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A 12-month survey of recreational fishing in the Gascoyne bioregion of Western Australia during 1998-99

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Fish for the future

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Fisheries research in Western Australia
The Fisheries Research Division of the Department of Fisheries is based at the Western Australian Marine Research Laboratories, P.O. Box 20, North Beach (Perth), Western Australia, 6020. The Marine Research Laboratories serve as the centre for fisheries research in the State of Western Australia.

Research programs conducted by the Fisheries Research Division and laboratories investigate basic fish biology, stock identity and levels, population dynamics, environmental factors, and other factors related to commercial fisheries, recreational fisheries and aquaculture. The Fisheries Research Division also maintains the State data base of catch and effort fisheries statistics.

The primary function of the Fisheries Research Division is to provide scientific advice to government in the formulation of management policies for developing and sustaining Western Australian fisheries.

Contents

A 12-month survey of recreational fishing in the Gascoyne bioregion of Western Australia during 1989-99

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Abstract

A 12-month creel survey of recreational boat-based and shore-based fishing in the Gascoyne bioregion of Western Australia was conducted between April 1998 and March 1999. During the survey 1,738 boat crews were interviewed at public boat ramps when they returned from their fishing trip. During patrols conducted along the coastline 695 groups of boat-based fishers and 1,060 groups of shore-based fishers were interviewed at fishing locations and camp sites.

The total annual recreational fishing effort for the Gascoyne bioregion was 243,000 fisher days (95%CI: 222,000 – 264,000). This comprised 113,000 fisher days by boats launched from public ramps, 53,000 fisher days by boats launched from beaches and 77,000 days by shore-based fishers.

The total recreational catch of all finfish species for the bioregion was estimated at 350 tonnes (95%CI: 320 – 380). This was one third of the commercial catch of 1,082 tonnes at the time. The most common species kept by recreational fishers in the Gascoyne bioregion were (in order of estimated weight kept) spangled emperor (79 tonnes), pink snapper (79 tonnes), narrow-barred Spanish mackerel (47 tonnes), blue-lined emperor (34 tonnes), golden trevally (20 tonnes), sweetlip emperor (16 tonnes), chinaman cod (10 tonnes gilled and gutted), western yellowfin bream (5 tonnes), tailor (5 tonnes), whiting species (5 tonnes), mullet species (2 tonnes) and western butterfish (2 tonnes). These catches do not include charter boats and therefore understate the total recreational catch for the bioregion.

Anglers have adopted modern technology to increase the efficiency of recreational fishing with 73 percent of boats launched from public boat ramps fitted with an echo-sounder and 49 percent using a global positioning system to find fishing locations. There was a very high level of compliance with the fishing regulations. Only four percent of boats launched from public ramps, one percent of boats launched from the beaches and one percent of shore-based fishers interviewed kept undersize fish. Very few fishers exceeded the bag limits. Most fishers had a reasonable knowledge of the fishing regulations and knew the bag (93%) and size (94%) limits for the species they were targeting or the predominant species they had caught.

1.0 Introduction

The Recreational Fisheries Program of Fisheries Western Australia has a strategic plan to conduct creel surveys of recreational fishing in each of the states bioregions (Penn, 2000) on a rotating bioregion-by-bioregion basis. The bioregions include the West Coast, Gascoyne Coast, North Coast and South Coast (Figure 1). To record and monitor changes in recreational catch and fishing effort, an integrated approach where all bioregions are to be surveyed on a regular basis (about once every five - six years) is in place.

Information on the recreational catch and fishing effort for each bioregion of Western Australia is required to develop management strategies to ensure the sustainability of fishing activities and for the conservation of fish stocks and fish habitat. These data will be used to assess the status of stocks for prime recreational species and provide fishing quality indicators such as catch rates, size composition, and variety of species caught. This information will also be used in the development of a management plan for each bioregion and will form the basis for future management decisions to improve or maintain the quality and diversity of recreational fishing experiences and to achieve equity between different users of this resource.

Recreational fishing is one of the most popular leisure activities in Western Australia. A recent survey (Baharthah and Sumner, 2000) estimated that 615,000 persons participate in recreational fishing one or more times a year. According to the survey, the Gascoyne bioregion was utilised by 39,000 (six percent) of recreational fishers each year.

The Gascoyne bioregion incorporates the area between False Entrance on the southern end of Shark Bay (27°S) up to north of Exmouth Gulf (114°50′E) and includes approximately 1,000 kilometres of coastline. The bioregion includes many of the prime recreational fishing locations in Australia. There is excellent shore-based cliff fishing at False Entrance, Steep Point, Dirk Hartog Island and many popular locations on Quobba and Gnaraloo stations. These locations provide shore-based anglers with the opportunity to tackle many prime pelagic species such as narrow-barred Spanish mackerel, yellowfin tuna and an occasional sailfish. There are ideal opportunities for boat-based fishers to catch a wide range of pelagic and demersal species in the Shark Bay and Ningaloo marine parks, Muiron Islands and Exmouth Gulf. However, increasing pressure from recreational fishers in the bioregion is providing many challenges for fisheries managers. The depletion of pink snapper stocks in the Shark Bay Marine Park is a case in point.

The purpose of this report is to provide an estimate of the recreational catch and fishing effort for the Gascoyne bioregion of Western Australia which has been derived using creel survey techniques. The estimated catch for all species recorded is presented together with information on species targeted, fisher’s place of residence, compliance with the regulations and attitudes of recreational fishers.

2.0 Methods

2.1 Survey design

There are many access sites for boats (including boat ramps and places boats may be launched from the beach) and potentially unlimited access for shore-based fishers on most of the Western Australian coastline. This is particularly true for the Gascoyne bioregion, which includes many of the State's prime locations for recreational fishing. Many of these locations are remote and only accessible by four-wheel drive vehicle. Nonetheless, many recreational fishers visit the bioregion and many camp out at these locations for extended periods. For this reason, creel surveys must cover a large geographical area that creates logistical difficulties for conducting field work. Furthermore, survey methods for boat-based fishers must be suitable for regions with many boat ramps and large distances between ramps (Figure 2).

Two creel survey methods were used to estimate the recreational catch of all species for boat-based and shore-based fishers in the bioregion. The bus route method (Robson and Jones 1989, Jones *et al*. 1990), where a survey interviewer visits all boat ramps in a district on the one day, was used for trailered boats launched from public boat ramps. Roving creel surveys were used to estimate the catch and fishing effort for shore-based fishers and fishers launching small boats from beaches.

Catch and fishing effort information for recreational fishers was recorded at a resolution of 5×5 nautical miles. These blocks fit within the statistical blocks used for recording the commercial catch in Western Australia (60×60 nautical mile) and offer a finer resolution preferred for reporting the recreational catch.

The catch and fishing effort from charter boats was not included in the study since a compulsory returns system for tour operators was undergoing development at the time. This information will be reported elsewhere.

2.2 Spatial and temporal stratification

The 12-month survey commenced in April 1998 and concluded at the end of March 1999.

The bioregion was divided into a number of districts so that an interviewer could visit all the boat ramps within a district in a day. Five geographic districts were defined, their boundaries were chosen to minimise travel time and hence costs of using the bus route method. Routes with prolonged stops at all public marine boat ramps were set up for each district (Figure 2). The districts and the number of boat ramps surveyed (in parentheses) were as follows: Shark Bay (3), Carnarvon (4), Quobba (1), Coral Bay (1) and Exmouth (3).

The survey of public boat ramps was stratified by district, season (spring, summer, autumn or winter) and school holiday periods (April, July and October). Separate total catch and fishing effort estimates were made for each of the 35 strata (5 districts × (4 seasons + 3 for school holidays)). These estimates were then aggregated to obtain the total recreational boat-based catch and effort for the bioregion.

The roving creel survey of shore-based fishers and boats launched from beaches was stratified by season and area. The areas were Steep Point, Tamala, Denham, Peron Peninsula, Carnarvon, Quobba, Gnaraloo, Ningaloo, Yardie Creek and Exmouth Gulf. Two or more areas were combined to obtain the catch and fishing effort for larger districts such as Shark Bay (Steep Point, Tamala, Denham, Peron Peninsula and Carnarvon) and the Ningaloo Marine Park (Gnaraloo, Ningaloo, Yardie Creek and Exmouth Gulf).

2.3 Sampling design

Boats launched at public boat ramps – bus route method

An independent bus route was set up for each of the five districts. The number of days surveyed per month depended on the location and season. More days were allocated to the locations and season where most fishing effort occurred, based on prior information on recreational fishing patterns provided by Fisheries Officers and recreational fishers. Between three and twelve survey days were allocated to each district per month.

The bus route schedules were constructed as described by Pollock *et al*. (1994). The start, travel and wait times for each ramp were rounded to the nearest minute. A Mathcad (Anon, 1999) worksheet was developed to generate the randomised schedules.

For each of the bus routes the starting location and direction of travel was chosen randomly. The bus route commenced either between ramps or at a ramp. However, due to the large distances between boat ramps, travel time and cost involved, starting at a ramp and returning to the same ramp to complete the route at the end of the shift was inefficient. Furthermore, removing this last leg of the bus route allowed more time to be spent at the boat ramps collecting data rather than travelling. For this reason the bus route method was constrained so that a shift could not commence part way through the wait time at a ramp although the probability of commencing at a ramp or travelling remained unchanged. It was likely that each site was visited during all hours of the day by the end of a season. McGlennon and Kinloch (1997) used a similar modification of the bus route method for a survey conducted in South Australia which also covered large distances.

The initial allocation of wait time to each ramp was based on prior information of ramp usage. This was reviewed as data from the survey became available. The wait time was then made proportional to the recreational fishing effort at each ramp. A minimum wait time of 20 minutes was introduced to ensure that adequate catch information was collected for all ramps. The route was chosen to minimise the distance travelled between boat ramps. Boat ramps were surveyed for the full day when there was one ramp in the district.

Within each season a random sample of survey days was chosen for each district. When it was not possible for recreational boats in a district to fish due to severe weather conditions, the survey was not conducted and it was assumed that there was zero catch and fishing effort for the day. The survey interviewer made this decision on the day after assessing the weather conditions. It was assumed that the number of days where recreational fishing was not possible due to severe weather was representative of each season.

The survey of boat ramps was restricted to seven hours during the day, from 11:00 am to 6:00 pm, which included preponderate fishing activity. Periods of lower fishing activity, such as at night, could not be covered with the available resources. Prior information suggested that, although night fishing occurred in some districts at certain times of the year, it comprised only a small portion of the total recreational fishing effort. Almost all recreational boats return to the boat ramps by 6:00 pm to avoid having to navigate the return trip in darkness. The safety of interviewers at night was also a concern.

The interviewer followed a pre-determined schedule specifying the boat ramps to visit and the sampling time for each boat ramp. Catch, fishing effort, biological, attitudinal and demographic information were collected from boat-based fishers. A form was used to record the environmental conditions as well as the time of boat launches and retrievals while the interviewer was at a boat ramp (Appendix A). Only recreational boat trailers were counted at the boat ramps; these could be distinguished from trailers used by professional fishers. A second form was used to record the time-spent fishing, catch, and other information for individual boats (Appendix B). The catch was recorded at the completion of the day's fishing and represents the entire catch for the duration of the trip. The catch of each species was counted and measured.

Boats launched from beaches – roving creel survey

A roving creel survey was used for boat-based fishers that launched small boats from beaches. The interviewers visited all fishing locations in the bioregion where a boat could be launched. This included locations only accessible by four-wheel drive vehicle. Instantaneous counts of the number of boats fishing, estimated by counting boat trailers and vehicles with roof racks, were made on arrival at each fishing location visited. The time spent fishing, catch and other relevant information was recorded when boat crews returned from the fishing trip (Appendix C). At camping sites groups of people were interviewed to collect participation and catch rate information.

The duration of the patrols were limited to daylight hours due to concerns for the safety of staff and budgetary constraints. Night fishing activities, although considered to be minor, were not included. This may have resulted in the lack of reporting of some species such as mulloway, which are known to occur in the area and generally caught at night.

Shore-based fishing – roving creel survey

A roving creel survey was used for shore-based fishers. The interviewers visited all locations in the bioregion where shore based fishing occurred, including those only accessible by four-wheel drive vehicle. Instantaneous counts of shore-based fishers were made on arrival at each fishing location visited. The time spent fishing, catch and other relevant information was recorded (Appendix C). At camping sites groups of people were interviewed to collect participation and catch rate information.

The duration of the patrols were limited to daylight hours due to concerns for the safety of staff and budgetary constraints. Night fishing activities, although considered to be minor, were not included. As noted previously this may have precluded records of some species taken at night. The Carnarvon jetty was not included in the survey since it was closed to fishing due to repair work in progress.

2.4 Estimation of total catch and effort

Boats launched at public boat ramps – bus route method

The fishing effort for the day was estimated from counts of the number of trailers at the boat ramps. Catch rates were estimated from information on the time spent fishing and catch obtained by interviewing fishers when they returned to the boat ramp at the completion of the fishing trip. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in fisher hours (Appendix D). The number of hooked fish eaten by sharks was estimated by multiplying the loss rate by fishing hours.

The measure of fishing effort for each season was adjusted to correct for the number of boats not involved in fishing activities. The correction was made by multiplying trailer counts by the proportion of boats interviewed that were participating in recreational fishing.

Fishing effort by boats that were launched before the start of a morning shift (11.00am) and returned after the start of the morning shift was also taken into account. The ratio of effort occurring prior to the start of a morning shift to that occurring after the start of a morning shift was estimated and a correction factor (*f*) applied to the effort estimate in the mornings for each season (Appendix D).

The total number of fish both kept and released for all species was estimated. The standard error associated with the estimate of the number of fish kept $SE(\hat{c})$ was calculated for each species. Assuming a student *t* distribution, the (1-α) percent confidence interval for the number kept ($\hat{c}$) was calculated from the standard error as follows:

$$\hat{c} \pm t(1 - \alpha / 2; \mathrm{n} - 1) SE(\hat{c})$$
$$\hat{c} \pm 1.96\ SE(\hat{c})$$

where $\alpha = 0.05$ for the 95% confidence interval and *n* is the number of boats surveyed (sample size). The estimates reported in the results (Section 3.0) have been rounded to reflect the level of precision.

Boats launched from beaches – roving creel survey

The boat-hours of fishing effort for the day were calculated by multiplying the instantaneous counts by the number of hours in the fishing day. Catch rates were estimated from information on the time spent fishing and catch obtained by interviewing boat-based fishers when they returned to the beach at the completion of the fishing trip. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in fisher hours (Appendix E).

Shore-based fishing – roving creel survey

The fisher-hours of fishing effort per day were calculated by multiplying the instantaneous counts by the number of hours in the fishing day. Catch rates were estimated from information on the time spent fishing and catch obtained by interviewing anglers while they were still fishing. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in fisher hours (Appendix F).

Weight estimation

For all three surveys, the whole weight of the catch, in tonnes, was estimated from length to weight relationships for each species. The weight of fish kept has been reported for the predominant species.

3.0 Results

During the survey 1,738 boat crews were interviewed at public boat ramps when they returned from their fishing trip. Of these 1,689 boat crews had been angling, 31 had used drop nets to catch blue swimmer crabs (of which 14 were both angling and crabbing), 28 had been diving using compressed air and four snorkelling.

During patrols conducted along the coastline 1,060 groups of shore-based fishers were interviewed at fishing locations and campsites. Of these groups 335 were shore-based fishing at the time of the interview, 411 had finished fishing for the day and 314 had not fished by the time they were interviewed, however, they had fished on the previous day. Of the 695 groups of fishers, that launched small boats from the beaches, interviewed at fishing locations and campsites, 12 were returning from fishing at the time of the interview, 386 had finished fishing for the day and 297 had not fished by the time they were interviewed, however, they had fished on the previous day.

The largest proportion of recreational fishers interviewed in the bioregion were from the Perth metropolitan area (Figure 3). However, there were also a large proportion of residents from elsewhere in the state. Residents of the Gascoyne bioregion predominantly fished from boats launched from public boat ramps. Most interstate visitors fished from the shore. Only twelve overseas residents were interviewed.

3.1 Species targeted

The target species varied with the district and fishing platform (boat or shore). For example, many boat-based anglers (i.e. boats launched from public ramps or beaches) from Shark Bay, Carnarvon and Quobba targeted pink snapper (Figures 4 and 5). However, boat-based anglers elsewhere and shore-based anglers fishing at locations other than Steep Point seldom targeted pink snapper (Figures 4, 5 and 6). Furthermore, the species targeted was related to the range of species frequently caught in each district and the time of the year. Anglers are more likely to target species such as narrow-barred Spanish mackerel in the season they are frequently caught. However, often anglers were not targeting a specific species. When this response occurred, the interviewer recorded whether they were fishing on the surface, bottom or both (i.e. surface fishing, bottom fishing or general fishing) since this determines the range of species that are likely to be caught.

Many recreational fishers caught the species being targeted (Tables 1, 2 and 3). For squid and blue swimmer crabs the gear used were specific to that species. However, anglers were also successful at targeting a specific species. Most anglers fishing from boats launched at public ramps targeting spangled emperor, pink snapper, narrow-barred Spanish mackerel, red emperor and blue-lined emperor caught that species. However, it was common for anglers to catch species other than the one targeted.

3.2 Recreational fishing effort

The recreational fishing effort for boats launched from public ramps, boats launched from the beaches and shore-based fishers were estimated separately due to the different creel survey methods used. Overall, recreational fishers in the bioregion spent more days boat-based fishing than shore-based fishing (Figure 7).

