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A 12-month survey of coastal recreational boat fishing between Augusta and Kalbarri on the west coast of Western Australia during 1996-97

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

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Abstract

A creel survey of recreational boat-based fishers on the west coast of Western Australia was conducted from September 1996 to August 1997 to provide information required by fisheries managers. The bus route method, where a survey interviewer visits all boat ramps in a district on the one day, was used. The time spent fishing, catch, demographic and attitudinal information was collected from boat crews returning to boat ramps at the completion of a fishing trip. The total marine catch (number of fish kept) was estimated for key recreational species. Whiting species (other than King George whiting) (564,000) and Australian herring (425,000) were the predominant catch. Other species caught included blue swimmer crabs, skipjack trevally (123,000), King George whiting (94,000), squid (88,000), southern sea garfish (79,000), various species of wrasse and groper (65,000), Western Australian dhufish (29,000), snook (28,000) and tailor (27,000). Large numbers of western rock lobster were also caught by boat-based recreational fishers.

The total annual boat-based fishing effort for the region was estimated at 453,000 fisher days. The recreational effort was higher in the more populated districts, especially near the Perth metropolitan area. Anglers have adopted modern technology to increase the efficiency of recreational fishing, with 36 per cent of boats fitted with an echo-sounder and 12 per cent using a global positioning system to find fishing locations. There was a very high level of compliance with the fishing regulations. Only 2.5 per cent of boat fishers interviewed kept under-size fish. Very few fishers exceeded the bag limits. Most fishers had a reasonable knowledge of the fishing regulations and knew the bag (80%) and size (84%) limits for the species they were targeting or a species they had caught.

1.0 Executive Summary

- The main marine species caught by boat-based recreational fishers are (in order of number caught) whiting species (other than King George whiting) (564,000), Australian herring (425,000), blue swimmer crabs (255,000), skipjack trevally (123,000), King George whiting (94,000), squid (88,000), southern sea garfish (79,000), various species of wrasse and groper (66,000), Western Australian dhufish (29,000), snook (28,000) and tailor (27,000). Large numbers of western rock lobster were also caught by boat-based recreational fishers.
- The recreational catch for many species is substantial. The recreational catch exceeds the reported commercial catch for species such as skipjack trevally. For many other species, such as Western Australian dhufish, baldchin groper and southern sea garfish the recreational catch forms a significant proportion of the total catch (combined recreational and commercial catch). The recreational catch, therefore, should be fully taken into account in any assessment of the sustainability of present fishing practices or when assessing the status of fish stocks.

- The total annual boat-based fishing effort for the region was 453,000 fisher days. The recreational effort was higher in the more populated districts. The effort was highest for the Perth South, Perth North and Busselton districts. Effort for the Mandurah, Jurien Bay and Lancelin districts was 'medium', while the effort for the other districts was lower. The summer months are the most popular time for recreational fishing followed by autumn and spring.
- Anglers have adopted modern technology to increase the efficiency of recreational fishing with 36 per cent of boats fitted with an echo-sounder and 12 per cent using a global positioning system to find fishing locations. Few boats (4%) had snapper winches fitted.
- The size limits are an effective catch control measure, with substantial numbers of under-size fish of many species caught being subsequently released.
- The present bag limits were effective in reducing large catches on occasions. However, the survey indicated that very few fishers achieve the daily bag limits specified under present statewide recreational fishing regulations.
- There was a very high level of compliance with the fishing regulations. Only 2.5 per cent of boat fishers interviewed kept under-size fish. Very few fishers exceeded the daily bag limits.
- Most fishers had a reasonable knowledge of the fishing regulations. The majority of fishers interviewed knew the bag (80%) and size (84%) limits for the species they were targeting or had caught.
- Information on the shore-based catch from the Perth metropolitan area to Kalbarri is required. Planned roads between Perth and Dongara will make this area more accessible to shore-based anglers in the near future. This is particularly important for species such as tailor where the shore-based catch is likely to increase substantially.
- Further monitoring of the recreational catch and effort in this and other regions of the state is necessary to better assess the impact of recreational fishing on fish stocks. This information is necessary for the improved management of this important fishery.
- The length to weight relationship is not known for many recreational species. This fundamental information is necessary to convert the recreational catch (in number of fish) to total weight in kilograms for comparison with the commercial catch. These basic data need to be collected and the relationships determined.

2.0 Introduction

The Recreational Fishing Program of Fisheries Western Australia has a strategic plan to conduct creel surveys of recreational fishing on a rotating region by region basis. The regions are defined as the West Coast, Gascoyne, Pilbara/Kimberley and South Coast (Figure 1). An integrated approach, where all regions are surveyed on a regular basis (about once every five years), to monitor changes in recreational catch and fishing effort is in place.

Information on the marine recreational boat-based catch and fishing effort for the west coast region of Western Australia was required to develop management strategies to ensure the sustainability of fishing activities and conservation of fish stocks and fish habitat. These data will provide fishing quality indicators such as catch rates, length-frequency, and the variety of species caught. This information will be used in the development of a management plan for

the region and 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 (Anon, 1997) estimated that 636,000 persons participate in recreational fishing one or more times a year. According to the survey, the most popular region for recreational fishing was the West Coast which was utilised by 63 per cent of recreational fishers. The median number of days per year that a person participated in fishing was seven.

Recreational marine boat-based fishers in the west coast region target a range of fish, crustaceans and molluscs. The region of interest covers 1,000 kilometres of coastline between Kalbarri and Augusta including 49 public marine boat ramps. Creel surveys in the region have been conducted in previous years, however, these were for specific estuaries or sounds (Caputi 1976, Dybdahl 1979) or focussed on shore-based fishing and did not account for boat-based fishing (Ayvazian *et al*. 1997).

A creel survey was used to estimate the recreational boat-based catch for all species. 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. The technique had to be modified (see 3.3 The bus route method) before it was suitable for use in the region. An additional problem with this method was that it is inappropriate for estimating the catch and fishing effort for non-trailered boats. The catch and effort for these boats was estimated separately. The application of the bus route method to this region is explored and the recreational catch and fishing effort estimates obtained are presented.

3.0 Methods

3.1 Survey design

Catch and fishing effort information for recreational boat-based fishers on the west coast and smaller areas within the study region was required. It was also important that the data collected were comparable with catch and effort data collected for commercial fisheries. For this reason the study region was divided into 5×5 nautical mile blocks so the approximate location of fishing could be determined. These blocks fit within the statistical blocks used for recording the commercial catch (60×60 nautical mile) and offer a finer resolution preferred for reporting the recreational catch.

There are many access sites for boats (including boat ramps and places boats may be launched across the beach) and potentially unlimited access for shore-based fishers on most of the Western Australian coastline. This is particularly true for the west coast region, which includes the Perth metropolitan area, and hence most of the state's population. For this reason, creel surveys must cover large geographical areas which creates logistical difficulties for conducting field work. Survey methods for boat-based fishers must be suitable for regions with many boat ramps and large distances between ramps.

The bus route method was used to estimate the total catch and fishing effort for recreational fishers using trailered boats launched at boat ramps (see section 3.3). A traditional access point survey (Malvestuto 1983) was used to estimate the catch and effort from non-trailered boats kept in residential developments with canals, on moorings or in pens at marinas and yacht clubs.

A number of boat ramps surveyed were located within a marina. In these cases, in addition to the boat ramp, recreational boats departing from and returning to the marina were surveyed during the scheduled time the interviewer spent at the boat ramp using the bus route method.

3.2 Spatial and temporal stratification

The survey spanned a 12-month period, commencing in September 1996 and concluding at the end of August 1997.

It was necessary to divide the region into smaller districts, where an interviewer could visit all the boat ramps in a day. The number of districts and location of boundaries between districts were chosen to minimise travel time and hence cost under the bus route method. This method also enabled an interviewer to visit all boat ramps within a district in one survey day. Twelve geographical districts where chosen. Routes similar to a bus route with prolonged stops at the boat ramps were set up for each district. All public marine boat ramps in each district were visited. The districts contained between one and eight boat ramps each. The districts and the number of boat ramps surveyed (in brackets) in each district were as follows: Augusta (5), Busselton (8), Bunbury (6), Mandurah (5), Perth South (8), Perth North (3), Lancelin (3), Jurien Bay (4), Dongara (1), Geraldton (3), Port Gregory (2) and Kalbarri (1).

The survey was stratified by district, season (spring, summer, autumn or winter) and weekdays or weekends/public holidays. Separate total catch and fishing effort estimates were made for each of the 96 strata (12 districts $\times$ 4 seasons $\times$ 2 for weekdays and weekends/public holidays). These estimates were then combined to obtain the total recreational boat-based catch and effort for the region.

The survey was restricted to eight hours during the day from 8:00 am to 4:00 pm which included most fishing activity. Periods of low 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 recreational fishing effort. The safety of interviewers at night was also a concern.

The interviewers commenced work before anglers started returning to the boat ramp. However, it could not be assumed that this was true for rock lobster fishers since they often returned to the ramp before 8:00 am. Almost all recreational boats return to the boat ramps by 4:00 pm due to the prevailing afternoon sea breeze that occurs on this section of the coastline most days. One eight hour shift was worked each survey day.

3.3 The bus route method

An independent bus route was set up for each of the 12 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. Between three and 12 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, 1995) 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 and 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. On average, each site was likely to be visited over all hours by the end of a season. A similar modification of the bus route method was used by McGlennon and Kinloch (1997).

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 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.

Prior information gained from Fisheries Officers in the region enabled many locations where beach launches occurred to be included in the survey. Due to the length of coastline, however, it was not possible to include all locations where beach launches occurred. One of the main locations for beach launches, Wedge Island, north of Lancelin, could not be included since it was only accessible by a rough four wheel drive track. Limited data for this location were collected during patrols conducted by Fisheries Officers.

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. This decision was made by the survey interviewer on the day after assessing the weather conditions. Each season, additional survey days were allocated to allow for severe 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.

3.4 Estimation of total catch and effort for trailered boats

Each survey day the survey 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 was collected from boat-based fishers. A form was used to record the environmental conditions as well as 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. The 5x5 nautical mile block (Appendix C) where the fishing occurred was recorded.

The boat-based fishing activities recorded included angling, spear fishing, as well as the use of nets to catch fish and crabs, and pots to catch rock lobster. The survey interviewer identified, counted and measured the catch for each boat.

Where possible, field staff measured the total length (mm) of all fish that were seen during interviews (the total length rather than the fork length is used for all species in Western Australia). However, since it was more important to interview as many anglers as possible to collect the basic catch information this was not always possible when several boats returned to a ramp at the same time. When this happened a random sample of the fish of each species was measured rather than all of the catch. A random sample, rather than all of the catch, was

also measured when anglers were in a hurry to leave the ramp. For species where the length to weight relationship was known the lengths could be converted to weights to estimate the total catch in kilograms.

The fishing effort for a day was estimated from the counts of the number of trailers at the boat ramps (Appendix D). The measure of fishing effort for each district and season was adjusted to correct for the number of recreational boats not involved in fishing activities. The trailer counts were multiplied by the proportion of boats interviewed that were participating in recreational fishing. A correction factor, the proportion of boats fishing in the ocean (obtained from interviews), was used for each district and season to remove effort attributed to boats fishing in estuaries. Another correction factor was used to adjust the fishing effort for each season to allow for fishing activity that occurred before the shift commenced at 8:00 am.

For rock lobster and blue swimmer crab fishing, the measure of fishing effort for each district and season was adjusted to correct for the number of recreational boats involved in these activities. All recreational boats that had either caught blue swimmer crabs or had crab nets on board were considered to be participating in this fishery. All recreational boats that had either caught rock lobsters or were using rock lobster pots were considered to be participating in this fishery.

Catch rates were estimated from information on time spent fishing and catch obtained from 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 (hours).

As the focus of the study was to obtain information on recreational marine fishing activities, only boat ramps in marine and near-estuary locations were included in this survey. It is, therefore, not possible to estimate the total catch and effort for estuaries from the information collected.

3.5 Estimation of total catch and effort for non-trailered boats

Data on non-trailered recreational boats, kept at moorings and yacht clubs in the Swan River and canals in the Peel Harvey Estuary, could not be collected using the bus route method. Instead, an observer recorded the registration number of boats both returning to and departing from these locations at random times during the day. The owners of these boats were then contacted by phone to determine the time spent fishing, catch and other information for the day that they were spotted. The owners were asked the same questions as the trailered boat fishers (Appendix B). The attitudinal questions were not asked to reduce the interview time.

The method was similar to a traditional access point survey (Malvestuto 1983), however, the boat owners were contacted by phone a day or two after the fishing trip rather than interviewed upon their return. This meant that the owners of non-trailered boats sighted both departing and returning from fishing could be interviewed. Although this provided additional information, the sampling method had to be taken into account when estimating the catch and fishing effort (Appendix E).

The fishing effort (boat-hours) for the day was estimated by the traditional access point method from the counts of the number of boats entering and leaving the rivers. The owners of boats sighted were surveyed by phone to obtain information on their catch and time spent fishing. This information was then used to estimate catch rates. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort.

4.0 Results

4.1 Overview

During the survey, 7,848 interviews were conducted at boat ramps. Of these 6,244 (80%) were fishing from the boat, 469 were diving from the boat to capture fish or rock lobsters, and 1,135 were not involved in fishing activities. In addition to the interviews at boat ramps, 353 fishers who keep boats at moorings, canals and marinas were interviewed by phone.

The main marine species targeted in the survey area were Western Australian dhufish (17%), rock lobster (14%), Australian herring (11%), King George whiting (8%), other whiting (9%), pink snapper (6%), blue swimmer crabs (6%), skipjack trevally (5%), squid (4%) and tailor (3%).

Observations showed that relatively few recreational fishers caught the species they targeted (Table 1). Rock lobster, blue swimmer crab and squid fishers were more successful since the gear used is more selective. However, since fishers were asked what species they were targeting after the fishing trip rather than before, the response may be influenced by the species caught. Recreational anglers are opportunistic and will target whatever species are present. For this reason the species targeted may change several times during the course of a fishing trip. It is common for anglers to catch species other than the one targeted and many anglers caught two or more different species.

