		1	1		1		1	1			1	1	1		**9**	3
north PM-SHOO	1																				**1**	0
PortS PS-AIBT											2	2	2	2							**12**	4
PortS PS-ANIV																					**2**	2
PortS PS-BESO	3																				**5**	0
PortS PS-BFSO			2		2		2		2												**20**	3
PortS PS-BILL																	2				**2**	0
PortS PS-BLUE	1	1	1	1																	**5**	2
PortS PS-FISH											2										**2**	0
PortS PS-INTC	4	3	4	4	6	6	4	4	4	2	4	4	4	4	3	3	4	4	1	1	**74**	45
PortS PS-LADY	1	1	1	1	1		1		1		1						1		1		**17**	2
PortS PS-SHOO					1	1															**1**	1
PortS PS-SHOR					1				2				2								**5**	0
PortS PS-SHOT											2		2		2		2		2		**10**	0
central BB-ANNI																					**5**	0
central BB-BHEY	2	1	2	2	2	2	2	2	2	2							2	2	2	2	**24**	15
central BB-CLUB																					**1**	0
central BB-OLYM																					**3**	0
central BB-SHOT																			1		**1**	0
central BK-CZON	1	1	2		2	1	2	1	2	2	2	2	2	2	2		2		1	1	**32**	12
central BK-SIGT																					**3**	0
central BW-BLUE													2		2		2		2		**8**	0
central LM-BFBZ	2		2	2	2	2	2	2	2	2	2	2	2	2	2				2	2	**38**	16
central LM-SHRK																					**4**	0
central PH-AIBT																					**2**	0
central PH-ANIV			2	2	2	1															**4**	3
central PH-BHEY											2	2	1	1	2						**5**	3
central PH-CZON			1	1	1	1			2	2	2	1	2		2		2	2	2	2	**24**	11
central PH-MACI									1												**1**	0
central PJ-CZON	2						1		2	1	2	2	2		2		2		2	2	**22**	7
central PJ-MAKO			2						1		2	1	2	1	1		2		2	2	**13**	4
central PJ-SIGT																					**1**	0
central SL-OPEN									2	2	2		2		2		2	2	2		**16**	6
central WG-CZON					1	1															**1**	1
central WG-OPEN			2		1		2	2	2		2	2	2	2			2	2	3	2	**25**	11
central WG-SHOT																	1		1		**2**	0

Appendix 1 cont. Tournaments monitored each game fishing season (financial year) with the number of fishing days per tournament that sched and/or interview data were obtained

Number of fishing days sched and interview data were obtained each game fishing season (financial year)

Game fishing (financial) year	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total Sum of Sched	Total Sum of Int
Zone Port-Tournament Code	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int	Sched	Int		
south BA-AIBT													3						3	3	3	3																			9	6
south BA-SZON													3													2					2										5	2
south BA-TOLL													3		3		3	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	2		3	3	2	2	38	32
south BA-YELO																			2		2	2	2		2		2	2	2	2	2		2	2	1		2		2		21	8
south BG-ALLI			3								3	3	3		3				3	2																	2	2			17	7
south BG-ANNI			3		4				3		3	3																													13	3
south BG-BLUE			4		3						4	4	4		3		3	2	3	3	1	2	3	3	3	1	2	2	2	3	2	2	2	2	3		1	3	1	1	44	28
south BG-BLUEL&J																									1		1														2	0
south BG-JINK	3		3						1																																7	0
south BG-SEIG	4		2		4																																				10	0
south BG-YELO	2		2		2						3	3	3		3				3	3	3	3	3		3		3	3	2	2	2	2	2	2	2		3	3	2	2	43	23
south ED-INVI																				2																					0	2
south ED-OPEN																															1				2		2	3	3	3	8	6
south GP-OPEN													3		3		1		3												3	3	3		3						19	3
south GP-SHOL											2	2			2		2		2		2										2	2									12	4
south JB-SAND											3	3	3		2				3	3	3	3	3	3	2	2	3	3	1	2	3	3	2		3		3		3		37	22
south KI-BBFC																	2		2		2	1	1		1		2	2			2	2	2		2		2		2	2	20	7
south KI-SZON																											2				2										4	0
south ME-BROA																																					2				2	0
south ME-OPEN																													3	3		2					3	3	3		9	8
south UL-JSLT	2						2																																		4	0
south UL-SAMS	2		3				3						3		3		2		3	3	4	3	3	2	3	3	3	3	3	3	3	3	3	3	3		3	3	2	2	49	28
south UL-SZON	2																				2		2																		6	0
Grand Total	**32**	**0**	**31**	**0**	**34**	**0**	**14**	**0**	**14**	**0**	**53**	**39**	**57**	**0**	**56**	**0**	**39**	**13**	**50**	**33**	**51**	**33**	**48**	**32**	**51**	**37**	**47**	**40**	**51**	**39**	**60**	**46**	**55**	**35**	**47**	**3**	**60**	**40**	**50**	**33**	**900**	**423**