3.2.1 Boats launched from public ramps

The estimated total annual recreational fishing effort by boats launched from public ramps was 112,857 fisher days (95%CI: 102,714 – 123,000). The recreational boat-based fishing effort was greatest in Shark Bay (Nanga, Denham and Monkey Mia) followed by Exmouth (Tantabiddi, Bundegi and Exmouth) (Figure 8). Autumn (March, April and May) and Winter (June, July and August) were the most popular seasons for fishing in all districts.

Results indicate that most fishing occurred during the period of the day surveyed. However, fishing also occurred both before and after the survey period as indicated by the boat launch and retrieval times. The ratio of fishing effort occurring prior to the start of the morning shift to that occurring after the start of the morning shift was estimated and a correction factor (f) applied to the effort estimate for each season (Table 4 and Appendix D).

Most boats had returned to the ramp before the end of the shift (6:00pm). The number of boats returning after this time of the day, based on the number of trailers remaining, was relatively small (four per ramp on average). Boat trailers were occasionally left at Denham while the boat crews camped at Shelter Bay (South Passage) overnight. It was assumed that these boat crews did not fish at night.

3.2.2 Boats launched from beaches

The estimated total annual recreational boat-based angling effort for the Gascoyne bioregion was 53,336 fisher days (95%CI: 43,467 – 63,205) (Figure 9). Approximately half of this fishing effort occurred within the Ningaloo Marine Park (see Section 3.5). Approximately one third of this fishing effort occurred within Shark Bay (see Section 3.4). Autumn and Winter were the most popular seasons for fishing in all districts.

3.2.3 Shore-based fishers

The estimated total annual recreational shore-based angling effort for the Gascoyne bioregion was 77,196 fisher days (95%CI: 61,724 – 92,668) (Figure 10). The recreational shore-based fishing effort was greatest in Exmouth Gulf. This area, particularly between Exmouth and Wapet Creek, was popular with retirees targeting whiting and western yellowfin bream (Appendix G). The shore-based fishing effort for the Ningaloo Marine Park was also high, however, this included a larger area of coastline. Winter was the most popular season for fishing in all areas other than Steep Point where fishing for narrow-barred Spanish mackerel occurred in the summer months (December, January and February) when they were most frequently caught.

3.2.4 Total fishing effort

The estimated total annual recreational fishing effort for the Gascoyne bioregion was 243,389 fisher days (95%CI: 222,421 – 264,357). The fishing effort was highest in the more accessible areas such as Shark Bay, and near Exmouth (Appendix G).

The fishing effort from diving using compressed air and snorkelling (less than 2% of boat crews interviewed at boat ramps) was small in comparison to the effort from anglers. Most diving occurred at Quobba, Steep Point and Exmouth where lobsters were the main species targeted.

3.3 Recreational fishing catch

The recreational catch for boats launched from public ramps, boats launched from the beaches and shore-based fishers were estimated separately due to the different creel survey methods used.

3.3.1 Boats launched from public ramps

The most common species kept by recreational fishers that launched a boat from a public ramp in the Gascoyne bioregion were (in order of estimated number kept rounded to nearest 100) blue-lined emperor (27,600), pink snapper (20,100), spangled emperor (14,900), chinaman cod (13,500), squid (7,700), sweetlip emperor (6,800), western butterfish (6,300), western rock lobster (4,300), blue swimmer crabs (3,900) and narrow-barred Spanish mackerel (3,600) (Appendix H).

Species with a small total catch that could not be accurately estimated were not included in the results.

3.3.2 Boats launched from beaches

The most common species kept by recreational fishers that launched a boat from the beaches in the Gascoyne bioregion were (in order of estimated number caught rounded to nearest 100) spangled emperor (13,500), chinaman cod (9,500), pink snapper (7,200), sweetlip emperor (6,200), squid (3,500) and mullet species (3,200) (Appendix I). Species with a small total catch that could not be accurately estimated were not included in the results.

3.3.3 Shore-based catch

The most common species kept by recreational shore-based fishers in the Gascoyne bioregion were (in order of estimated number caught rounded to nearest 100) whiting species (30,100), western yellowfin bream (9,900), mullet species (8,600), squid (4,900), threadfin salmon species (4,300) and tailor (3,300) (Appendix J). Species with a small total catch that could not be accurately estimated were not included in the results.

3.3.4 Total catch

The most common species kept by all recreational fishers in the Gascoyne bioregion were (in order of estimated number kept rounded to nearest 100) whiting species (34,400), blue-lined emperor (33,400), spangled emperor (29,800), pink snapper (28,000), chinaman cod (23,300), squid (16,100), mullet species (14,700), sweetlip emperor (13,100), western yellowfin bream (10,000) and narrow-barred Spanish mackerel (7,600) (Appendix K). The range of species caught depends on the district and fishing platform (boat or shore). For instance, many boat-based anglers in Shark Bay and Carnarvon caught pink snapper (Figures 11 and 12). However, boat-based anglers elsewhere and shore-based anglers fishing at locations other than Steep Point seldom caught pink snapper (Figures 11, 12 and 13). Furthermore, the species caught related to the catchability of species in each district and the time of the year. Anglers are more likely to catch species such as narrow-barred Spanish mackerel in the season they are most abundant.

For many species, including blue-lined emperor, spangled emperor, pink snapper, chinaman cod and sweetlip emperor, the number of fish released was greater than the number kept.

For example, four pink snapper were released for every fish kept. Species with a small total catch that could not be accurately estimated have not been included in the results (Appendix K).

The total weight of fish kept was calculated from size composition data (Figures 14 to 20) for species where a length to weight relationship was available (Table 5). The total weight of fish kept in the bioregion was estimated for the following species: spangled emperor (79 tonnes), pink snapper (79 tonnes), narrow-barred Spanish mackerel (47 tonnes), blue-lined emperor (34 tonnes), golden trevally (20 tonnes), sweetlip emperor (16 tonnes), chinaman cod (10 tonnes gilled and gutted), western yellowfin bream (5 tonnes), tailor (5 tonnes), whiting species (5 tonnes), mullet species (2 tonnes) and western butterfish (2 tonnes).

Spangled emperor

Spangled emperor is an important species for recreational and commercial fishers. The estimated recreational catch for the bioregion was 29,800 fish kept (79 tonnes). A further 2,900 fish were estimated to have been eaten by sharks. The commercial catch from the bioregion for the same period was 81 tonnes. Spangled emperor was predominantly (95%) caught by boat-based fishers. Most of the catch was taken from within the Ningaloo Marine Park (76%) (see Section 3.5). Most fish kept were between 410 and 529 mm in length (Figure 14). A small number of fish kept by anglers were below the minimum size limit at the time of 410 mm.

Pink snapper

Pink snapper was predominantly (99%) caught by boat-based fishers. The estimated recreational catch for the bioregion was 28,000 fish kept (79 tonnes). A further 600 fish were estimated to have been eaten by sharks. Most of the recreational catch was taken from Shark Bay (73%) (see Section 3.4). Almost half of the recreational catch from the Gascoyne bioregion (38 tonnes) was from the western gulf stock (48% by weight). This exceeds the commercial pink snapper catch of five tonnes from the western gulf of Shark Bay during 1998. The number of pink snapper caught by recreational fishers in the western gulf was substantial (Table 6). Pink snapper was also the prime species caught by recreational fishers in Shark Bay in a previous survey (Sumner and Steckis, 1999).

There were management and community concerns whether the recreational catch level from the inner gulfs of Shark Bay could be sustained. Several management measures have been subsequently introduced to protect pink snapper stocks in the inner gulfs and reduce fishing pressure from the recreational sector. In 1997 a bag limit of two pink snapper per person, a minimum size limit of 500 mm, and a maximum size of 700 mm was introduced for the eastern gulf. The eastern gulf was then closed to pink snapper fishing on 9 June 1998 to enable this stock to recover from several years of intensive recreational fishing effort leading to severely reduced breeding stocks. For the western gulf, a minimum size of 450 mm, a bag limit of four and a limit of two fish over 700 mm per person was introduced during 1997.

The eastern gulf was closed to pink snapper fishing for most of the period when the survey was conducted with the result that a catch of less than three tonnes was recorded. For this reason, the recreational catch of pink snapper for previous years is likely to be greater than the catch for 1998-99. This survey shows that larger pink snapper were being kept from the Freycinet Estuary near Nanga (Figure 15) where anglers were targeting large fish in spawning aggregations. In contrast, most pink snapper kept from Freycinet Reach near Denham were just over the size limit of 450 mm at the time (Figure 16). For this reason, although the number of pink snapper kept from each area was similar, the weight of the catch from the Freycinet Estuary was twice that for Freycinet Reach (Table 7).

In contrast to the recreational fishery, commercial fishers predominantly target the oceanic stock of pink snapper. The catch of oceanic stock from the commercial quota-managed fishery during 1998 was 567 tonnes (Penn, 1999) compared to an estimated recreational catch of 17 tonnes. The oceanic stock is beyond the reach of many recreational fishing boats, however, charter boats operating from Denham also target this stock. The commercial oceanic stock quota-managed fishery is close to fully exploited (Penn, 1999). The number of recreational fishing boats and charter boats targeting the oceanic stock may increase in future years and should be monitored. The catch from charter boats was not included in this survey but is thought to be in the order of five tonnes from the oceanic stock and negligible for inner gulf stocks.

Narrow-barred Spanish mackerel and other mackerel species

Narrow-barred Spanish mackerel was predominantly (75%) caught by boat-based fishers. The estimated recreational catch for the bioregion was 7,600 fish kept (47 tonnes). A further 600 fish were estimated to have been eaten by sharks. The commercial landed catch for the combined West Coast and Gascoyne bioregions during 1998 was 67 tonnes (Mackie, 2000). This may be compared to a recreational catch of 59 tonnes from the same bioregions. The most common size class for fish kept was 950-999 mm (Figure 17). A small number of fish kept by anglers were below the minimum size limit at the time of 750 mm. Large fish of up to 1,600 mm were caught on occasions.

Recreational fishers also caught eight tonnes of other mackerel species. These were predominantly Queensland school mackerel (2,000 fish kept) and shark mackerel (1,900 fish kept). The commercial catch of these species for the same period was estimated to be 40 tonnes (Mackie, 2000).

Blue-lined emperor

Blue-lined emperor, locally known as black snapper, is predominantly a recreationally caught species as very low catches are recorded in the commercial fishery. The estimated recreational catch for the bioregion was 33,300 fish kept (34 tonnes). Blue-lined emperor was predominantly (99%) caught by boat-based fishers. Most of the catch was taken from Shark Bay (76%) (see Section 3.4). The most common size class for fish kept was 300-319 mm (Figure 18). Large fish of up to 660 mm were caught on occasions.

Golden trevally

Golden trevally is predominantly a recreationally caught species. The estimated recreational catch for the bioregion was 6,500 fish kept (20 tonnes). The commercial catch from the bioregion for the same period was about one tonne. Golden trevally was predominantly (63%) caught by boat-based fishers. Most of the catch was taken from within the Ningaloo Marine Park (74%) (see Section 3.5). There was no minimum size for this species at the time of the survey.

Sweetlip emperor

Sweetlip emperor is an important species for recreational and commercial fishers. The estimated recreational catch for the bioregion was 13,100 fish kept (16 tonnes). The commercial catch from the bioregion for the same period was about 14 tonnes. Sweetlip emperor was predominantly (99%) caught by boat-based fishers. Most of the catch was taken from within the Ningaloo Marine Park (79%) (see Section 3.5). Most fish kept were just above the minimum size limit of 280 mm at the time. Large fish over 450 mm were caught on occasions.

Chinaman cod

Chinaman cod is predominantly a recreationally caught species. The estimated recreational catch for the bioregion was 23,300 fish kept (10 tonnes gilled and gutted). The commercial catch from the bioregion for the same period was about one tonne. Chinaman cod was predominantly (99%) caught by boat-based fishers. Most of the catch was taken from within the Ningaloo Marine Park (85%) (see Section 3.5). Most fish kept were between 281 and 340 mm in length (Figure 20). There was no minimum size for this species at the time of the survey.

Western yellow-fin bream

Western yellow-fin bream is an important species for recreational and commercial fishers. The estimated recreational catch for the bioregion was 10,000 fish kept (5 tonnes). This is exceeded by the commercial catch for the bioregion of about 10 tonnes mostly from Shark Bay. Western yellow-fin bream was predominantly (99%) caught by shore-based fishers. Most of the recreational catch (92%) was taken from Exmouth Gulf.

Tailor

Tailor is an important species for recreational and commercial fishers. The estimated recreational catch for the bioregion was 6,600 fish kept (5 tonnes). This is exceeded by the commercial catch for the bioregion of 44 tonnes. Tailor was caught by boat-based (50%) and shore-based (50%) fishers. Most of the catch was taken from Shark Bay (87%) (see Section 3.4).

Whiting species

Whiting is predominantly a commercial species with a catch of 115 tonnes from Shark Bay during 1998 (Penn, 1999). The estimated recreational catch for the bioregion was 34,400 fish kept (5 tonnes). Present catch levels are considered to be sustainable (Penn, 1999). Shore-based fishers predominantly caught whiting species (88%). Most of the catch was taken from Shark Bay (64%) (see Section 3.4). There was no minimum size for this species at the time of the survey.

3.4 Shark Bay

The Shark Bay district takes in the Shark Bay Marine Park including Steep Point and the area on the east side of the Eastern Gulf from Uendoo Creek (south of Carnarvon) to Gladstone. The Shark Bay district also includes areas outside the marine park such as Denham Sound and the west side of Dirk Hartog Island. Almost all the fishing activity occurred within the boundaries of the Shark Bay Marine Park (Appendix G). There are specific regulations that apply to pink snapper caught within Shark Bay. State wide fishing regulations apply to other species.

The total annual recreational fishing effort for Shark Bay was 89,065 fisher days. This comprised 49,321 fisher days by boats launched from public ramps at Nanga, Denham and

Monkey Mia, 17,448 fisher days by boats launched from beaches within the marine park and 22,296 days by shore-based fishers.

The most common species kept by all recreational fishers in Shark Bay were (in order of weight kept) pink snapper (58 tonnes), blue-lined emperor (22 tonnes), narrow-barred Spanish mackerel (15 tonnes), spangled emperor (7 tonnes), tailor (4 tonnes), whiting species (3 tonnes), western butterfish (2 tonnes) and mullet species (2 tonnes). The catch of pink snapper includes the inner gulf stock (41 tonnes) and oceanic stock (17 tonnes) landed in Shark Bay.

The most common species kept by all recreational fishers in Shark Bay were (in order of estimated number kept) whiting species (22,100), pink snapper (21,800), blue-lined emperor (21,800), mullet species (11,900), western butterfish (6,300) and tailor (5,700) (Appendix L). The catch of pink snapper includes the inner gulf stock (13,900) and oceanic stock (7,900) landed in Shark Bay.

3.5 Ningaloo Marine Park

The Ningaloo Marine Park includes 260 kilometers of coastline down the west coast of the Exmouth Peninsula from Bundegi to Amherst Point. The marine park includes most of the Ningaloo Reef. There are eight sanctuary areas within the marine park where fishing is not permitted. There are specific fishing regulations for areas of the Ningaloo Marine Park where fishing is permitted.

The total annual recreational fishing effort for the Ningaloo Marine Park was 85,254 fisher days. This comprised 40,476 fisher days by boats launched from public ramps at Coral Bay, Tantabiddi, Bundegi and Exmouth, 25,881 fisher days by boats launched from beaches within the Marine Park and 18,897 days by shore-based fishers.

The most common species kept by all recreational fishers in the Ningaloo Marine Park were (in order of weight kept) spangled emperor (60 tonnes), golden trevally (15 tonnes), sweetlip emperor (13 tonnes), blue-lined emperor (9 tonnes) and chinaman cod (8 tonnes gilled and gutted).

The most common species kept by all recreational fishers in the Ningaloo Marine Park were (in order of estimated number kept) spangled emperor (22,600), chinaman cod (19,700), sweetlip emperor (10,400), blue-lined emperor (8,500), squid (8,200), golden trevally (4,800) and yellow-tailed emperor (4,700) (Appendix M).

3.6 Equipment used by fishers

Anglers have adopted modern technology to increase the efficiency of recreational fishing with 74% percent of boats launched at public boat ramps fitted with an echo-sounder (57% black and white, 17% colour) and 49% using a global positioning system to find fishing locations. Few boats had snapper winches fitted (3%). Most boats had a marine band radio fitted (79%).

The global positioning systems and echo sounders enable boat crews to easily locate fishing grounds and return to the same ground on future trips. This increases the efficiency of recreational fishers by enabling anglers to effectively target a range of species as well as increasing the catch rates for these species.

3.7 Compliance with fishing regulations

The survey data indicated that there was a very high level of compliance with the fishing regulations. Only 67 (4%) of the 1,738 boat crews interviewed at boat ramps, five (1%) of crews fishing from small boats launched from the beach and five (1%) of shore-based fishers had kept undersize fish. Very few fishers exceeded the bag limits.

Most fishers were able to demonstrate a reasonable knowledge of the fishing regulations. That is, the majority of fishers knew the bag (93%) and size (94%) limits for the species they were targeting or the predominant species they had caught.