The main species targeted in estuaries were blue swimmer crabs (81%), tailor (7%), herring (3%) and whiting (3%).

4.2 Fishing effort

Most fishing occurred during the interviewer's shift from 8:00 am to 4:00 pm. However, fishing also occurred both before and after the survey period, as indicated by the boat launch and retrieval times. Fishing by boats that were launched before 8:00 am and returned after 8:00 am was taken into account. The ratio of effort occurring prior to 8:00 am to that occurring after 8:00 am was estimated and a correction factor applied to the effort estimate for each season (Table 2 and Appendix D). Most boats had returned to the ramp before 4:00 pm and the number of boats returning after this time of the day, based on the number of trailers remaining, was relatively small.

The estimated total marine recreational fishing effort was higher in the more populated districts. The effort was highest for the Perth South and Perth North districts (Figure 2 and Appendix F). Effort was 'medium' for the Busselton, Jurien Bay, Lancelin and Mandurah districts, while the effort for the other districts was lower. The fishing effort for both Bunbury and Geraldton were low considering the population in these districts. The summer months were the most popular time for recreational fishing followed by autumn and spring. This is related to holiday activities and the number of days suitable for fishing at these times of the year due to the weather conditions.

The estimated total annual recreational angling effort for the region is 453,000 fisher days (722,000 boat hours or 1,730,000 angler hours based on a mean of 2.4 persons fishing per boat). The recreational angling effort for all species varied from 383 fisher days (747 boat hours) per 3-month season for Kalbarri in winter, to 48,225 fisher days (75,271 boat hours) for the Perth South region in summer.

The fishing effort can also be expressed as the number of boat trips (Figure 3). In all districts most boats fishing were successful, catching at least one fish, crustacean or mollusc

depending on the type of fishing and gear used. The number of boats not catching anything (15%) was low in comparison.

4.3 Catch of all species

The estimated total number of marine fish, crustaceans and molluscs captured was greatest near the Perth metropolitan area where most of the fishing effort occurs (Figure 4). Overall the number of animals kept (75%) was greater than the number released (25%).

The main marine species caught by boat-based fishers are (in order of number caught) whiting species (other than King George whiting), Australian herring, blue swimmer crabs, skipjack trevally, King George whiting, squid, southern sea garfish, various species of wrasse, groper and Western Australian dhufish (Figure 5). Large numbers of western rock lobster were also caught by boat-based recreational fishers (see Section 4.5). The estimated catch does not include fish and crustaceans caught in estuaries, which are the subject of other separate studies.

The composition of the catch varied according to the district (Figures 6a and 6b). Many species such as whiting (other than King George whiting) and herring were commonly caught in most districts. Western Australian dhufish comprised a significant proportion of the catch in Bunbury, Lancelin, Jurien Bay, Dongara, Geraldton, Port Gregory and Kalbarri. Pink snapper was common in Dongara, Port Gregory and Kalbarri. Narrow-barred Spanish mackerel was only recorded in Kalbarri. Figures 6a and 6b give an indication of the relative rather than absolute number of each species kept by district.

4.4 Catch of fish

The total number of fish both kept and released for all species by trailered and non-trailered boats was estimated (Appendices G and H). The error associated with the estimate of the number of fish kept was calculated for each species; the standard error for the estimated number kept $SE(\hat{c})$ is given (Appendix G and H). If we assume a student *t* distribution, the (1-α) per cent confidence interval for the number kept $(\hat{c})$ can be calculated from the standard error as follows:

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

where α = 0.05 for the 95% confidence interval and *n* is the number of boats surveyed (sample size).

The total weight of fish kept was calculated for species where a length to weight relationship was available. Unfortunately this information was not available for many species.

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

Whiting other than King George whiting

Whiting (*Sillago* spp.), other than King George whiting, includes various species of whiting such as yellow-finned whiting and western school whiting. The estimated boat catch from Augusta to Kalbarri for these species was 548,741 fish kept for trailered boats and 15,647 fish kept for non-trailered boats. The estimated total number of fish kept was 564,388. Much of the recreational catch is likely to occur outside the survey region. The shore-based catch must also be considered.

The catch of whiting, other than King George whiting, was highest in Perth North and Perth South where the fishing effort was highest (Figure 7). The mean catch rate for anglers targeting whiting other than King George was 8.91 fish per angler.

Australian herring

Australian herring are distributed from Victoria to Shark Bay. Therefore, much of the recreational catch in Western Australia may occur outside the area surveyed. For this reason the total recreational catch will exceed the estimate available. The estimated boat catch from Augusta to Kalbarri for this species was 416,657 fish kept for trailered boats and 8,243 fish kept for non-trailered boats. The estimated total number of herring kept was 424,891 (50,000 kilograms). The shore-based catch must also be considered which, from Perth to Cape Arid, has been estimated at 168,000 and 149,000 kilograms for 1994 and 1995 respectively (see Ayvazian *et al*. 1997).

The catch of Australian herring was highest in Perth North and Perth South where the fishing effort was highest (Figure 8) with more fish caught in autumn than the other seasons. The most common size class for fish caught was 200-209 mm (Figure 9). The mean catch rate for anglers targeting Australian herring was 5.96 fish per angler.

Skipjack trevally

Skipjack trevally are distributed from Southern Queensland to N.W. Cape. Therefore, much of the recreational catch in Western Australia may occur outside the region surveyed. For this reason the total recreational catch will exceed the estimate available. The estimated boat catch from Augusta to Kalbarri for this species was 120,439 fish kept for trailered boats and 2,217 fish kept for non-trailered boats. The estimated total number of skipjack trevally kept was 122,656 (43,000 kilograms). The shore-based catch must also be considered.

The catch of skipjack trevally was highest in the Busselton, Perth South and Mandurah districts (Figure 10), with more fish caught in winter than the other seasons. Most fish caught were between 200 and 400 mm in length (Figure 11). The mean catch rate for anglers targeting skipjack trevally was 2.49 fish per angler.

King George whiting

King George whiting are distributed from New South Wales to Jurien Bay. Therefore, much of the recreational catch in Western Australia may occur outside the region surveyed. For this reason the total recreational catch will exceed the estimate available. The estimated boat catch from Augusta to Kalbarri for this species was 93,982 fish kept for trailered boats and 447 fish kept for non-trailered boats. The estimated total number of King George whiting kept was 94,429 (21,000 kilograms). There will also be a small shore-based catch.

The catch of King George whiting was highest in the Perth South and Busselton districts (Figure 12). Many fish caught were just over the minimum size limit at the time of 250 mm (Figure 13). Larger fish between 370 mm and 500 mm were also caught in reasonable quantities. The mean catch rate for anglers targeting King George whiting was 2.35 fish per angler.

Southern sea garfish

Since garfish species are also caught outside the area of the survey, particularly along the south coast, the total recreational catch will exceed the estimate available. The estimated boat catch from Augusta to Kalbarri for this species was 77,868 fish kept for trailered boats and 1,323 fish kept for non-trailered boats. The estimated total number of southern sea garfish kept was 79,191 (7,600 kilograms). The shore-based catch must also be considered.

The catch of southern sea garfish was highest in the Perth North, Perth South and Mandurah districts (Figure 14), with more fish caught in autumn than the other seasons. Many of the fish caught were between 270 and 309 mm. There was also a reasonable number of larger fish caught (Figure 15).

Western Australian dhufish

Western Australian dhufish are caught from Steep Point to the Recherche Archipelago. The survey included the area where most of the recreational catch occurs. Since the shore-based catch is negligible, the boat catch is a reasonable approximation of the total catch. The estimated trailered boat catch was 28,967 (67%) fish kept and 13,991 (33%) released. The estimated non-trailered boat catch was 304 (65%) fish kept and 161 (35%) released. The estimated total number of Western Australian dhufish kept is 29,271 (132,000 kilograms).

The catch of Western Australian dhufish was highest in the Jurien Bay, Lancelin and Geraldton districts (Figure 16). Most Western Australian dhufish were caught in the summer season when the fishing effort was highest. The mean catch rate for anglers targeting Western Australian dhufish was 0.42 fish per angler.

Of the Western Australian dhufish caught in which the sex could be determined, 361 (56%) were males and 282 (44%) were females.

The catch of Western Australian dhufish in water deeper than 20 meters was of interest due to the susceptibility of this species to swim bladder embolism at depths greater than 20 m. From the fishing location information collected, 70.9 per cent of the recreational dhufish catch (kept and released) occurred in a depth of 20 metres or more (Table 3).

Anglers have adopted modern technology to catch dhufish. Fifty-six per cent of boats that caught dhufish had a global positioning system on board compared with twelve per cent for all recreational fishing boats. Sixty-one per cent of boats that caught dhufish had either a black and white or colour echo-sounder fitted, compared with thirty-six per cent for all fishing boats.

Tailor

Tailor are distributed from Queensland to Quobba. Therefore, much of the recreational catch in Western Australia may occur outside the area surveyed. For this reason the total recreational catch will exceed the estimate available. The estimated recreational boat catch from Augusta to Kalbarri for this species was 26,627 fish (10,000 kilograms) kept. The shore-based catch must also be considered.

The catch of tailor was highest in the Perth South district (Figure 18). Many fish caught were just over the minimum size limit at the time of 250 mm (Figure 19). Larger fish between 340 and 600 mm were also caught in reasonable quantities. The mean catch rate for anglers targeting tailor was 1.73 fish per angler.

Pink snapper

Pink snapper are distributed from Queensland to Barrow Island. Therefore, much of the recreational catch in Western Australia may occur outside the region surveyed. The total recreational catch will exceed the estimate available for the survey area for this reason. The year that the survey was conducted, 1996/97, was considered by many recreational anglers to be a poor year for pink snapper, particularly in Cockburn Sound. The estimated recreational catch from Augusta to Kalbarri for this species was 18,077 fish (27,000 kilograms) kept.

The catch of pink snapper was highest in the Mandurah district (Figure 20), with more fish caught in the spring than the other seasons. Most of the recreational catch was between 410 and 509 mm in length (Figure 21). A small number of under-size fish were kept by anglers (the minimum size limit at the time was 410 mm). The mean catch rate for anglers targeting pink snapper was 0.27 fish per angler.

Breaksea cod

Breaksea cod are distributed from the Recherche Archipelago to Shark Bay. Therefore, much of the recreational catch may occur outside the region surveyed. The total recreational catch will exceed the estimate available for the survey area for this reason. The estimated recreational catch from Augusta to Kalbarri for this species was 15,883 fish kept.

The catch of breaksea cod was highest in the Perth North, Perth South and Lancelin districts (Figure 22), with more fish caught in the summer than the other seasons. Most of the recreational catch was between 300 and 459 mm in length (Figure 23). There was no minimum size limit for this species at the time of the survey.

Baldchin groper

Baldchin groper are distributed from Geoghaphe Bay to Coral Bay. Therefore, much of the catch may occur outside the region surveyed. The total recreational catch will exceed the estimate available for the survey area for this reason. The estimated recreational catch from Augusta to Kalbarri for this species was 8,466 fish (23,000 kilograms) kept.

The catch of baldchin groper was highest in the Jurien Bay district (Figure 24), with most fish caught in the summer and autumn. Most fish caught were between 400 and 459 mm, however, there were good catches ranging up to 619 mm (Figure 25).

Flathead (all species)

Since flathead species are also caught outside the region of the survey, particularly along the south coast, the total recreational catch will exceed the estimate available. The estimated recreational boat catch was 8,187 fish (5,400 kilograms) from Augusta to Kalbarri for these species. The shore-based and estuarine catch must also be considered.

The catch of flathead was highest in the Perth South district (Figure 26).

Silver bream (tarwhine)

Silver bream are distributed from Albany to Coral Bay. Therefore, much of the recreational catch may occur outside the region surveyed. For this reason the total recreational catch will exceed the estimate available. The estimated recreational boat catch from Augusta to Kalbarri for this species was 6,083 fish (1,400 kilograms) kept. The shore-based catch must also be considered.

The catch of silver bream was highest in the Perth South and Mandurah districts (Figure 27). Most fish caught were between 190 and 269 mm in length (Figure 28). A large number of under-size fish of this species were kept. The legal minimum length at the time was 230 mm.

Western blue groper

Western blue groper are found in Port Phillip Bay, Victoria and also distributed from South Australia to the Abrolhos Islands. Since western blue groper are also caught outside the region of the survey, particularly along the south coast, the total recreational catch will exceed the estimate available. The estimated recreational catch from Augusta to Kalbarri for this species was 557 fish (2,700 kilograms) kept.

Other species

The trailered boat and non-trailered boat catch for other species are listed in Appendices G and H respectively. The annual catch for a species was only reported when it exceeded 300 fish. Catches below this quantity could not be reported with a reasonable precision due to large errors.

4.5 Catch of crustaceans

Western rock lobster

The survey was designed to estimate the catch of marine fish rather than crustaceans. The recreational catch and fishing effort for western rock lobster are estimated by an annual mail survey of licence holders (Melville-Smith and Caputi 1996). The total catch and fishing effort for recreational rock lobster fishing using pots have not been estimated since many fishers targeting western rock lobster returned to the boat ramps before the interviewer commenced at 8:00 am. However, the catch rate of 0.75 rock lobster per potlift could be estimated. The total catch for boat-based divers was 70,646. The number of rock lobsters kept per boat was higher for divers than for fishers using pots and is listed below:

	Pots	**Diving**
Mean number kept	2.12	5.61
Standard error	0.08	0.33
Number of boats	1211	236

The mean catch of western rock lobsters per licence was 1.46 with a 0.05 standard error. The number of boats interviewed with one licence holder (one or two pots) was 382, and 560 for boats with two licence holders (three or four pots). The number of licence holders per boat was estimated from the number of pots. The length-frequency for western rock lobster (Figure 29) shows the size range for animals kept.