Port Codes: BA=Batemans Bay; BB=Botany Bay; BG=Bermagui; BK=Broken Bay; BW=Brisbane Waters; CH=Coffs Harbour; ED=Eden; FT=Forster; GP=Greenwell Point; JB=Jervis Bay; KI=Kiama; LM=Lake Macquarie; ME=Merimbula; PH=Port Hacking; PJ=Port Jackson; PM=Port Macquarie; PS=Port Stephens; SL=Shellharbour; UL=Ulladulla and WG=Wollongong

Tournament Codes: AIBT=Australian International Billfish Tournament; ALLI=Alliance Tag and Release; ANNI=Anniversary; ANIV=Anniversary; BBFC=Blowhole Bigfish Classic; BESO=George Besoff Memorial; BFBZ=Big Fish Bonanza; BFSO=Big Fish Shootout; BHEY=Bill Heyward Memorial; BILL=Billfish Classic; BLUE=Bluewater Classic; BLUEL&J=Bluewater Classic Ladies and Juniors; BROA=Broadbill; CLUB=Club point score, CZON=Central Zone; FISH=Fish Port Stephens; GOLD=Golden Lure; GOLDL&J=Golden Lure Ladies and Juniors; HOTC=Hot Current; INTC=Interclub; INVI=Invitational; JINK=Jinkai Classic; JSLT; Jess Sams Light Tackle; LADY=Ladies; MACI=John McIntyre; MAKO=Mako (since the passing of Geoff Woolley, named the Geoff Wolley Memorial Mako); OLYM=Olympic; OPEN=Open; SAMS; Jess Sams; SAND; White Sands Light Tackle; SEIG=Sydney Easter International Game Fish; SHOL=Shoalhaven Light Tackle; SHOO=Shootout; SHOR=Shores; SHOT=Shootout; SHRK=Shark; SIGT=Sydney International Game Fish Tournament; SZON=Southern Zone; TOLL=Tollgate Islands Classic; YELO=Yellowfin tuna

Appendix 2. Table of a (A_Term) and b (B_Term) terms used to convert fork lengths to fish weight in grams for each species. References for terms used available upon request.

Common name	Scientific name	A_Term	B_Term
Australian bonito	Sarda australis	0.0121994	3.065094
Albacore	Thunnus alalunga	0.025955	2.9495
Black marlin	Makaira indica	0.001728	3.3125659
Chinaman leatherjacket	Nelusetta ayraudi	0.01994	2.807961
Dolphin fish	Coryphaena hippurus	0.0372726	2.67
Eastern blue-spotted flathead	Platycephalus caeruleopunctatus	0.0022404	3.2959
Frigate mackerel	Auxis thazard	0.02	2.99
Grey-banded cod (bar-cod)	Epinephelus ergastularius	0.0200831	2.96428
Gemfish	Rexea solandri	0.0103773	2.908396
Hammerhead sharks	Sphyrna spp.	0.0042	3.239
Kingfish	Seriola lalandi	0.0172349	2.92134
Shortfin mako shark	Isurus oxyrinchus	0.0074	3.07
Blue morwong	Nemadactylus douglasii	0.0247076	2.9528
Nannygai	Centroberyx affinis	0.0477	2.8213
Skipjack	Katsuwonus pelamis	0.0067819	3.28916
Slimy mackerel	Scomber australasicus	0.0095483	3.092431
Striped marlin	Tetrapturus audax	0.0041969	3.0875898
Snapper	Pagrus auratus	0.0467727	2.781
Tiger shark	Galeocerdo cuvier	0.0074	3.07
Southern bluefin tuna	Thunnus maccoyii	0.0313088	2.9058
Tiger flathead	Platycephalus richardsoni	0.00365	3.1922
Mackerel tuna	Euthynnus affinis	0.0065	3.22
Whaler sharks	Carcharhinidae - Generic code	0.0013	3.508
Yellowfin tuna	Thunnus albacares	0.0139086	3.086

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