3.8 Attitudinal responses

The attitudinal responses show that fishers had an appreciation of the impact of recreational fishing on fish stocks and the importance of keeping within bag and size limits (Table 8). Almost all fishers believed they knew the rules and that information on fishing rules was easy to obtain. Almost all fishers also reported that they had enjoyed their trip and this was not related to the quantity of fish caught, or the cost of the trip. Once they have caught enough fish for a couple of meals most fishers said that they stop fishing. The responses to the statement "I usually try to catch as many as the bag limit allows" (Appendix B, question 5) have a bimodal distribution (Table 8). Almost all fishers enjoy fishing even if they don't catch anything. The responses to the statement "Once I've caught enough for a couple of meals I usually release the rest" (Appendix B, question 5) have a bimodal distribution (Table 8). Many fishers that disagreed with this statement indicated to the interviewer that they stop fishing rather than catch fish to release. Once they have caught the bag limit for a species most fishers said they usually release the rest.

4.0 Discussion of results

Historically, annual stock assessments for species important to recreational fishers have had to be based solely on the available commercial catch data. These assessments have generally used age-structured models incorporating either yield per recruit or eggs per recruit information to determine target and limit reference points. A time series of recreational catch is clearly needed to improve the reliability of these stock assessments of recreational species. However, due to the costs involved, it is not practical to conduct creel surveys to obtain this information in all bioregions of the state on an annual basis. For this reason, comprehensive creel surveys are planned for each bioregion about once every five to six years. Other sources of information such as recreational fisher log books and surveys conducted by Fisheries Officers and Volunteer Fisheries Liaison Officers are expected to provide information on variations in recreational catch rates for the years between surveys.

At present there is little information available on the catch and fishing effort for charter boats. Charter boats were not included in the study since a compulsory returns system for tour operators was undergoing development at the time. This information will be available for future years. During 2001, 74 licenses to conduct fishing tours in the Gascoyne bioregion were issued. These licences were based in Shark Bay (13), Carnarvon (5), Coral Bay (5) and Exmouth (15). A further 36 licences to conduct fishing tours in the Gascoyne bioregion were issued to tour operators based outside the region. Several tour operators held more than one licence.

Based on the survey, size limits are an effective catch control measure as anglers reported releasing substantial numbers of undersize fish. Most anglers were able to demonstrate a good knowledge of the fishing regulations for species that they were targeting. This was supported by a high level of compliance in this bioregion of the state. At the time, however, the regulation of a minimum size limits allowed the retention of the largest individuals, which are usually the most fecund. This is an issue for some species and has now been addressed for pink snapper by the introduction of a bag limit of one over 700 mm in the western gulf of Shark Bay. Secondly, the release of undersize fish to meet the regulations does not necessarily relate to survival, particularly in deep waters. This issue is being addressed by a separate study (St John, pers. comm.).

The present bag limits were effective in limiting large catches on occasions. However, the survey indicated that very few fishers achieved the daily bag limits specified under present statewide recreational fishing regulations. For this reason, the present bag limits for some species are too large to offer any significant protection. Furthermore, bag limits will become even less effective if abundance declines further.

On occasions there were boats remaining at the boat ramps when the interviewer's shift finished at 6:00pm. However, it was not possible to account for boats that returned to the ramp after 6:00pm since no catch and fishing effort information was collected beyond this time. For this reason the catch and effort for species caught at night has been underestimated by the survey although this bias is likely to be small in comparison to the total catch and effort. Boat trailers were occasionally left at Nanga and Denham while the boat crews camped at Tamala Station or Shelter Bay (South Passage) overnight. These boat crews did not report fishing at night.

A roving creel survey was used to estimate the catch and fishing effort for boats launched from beaches and shore-based fishers. For this method the length of the fishing day was estimated as nine hours (9:00am to 6:00pm). There was little fishing activity outside this time at most locations. However, at a few locations, including Steep Point, some night fishing occurred. It was often not practical to record fishing activities after 6:00pm due to concerns for the safety of staff travelling on rough bush tracks in four wheel drive vehicles at night. For this reason, little catch and fishing effort information was collected beyond this time. The catch and effort for boats launched from beaches and shore-based fishers has therefore been underestimated by the survey, however, this underreporting is likely to be small in comparison to the total catch and effort.

5.0 Conclusions

The total recreational catch of all finfish species for the bioregion was estimated to be 350 tonnes. The recreational catch was one third of the commercial catch of 1,082 tonnes at the time. The commercial catch included 567 tonnes of pink snapper, 115 tonnes of whiting, 107 tonnes of mackerel and 293 tonnes of other species. The results clearly show the importance of recreational fishing in the Gascoyne bioregion, particularly in the Shark Bay and Ningaloo Marine Parks. The bioregion offers excellent opportunities for boat-based and shore-based recreational fishers who catch an extensive variety of prime angling species.

The true recreational catch for the Gascoyne bioregion will exceed the estimates provided by the survey. Charter boats, that operate in the region, catch a range of species including pink snapper, spangled emperor, sweetlip emperor, red emperor, baldchin groper and narrow barred Spanish mackerel that has not been included. The catch of pink snapper and blue-lined emperor from the western gulf of Shark Bay has been underestimated since no data was recorded for the Useless Loop community in Shark Bay. It is also likely that the catch of species such as mulloway, which are known to occur in the area and are generally caught at night, have been underestimated since night fishing activities were not included.

The information from this survey is being used in the development of bioregional recreational management arrangements and will provide a basis for future management decisions to improve or maintain the quality and diversity of recreational fishing experiences in the Gascoyne bioregion. The information collected will be used to assess the sustainability of fishing activities and will provide a basis for future catch allocation decision processes. Furthermore, these data provide indicators of fishing quality such as catch rates, size composition, and variety of species caught.

The closure of the eastern gulf of Shark Bay to pink snapper fishing on June 9, 1998 reduced the recreational catch of this species for the bioregion. Furthermore, it is likely that management measures for the western gulf introduced in 1998 also reduced the catch of pink snapper for the bioregion. For these reasons the recreational pink snapper catch for the period surveyed will be lower than previous years.

Further creel surveys are planned on a regular basis i.e. about every five to six years, to assess changes in the recreational catch for this and other bioregions of the state, with less comprehensive survey data being used to indicate trends during the intervening years.

6.0 Acknowledgments

The Recreational Fisheries Program of Fisheries WA with the support of the Recreational Fishing Advisory Committee funded the project. The authors acknowledge many people who assisted with the creel survey. We especially wish to thank our interviewers Paul and Pam Dickenson, Keith Shadbolt, Kevin O'Meara, Tracy Bowden, Lloyd Goodlad and Rod Ellison for their dedication and commitment that made completion of the project possible. The Fisheries Officers in the bioregion interviewed many recreational fishers to provide information. In particular Brendon Graham and Kerry Councillor conducted many of these patrols. Kerry King collected information from groups camped on Tamala Station. We would like to thank the owners of Tamala Station, Quobba Station, Gnaraloo Station, Warroora Station and Ningaloo Station for allowing access to their properties. Maria Tassone completed the arduous task of entering the information collected into the database. Elizabeth Roberts prepared many of the figures presented. Tim Leary provided technical support. Dr Jim Penn, Dr Mike Moran, Gary Jackson, Dr Rod Lenanton and Dr Rick Fletcher reviewed the draft manuscript and provided many useful comments.

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8.0 Tables

Table 1. Relationship between number of boats launched from public ramps targeting a species and number keeping that species in Gascoyne bioregion.

		SPECIES TARGETED										
		Bottom fish	Spangled emperor	General fish	Pink snapper	Surface fish	Squid	Emperor, general	Narrow-barred Spanish mackerel	Red emperor	Blue-lined emperor	Blue swimmer crab
SPECIES KEPT	Spangled emperor	197	84	25	8	4	0	9	12	17	1	0
	Pink snapper	146	0	4	80	0	0	0	1	0	1	0
	Squid	27	2	0	0	2	46	0	0	0	0	0
	Emperor, general	1	0	1	0	0	0	1	0	0	0	0
	Narrow-barred Spanish mackerel	19	8	24	4	26	0	1	27	1	0	0
	Red emperor	14	1	6	3	0	0	2	1	17	0	0
	Blue lined emperor	213	24	8	13	2	0	20	3	1	16	0
	Blue swimmer crab	0	0	0	1	0	0	1	0	0	0	20
	Nil catch	95	21	12	10	10	5	11	6	1	2	2
	Other	495	99	71	40	30	6	31	25	22	16	2
	Total No. of boats*	851	157	108	105	63	55	52	44	25	22	22

**Since more than one species was often kept by boat crews, the sum of species kept does not equal the total number of boats.*

Table 2. Relationship between number of boats launched from beaches targeting a species and number keeping that species in Gascoyne bioregion.

		SPECIES TARGETED								
		Spangled emperor	Bottom fish	Pink snapper	General fish	Narrow-barred Spanish mackerel	Trevally, general	Emperor, general	Squid	Blue-lined emperor
SPECIES KEPT	Spangled emperor	78	25	4	12	1	3	6	0	0
	Pink snapper	0	35	44	8	2	0	0	0	3
	Narrow-barred Spanish mackerel	3	14	2	7	17	0	0	0	0
	Trevally, general	16	6	1	3	0	9	0	0	0
	Emperor, general	1	0	0	0	0	0	2	0	0
	Squid	5	1	0	3	0	1	0	11	0
	Blue-lined emperor	6	24	11	3	0	1	0	0	13
	Nil catch	39	54	30	19	4	8	11	6	2
	Other	83	70	23	28	9	7	5	2	12
	Total No. of boats*	167	149	96	58	23	23	21	17	16

**Since more than one species was often kept by boat crews, the sum of species kept does not equal the total number of boats.*

Table 3. Relationship between number of shore-based fishers targeted a species and number keeping that species in Gascoyne bioregion.

	SPECIES TARGETED												
SPECIES KEPT	Whiting, general	Bottom fish	Spangled emperor	General fish	Surface fish	Mullet, general	Pink snapper	Narrow-barred Spanish mackerel	Queenfish, general	Tailor	Trevally, general	Western yellowfin bream	Emperor, general
Whiting, general	73	6	0	8	0	1	0	0	0	2	0	2	0
Spangled emperor	0	8	25	5	8	0	0	4	0	0	1	0	0
Mullet, general	0	0	0	1	1	16	0	0	0	0	0	0	0
Pink snapper	0	21	0	6	4	1	10	3	0	0	0	0	0
Narrow-barred Spanish mackerel	0	14	0	9	59	0	0	12	0	0	0	1	0
Queenfish, general	0	0	1	0	0	0	0	0	6	0	0	0	0
Tailor	2	12	2	6	11	3	2	1	0	8	0	0	0
Trevally, general	2	3	7	4	2	2	0	1	3	0	2	1	0
Western yellowfin bream	15	3	0	0	0	1	0	0	0	0	0	10	0
Emperor, general	0	0	0	0	0	0	0	0	0	0	0	0	0
Nil catch	78	79	77	69	37	12	15	11	7	8	11	6	12
Other	32	40	24	32	29	4	1	9	5	7	3	2	2
Total No. of boats*	178	144	135	127	119	32	32	30	23	23	18	17	14

**Since more than one species was often kept by boat crews, the sum of species kept does not equal the total number of boats.*

Table 4. Correction factors for fishing effort occurring before the start of the daily survey period.

Season	Ratio of effort prior to start to after start	Correction factor (f)
Summer	0.78	1.78
Autumn	0.40	1.40
Winter	0.29	1.29
Spring	0.42	1.42

Table 5. Estimated total recreational catch by weight for major species caught in Gascoyne bioregion.

Common Name	Length-weight relationship	Source for length-weight relationship	Total weight (tonnes)	Standard error
Emperor, spangled	$W=1.24x10^{-5}L^{3.07}$	Moran *et al.*, 1988	79.4	6.5
Snapper, pink	$W=4.68x10^{-2}FL^{2.78}$ FL=((L-0.7)/1.179)/10	Moran and Burton 1990	78.9	7.0
Mackerel, narrow-barred Spanish	$W=6.50x10^{-7}L^{3.31}$	Mackie, M., 2000	46.8	10.0
Emperor, blue-lined	$W=9.15x10^{-6}L^{3.09}$	Keay, I. unpublished data	34.1	3.5
Trevally, golden	$W=4.82x10^{-4}L^{2.45}$	Moran *et al.*, 1988	20.2	4.4
Emperor, sweetlip	$W=5.12x10^{-5}L^{2.84}$	Moran *et al.*, 1988	15.7	2.1
Cod, chinaman	$W=1.04x10^{-5}FL^{3.04}$	Mackie, 2000	9.7 gilled & gutted	0.9
Bream, western yellowfin	$W=1.76x10^{-5}L^{2.99}$	Hesp, A. unpublished data	5.2	2.0
Tailor	$W=7.0x10^{-6}L^{3.05}$	Steckis, R. unpublished data	5.0	1.0
Whiting, general	$W=8.32x10^{-6}L^{2.98}$	Hyndes, G. unpublished data	4.8	0.7
Mullet, general	$W=8.57x10^{-6}L^{3.02}$	Torres, 1991	1.8	0.6
Butterfish, western	$W=1.22x10^{-5}FL^{3.06}$ FL=TL/1.117+2.347	Mant, 2000	1.5	0.4

Note: W is weight in grams; L is total length in millimetres; FL is fork length in millimetres;

Table 6. The Recreational catch of pink snapper from three separate snapper stocks (western gulf, eastern gulf and oceanic) in Shark Bay for the 12-month period between April 1998 and March 1999.

Area	Effort (boat-based fisher days)	Number Kept	Standard Error	Number Released	Weight Kept (tonnes)
Freycinet Reach (Denham)	21,047	6,257	869	61,216	12.2
Freycinet Estuary (Nanga)	17,208	6,351	916	14,695	25.7
Total Western Gulf	38,255	12,608	1,263	75,911	37.9
Eastern Gulf#	11,066	1,318	542	12,109	2.9
Mainly Oceanic (includes boats launched from beaches)	17,448	7,898	1,123	5,938	17.1

#Since the Eastern Gulf was closed to pink snapper fishing on June 9, 1998 the number kept from April 1 to June 8 is shown. The number released is for the full twelve-month period.

Table 7. Total length and weight of pink snapper caught in Shark Bay.

Area	No. Fish Measured	Mean Length (mm)	Mean Weight (kilograms)
Freycinet Reach (Denham)	185	530	1.949
Freycinet Estuary (Nanga)	230	685	4.053
Eastern Gulf	18	564	2.231

Table 8. Response to statements about recreational fishing in WA.

Statement	Disagree	Not Sure	Agree
There are so many fish off the West Coast that we can catch as many as we like.	449	16	19
The recreational fishing catch is too small to affect fish stocks.	282	82	115
Individual fishers can help protect fish stocks by keeping within bag and size limits.	6	9	469
I know the current rules for the fish I catch and try to keep up to date.	3	29	450
Information of fishing rules is hard to get.	431	24	28
If I don't catch enough fish to justify the cost I don't really enjoy the trip.	429	23	29
Once I have caught enough for a couple of meals I usually stop fishing.	155	91	232
I usually try to catch as many fish as the bag limit allows.	171	37	271
I enjoy fishing even if I don't catch anything.	44	29	408
Once I've caught enough for a couple of meals I usually release the rest.	196	87	191
Once I've caught the bag limit for a species I usually release the rest.	58	11	410

9.0 Figures

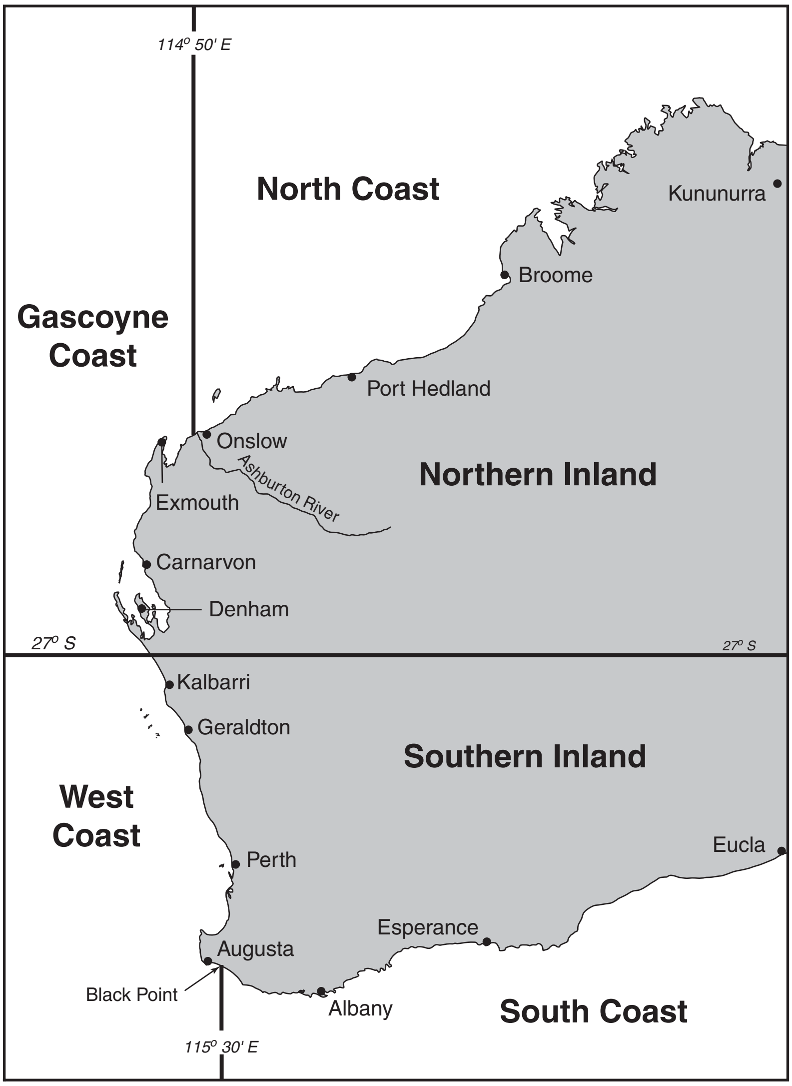


Figure 1. Map of Western Australia showing the boundaries of the marine Bioregions used for management of the state's fisheries.