Blue swimmer crabs

The total catch and fishing effort for Geographe Bay, Cockburn Sound, Warnbro Sound and Perth South (which includes Warnbro Sound, Shoalwater Bay, Cockburn Sound to Fremantle and West of Garden Island) were estimated from the survey data collected. It was not possible to estimate the total catch and effort for the Leschenault estuary, Peel-Harvey estuary and Swan River, since not all boat ramps in these estuaries were surveyed. However, there were sufficient data from boat ramps surveyed to estimate catch rates for all areas other than the Swan River (Table 4). Surveys to estimate the recreational catch and effort for Leschenault estuary, Peel-Harvey estuary and Swan River are now being conducted as separate projects.

The estimates for Cockburn Sound included the recreational blocks BQ59, BQ58 and the catch from block BQ57 (Appendix C) landed in the sound. The catch estimates for Cockburn Sound are not directly comparable with those provided by Dybdahl (1997). Among other differences, the earlier study included crabs caught outside Cockburn Sound and landed at a boat ramp in the Sound.

The shore-based catch of blue swimmer crabs for these areas, especially Geographe Bay, is likely to be significant and must also be considered.

4.6 Equipment used by fishers

Anglers have adopted modern technology to increase the efficiency of recreational fishing with 36 per cent of trailered boats fitted with an echo-sounder (26% black and white, 11% colour) and 12 per cent using a global positioning system to find fishing locations. Few boats (4%) had snapper winches fitted. Only 37 per cent of boats had a marine band radio fitted.

4.7 Fishing regulations

There was a very high level of compliance with the fishing regulations. Only 169 (2.5%) of the 6,713 boat-based fishers interviewed had kept under-size fish. Very few fishers exceeded the bag limits.

Most fishers had a reasonable knowledge of the fishing regulations. The majority of fishers knew the bag (80%) and size (84%) limits for the species they were targeting or the species they had caught.

4.8 Attitudinal responses

The attitudinal responses show that most fishers had an appreciation of the impact of recreational fishing on fish stocks and the importance of keeping within bag and size limits (Table 5). Most fishers believed they knew the rules and that information on fishing rules was easy to obtain. Most fishers enjoyed their trip whether they caught enough fish to justify the cost or not. 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 5). Most 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 5). 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.

5.0 Discussion of results

The bus route method estimates fishing effort from the amount of time boat trailers are present at boat ramps. The effort includes the elapsed time between the boat launch and boat retrieval rather than the time spent fishing. Furthermore, the effort for the bus route method includes travelling time between the boat ramp and the fishing destination. If the travelling time is small there will be close agreement between the effort estimated from the bus route method and the actual fishing time. However, there will be a disagreement between the elapsed time and time spent fishing for a small number of boats involved in other activities such as sight seeing and wildlife observation as well as fishing.

There were few boats remaining at the boat ramps when the interviewer's shift finished at 4:00 pm. It is likely that most of the boats remaining after 4:00 pm would return to the ramp before nightfall, although this could vary depending on the location and time of the year. It was not, however, possible to account for boats that returned to the ramp after 4:00 pm since no catch and fishing effort information was collected beyond this time. For this reason the effort has been under-estimated by the survey, although this is likely to be small due to the prevailing afternoon sea breeze that occurs on this section of the coastline most days.

The survey was not intended to include the recreational catch and fishing effort occurring in estuaries. However, limited information (eg. catch rates) for estuaries is available since boat ramps in estuaries that were used to launch boats for marine fishing were included in the study. Since not all ramps in the estuaries were surveyed the total catch and effort could not be calculated.

At present there is little information available on the catch and fishing effort for charter boats. However, charter boats were not included in the survey since a log book was being developed for this purpose. This information will be available for future years.

Size limits are an effective catch control measure with substantial numbers of under-size fish of many species caught and then subsequently released. This was supported by most anglers having a knowledge of the fishing regulations for species that they were targeting and a high level of compliance in this region of the state. However, the present regulation of a minimum size limit allows the retention of the largest individuals, which are often the most fecund.

Although substantial numbers of under-size Western Australian dhufish were released, this may not be an effective catch control mechanism for this species due to susceptibility to swim bladder embolism. Most (70.9%) of the recreational dhufish catch (kept and released) occurred in depths of 20 metres or more. Under-size Western Australian dhufish caught at depths greater than 20 meters and subsequently released (23.4% of fish caught), are unlikely to survive (Ashby 1996). This has implications concerning the effectiveness of the size limit as a means of catch control for this species. Since it is likely that most Western Australian dhufish will not survive when released, the total number of all fish kept and released (42,958) may give a better indication of the mortality of this species due to recreational fishing.

The present bag limits were effective in reducing large catches on occasions. However, the survey indicated that very few fishers achieve the daily bag limits specified under present statewide recreational fishing regulations. For instance, only one of the 501 boats owners interviewed that had caught Western Australian dhufish achieved the bag limit of four fish per person. Only four of the 6,683 boats interviewed achieved or exceeded the bag limit of eight prize fish per person. For this reason, the present bag limits for many species are too large to offer any significant protection for the species they aim to protect. Furthermore, bag limits will become more ineffective when abundances decline.

In previous years annual stock assessments for species important to recreational fishers have been based solely on commercial catch data. These have used age-structured models incorporating either yield per recruit or eggs per recruit information to determine target reference points and limit reference points. A time series of recreational catch is required for improved stock assessment of recreational species. However, due to the costs involved, it is not practical to conduct creel surveys to obtain this information in all regions of the state on an annual basis. Instead, creel surveys are being conducted in each region about once every five years. Other sources of information, such as log books and surveys conducted by Fisheries Officers and Volunteer Fisheries Liaison Officers, will provide information on recreational catch rates for the intervening years between surveys. Fishing effort could be estimated from population census data using estimates of participation rates available from annual community surveys.

The polarised responses to Question 5 (Table 5 and Appendix B) ,“Once I’ve caught enough for a couple of meals I usually release the rest”, suggest the existence of two distinct groups of fishers: one group (disagree) was fishing to catch enough for a couple of meals and the other group (agree) preferred to keep fishing to try to catch the bag limit. The responses to the

statement “I usually try to catch as many as the bag limit allows” were also polarised, suggesting the existence of two groups of fishers.

Information on the shore-based catch from the Perth metropolitan area to Kalbarri has not been collected by this or previous creel surveys and is required. This is particularly important since new roads between Perth and Dongara will make this area more accessible to shore-based anglers in the near future. As a consequence, the shore-based catch for many species such as tailor is likely to increase.

6.0 Conclusions

On the basis of the results of this study, it can be concluded that the bus route method, with adaptations, proved to be a suitable approach for estimating the recreational catch and fishing effort for the region. The survey method proved to be robust and was readily adapted to the large survey area. The bus route method gave a more precise estimate of recreational fishing effort than possible with a conventional access site survey of the same area.

On the west coast, recreational fishing effort occurs where the population is located, with most effort occurring near the Perth metropolitan area.

The level of sampling (number of days worked by interviewers) gave estimates of the total catch for all species with an acceptable level of precision. The standard error was small for most species important to recreational anglers such as whiting (6%), herring (6%), skipjack trevally (13%) southern sea garfish (11%), Western Australian dhufish (7%), tailor (15%) and pink snapper (9%). As expected, the estimates were less precise for species such as dolphin fish (54%) and sea perch (60%) that were seldom caught. However, the results are likely to understate the recreational catch since the survey could not include boats fishing after 4:00 pm, and boats that had finished fishing and returned to the boat ramp before 8:00 am. Boats launched from beaches or leaving from marinas and yacht clubs not covered by the survey could not be included.

The data collected, along with other survey data, should be integrated with a geographical information system so that information on catch and fishing effort for all regions of the state is readily available. However, it is important that the assumptions made when extrapolating this sample data to estimate total catch and effort are clearly stated. Consideration should also be given to making these survey results available via the internet as has been done by the South Australian Research and Development Institute.

The results clearly show the importance of recreational fishing in Western Australian marine waters on the west coast. Further creel surveys are required on a systematic basis to determine the recreational catch for other parts of the state and to study long term trends in fishing effort, total catch and fishing quality indicators such catch rates, size composition and variety of species caught.

7.0 Acknowledgements

The project was funded by the Recreational Fisheries Program of Fisheries WA with the support of the Recreational Fishing Advisory Committee. The authors acknowledge many people who assisted with the creel survey. We especially wish to thank our interviewers Bruce Barlow, Brian Billi, Ken Dowse, Trevor Earl, Tony French, Adrian Granger, Lloyd Goodlad, Tim Leary, Peter Powell, Rodney Rathbone, Barbara Saunders, Brad Smith and Bob Williamson for their dedication and commitment which made completion of the project possible. Tim Leary and Rick Allison provided technical support. Nick Caputi, Andrew Cribb, Norm Hall, Nathan Harrison and Mike Moran reviewed the draft manuscript and provided many useful comments.

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9.0 Tables

Table 1 Relationship between species targeted and species kept for recreational boats.

		Species Targeted									
		WA dhufish	Western rock lobster	Australian herring	King George whiting	Other whiting	Pink snapper	Blue swimmer crab	Skipjack trevally	Squid	Tailor
Species Kept	WA dhufish	266	2	1	1	0	18	0	0	0	0
	Western rock lobster	17	337	11	1	3	12	2	0	0	1
	Australian herring	5	7	283	54	24	7	8	34	13	39
	King George whiting	23	2	11	168	30	22	4	17	2	5
	Other whiting	26	1	24	53	275	16	4	15	5	16
	Pink snapper	98	0	0	3	3	58	0	4	0	0
	Blue swimmer crab	1	4	2	6	5	2	578	0	0	5
	Skipjack trevally	44	7	43	38	34	37	0	108	3	3
	Squid	7	6	28	32	19	14	13	11	95	4
	Tailor	0	5	16	4	4	2	1	5	1	69
	Nil catch	72	97	41	25	25	32	15	10	12	19
	Other	516	68	193	117	183	196	18	125	26	48
	Total No. of boats *	552	490	363	247	325	197	613	153	114	124

* *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 Correction factor for effort occurring before 8:00 am

Season	Ratio of effort prior to 8:00 am to after 8:00 am	Correction factor (*f*)
Spring	0.17	1.17
Summer	0.28	1.28
Autumn	0.17	1.17
Winter	0.06	1.06

Table 3 Depth of Western Australian dhufish catches.

	Depth				Total	
	Less than 20 m		Greater than 20 m			
Number kept	280	(17.6%)	755	(47.4%)	1035	(65.0%)
Number released	184	(11.6%)	373	(23.4%)	557	(35.0%)
Total	464	(29.1%)	1128	(70.9%)	1592	(100%)

Table 4 Recreational catch and effort for blue swimmer crabs (standard error in italics).

	Geographe Bay	Cockburn Sound	Warnbro Sound	Perth South	Leschenault Estuary	Peel-Harvey Estuary
Effort (hours)	13,830	19,048	6,461	37,963		
	1,150	*1,042*	*345*	*2,058*		
Catch (no. of crabs)	85,380	91,775	30,530	169,256		
	14,179	*11,980*	*4,834*	*15,443*		
Catch (in kilograms)	17,532	18,845	6,269	34,755		
	2,911	*2,460*	*993*	*3,171*		
Catch rate (crabs/boat/hr)	6.8	5.6	5.7	5.2	8.9	8.0
	0.7	*0.7*	*0.9*	*0.4*	*1.2*	*0.2*
Catch rate (crabs/net)	2.3	2.6	1.3	2.0	2.0	2.4
	0.4	*0.8*	*0.4*	*0.4*	*0.4*	*0.1*
Catch rate (crabs/boat)	18.2	16.4	17.8	14.5	20.5	22.3
	1.8	*1.9*	*2.5*	*1.0*	*2.5*	*0.4*

Table 5 Response to statements about 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.	3,083	99	66
The recreational fishing catch is too small to affect fish stocks.	1,983	696	649
Individual fishers can help protect fish stocks by keeping within bag and size limits.	27	39	3,328
I know the current rules for the fish I catch and try to keep up to date.	119	286	3,003
Information of fishing rules is hard to get.	2,949	214	248
If I don't catch enough fish to justify the cost I don't really enjoy the trip.	2,885	126	340
Once I have caught enough for a couple of meals I usually stop fishing.	793	342	2,195
I usually try to catch as many fish as the bag limit allows.	1,678	197	1,468
I enjoy fishing even if I don't catch anything.	232	172	2,988
Once I've caught enough for a couple of meals I usually release the rest.	1,424	388	1,243
Once I've caught the bag limit for a species I usually release the rest.	288	77	2,710