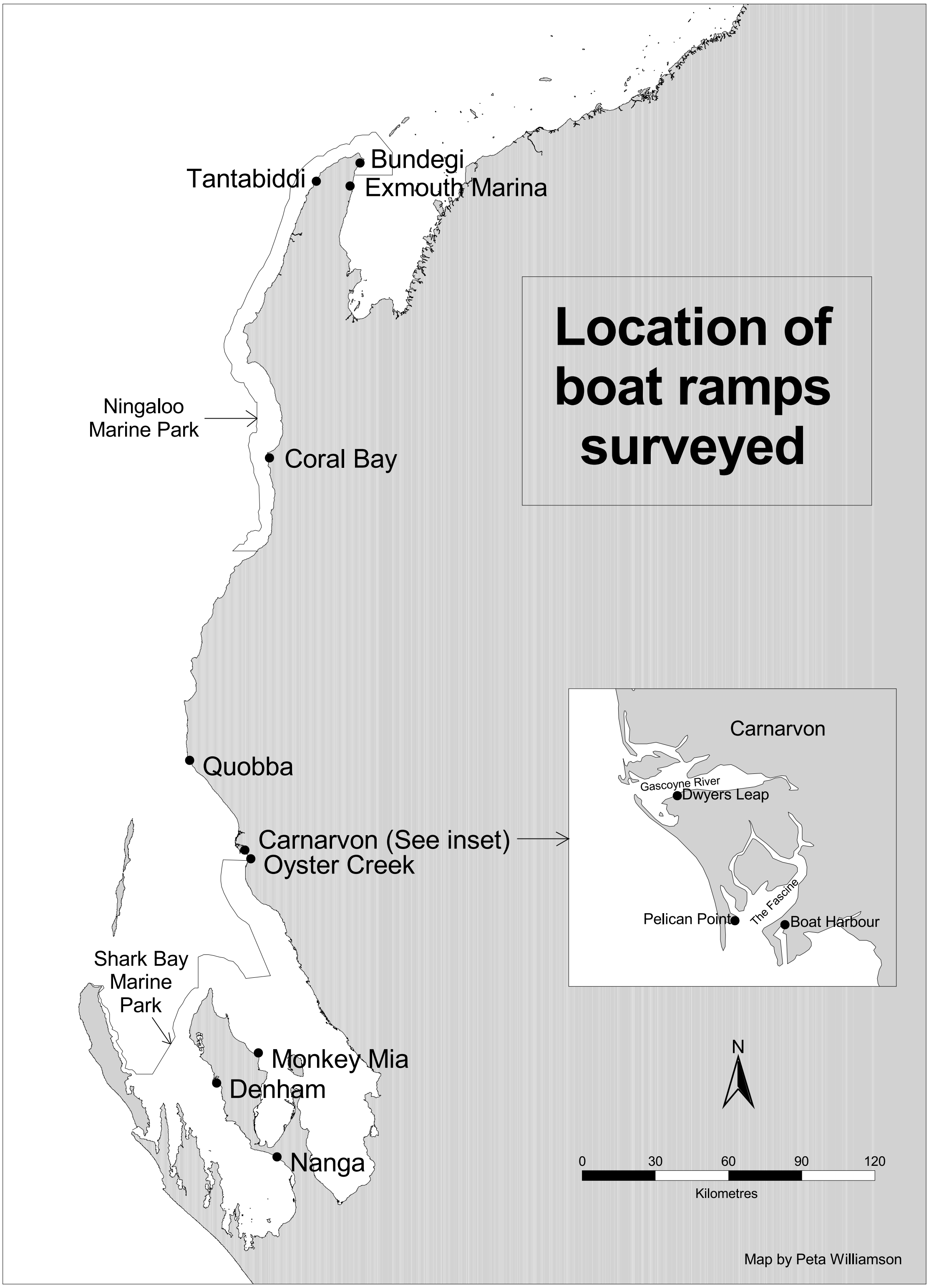


Figure 2. Map of Gascoyne bioregion showing boat ramps surveyed to record recreational fishing catch and effort 1998-99.

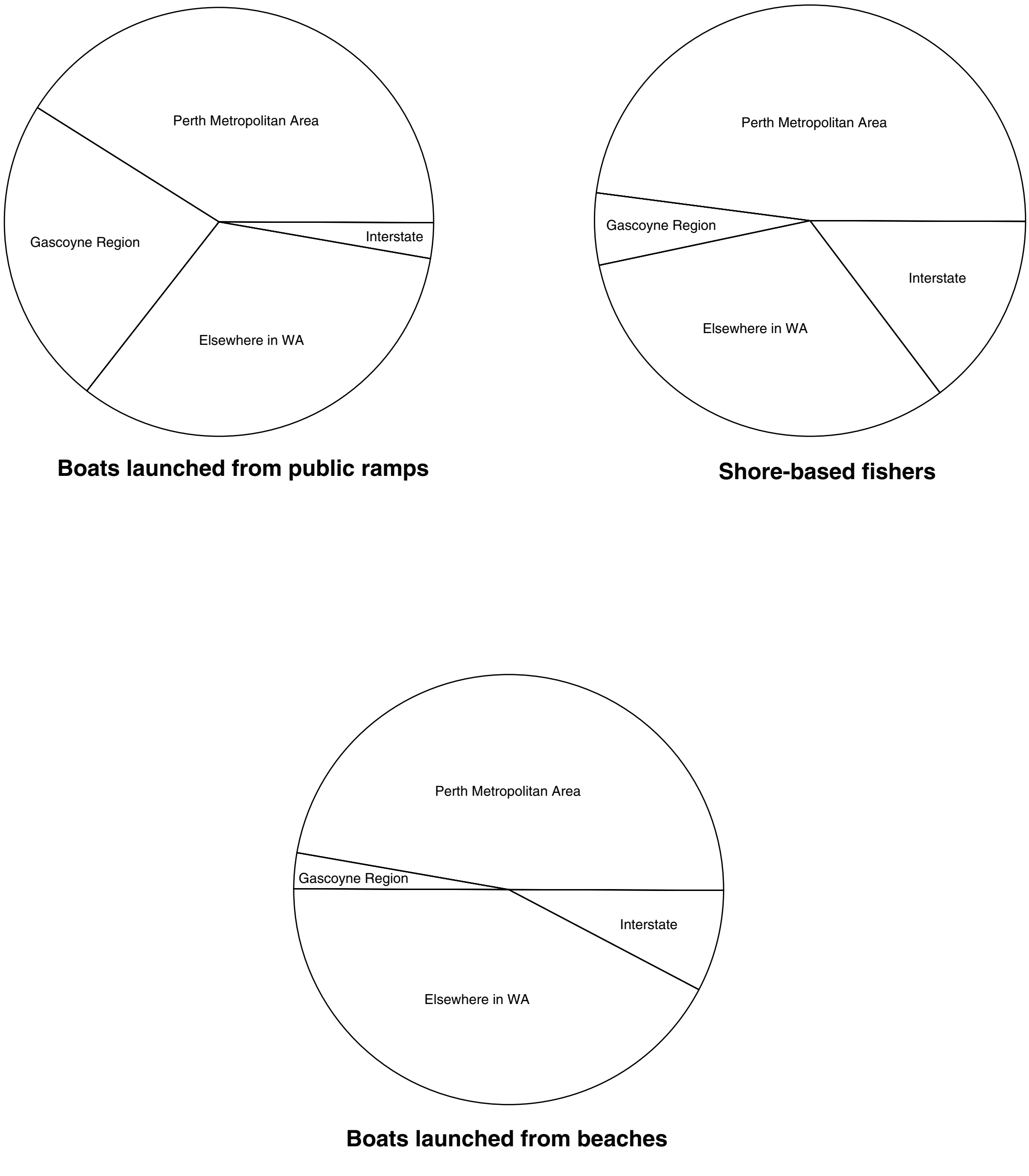


Figure 3. Place of residence for recreational fishers interviewed during the survey of recreational fishing in the Gascoyne bioregion 1998-99.

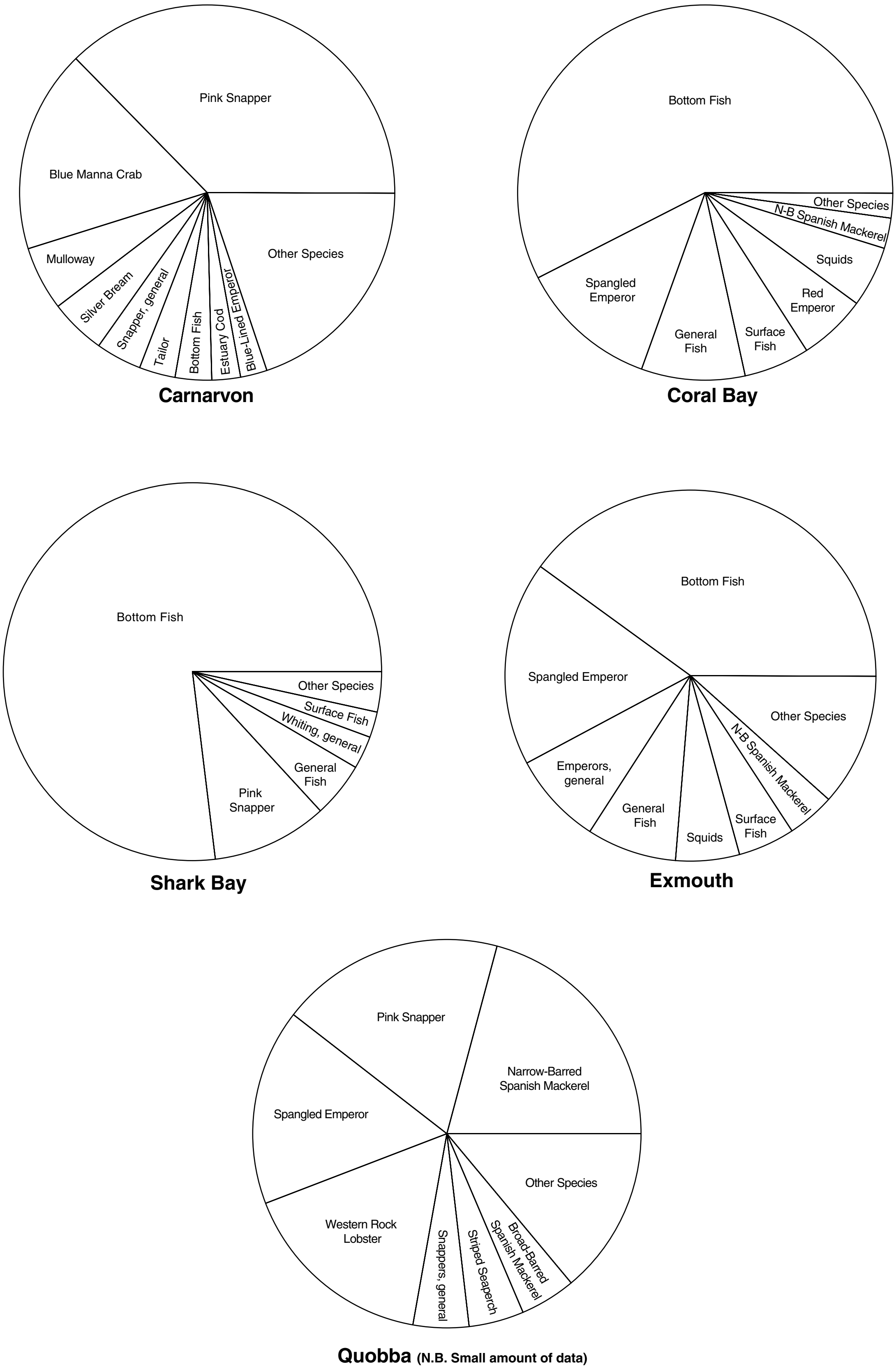


Figure 4. Species targeted by boats launched from public ramps during the survey of recreational fishing in the Gascoyne bioregion 1998-99.

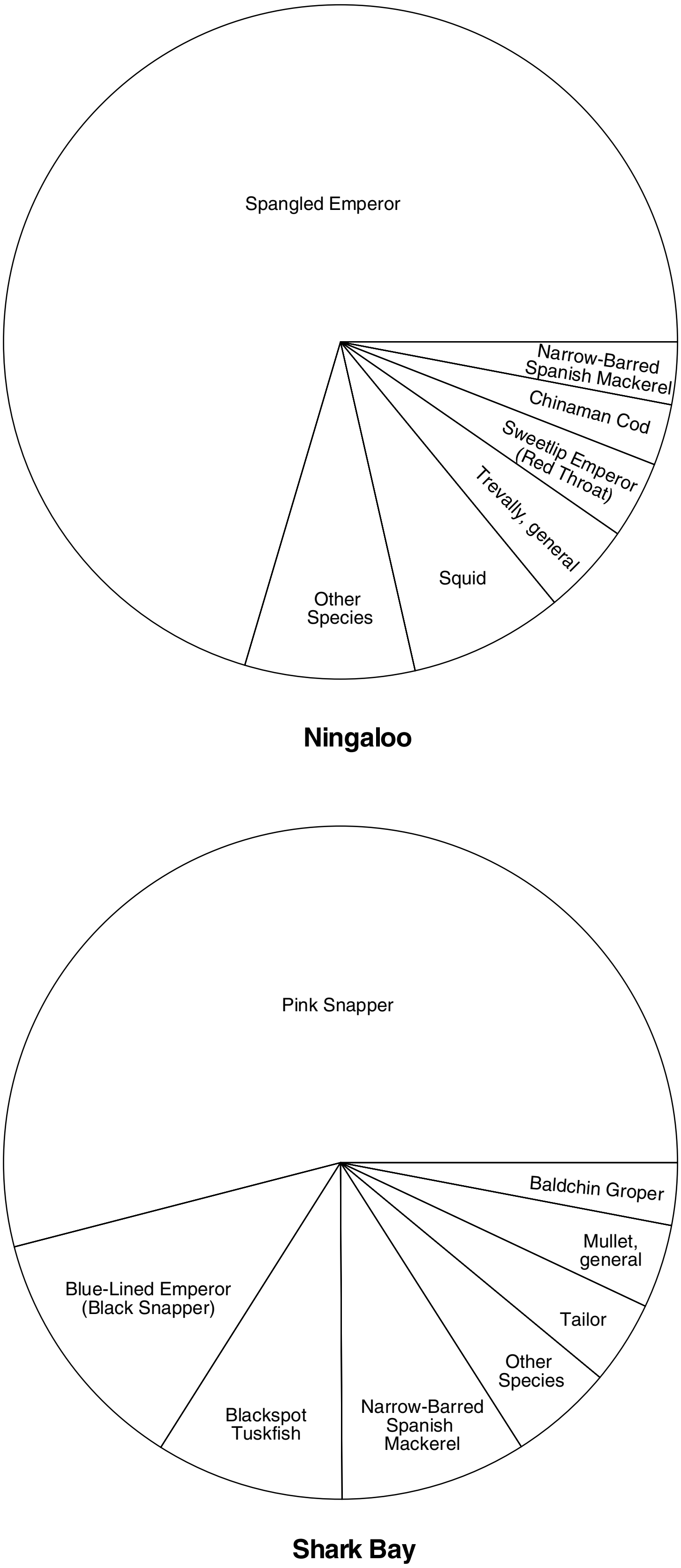


Figure 5. Species targeted by boats launched from beaches during the survey of recreational fishing in the Gascoyne bioregion 1998-99.

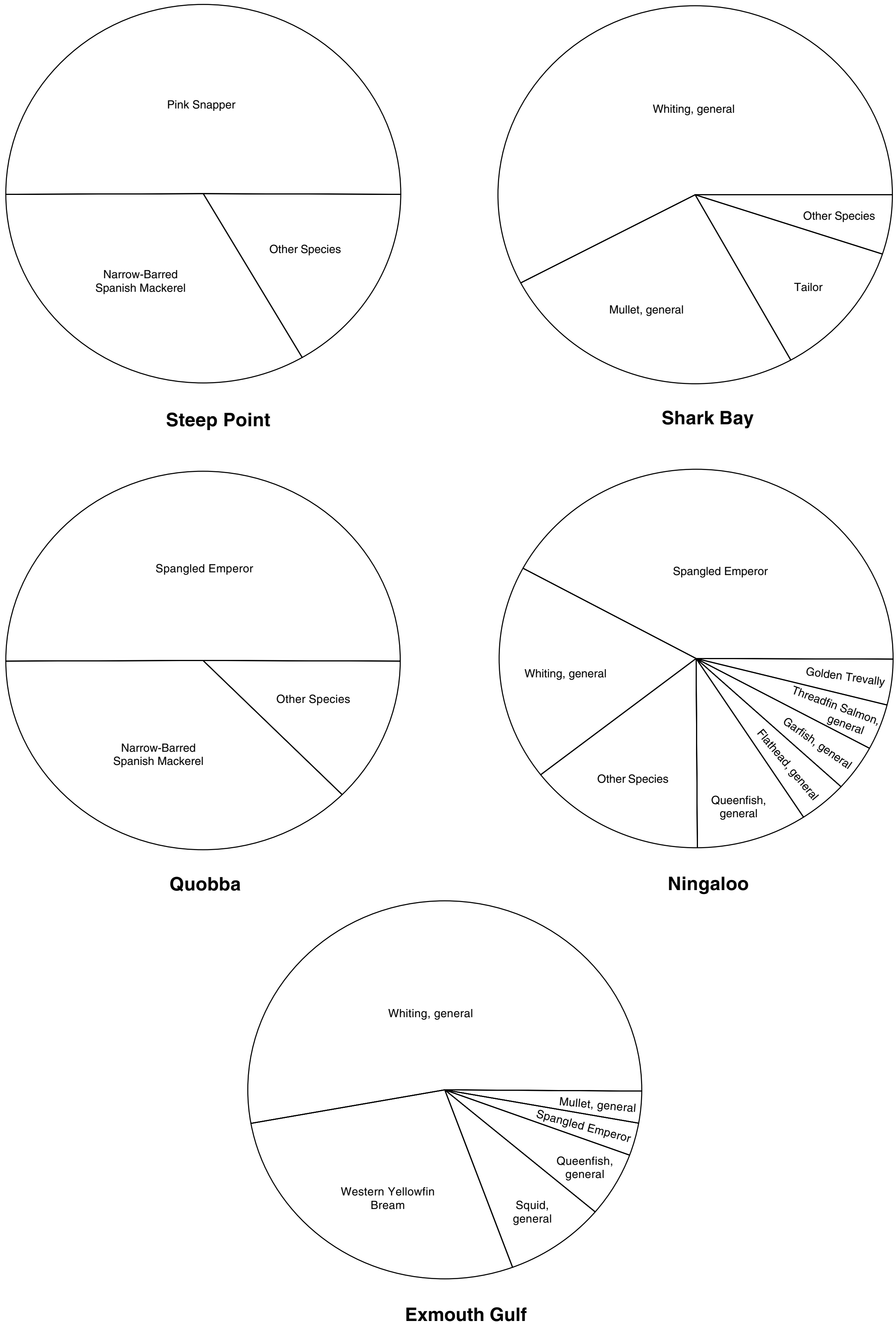


Figure 6. Species targeted by shore-based fishers during the survey of recreational fishing in the Gascoyne bioregion 1998-99.