10.0 Figures

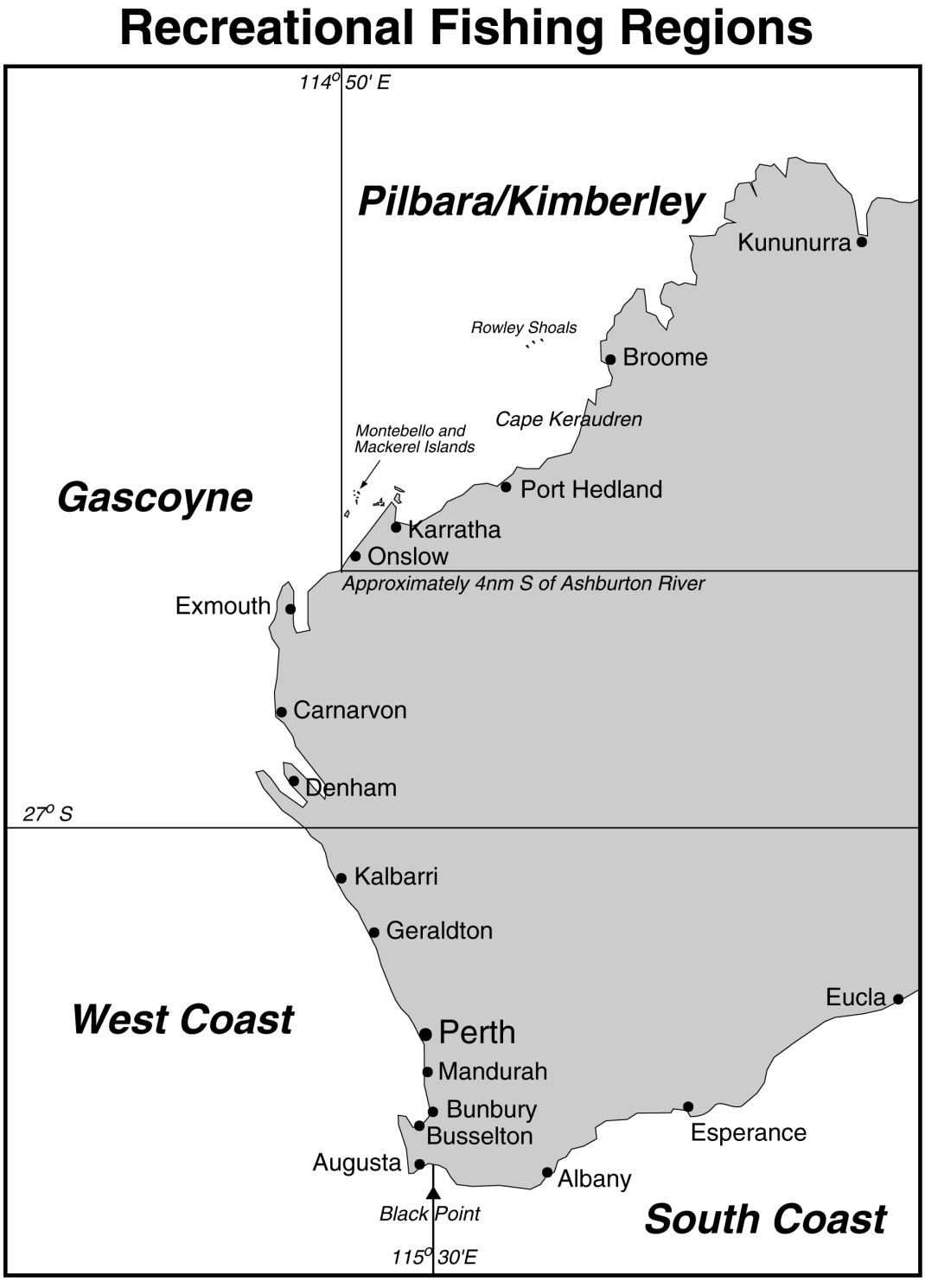


Figure 1 Recreational fishing regions.

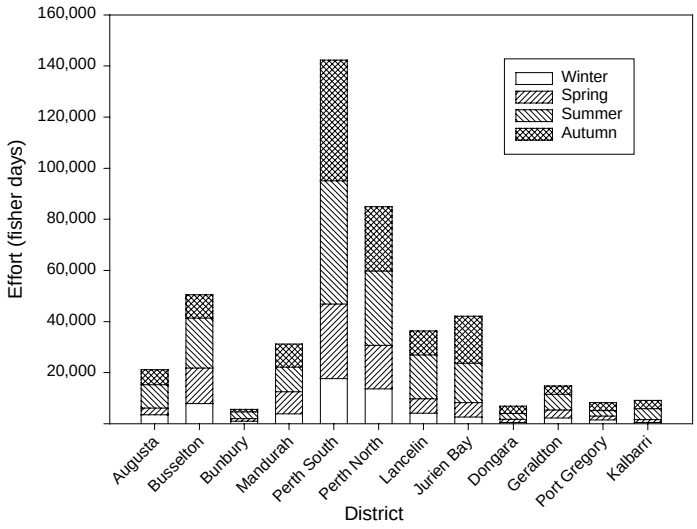


Figure 2 Recreational fishing effort.

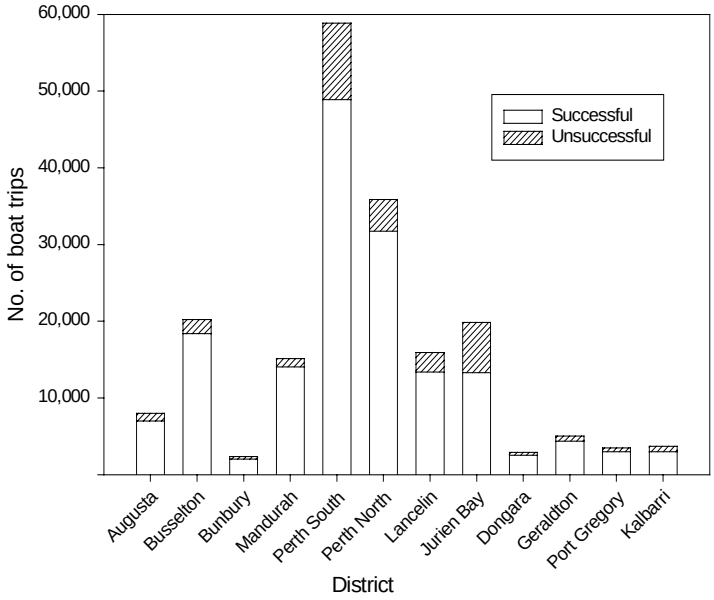


Figure 3 Recreational fishing effort.

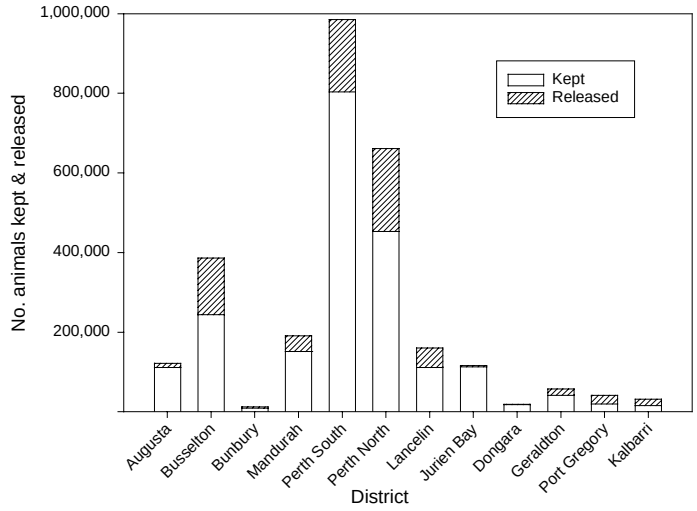


Figure 4 Total number kept and released for all species.

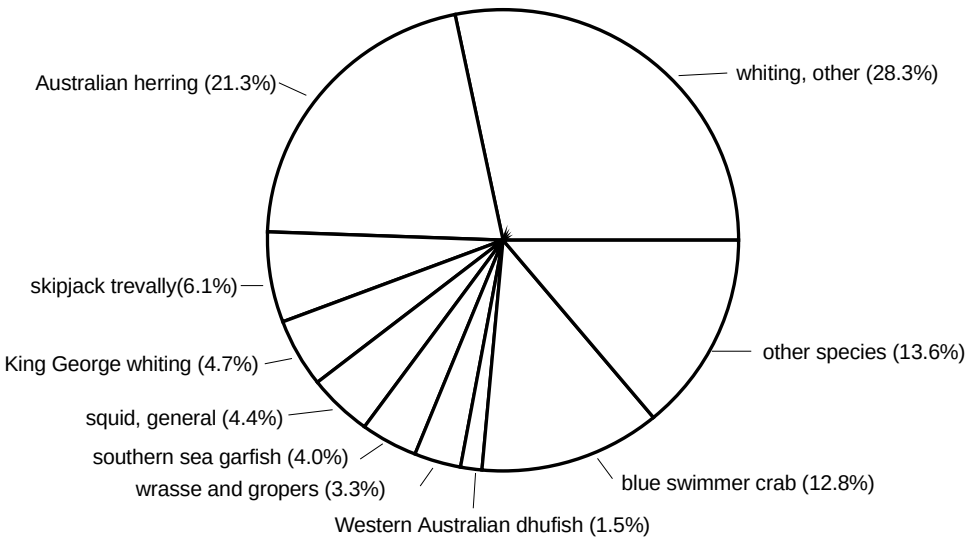


Figure 5 Composition of recreational catch.

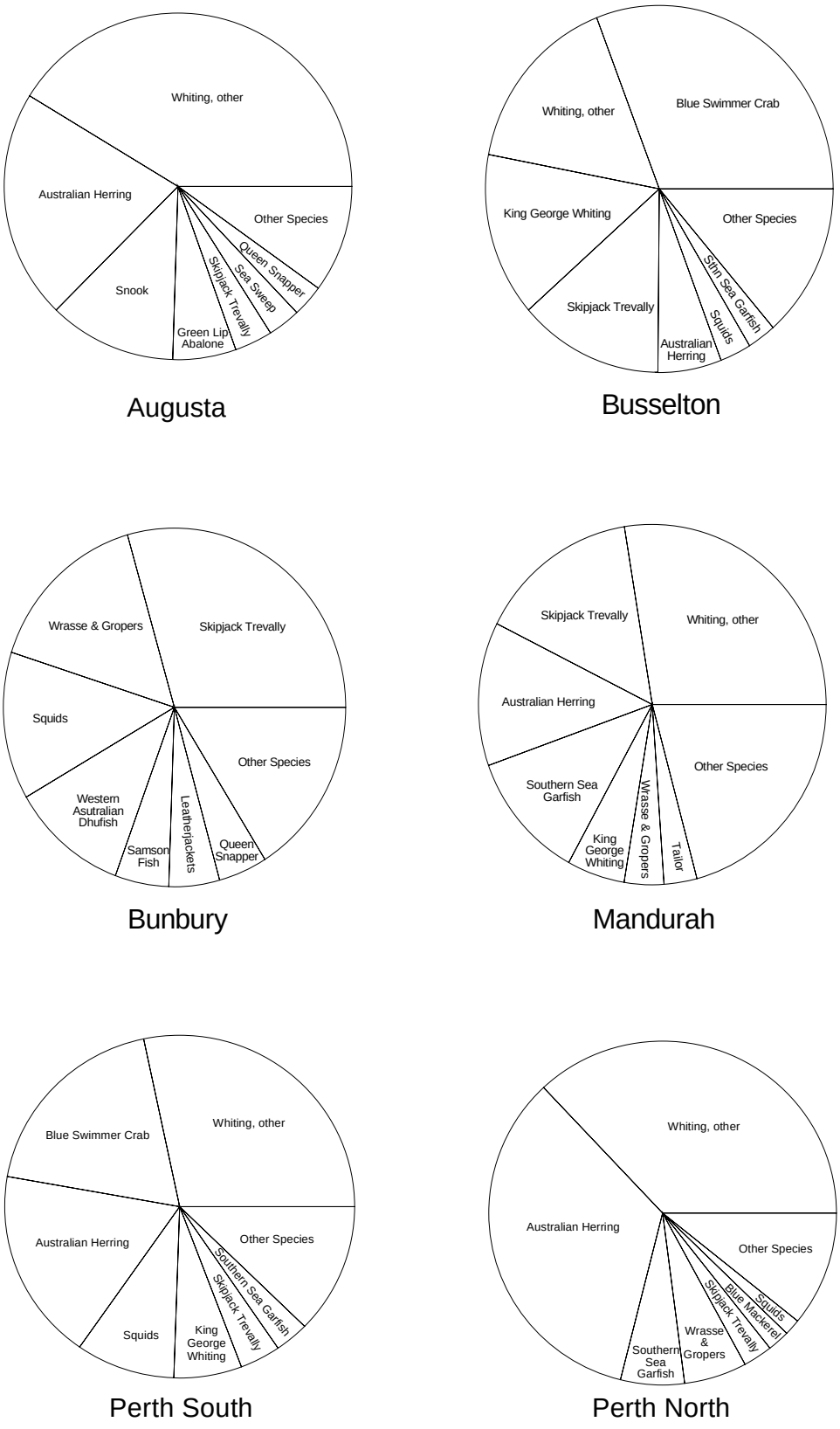


Figure 6a Composition of recreational catch by district.

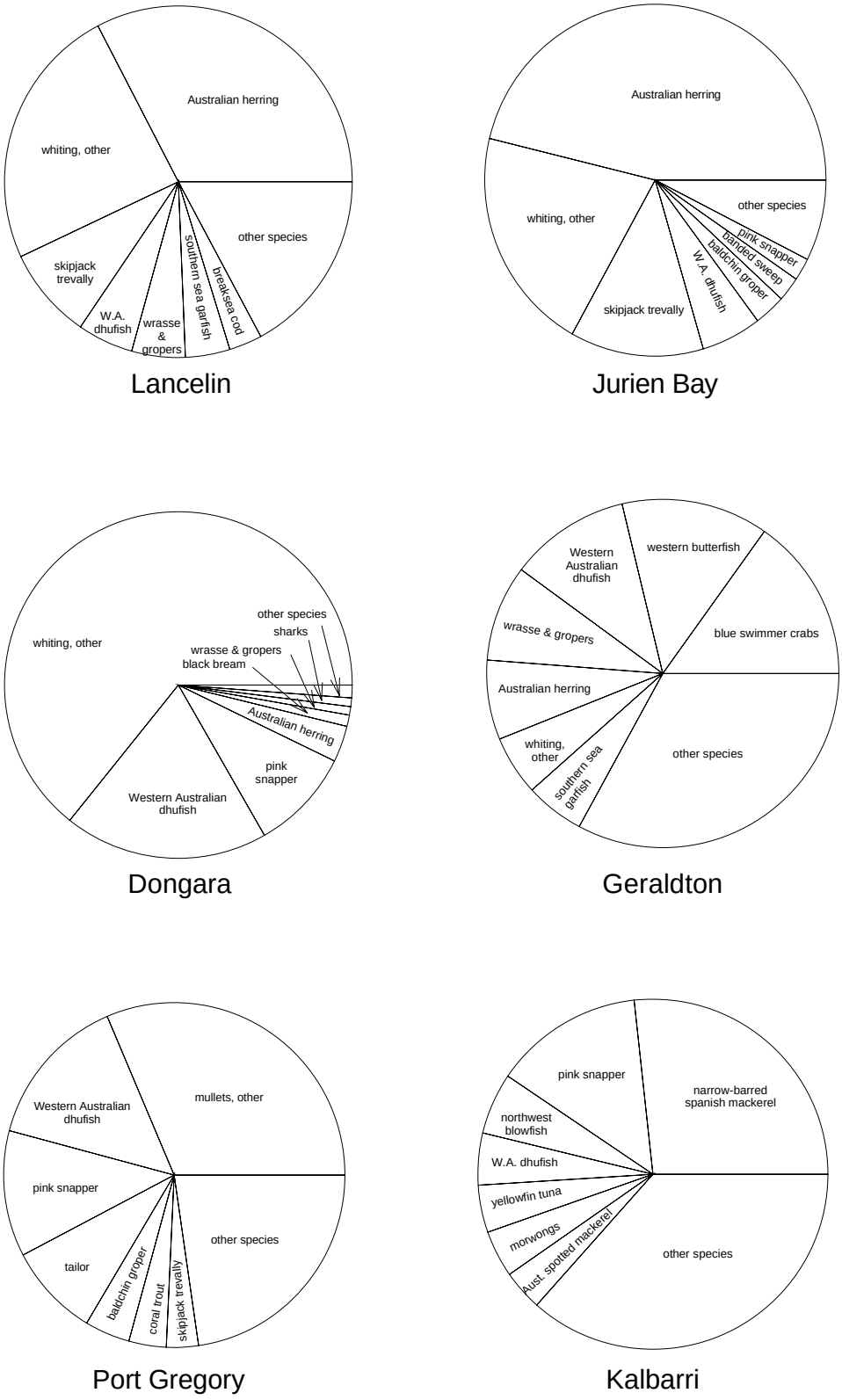


Figure 6b Composition of recreational catch by district.

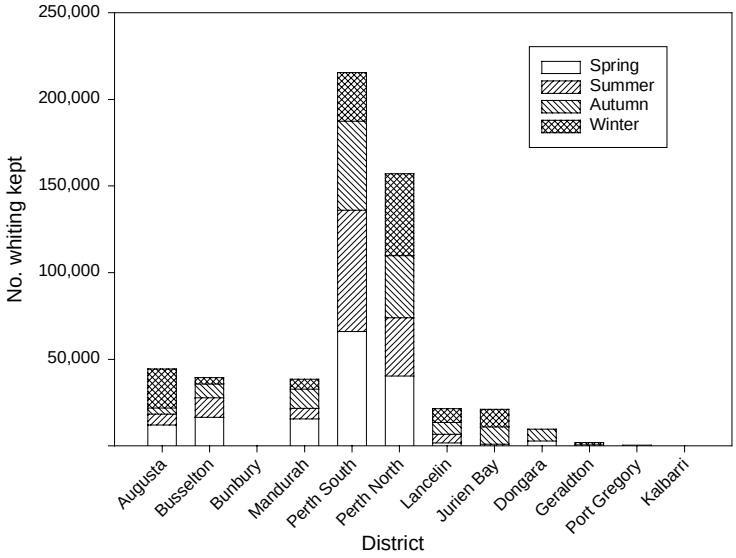


Figure 7 Catch of whiting other than King George whiting.

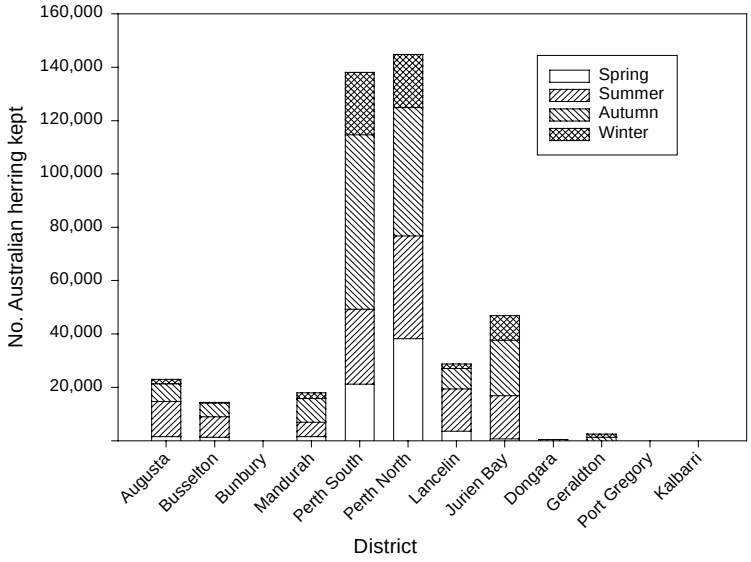


Figure 8 Catch of Australian herring.

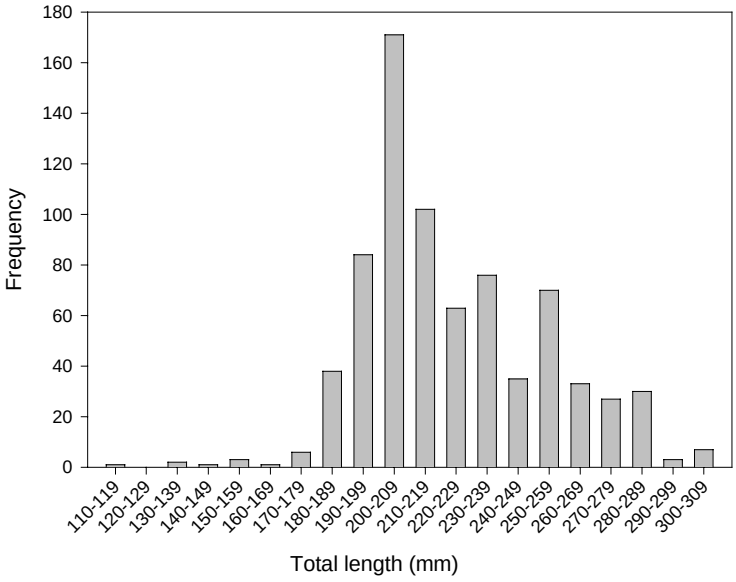


Figure 9 Length-frequency for Australian herring kept.

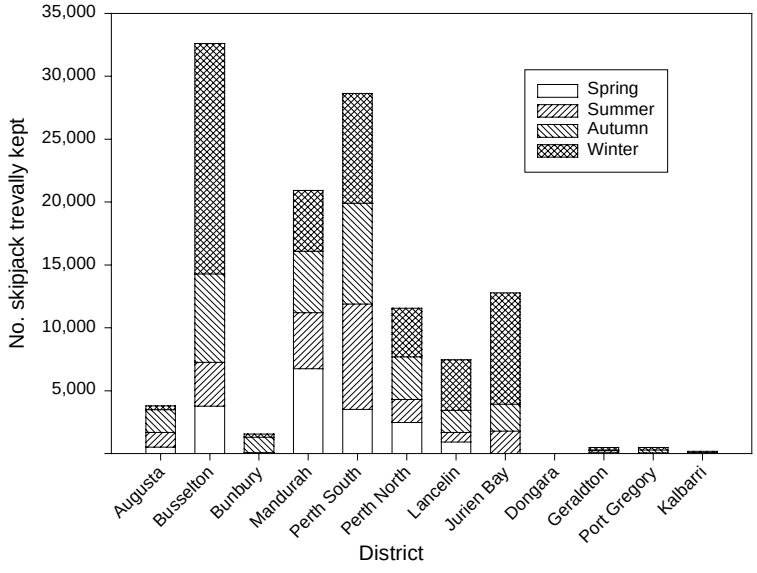


Figure 10 Catch of skipjack trevally.

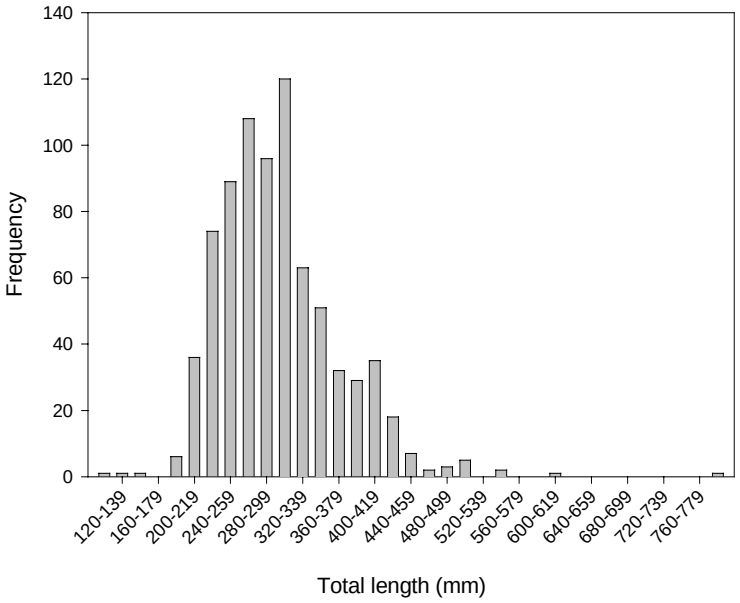


Figure 11 Length-frequency for skipjack trevally kept (minimum length 200 mm).

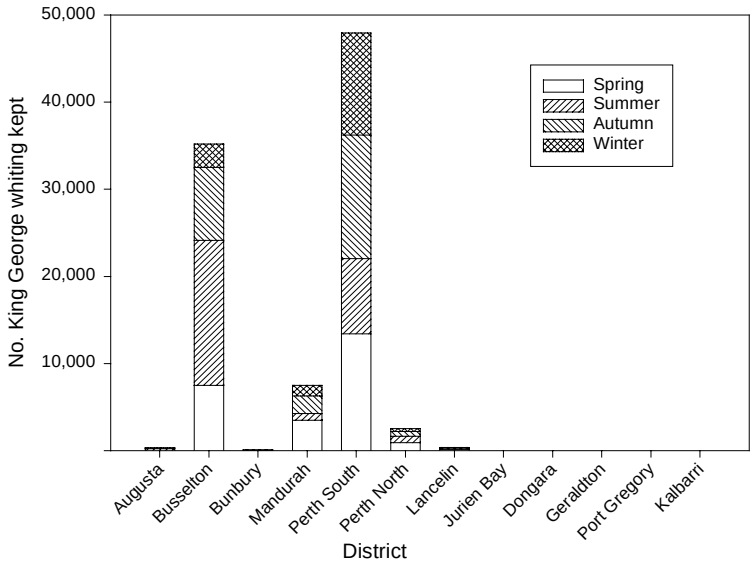


Figure 12 Catch of King George whiting.

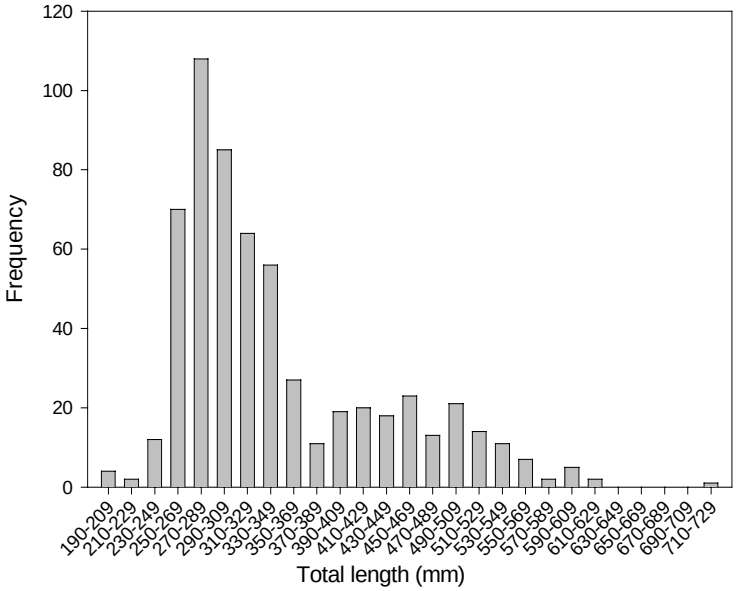


Figure 13 Length-frequency for King George whiting kept (minimum length 250 mm).

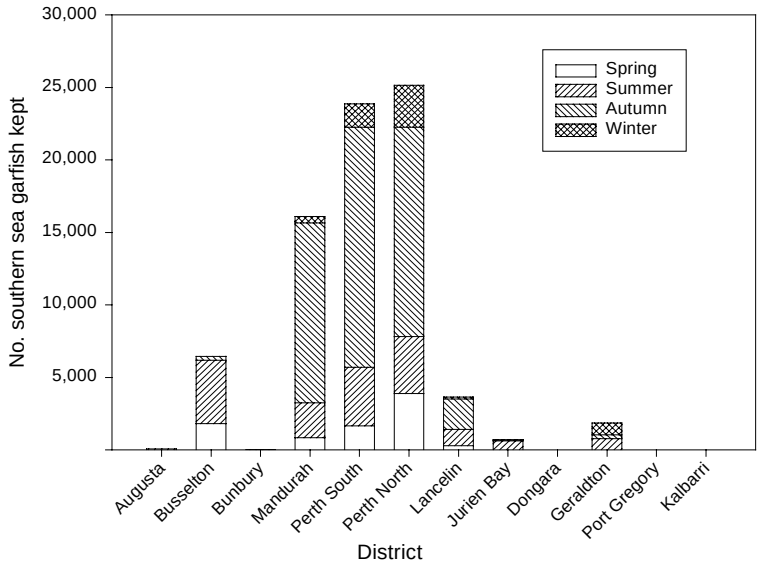


Figure 14 Catch of southern sea garfish.