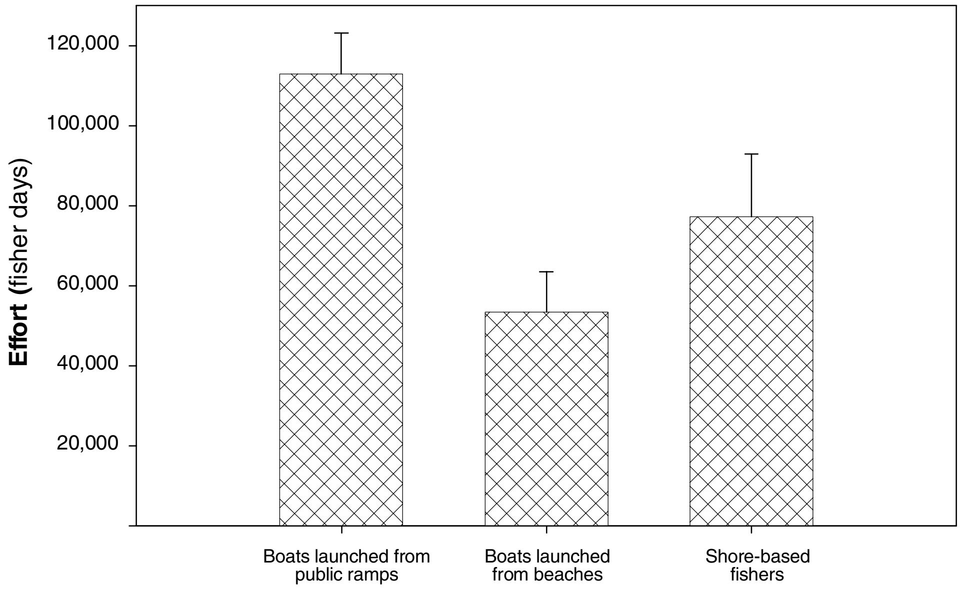


Figure 7. Recreational fishing effort in Gascoyne bioregion.

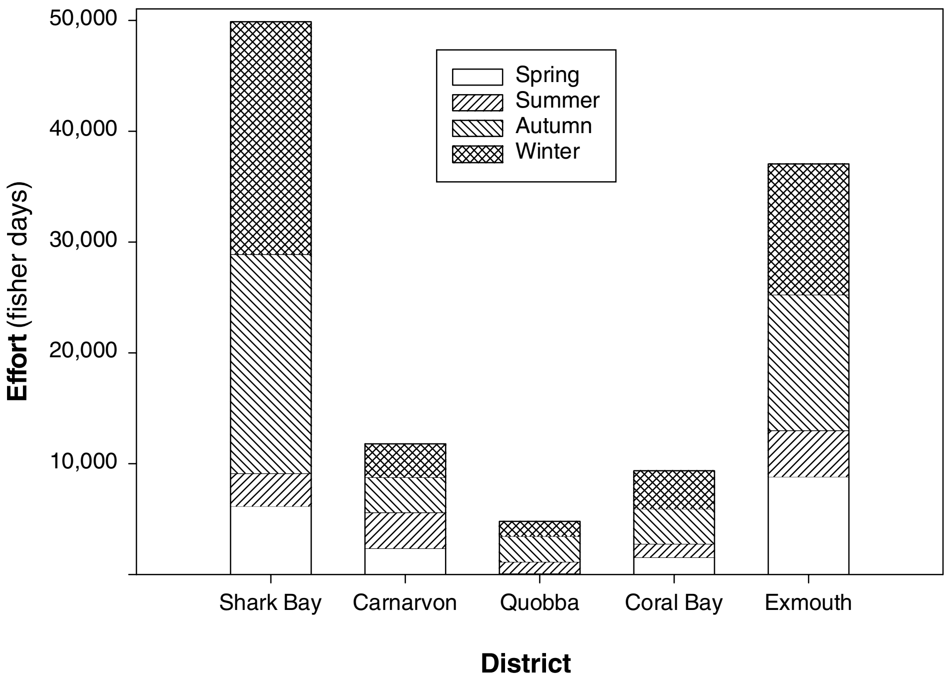


Figure 8. Seasonal fishing effort for boats launched from public ramps in Gascoyne bioregion.

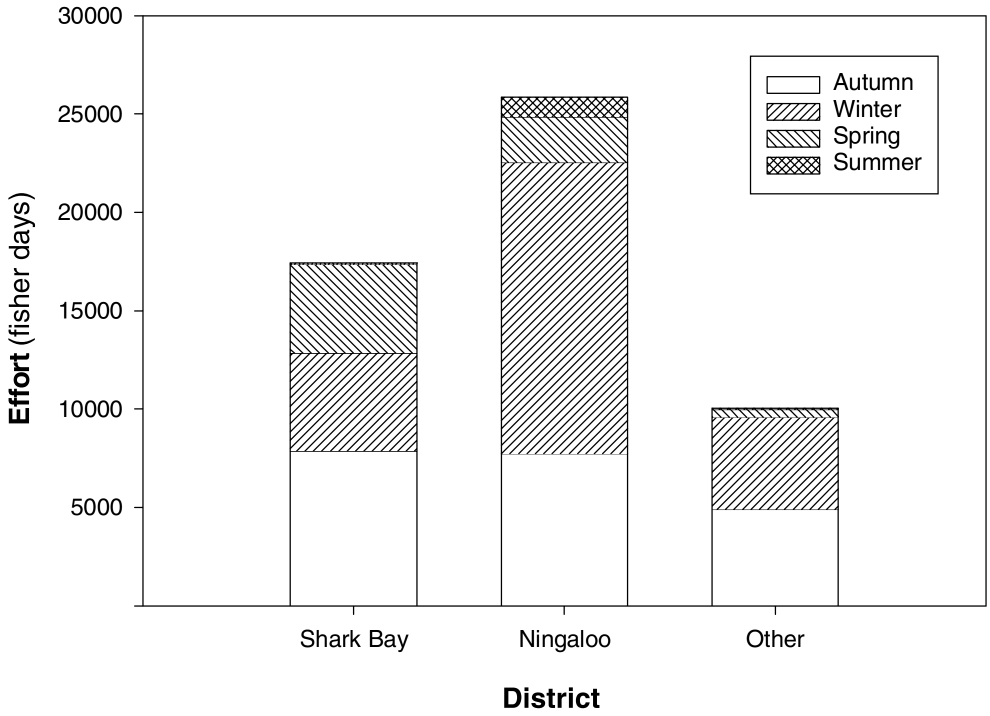


Figure 9. Seasonal fishing effort for boats launched from beaches in Gascoyne bioregion.

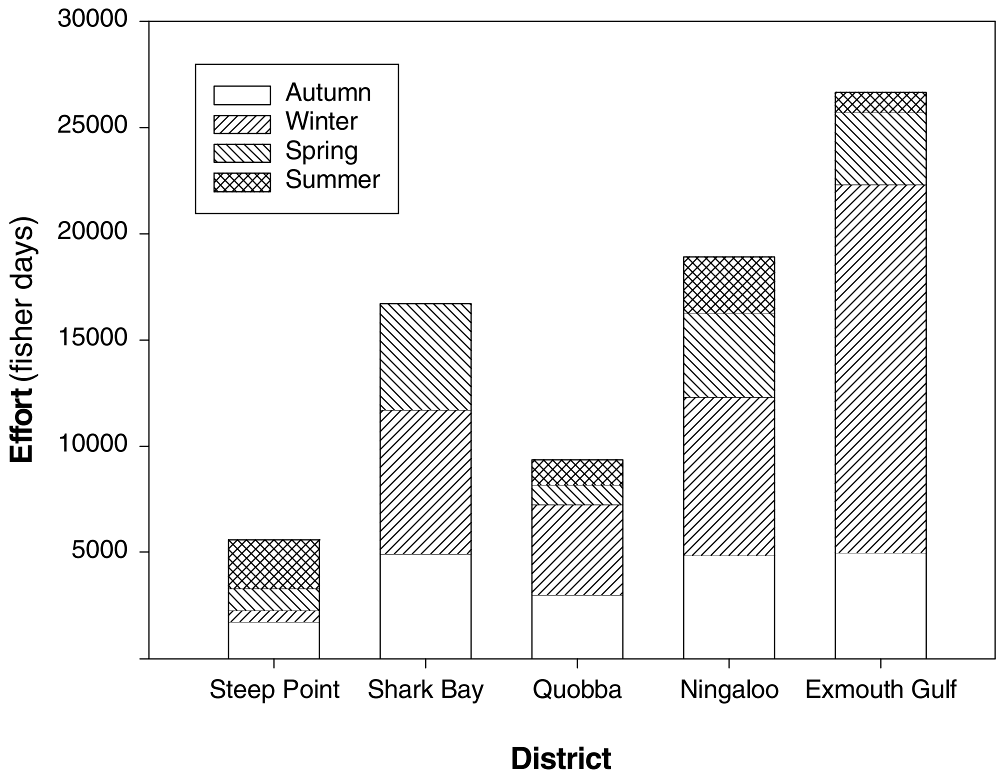


Figure 10. Seasonal fishing effort for shore-based fishers in Gascoyne bioregion.

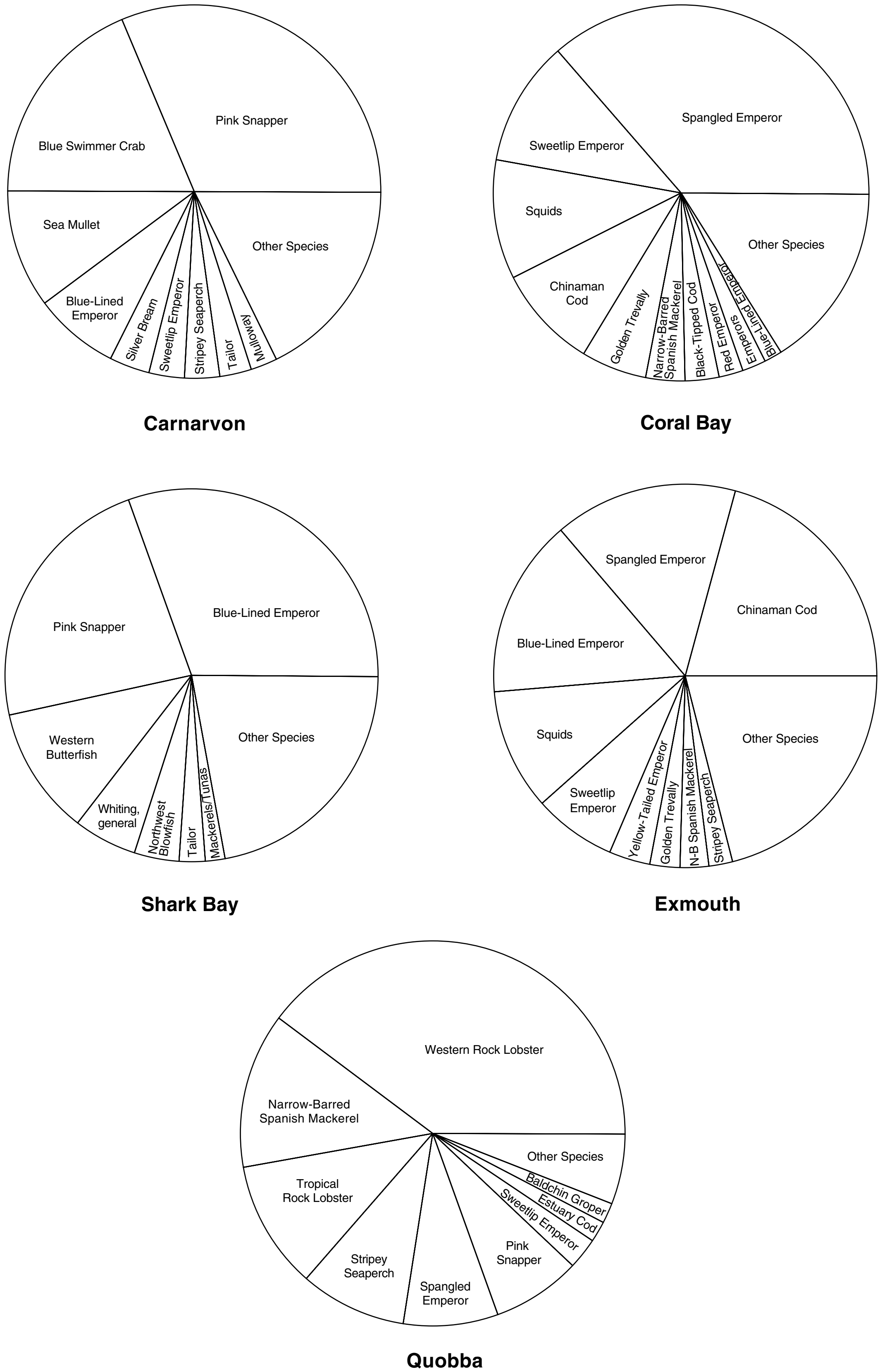
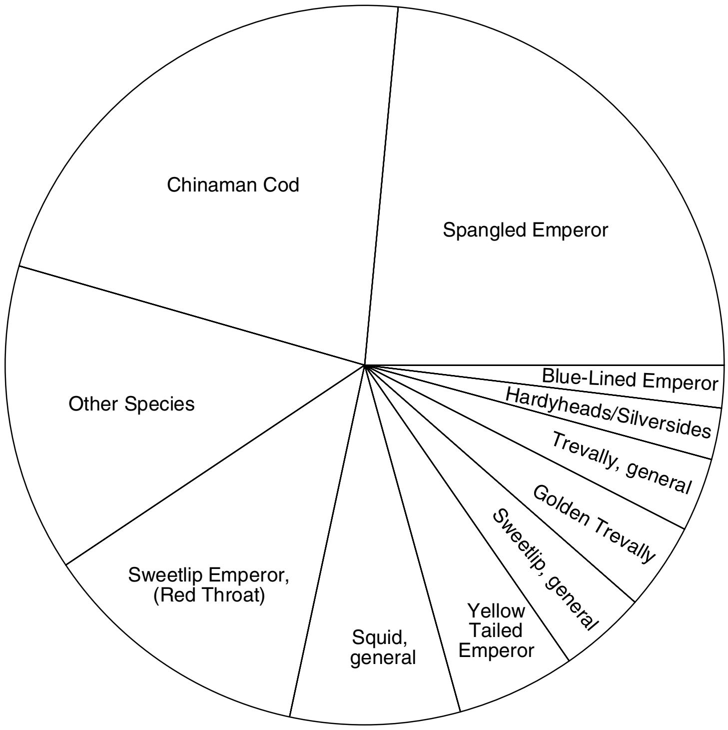
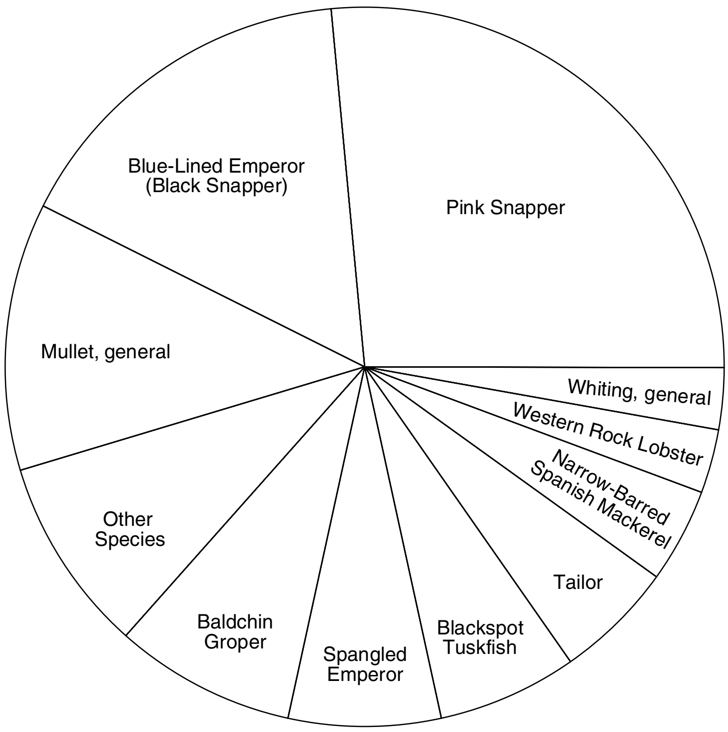


Figure 11. Species composition (by number of fish) of recreational catch for boats launched from public ramps in Gascoyne bioregion.