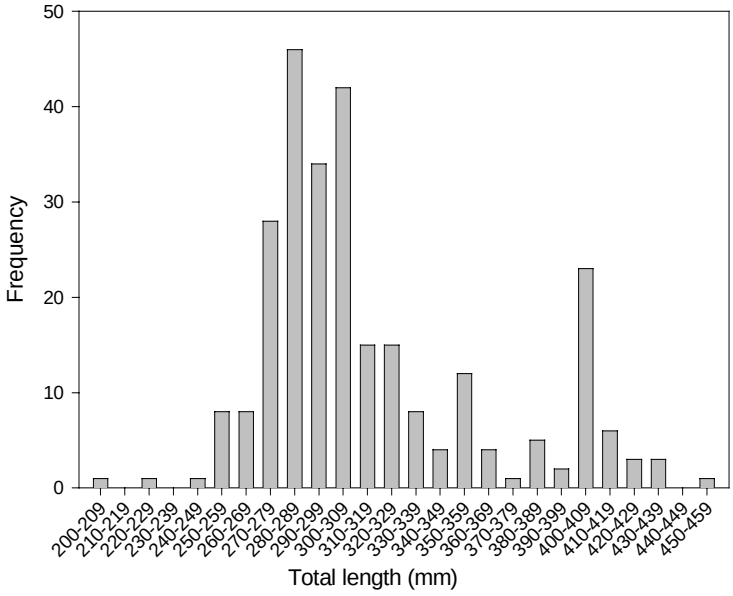


Figure 15 Length-frequency for southern sea garfish kept.

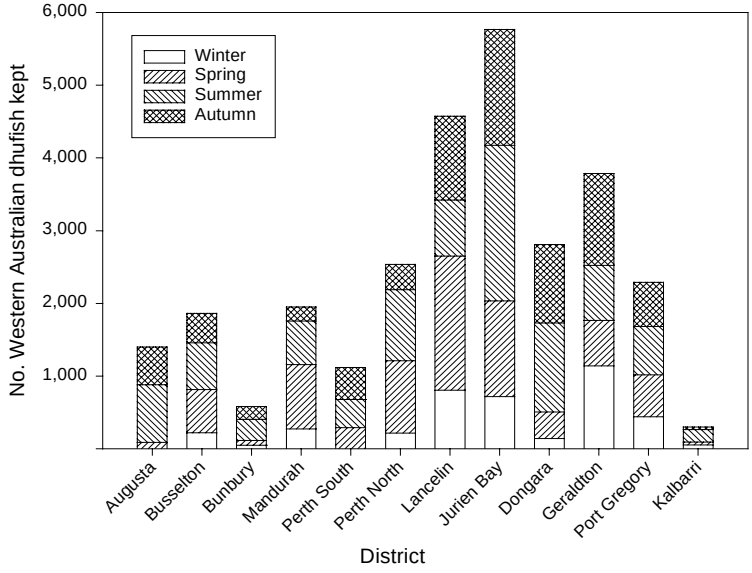


Figure 16 Catch of Western Australian dhufish.

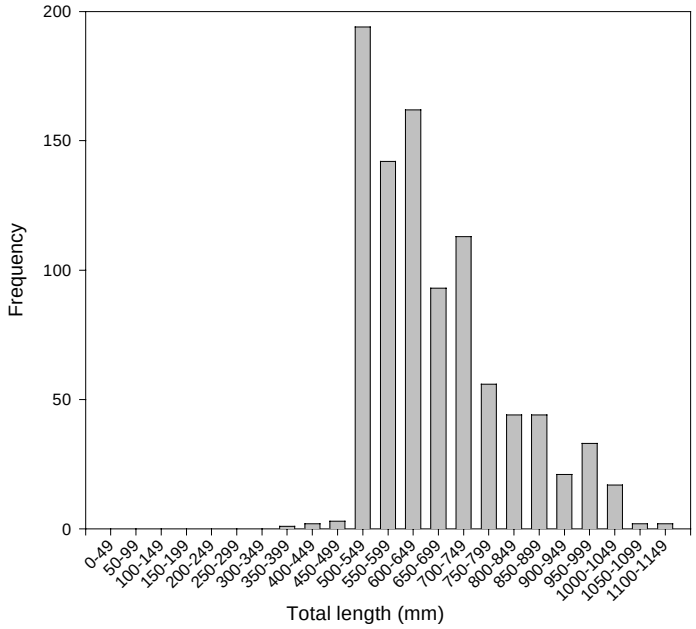


Figure 17 Length-frequency for Western Australian dhufish kept (minimum length 500 mm).

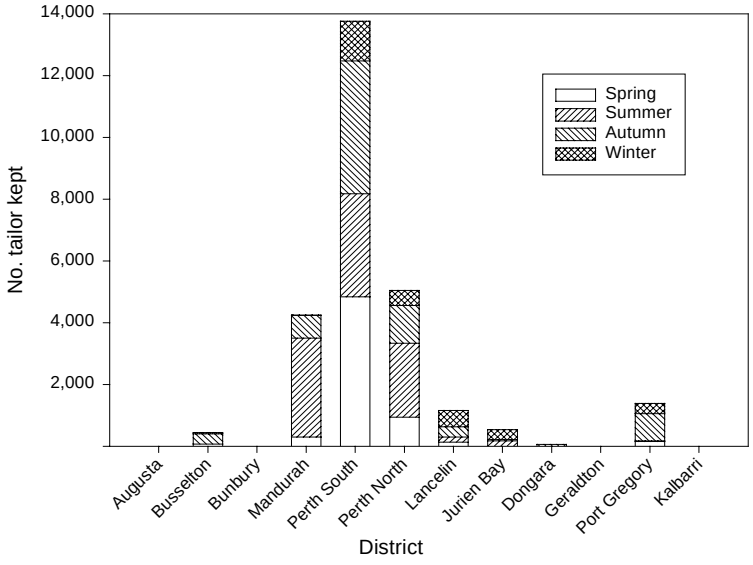


Figure 18 Catch of tailor.

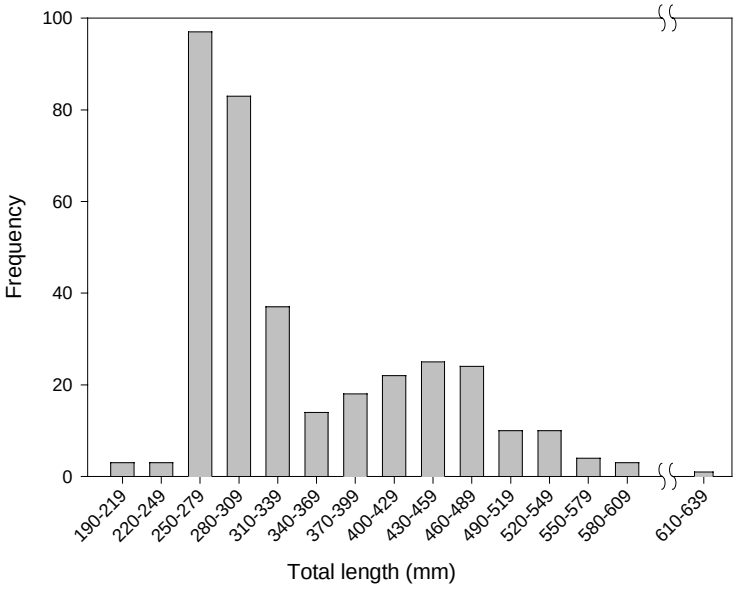


Figure 19 Length-frequency for tailor kept (minimum length 250 mm).

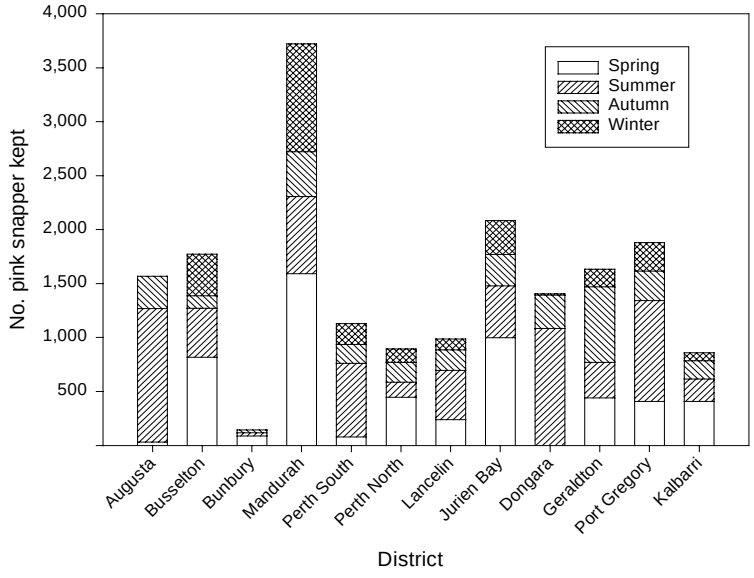


Figure 20 Catch of pink snapper.

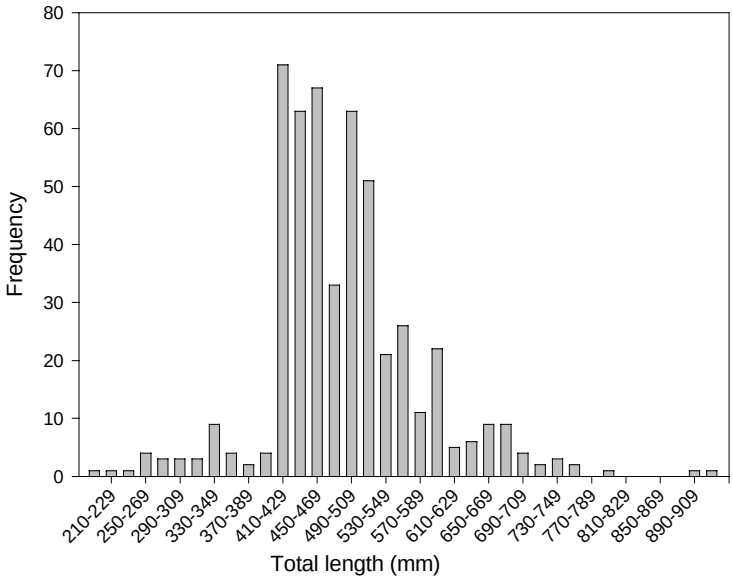


Figure 21 Length-frequency for pink snapper kept (minimum length 410 mm).

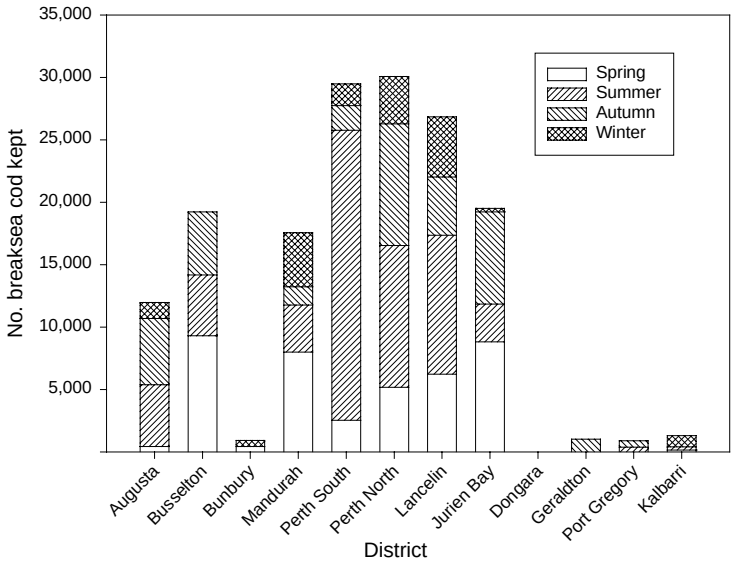


Figure 22 Catch of breaksea cod.

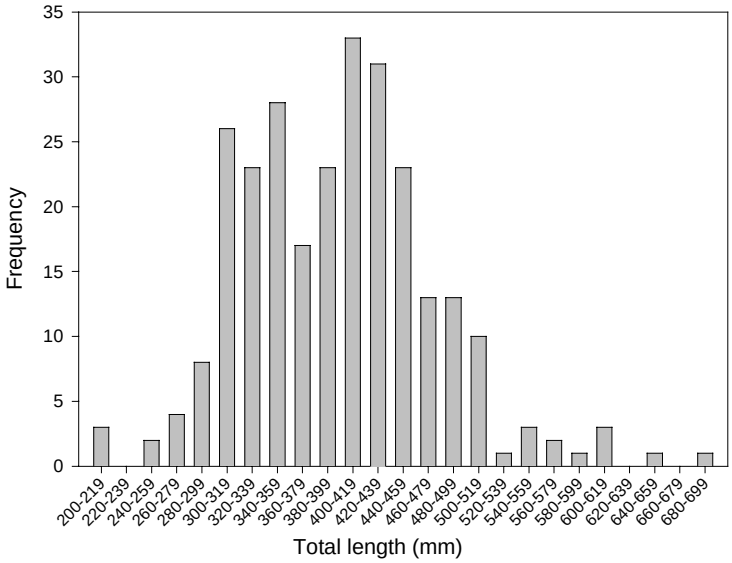


Figure 23 Length-frequency for breaksea cod kept.

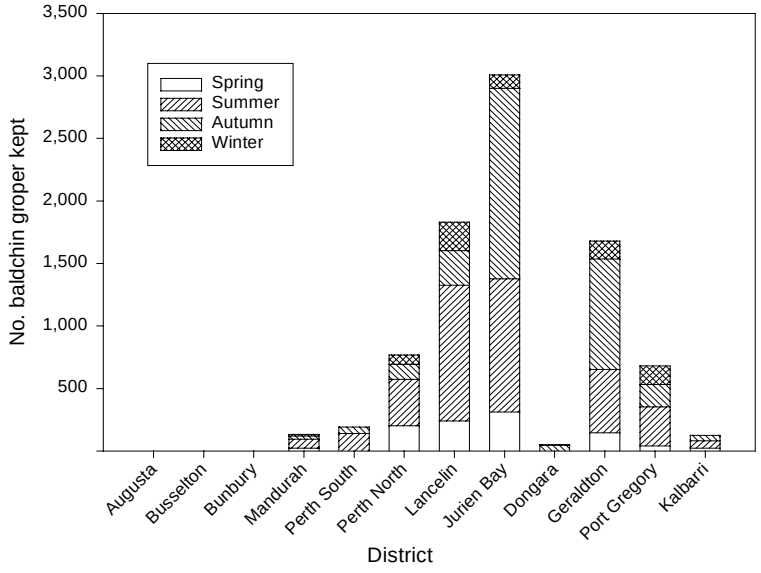


Figure 24 Catch of baldchin groper.

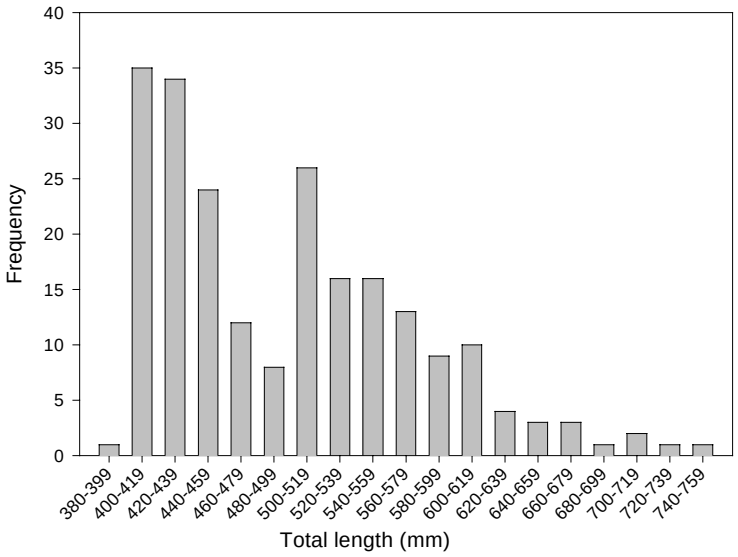


Figure 25 Length-frequency for baldchin groper kept (minimum length 400 mm).

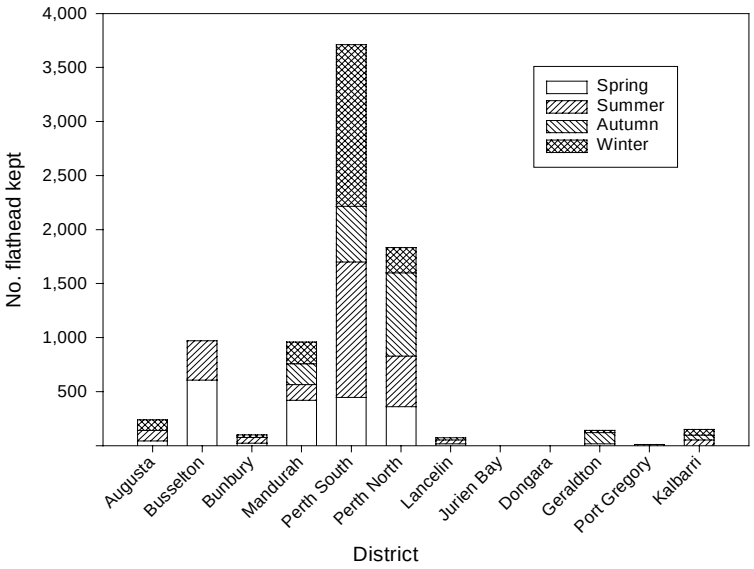


Figure 26 Catch of flathead.

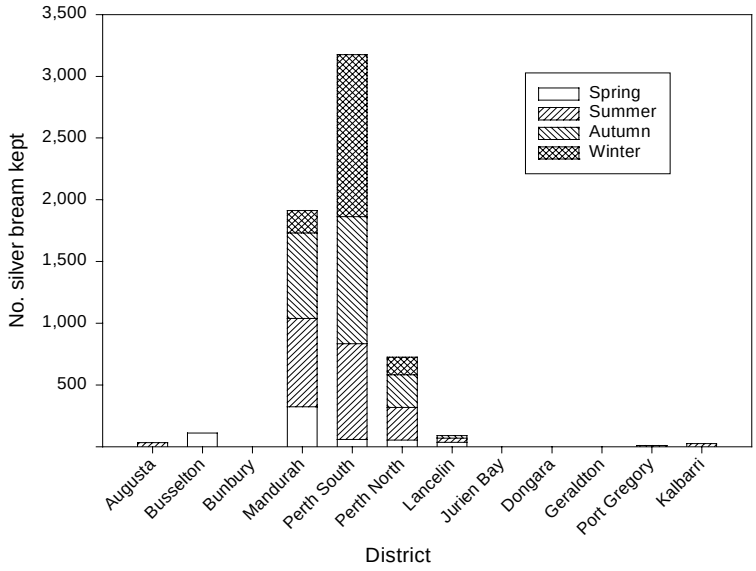


Figure 27 Catch of silver bream.

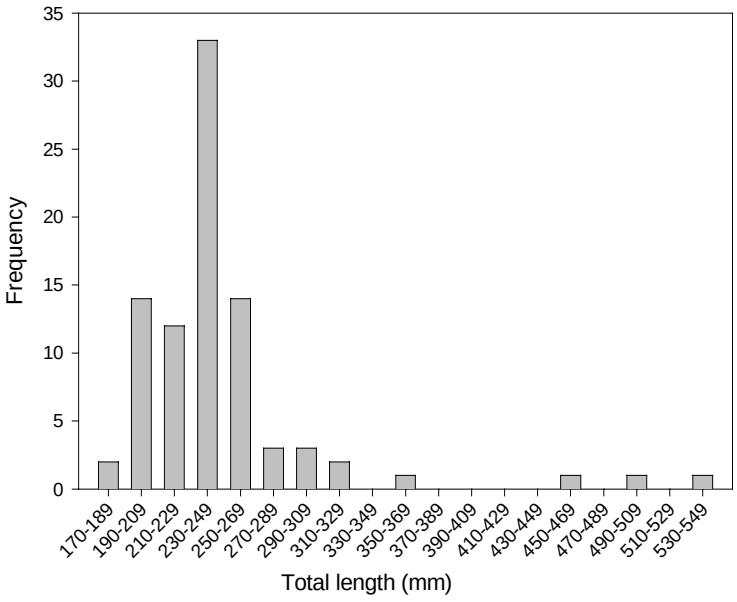


Figure 28 Length-frequency for silver bream kept (minimum length 230 mm).

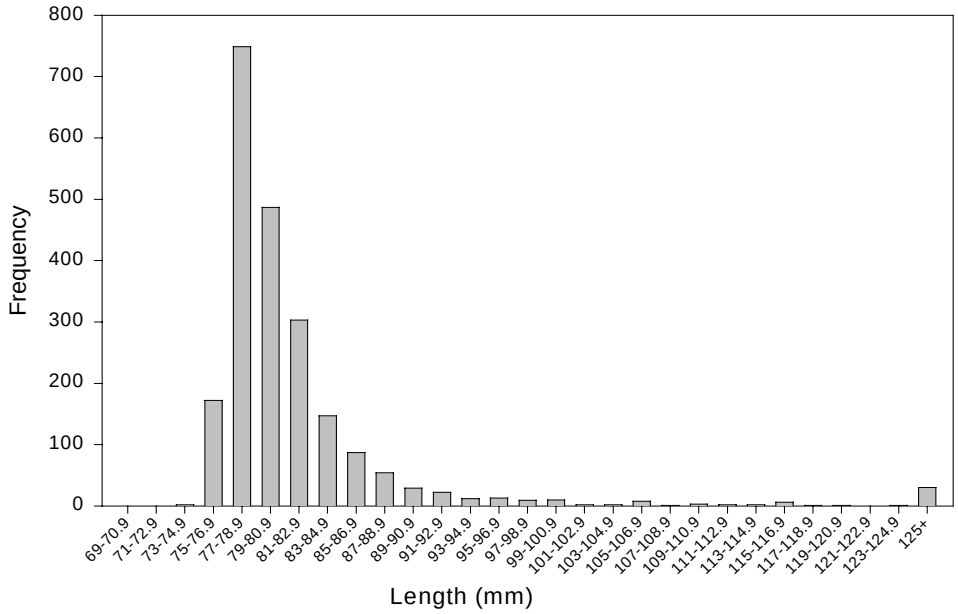


Figure 29 Western rock lobster length-frequency.

11.0 Appendices

APPENDIX A - Recreational fishing boat survey form

RECREATIONAL FISHING BOAT SURVEY

Interviewer's Name: _____

Date: _____ **Start Time:** _____ **Finish Time:** _____

Region: _____ **Boat Ramp:** _____

ENVIRONMENTAL DATA

Wind:	**Calm 1**	**Light 2**	**Mod 3**	**Strong 4**	**Gale 5**	**Direction**

Seas:	**Calm 1**	**Slight 2**	**Mod 3**	**Rough 4**	**V. Rough 5**

Cloud Cover:	**Cloud %**	**Rainfall:**	**Nil 1**	**Light 2**	**Mod 3**	**Heavy 4**

Weather conditions suitable for boat fishing (Yes/No): _____

Total Number of Boats								**Total Number of Trailers**	
Boat Launches				**Boat Retrievals**				**On Arrival**	**On Departure**
Time	**Type**	**Time**	**Type**	**Time**	**Type**	**Time**	**Type**		

Boat Type
P: Power
Y: Yacht
O: Other

APPENDIX B - Interview questionnaire form

INTERVIEW QUESTIONNAIRE

Date: _____ Ramp: _____ Boat Reg. No.: _____

Boat Arrival Time	Type of Boat (Pwr/Ycht)	Boat Departure Time	Boat/Dive/Other	Number in Boat	No. of Females in Boat	Age Group	Postcode (Home)	Length of Boat (ft/m)	Angling Club (Yes/No)	Time Spent Fishing (Hrs)	Block No. or Estuary	Number of Lines Used	Nets (Crab,Set,Haul,Pots)	Times Interviewed Before

FISHERS ONLY

Species	Number Kept	Number Released	Undersize Kept	Lengths
W.A. Jewfish (Male)				
W.A. Jewfish (Female)				
W.A. Jewfish (Juvenile)				
Pink Snapper				

APPENDIX B - Interview questionnaire form (continued)

ATTITUDINAL QUESTIONNAIRE

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

Black and white echo sounder (Yes/No)		Radar(Yes/No)	
Colour echo sounder(Yes/No)		Marine Band Radio(Yes/No)	
Global Positioning System(Yes/No)		Number of Snapper winches	

2. What species were you fishing for: _____

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*?

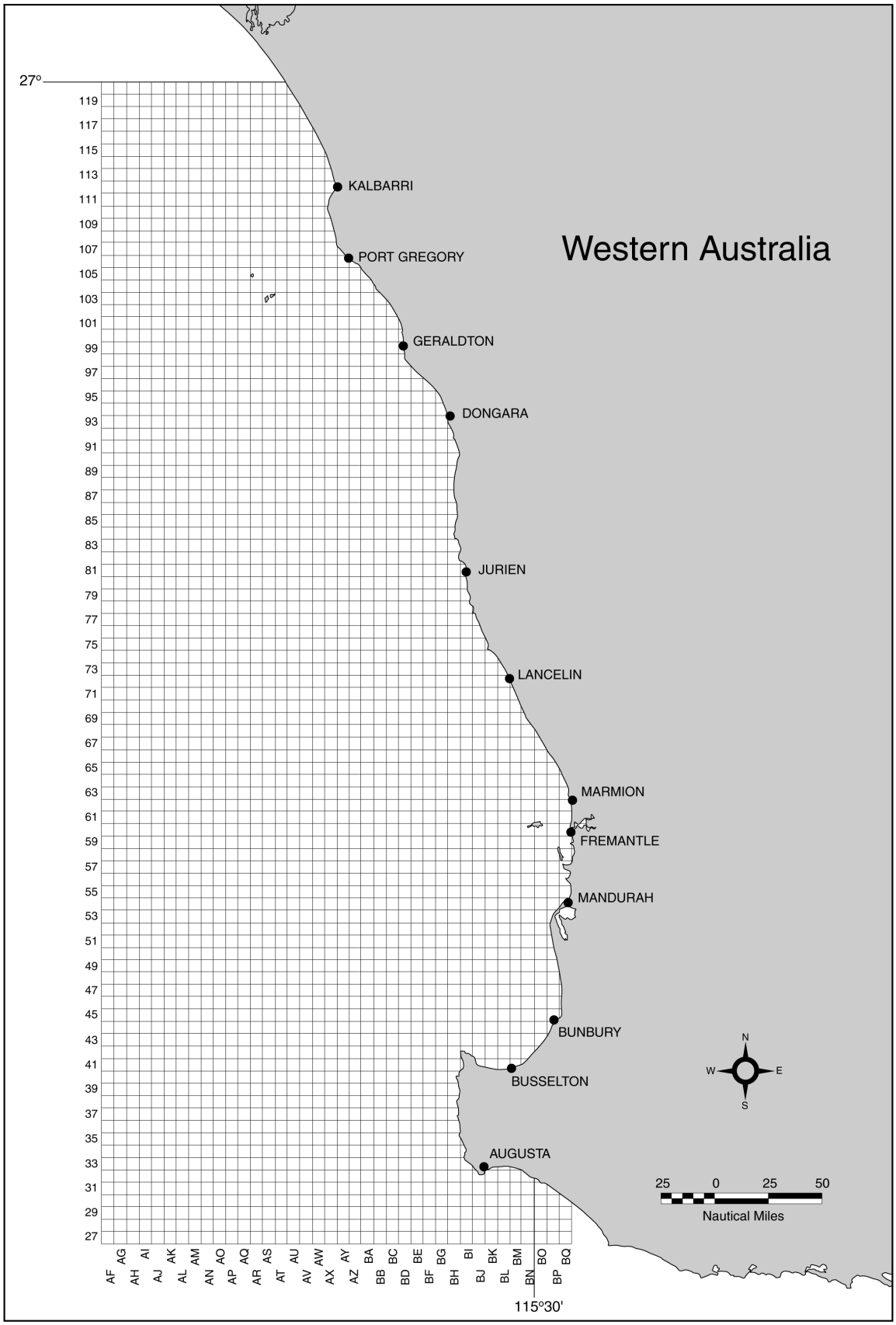
Correct	Incorrect	Don't Know

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 - Map showing recreational catch and effort blocks