Ningaloo



Shark Bay

Figure 12. Species composition (by number of fish) of recreational catch for boats launched from beaches in Gascoyne bioregion.

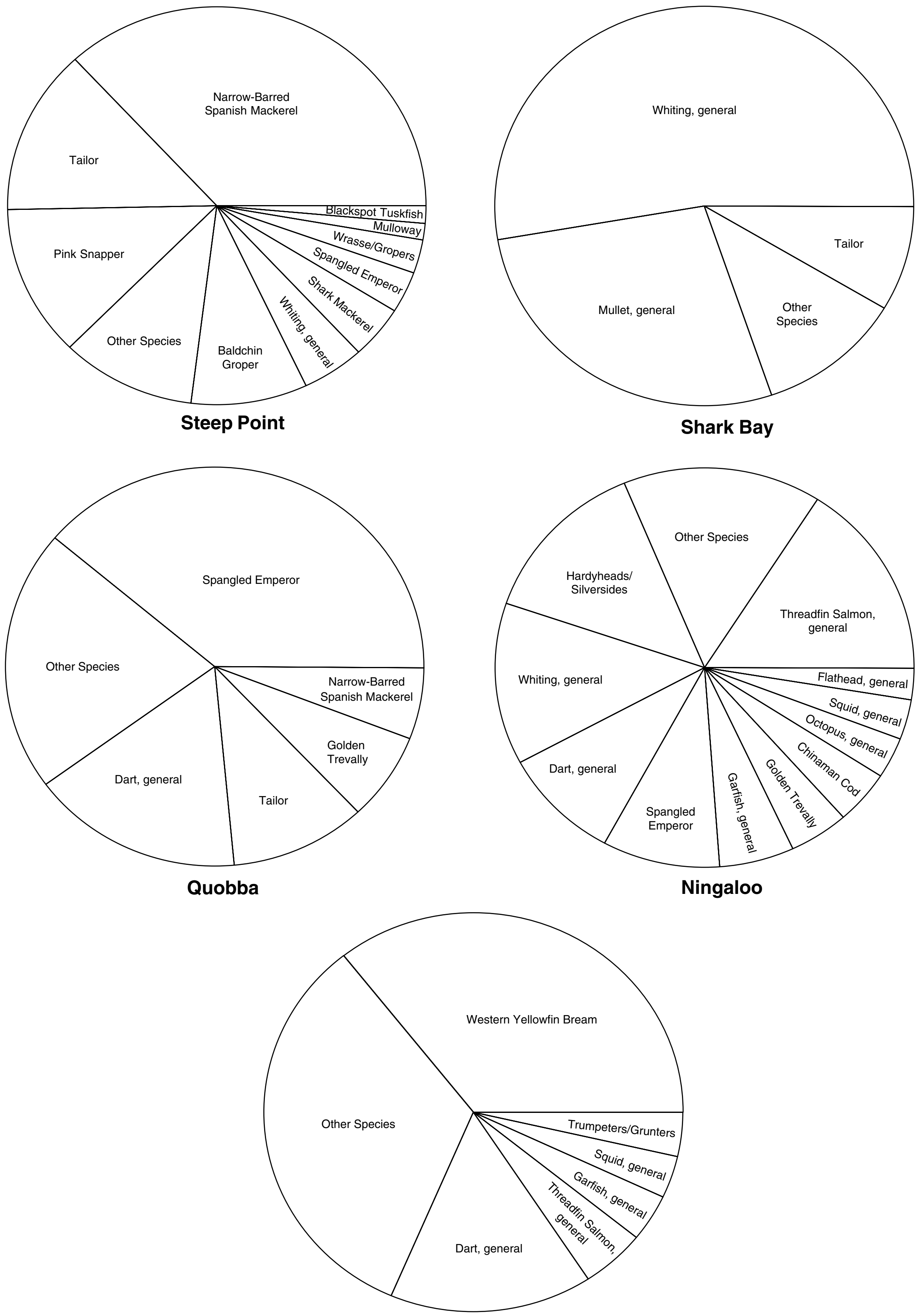


Figure 13. Species composition (by number of fish) of recreational catch for shore-based fishers in Gascoyne bioregion.

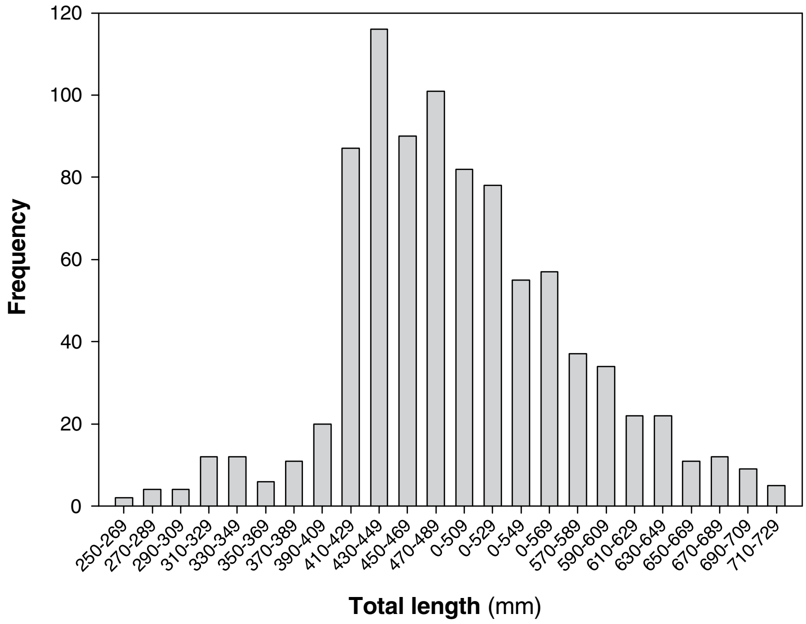


Figure 14. Size composition for spangled emperor (minimum length 410mm) kept by recreational anglers

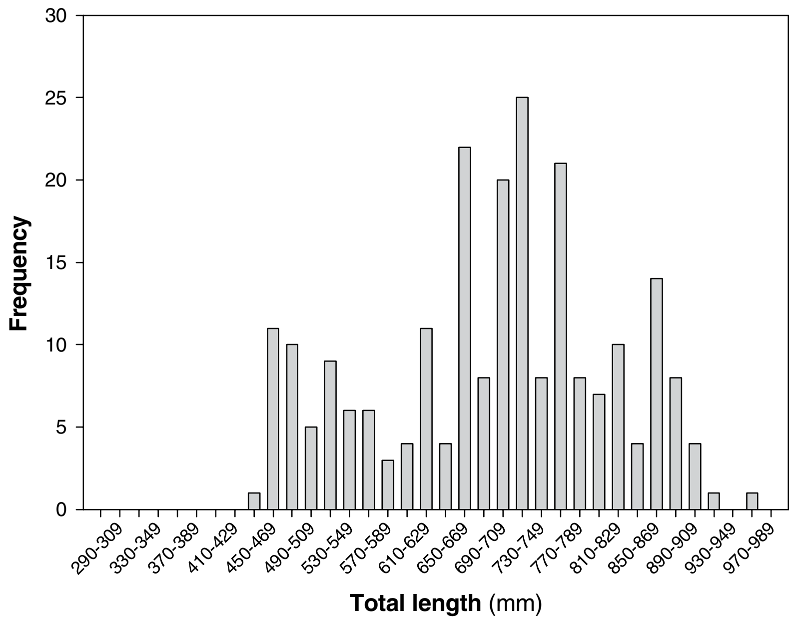


Figure 15. Size composition for Freycinet Estuary pink snapper (minimum length 450mm) kept by recreational anglers

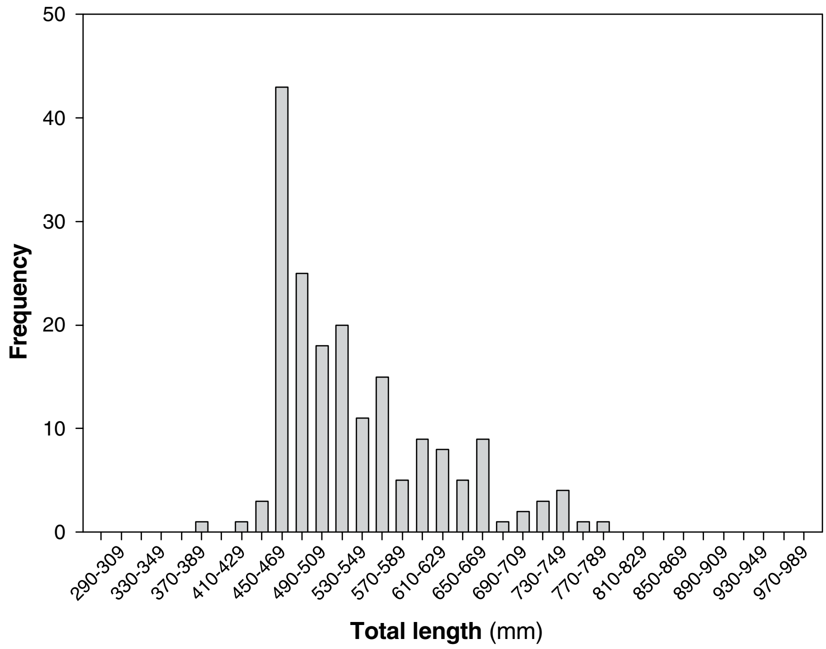


Figure 16. Size composition for Freycinet Reach pink snapper (minimum length 450mm) kept by recreational anglers

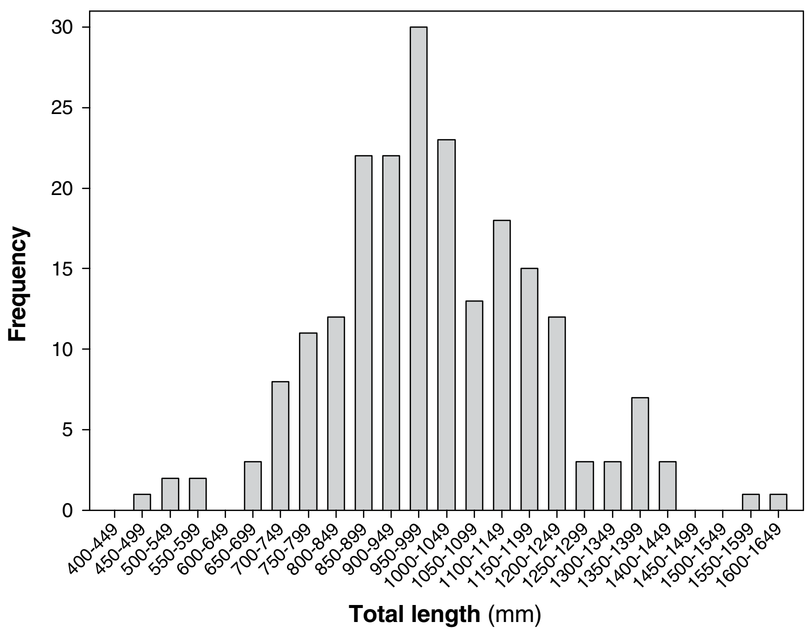


Figure 17. Size composition for narrow-barred Spanish mackerel (minimum length 750mm) kept by recreational anglers

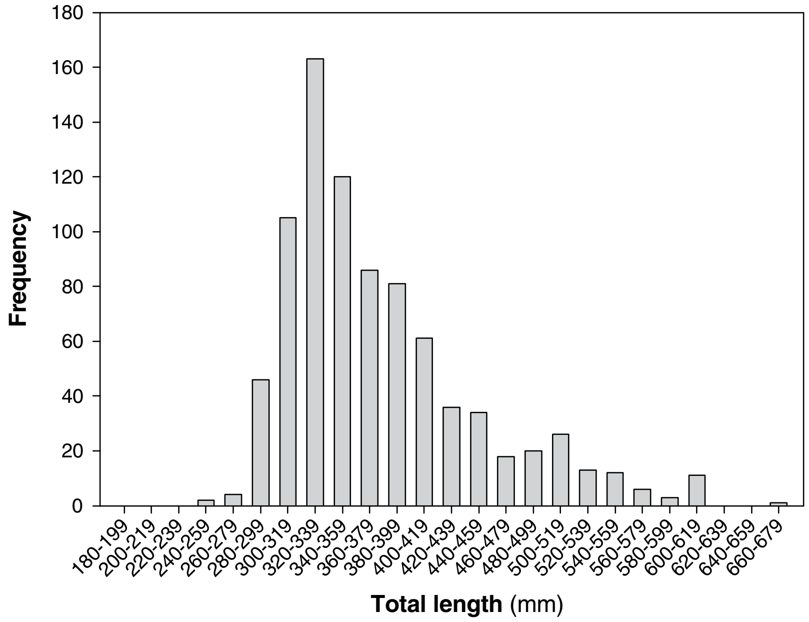


Figure 18. Size composition for blue-lined emperor (minimum length 280mm) kept by recreational anglers

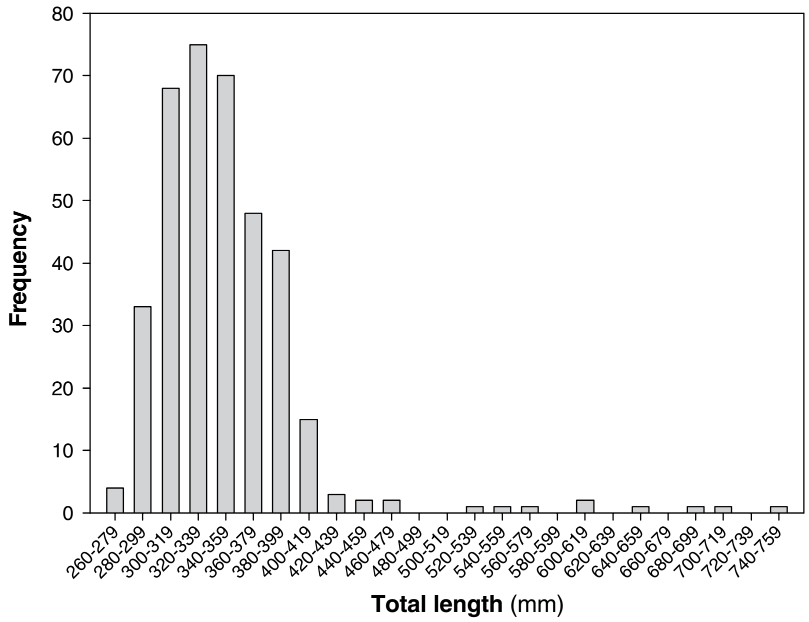


Figure 19. Size composition for sweetlip emperor (minimum length 280mm) kept by recreational anglers

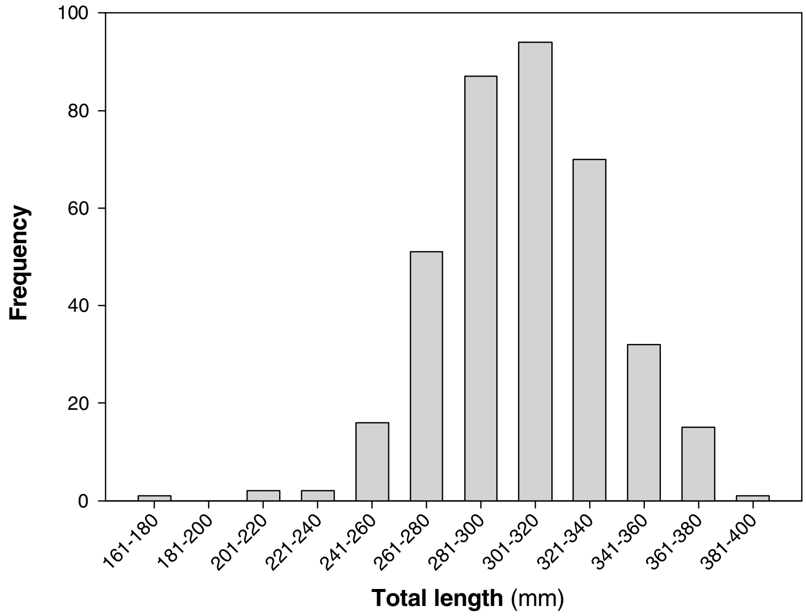


Figure 20. Size composition for chinaman cod (no minimum length) kept by recreational anglers

10.0 Appendices

Appendix A: Recreational fishing boat survey form.

Interviewer's Name: ______________________________

Date: ____________ **Start Time(24hr):** ____________ **Finish Time(24hr):** ____________

Area: ____________________ **Boat Ramp:** ____________________

ENVIRONMENTAL DATA

Wind:

Calm 1	Light 2	Mod 3	Strong 4	Gale 5	Direction

Water:

Calm 1	Slight 2	Mod 3	Rough 4	V. Rough 5

Cloud Cover:

Cloud %

Rainfall:

Nil 1	Light 2	Mod 3	Heavy 4

Boat Launches				Boat Retrievals				Total Number of Trailers	
Time	Type	Time	Type	Time	Type	Time	Type	At Start	At Finish

Boat Types

P: Power boat

Y: Yacht

O: Other

Appendix B: Interview questionnaire form.

Date: _________ **Location:** ________________________ **Boat Reg. No.:** __________________

Interview Time	Boat (Pwr/Yacht/Charter/Othr)	Boat Departure Time	Fish/Dive/Snorkel/Other	Number in Boat	Number of Females in Boat	Age Group of Interviewee	Home Postcode of Interviewee	Length of Boat (ft/m)	Member Angling Club (Yes/No)	Time Spent Fishing (decimal hrs)	Block Number	Number of Lines Used	Number and type of nets - Crab,Set, Haul,cAst, Pots	Number of Times Interviewed Before
				FISHERS ONLY										

Species	Number Kept	Number Released	Taken by Sharks	Under/Over size Kept	Species Targeted________________________ Measurements (mm)

Appendix B: Interview questionnaire form (continued).

1. Does your boat have any of the following equipment:

Black and white echo sounder (Yes/No)	
Colour echo sounder(Yes/No)	
Global Positioning System(Yes/No)	

Radar(Yes/No)	
Marine Band Radio(Yes/No)	
Number of Snapper winches	

2. Were you fishing here at this time last year (Yes/Not Fishing/Fishing Elsewhere:__________________)

3. What is the size limit for _______________*targeted/predominant species from catch*?

Correct	Incorrect	Don't Know

4. What is the bag limit for ________________*targeted/predominant species from catch*?

Correct	Incorrect	Don't Know

5. To what extent do you agree or disagree with the following statements about fishing in W.A.:

	Disagree	Not Sure	Agree
There are so many fish off the West Coast that we can catch as many as we like	1	2	3
The recreational fishing catch is too small to affect fish stocks	1	2	3
Individual fishers can help protect fish stocks by keeping within bag and size limits	1	2	3
I know the current rules for the fish I catch and try to keep up to date	1	2	3
Information on fishing rules is hard to get	1	2	3
If I don't catch enough fish to justify the costs I don't really enjoy the trip	1	2	3
Once I've caught enough for a couple of meals I usually stop fishing	1	2	3
I usually try to catch as many fish as the bag limit allows	1	2	3
I enjoy fishing even if I don't catch anything	1	2	3
Once I've caught enough for a couple of meals I usually release the rest	1	2	3
Once I've caught the bag limit for a species I usually release the rest	1	2	3

6. How many times have you seen a Fisheries Officer or Fisheries Patrol in this region in the last 10 years?_______

Appendix C: Shore Patrol Interview Questionnaire Form.

FISHERIES
WESTERN AUSTRALIA

Gascoyne Region Shore Survey 1998/99

Officer's Name: ________________

Area: ________________________

Location: _____________________

Date: ____/____/____

Time (24hr): ___________________

Number groups camped: __________

Number boats not fishing: _________

Number boats fishing: ____________

Number shore fishers: ____________

WIND

Calm 1	Light 2	Mod 3	Strong 4	Gale 5

Direction: ___________

WATER

Calm 1	Slight 2	Mod 3	Rough 4	V. Rough 5

CLOUD COVER & RAINFALL

Cloud %	Nil 1	Light 2	Moderate 3	Heavy 4

LENGTHS OF RANDOM SAMPLE (mm)

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

Species: ______________________

Lengths: ______________________

BC: Black Tipped Cod	QM: Qld Schl Mackerel
BG: Baldchin Groper	RC: Rankin's Cod
BL: Blue Lined Emperor	RE: Red Emperor
BT: Blackspot Tuskfish	SE: Spangled Emperor
CC: Chinaman Cod	SK: Shark Mackerel
CT: Coral Trout	SL: Sweetlip Emperor
ES: Estuary Cod	SM: Spanish Mackerel
GT: Golden Trevally	ST: Silver Trevally
PE: Pink Eared Emperor	TA: Tailor
PS: Pink Snapper	YT: Yellow Tailed Emperor

Fisher Number	1	2	3	4
Home postcode				
Number in group				
Times interviewed before				
Fishing today (**Y**/**N**/**F**/**L**)				
Fishing yesterday (**Y**/**N**/**E**)				
Boat/**S**hore/**D**ive/s**N**orkel				
Number persons fishing				
Time spent fishing (decimal hours)				
Number of lines used				
Nets (**C**rab, **S**et, **H**aul, c**A**st)				
Species Targeted				
Species 1				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				
Species 2				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				
Species 3				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				
Species 4				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				
Species 5				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				
Species 6				
Total number kept				
Number released				
Number lost to sharks				
Under/Over size kept				

Appendix D: Catch and effort calculations for boats launched from public boat ramps.

Estimation of total effort

The fishing effort for a day (hours) was estimated by the method of Jones and Robson (1991) as follows:

$$e = fT\sum_i \left[\left(\frac{1}{w_i} \right) \sum_j X_{ij} \right] \tag{1}$$

where T=8 is the time taken to complete the bus route, w_i is the interviewer wait time at site i and X_{ij} is the time trailer j spends at site i. A correction factor $f \geq 1$ was used to adjust the effort for fishing that occurred before the morning shift commenced at time t.

$$f = \frac{\sum_j (r_j - \ell_j)}{\sum_j b_j} \tag{2}$$

where

$$b_j = \begin{cases} r_j - t, & \ell_j < t \\ r_j - \ell_j, & \ell_j \geq t \end{cases}$$

r_j is the retrieval time for boat j and ℓ_j is the launch time for boat j. The fishing effort was estimated for a random sample of days in each stratum (see Section 2.2). The estimated variance within stratum k is (Pollock *et al.*, 1994)

$$s_k^2 = \frac{1}{n_k - 1} \sum_{m=1}^{n_k} \left(e_{km} - \bar{e}_k \right)^2 \tag{3}$$

where n_k is the sample size (days) for stratum k, e_{km} the effort for stratum k on day m and $\bar{e}_k$ the mean daily fishing effort for stratum k. The variance associated with the estimate of the mean, with finite population correction (Neter *et al.*, 1988), is calculated as

$$Var(\bar{e}_k) = \frac{s_k^2}{n_k} \left(\frac{N_k - n_k}{N_k} \right) \tag{4}$$

where N_k is the total number of days in stratum k. The total effort for stratum k is estimated as

$$\hat{E}_k = \frac{N_k}{n_k} \sum_{m=1}^{n_k} e_{km} \tag{5}$$

The variance associated with $\hat{E}_k$ is estimated by

$$Var(\hat{E}_k) = N_k^2 \, Var(\bar{e}_k) \tag{6}$$

The standard error is calculated by the usual method

$$SE(\hat{E}_k) = \sqrt{Var(\hat{E}_k)} \tag{7}$$

The total effort is estimated by summing the effort for the strata as follows

$$\hat{E} = \sum_{k=1}^{n} \hat{E}_k \tag{8}$$

where n is the number of strata. Similarly the variance of $\hat{E}$ is estimated from the independent variances for the strata

$$Var(\hat{E}) = \sum_{k=1}^{n} Var(\hat{E}_k) \tag{9}$$

The standard error of $\hat{E}$ is calculated by the usual method

$$SE(\hat{E}) = \sqrt{Var(\hat{E})} \tag{10}$$

Estimation of total catch

The catch rate for each stratum k is estimated by (Crone and Malvestuto, 1991) since the probability of sampling a boat is independent of trip length

$$\hat{R}_k = \frac{\bar{c}_k}{\bar{L}_k} = \frac{\sum_{j=1}^{n_k} c_{kj} / n_k}{\sum_{j=1}^{n_k} L_{kj} / n_k} \tag{11}$$

where n_k is the number of boats where the catch was recorded, c_{kj} the catch for boat j and L_{kj} the effort, in hours, for boat j. The variances for $\bar{c}_k$ and $\bar{L}_k$ can be calculated by the usual method (see (3) and (4) without the finite population correction factor). The variance for $\hat{R}_k$ can be estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{R}_k) \approx \hat{R}_k^2 \left(\frac{Var(\bar{c}_k)}{\bar{c}_k^2} + \frac{Var(\bar{L}_k)}{\bar{L}_k^2} - \frac{2Cov(\bar{c}_k, \bar{L}_k)}{\bar{c}_k \bar{L}_k} \right) \tag{12}$$

The covariance term was assumed to be zero.

The total catch for stratum k is estimated as

$$\hat{C}_k = \hat{E}_k \hat{R}_k \tag{13}$$

The variance was estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{C}_k) \approx \hat{C}_k^2 \left(\frac{Var(\hat{E}_k)}{\hat{E}_k^2} + \frac{Var(\hat{R}_k)}{\hat{R}_k^2} + \frac{2Cov(\hat{E}_k, \hat{R}_k)}{\hat{E}_k \hat{R}_k} \right) \qquad (14)$$

where the covariance term was assumed to be zero. The total catch is estimated by summing the catch for each strata as follows

$$\hat{C} = \sum_{k=1}^{n} \hat{C}_k \qquad (15)$$

The variance of $\hat{C}$ is estimated as

$$Var(\hat{C}) = \sum_{k=1}^{n} Var(\hat{C}_k) \qquad (16)$$

The standard error of $\hat{C}$ is calculated by the usual method

$$SE(\hat{C}) = \sqrt{Var(\hat{C})} \qquad (17)$$

Appendix E: Catch and effort calculations for boats launched from beaches.

Estimation of total effort

The fishing effort (hours) was estimated by the roving creel survey method (Pollock *et al.*, 1994) as follows:

$$e = IT \tag{1}$$

where I is the count of boats and T=9 is the length of the shift. The estimated variance within stratum k is (Pollock *et al.*, 1994)

$$s_k^2 = \frac{1}{n_k - 1} \sum_{m=1}^{n_k} \left(e_{km} - \bar{e}_k\right)^2 \tag{2}$$

where n_k is the sample size (days) for stratum k, e_{km} the effort for stratum k on day m and $\bar{e}_k$ the mean daily fishing effort for stratum k. The variance associated with the estimate of the mean, with finite population correction (Neter *et al.*, 1988), is calculated as

$$Var(\bar{e}_k) = \frac{s_k^2}{n_k} \left(\frac{N_k - n_k}{N_k} \right) \tag{3}$$

where N_k is the total number of days in stratum k. The total effort for stratum k is estimated as

$$\hat{E}_k = \frac{N_k}{n_k} \sum_{m=1}^{n_k} e_{km} \tag{4}$$

The variance associated with $\hat{E}_k$ is estimated by

$$Var(\hat{E}_k) = N_k^2 \, Var(\bar{e}_k) \tag{5}$$

The standard error is calculated by the usual method

$$SE(\hat{E}_k) = \sqrt{Var(\hat{E}_k)} \tag{6}$$

The total effort is estimated by summing the effort for each strata as follows

$$\hat{E} = \sum_{k=1}^{n} \hat{E}_k \tag{7}$$

where n is the number of strata. Similarly the variance of $\hat{E}$ is estimated as

$$Var(\hat{E}) = \sum_{k=1}^{n} Var(\hat{E}_k) \tag{8}$$

The standard error of $\hat{E}$ is calculated by the usual method

$$SE(\hat{E}) = \sqrt{Var(\hat{E})} \tag{9}$$

Estimation of total catch

The catch rate for each stratum k is estimated by (Crone and Malvestuto, 1991) since the probability of sampling a boat is independent of trip length

$$\hat{R}_k = \frac{\overline{c}_k}{\overline{L}_k} = \frac{\sum_{j=1}^{n_k} c_{kj} / n_k}{\sum_{j=1}^{n_k} L_{kj} / n_k} \tag{10}$$

where n_k is the number of boats where the catch was recorded, c_{kj} the catch for boat j and L_{kj} the effort, in hours, for boat j. The variances for $\overline{c}_k$ and $\overline{L}_k$ can be calculated by the usual method (see (2) and (3) without the finite population correction factor). The variance for $\hat{R}_k$ can be estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{R}_k) \approx \hat{R}_k^2 \left(\frac{Var(\overline{c}_k)}{\overline{c}_k^2} + \frac{Var(\overline{L}_k)}{\overline{L}_k^2} - \frac{2Cov(\overline{c}_k, \overline{L}_k)}{\overline{c}_k \overline{L}_k} \right) \tag{11}$$

The covariance term was assumed to be zero. The total catch for stratum k is estimated as

$$\hat{C}_k = \hat{E}_k \hat{R}_k \tag{12}$$

The variance was estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{C}_k) \approx \hat{C}_k^2 \left(\frac{Var(\hat{E}_k)}{\hat{E}_k^2} + \frac{Var(\hat{R}_k)}{\hat{R}_k^2} + \frac{2Cov(\hat{E}_k, \hat{R}_k)}{\hat{E}_k \hat{R}_k} \right) \tag{13}$$

where the covariance term was assumed to be zero. The total catch is estimated by summing the catch for each strata as follows

$$\hat{C} = \sum_{k=1}^{n} \hat{C}_k \tag{14}$$

The variance of $\hat{C}$ is estimated as

$$Var(\hat{C}) = \sum_{k=1}^{n} Var(\hat{C}_k) \tag{15}$$

The standard error of $\hat{C}$ is calculated by the usual method

$$SE(\hat{C}) = \sqrt{Var(\hat{C})} \tag{16}$$

Appendix F: Catch and effort calculations for shore-based fishers.

Estimation of total effort

The fishing effort (hours) was estimated by the roving creel survey method (Pollock *et al.*, 1994) as follows:

$$e = IT \tag{1}$$

where I is the count of anglers and T=9 is the length of the shift. The estimated variance within stratum k is (Pollock *et al.*, 1994)

$$s_k^2 = \frac{1}{n_k - 1}\sum_{m=1}^{n_k}\left(e_{km} - \bar{e}_k\right)^2 \tag{2}$$

where n_k is the sample size (days) for stratum k, e_{km} the effort for stratum k on day m and $\bar{e}_k$ the mean daily fishing effort for stratum k. The variance associated with the estimate of the mean, with finite population correction (Neter *et al.*, 1988), is calculated as

$$Var(\bar{e}_k) = \frac{s_k^2}{n_k}\left(\frac{N_k - n_k}{N_k}\right) \tag{3}$$

where N_k is the total number of days in stratum k. The total effort for stratum k is estimated as

$$\hat{E}_k = \frac{N_k}{n_k}\sum_{m=1}^{n_k} e_{km} \tag{4}$$

The variance associated with $\hat{E}_k$ is estimated by

$$Var(\hat{E}_k) = N_k^2\, Var(\bar{e}_k) \tag{5}$$

The standard error is calculated by the usual method

$$SE(\hat{E}_k) = \sqrt{Var(\hat{E}_k)} \tag{6}$$

The total effort is estimated by summing the effort for each strata as follows

$$\hat{E} = \sum_{k=1}^{n} \hat{E}_k \tag{7}$$

where n is the number of strata. Similarly the variance of $\hat{E}$ is estimated as

$$Var(\hat{E}) = \sum_{k=1}^{n} Var(\hat{E}_k) \tag{8}$$

The standard error of $\hat{E}$ is calculated by the usual method

$$SE(\hat{E}) = \sqrt{Var(\hat{E})} \tag{9}$$

Estimation of total catch

The catch rate for each stratum k is estimated by (Pollock *et al*., 1994) since the probability of sampling an angler is dependent on trip length

$$\hat{R}_k = \frac{\sum_{j=1}^{n_k} \frac{w_{kj} c_{kj}}{L_{kj}}}{\sum_{j=1}^{n_k} w_{kj}} \tag{10}$$

where c_{kj} is the total catch and L_{kj} the total effort, in person hours, for party j with w_{kj} fishers, n_k is the number of shore-based parties where the catch was recorded. The variance for $\hat{R}_k$ can be estimated using the formulae

$$Var(\hat{R}_k) \approx \frac{1}{\sum_{j=1}^{n_k} w_{kj} \left(\sum_{j=1}^{n_k} w_{kj} - 1 \right)} \sum_{j=1}^{n_k} w_{kj} \left(\frac{c_{kj}}{L_{kj}} - \hat{R}_k \right)^2 \tag{11}$$

The total catch for stratum k is estimated as

$$\hat{C}_k = \hat{E}_k \hat{R}_k \tag{12}$$

The variance was estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{C}_k) \approx \hat{C}_k^2 \left(\frac{Var(\hat{E}_k)}{\hat{E}_k^2} + \frac{Var(\hat{R}_k)}{\hat{R}_k^2} + \frac{2Cov(\hat{E}_k, \hat{R}_k)}{\hat{E}_k \hat{R}_k} \right) \tag{13}$$

where the covariance term was assumed to be zero. The total catch is estimated by summing the catch for each strata as follows

$$\hat{C} = \sum_{k=1}^{n} \hat{C}_k \tag{14}$$

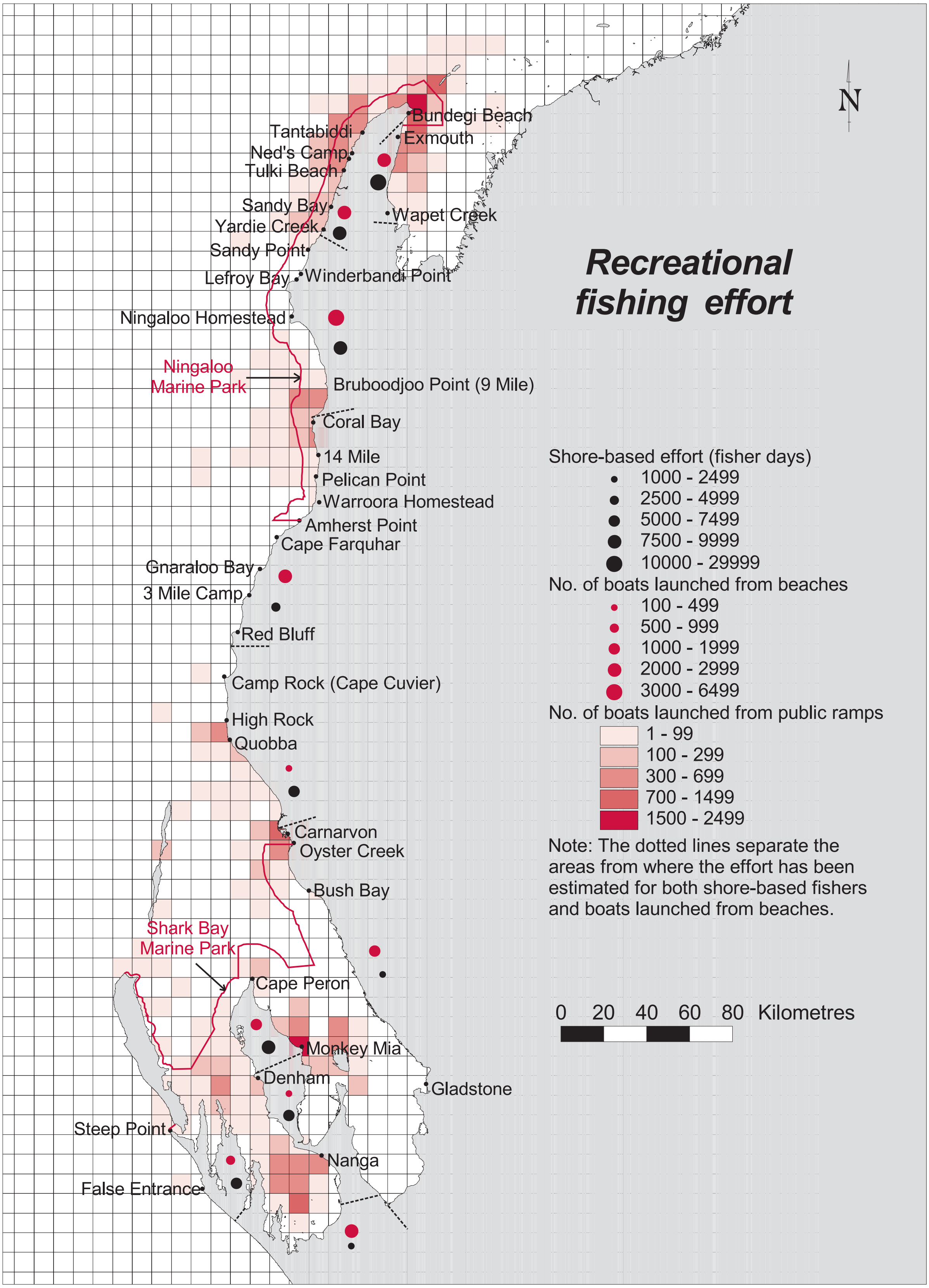
The variance of $\hat{C}$ is estimated as

$$Var(\hat{C}) = \sum_{k=1}^{n} Var(\hat{C}_k) \tag{15}$$

The standard error of $\hat{C}$ is calculated by the usual method

$$SE(\hat{C}) = \sqrt{Var(\hat{C})} \tag{16}$$

Appendix G: Spatial distribution of recreational fishing effort in the Gascoyne bioregion.



Appendix H: Estimated recreational catch (by species) for boats launched from public ramps in the Gascoyne bioregion.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Emperor, blue-lined	*Lethrinus laticaudis*	27,587	3,148	40,011	82
Snapper, pink	*Pagrus auratus*	20,082	2,544	82,082	359
Emperor, spangled	*Lethrinus nebulosus*	14,888	1,445	13,154	890
Cod, chinaman	*Epinephelus rivulatus*	13,545	1,592	21,216	41
Squids, general	Family – *Cephalopodidae*	7,651	1,636	28	0
Emperor, sweetlip	*Lethrinus miniatus*	6,821	822	8,079	0
Butterfish, western	*Pentapodus vitta*	6,343	1,357	17,011	0
Rock lobster, western	*Panulirus cygnus*	4,250	1,263	0	0
Crab, blue swimmer	*Portunus pelagicus*	3,870	1,154	2,892	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	3,639	715	1,095	194
Whiting, general	Family – *Sillaginidae*	3,514	1,232	749	0
Seaperch, stripey	*Lutjanus carponotatus*	3,308	663	1,946	0
Mullets, general	Family – *Mugilidae*	2,869	1,429	0	0
Trevally, golden	*Gnathanodon speciosus*	2,305	398	1,098	33
Blowfish, northwest	*Lagocephalus sceleratus*	2,225	711	3,637	0
Emperor, yellow-tailed	*Lethrinus atkinsoni*	2,100	444	2,457	0
Tailor	*Pomatomus saltator*	1,877	563	787	0
Mackerel, Queensland school	*Scomberomorus queenslandicus*	1,773	914	146	0
Rock lobster, tropical		1,677	912	1,117	0
Cod, estuary	*Epinephelus coioides*	1,642	264	114	0
Garfish, general	Family – *Hemiramphidae*	1,175	521	0	0
Tuskfish, blackspot	*Choerodon schoenleinii*	1,113	287	2,340	0
Groper, baldchin	*Choerodon rubescens*	1,089	263	566	0
Seapike, striped	*Sphyraena obtusata*	1,044	303	908	0
Bream, silver	*Rhabdosargus sarba*	1,038	353	684	0
Trevally, gold-spotted	*Carangoides fulvoguttatus*	853	216	487	12
Flatheads, general	Family – *Platycephalidae*	849	271	470	0
Emperor, variegated	*Lethrinus variegatus*	774	437	511	0
Trumpeters/grunters	Family – *Terapontidae*	749	303	4,766	0
Emperor, red	*Lutjanus sebae*	748	198	438	0
Trout, coral	*Plectropomus species*	714	189	254	21
Emperor, blue-spotted	*Lethrinus punctulatus*	685	293	475	0
Wrasse/gropers	Family – *Labridae*	675	213	9,002	0
Rankin's cod	*Epinephelus multinotatus*	672	167	302	0
Mackerel, Australian spotted	*Scomberomorus munroi*	664	160	360	12
Cobia	*Rachycentron canadus*	629	163	93	54
Cod, black-tipped	*Epinephelus fasciatus*	559	206	557	0
Mulloway	*Argyrosomus hololepidotus*	556	221	335	0
Mackerel, shark	*Grammatorcynus bicarinatus*	531	178	366	0
Cockles	*Anadara & Katelysia spp.*	512	366	0	0
Lizardfishes/grinners	Family – *Synodontidae*	450	222	617	0
Seaperch, dark-tailed	*Lutjanus lemniscatus*	384	139	102	0
Cods, general	Family – *Serranidae*	352	127	227	0
Shark, general	Family – *Carcharhinidae*	348	94	1,061	0

Appendix I: Estimated recreational catch (by species) for boats launched from beaches in the Gascoyne bioregion.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Emperor, spangled	*Lethrinus nebulosus*	13,516	1,874	16,997	1,967
Cod, chinaman	*Epinephelus rivulatus*	9,450	1,515	16,558	230
Snapper, pink	*Pagrus auratus*	7,220	1,625	18,769	109
Emperor, sweetlip	*Lethrinus miniatus*	6,169	1,304	6,347	197
Emperor, blue-lined	*Lethrinus laticaudis*	5,373	1,479	5,684	16
Squids, general	Family – *Cephalopodidiae*	3,544	1,198	164	0
Mullets, general	Family – *Mugilidae*	3,234	849	0	0
Groper, baldchin	*Choerodon rubescens*	2,685	1,423	1,583	0
Emperor, yellow-tailed	*Lethrinus atkinsoni*	2,247	1,415	4,495	0
Tuskfish, blackspot	*Choerodon schoenleinii*	2,056	1,417	3,276	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	2,021	1,409	475	66
Trevally, golden	*Gnathanodon speciosus*	1,768	1,411	950	33
Sweetlips, general	Family – *Haemulidae*	1,558	1,411	1,903	197
Tailor	*Pomatomus saltator*	1,446	793	0	0

Appendix J: Estimated recreational catch (by species) for shore-based fishing in the Gascoyne bioregion.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Whiting, general	Family – *Sillaginidae*	30,124	4,999	13,558	0
Bream, western yellowfin	*Acanthopagrus latus*	9,850	3,743	17,998	0
Mullets, general	Family – *Mugilidae*	8,608	2,723	0	0
Squid, general	Family – *Cephalopodidiae*	4,898	2458	0	0
Salmon, threadfin, general	Family – *Polynemidae*	4,286	1,275	468	0
Tailor	*Pomatomus saltator*	3,308	826	780	24
Flathead, general	Family – *Platycephalidae*	2,532	866	2,437	0
Trevally, golden	*Gnathanodon speciosus*	2,409	784	278	0
Garfish, general	Family – *Hemiramphidae*	2,313	621	670	0
Dart, general	Family – *Carangidae*	2,245	832	521	0
Hardyheads/silversides	Family – *Atherinidae*	2,035	1,170	0	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	1,897	170	56	299
Emperor, spangled	*Lethrinus nebulosus*	1,395	267	2,245	88
Mackerel, shark	*Grammatorcynus bicarinatus*	1,242	702	0	14
Rock lobster, western	*Panulirus cygnus*	1,125	365	1,260	0
Groper, baldchin	*Choerodon rubescens*	1,031	366	157	24
Trumpeters/grunters	Family – *Terapontidae*	958	624	1,753	0
Snapper, pink	*Pagrus auratus*	703	115	549	92
Tuskfish, blackspot	*Choerodon schoenleinii*	590	261	491	129
Seapearch, stripey	*Lutjanus carponotatus*	585	463	14	0
Emperor, blue-lined	*Lethrinus laticaudis*	428	364	32	0

Appendix K: Estimated total recreational catch (by species) from the Gascoyne bioregion.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Whiting, general	Family – *Sillaginidae*	34,384	5,208	14,468	0
Emperor, blue-lined	*Lethrinus laticaudis*	33,388	3,497	45,727	98
Emperor, spangled	*Lethrinus nebulosus*	29,799	2,382	32,396	2,945
Snapper, pink	*Pagrus auratus*	28,005	3,021	101,400	560
Cod, chinaman	*Epinephelus rivulatus*	23,297	2,200	38,690	291
Squid, general	Family – *Cephalopodidiae*	16,093	3,187	192	0
Mullets, general	Family – *Mugilidae*	14,711	3,190	0	0
Emperor, sweetlip	*Lethrinus miniatus*	13,077	1,543	14,944	197
Bream, western yellowfin	*Acanthopagrus latus*	10,001	3,826	18,060	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	7,557	1,589	1,626	559
Tailor	*Pomatomus saltator*	6,631	1,276	1,567	24
Trevally, golden	*Gnathanodon speciosus*	6,482	1,663	2,326	66
Butterfish, western	*Pentapodus vitta*	6,390	1,570	17,168	0
Rock lobster, western	*Panulirus cygnus*	6,284	1,931	1,699	0
Emperor, yellow-tailed	*Lethrinus atkinsoni*	4,399	1,484	7,072	0
Groper, baldchin	*Choerodon rubescens*	4,805	1,493	2,306	24
Salmon, threadfin, general	Family – *Polynemidae*	4,319	1,734	468	0
Seapearch, stripey	*Lutjanus carponotatus*	4,280	1,629	2,463	129
Crab, blue swimmer	*Portunus pelagicus*	3,870	1,154	2,892	0
Tuskfish, blackspot	*Choerodon schoenleinii*	3,759	1,464	6,107	0
Flathead, general	Family – *Platycephalidae*	3,681	1,859	2,985	0
Garfish, general	Family – *Hemiramphidae*	3,557	1,429	670	0
Hardyheads/silversides	Family – *Atherinidae*	3,019	1,653	0	0
Sweetlips, general	Family – *Haemulidae*	2,492	2,480	1,968	197
Cod, Estuary	*Epinephelus coioides*	2,389	1,438	290	0
Dart, general	Family – *Carangidae*	2,278	1,489	587	0
Blowfish, Northwest	*Lagocephalus scleratus*	2,225	711	3,700	0
Mackerel, Queensland school	*Scomberomorus queenslandicus*	1,947	917	146	0
Mackerel, shark	*Grammatorcynus bicarinatus*	1,852	1,592	826	14
Trumpeters/grunters	Family – *Terapontidae*	1,864	1,056	8,126	0
Rock Lobster, Tropical	*Panulirus spp.*	1,677	912	1,117	0
Bream, Silver (Tarwhine)	*Rhabdosargus sarba*	1,093	866	778	0
Seapike, striped	*Sphyraena obtusata*	1,139	1,449	916	0

Appendix L: Estimated total recreational catch (by species) from Shark Bay.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Whiting, general	Family – *Sillaginidae*	22,126	3,894	9,990	0
Snapper, pink	*Pagrus auratus*	21,824	1,985	93,958	280
Emperor, blue-lined	*Lethrinus laticaudis*	21,824	3,076	36,992	16
Mullets, general	Family – *Mugilidae*	11,863	2,852	0	0
Butterfish, western	*Pentapodus vitta*	6,308	1,570	17,128	0
Tailor	*Pomatomus saltator*	5,743	1,240	1,006	24
Groper, baldchin	*Choerodon rubescens*	3,752	918	2,076	25
Toadfish, silver	*Lagocephalus scleratus*	3,069	1,217	788	0
Tuskfish, blackspot	*Choerodon schoenleinii*	2,917	865	4,979	0
Emperor, spangled	*Lethrinus nebulosus*	2,465	852	2,859	33
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	2,402	803	390	293
Rock lobster, western	*Panulirus cygnus*	1,902	868	1,633	0
Flathead, general	Family – *Platycephalidae*	1,814	1,175	1,341	0
Garfish, general	Family – *Hemiramphidae*	1,140	499	0	0
Mackerel, Queensland school	*Scomberomorus queenslandicus*	971	281	87	0
Wrasse/gropers	Family – *Labridae*	931	819	9,151	8
Shark, general	Family – *Carcharhinidae*	878	1,131	1,352	0
Trumpeters/grunters	Family – *Terapontidae*	844	849	5,240	0
Cod, estuary	*Epinephelus coioides*	767	806	164	0
Squid, general	Family – *Cephalopodidiae*	758	340	25	0
Bream, western yellowfin	*Acanthopagrus latus*	728	898	125	0
Seapearch, stripey	*Lutjanus carponotatus*	708	845	523	0
Tuna, general		660	1,117	547	0
Emperor, sweetlip	*Lethrinus miniatus*	632	273	2,134	0
Seapike, striped	*Sphyraena obtusata*	511	1,133	781	0

Appendix M: stimated total recreational catch (by species) from Ningaloo Marine Park.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Emperor, spangled	*Lethrinus nebulosus*	22,575	2,064	25,056	2,482
Cod, chinaman	*Epinephelus rivulatus*	19,708	2,053	31,963	189
Emperor, sweetlip	*Lethrinus miniatus*	10,377	1,732	9,823	145
Emperor, blue-lined	*Lethrinus laticaudis*	8,474	1,470	6,877	78
Squids, general	Family – *Cephalopodidiae*	8,191	1,580	124	0
Trevally, golden	*Gnathanodon speciosus*	4,805	1,143	1,947	62
Emperor, yellow-tailed	*Lethrinus atkinsoni*	4,672	1,165	5,944	0
Hardyheads/silversides	Family – *Atherinidae*	2,658	1,577	0	0
Salmon, threadfin, general	Family – *Polynemidae*	2,472	851	313	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	2,361	1,081	623	185
Whiting, general	Family – *Sillaginidae*	2,078	573	212	0
Sweetlips, general	Family – *Haemulidae*	1,816	2,133	1,425	145
Trevally, gold-spotted	*Carangoides fulvoguttatus*	1,767	1,088	510	11
Seapearch, stripey	*Lutjanus carponotatus*	1,427	1,152	672	129
Flathead, general	Family – *Platycephalidae*	1,241	1,308	172	0
Trevallies, general	Family - *Carangidae*	999	1,078	148	51
Dart, general	Family – *Carangidae*	967	1,067	379	0
Cod, Estuary	*Epinephelus coioides*	852	1,069	99	0
Emperor, blue-spotted	*Lethrinus punctulatus*	820	1,114	725	0
Cod, Black-tipped	*Epinephelus fasciatus*	779	1,069	858	0
Trevally, Skipjack	*Pseudocaranx dentex*	770	1,066	652	498
Garfish, general	Family – *Hemiramphidae*	758	1,087	29	0
Emperor, variegated	*Lethrinus variegatus*	750	413	782	0
Emperor, Red	*Lutjanus sebae*	680	1,081	29	0
Tuskfish, blackspot	*Choerodon schoenleinii*	648	1,072	831	0
Mackerel, Queensland School	*Scomberomorus queenslandicus*	554	148	149	0
Trout, Coral	*Plectropomus species*	538	1,072	208	47
Rock lobster, tropical	*Panulirus spp.*	536	307	0	0
Groper, baldchin	*Choerodon rubescens*	495	1,476	169	0
Mackerel, shark	*Grammatorcynus bicarinatus*	492	1,062	298	0
Emperor, Spotcheek	*Lethrinus rubrioperculatus*	363	1,062	48	0
Bream, western yellowfin	*Acanthopagrus latus*	146	61	126	0