APPENDIX D - Catch and effort calculations for trailered boats

Estimation of Total Effort

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

$$e = f_1 f_2 f_3 T \sum_i \left[\left| \frac{1}{w_i} \right| \sum_j X_{ij} \right| \qquad (1)$$

where T 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. For each district and season a correction factor $0 \le f_1 \le 1$, the proportion of boats fishing, was used to adjust the trailer counts to allow for boats not fishing. A correction factor $0 \le f_2 \le 1$, the proportion of boats fishing in the ocean, was used for each district and season to remove effort attributed to boats fishing in estuaries. Another correction factor $f_3 \ge 1$ was used to adjust the fishing effort for each season to allow for fishing activity that occurred before the shift commenced at 8:00 am.

$$f_3 = \frac{\sum_j (r_j - l_j)}{\sum_j b_j} \qquad (2)$$

where $$b_j = \begin{cases} r_j - 8, & l_j < 8 \\ r_j - l_j, & l_j \ge 8 \end{cases}$$

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 3.2). The estimated variance within stratum 1 is (Pollock *et al*. 1994)

$$s_1^2 = \frac{1}{n_1 - 1} \sum_{k=1}^{n_1} \left(e_{1k} - \bar{e}_1 \right)^2 \qquad (3)$$

where n_1 is the sample size (days) for stratum 1, e_{1k} the effort for stratum 1 on day k and $\bar{e}_1$ the mean daily fishing effort for stratum 1. The variance associated with the estimate of the mean, with finite population correction (Neter *et al*. 1988), is calculated as

$$Var(\bar{e}_1) = \frac{s_1^2}{n_1} \left| \frac{N_1 - n_1}{N_1} \right| \qquad (4)$$

where N_1 is the total number of days in stratum 1. The total effort for stratum 1 is estimated as

$$\hat{E}_1 = \frac{N_1}{n_1} \sum_{k=1}^{n_1} e_{1k} \qquad (5)$$

APPENDIX D - Catch and effort calculations for trailered boats (continued)

The variance associated with $\hat{E}_1$ is estimated by

$$Var(\hat{E}_1) = N_1^2 \, Var(\bar{e}_1) \qquad (6)$$

and the standard error is calculated by the usual method

$$SE(\hat{E}_1) = \sqrt{Var(\hat{E}_1)} \qquad (7)$$

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

$$\hat{E} = \sum_{i=1}^{n} \hat{E}_i \qquad (8)$$

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

$$Var(\hat{E}) = \sum_{i=1}^{n} Var(\hat{E}_i) \qquad (9)$$

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

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

Estimation of Total Catch

The catch rate for each stratum 1 is estimated by (Crone and Malvestuto 1991)

$$\hat{R}_1 = \frac{\bar{c}_1}{\bar{L}_1} = \frac{\sum_{i=1}^{n_1} c_i / n_1}{\sum_{i=1}^{n_1} L_i / n_1} \qquad (11)$$

where n_1 is the number of boats where the catch was recorded, c_i the catch for boat *i* and L_i the effort, in hours, for boat *i*. The variances for $\bar{c}_1$ and $\bar{L}_1$ can be calculated by the usual method (see (3) and (4) without the finite population correction factor). The variance for $\hat{R}_1$ can be estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{R}_1) \approx \hat{R}_1^2 \left| \frac{Var(\bar{c}_1)}{\bar{c}_1^2} + \frac{Var(\bar{L}_1)}{\bar{L}_1^2} - \frac{2Cov(\bar{c}_1, \bar{L}_1)}{\bar{c}_1 \bar{L}_1} \right| \qquad (12)$$

Equivalently the following may be used (Cochran 1977)

$$Var(\hat{R}_1) \approx \frac{1}{n_1 \bar{L}_1^2} \frac{\sum_{i=1}^{n_1} \left(c_i - \hat{R}_1 L_i \right)^2}{n_1 - 1} \qquad (13)$$

APPENDIX D - Catch and effort calculations for trailered boats (continued)

or for easier programming on a computer (13) can be expressed as

$$Var(\hat{R}_1) \approx \frac{1}{n_1 \bar{L}_1^2} \frac{\sum_{i=1}^{n_1} c_i^2 - 2\hat{R}_1 \sum_{i=1}^{n_1} c_i L_i + \hat{R}_1^2 \sum_{i=1}^{n_1} L_i^2}{n_1 - 1} \qquad (14)$$

The total catch for stratum 1 is estimated as

$$\hat{C}_1 = \hat{E}_1 \hat{R}_1 \qquad (15)$$

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

$$Var(\hat{C}_1) \approx \hat{C}_1^2 \left| \frac{Var(\hat{E}_1)}{\hat{E}_1^2} + \frac{Var(\hat{R}_1)}{\hat{R}_1^2} + \frac{2Cov(\hat{E}_1, \hat{R}_1)}{\hat{E}_1 \hat{R}_1} \right| \qquad (16)$$

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

$$\hat{C} = \sum_{i=1}^{n} \hat{C}_i \qquad (17)$$

and the variance of $\hat{C}$ is estimated as

$$Var(\hat{C}) = \sum_{i=1}^{n} Var(\hat{C}_i) \qquad (18)$$

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

$$SE(\hat{C}) = \sqrt{Var(\hat{C})} \qquad (19)$$

APPENDIX E - Catch and effort calculations for non-trailered boats

Estimation of Total Effort

The fishing effort for a day (hours) was estimated by the traditional access point method (Malvestuto 1983) as follows:

$$e = T \left| \frac{1}{2w_i} \right|_i \left| x_{ij} \right|_j \quad (1)$$

where T is the number hours of fishing time in the day, w_i is the interviewer wait time at site i, x_{ij} is the time boat j at site i spent fishing. The effort is divided by two since boats both entering and leaving the river were interviewed. The fishing effort was estimated for a random sample of days in each stratum (see Section 3.2). The estimated variance within stratum 1 is (Pollock *et al*. 1994)

$$s_1^2 = \frac{1}{n_1 - 1} \sum_{k=1}^{n_1} \left(e_{1k} - \bar{e}_1 \right)^2 \quad (2)$$

where n_1 is the sample size (days) for stratum 1, e_{1k} the effort for stratum 1 on day k and $\bar{e}_1$ the mean daily fishing effort for stratum 1. The variance associated with the estimate of the mean, with finite population correction (Neter *et al*. 1988), is calculated as

$$Var(\bar{e}_1) = \frac{s_1^2}{n_1} \left| \frac{N_1 - n_1}{N_1} \right| \quad (3)$$

where N_1 is the total number of days in stratum 1. The total effort for stratum 1 is estimated as

$$\hat{E}_1 = \frac{N_1}{n_1} \sum_{k=1}^{n_1} e_{1k} \quad (4)$$

The variance associated with $\hat{E}_1$ is estimated by

$$Var(\hat{E}_1) = N_1^2 \, Var(\bar{e}_1) \quad (5)$$

and the standard error is calculated by the usual method

$$SE(\hat{E}_1) = \sqrt{Var(\hat{E}_1)} \quad (6)$$

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

$$\hat{E} = \sum_{i=1}^{n} \hat{E}_i \quad (7)$$

APPENDIX E - Catch and effort calculations for non-trailered boats (continued)

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

$$Var(\hat{E}) = \sum_{i=1}^{n} Var(\hat{E}_i) \qquad (8)$$

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

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

Estimation of Total Catch

The catch rate for each stratum 1 is estimated by (Crone and Malvestuto 1991)

$$\hat{R}_1 = \frac{\bar{c}_1}{\bar{L}_1} = \frac{\sum_{i=1}^{n_1} c_i / n_1}{\sum_{i=1}^{n_1} L_i / n_1} \qquad (10)$$

where n_1 is the number of boats where the catch was recorded, c_i the catch for boat i and L_i the effort, in hours, for boat i. The variances for $\bar{c}_1$ and $\bar{L}_1$ can be calculated by the usual method (see (2) and (3) without the finite population correction factor). The variance for $\hat{R}_1$ can be estimated using the formulae described in Kendall and Stuart (1969)

$$Var(\hat{R}_1) \approx \hat{R}_1^2 \left| \frac{Var(\bar{c}_1)}{\bar{c}_1^2} + \frac{Var(\bar{L}_1)}{\bar{L}_1^2} - \frac{2Cov(\bar{c}_1, \bar{L}_1)}{\bar{c}_1 \bar{L}_1} \right| \qquad (11)$$

Equivalently the following may be used (Cochran 1977)

$$\hat{Var}(\hat{R}_1) \approx \frac{1}{n_1 \bar{L}_1^2} \frac{\sum_{i=1}^{n_1} \left(c_i - \hat{R}_1 L_i\right)^2}{n_1 - 1} \qquad (12)$$

or for easier programming on a computer (12) can be expressed as

$$Var(\hat{R}_1) \approx \frac{1}{n_1 \bar{L}_1^2} \frac{\sum_{i=1}^{n_1} c_i^2 - 2\hat{R}_1 \sum_{i=1}^{n_1} c_i L_i + \hat{R}_1^2 \sum_{i=1}^{n_1} L_i^2}{n_1 - 1} \qquad (13)$$

The total catch for stratum 1 is estimated as

$$\hat{C}_1 = \hat{E}_1 \hat{R}_1 \qquad (14)$$

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

$$Var(\hat{C}_1) \approx \hat{C}_1^2 \left| \frac{Var(\hat{E}_1)}{\hat{E}_1^2} + \frac{Var(\hat{R}_1)}{\hat{R}_1^2} + \frac{2Cov(\hat{E}_1, \hat{R}_1)}{\hat{E}_1 \hat{R}_1} \right| \qquad (15)$$

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

$$\hat{C} = \sum_{i=1}^{n} \hat{C}_i \qquad (16)$$

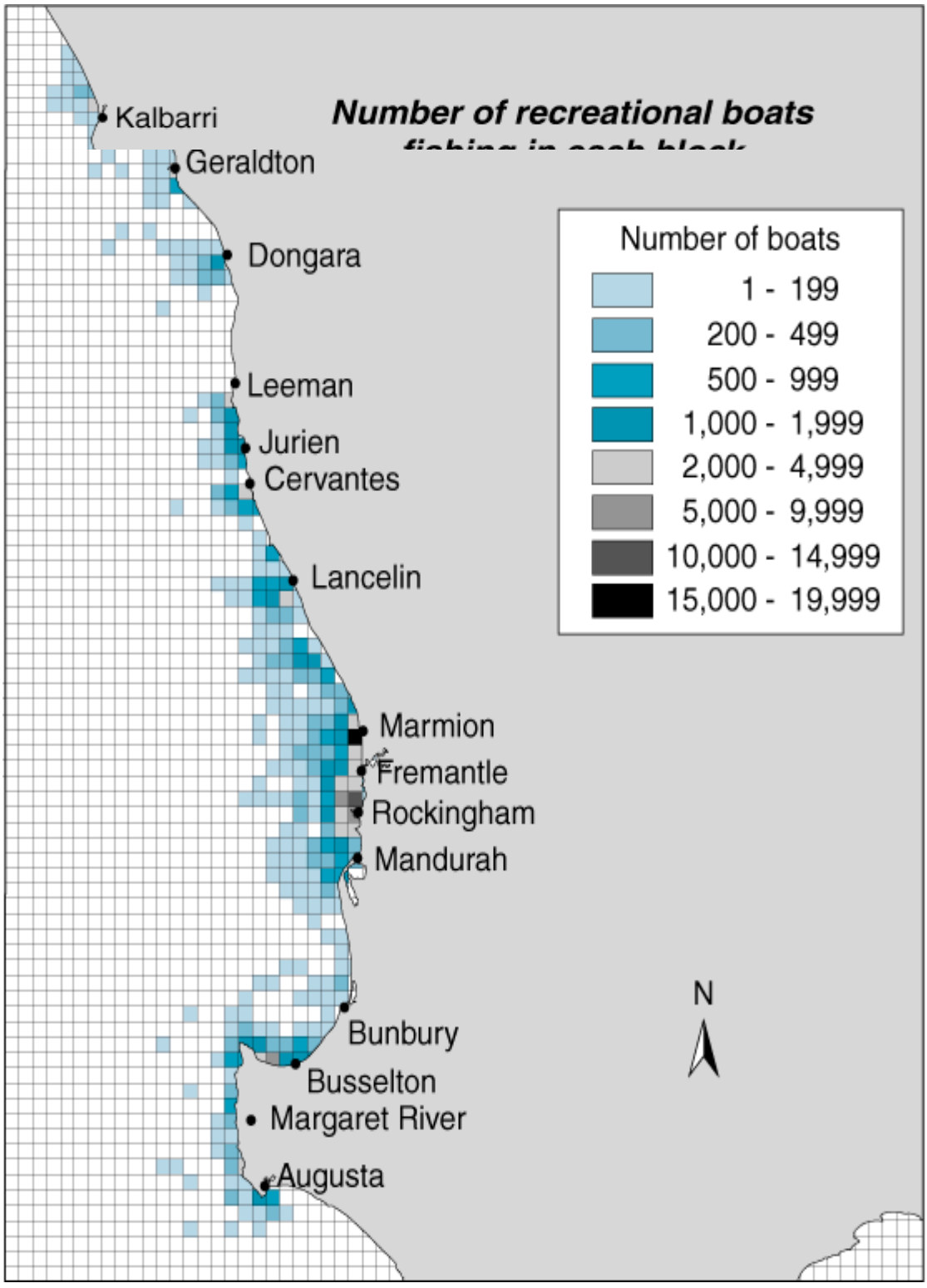
and the variance of $\hat{C}$ is estimated as

$$Var(\hat{C}) = \sum_{i=1}^{n} Var(\hat{C}_i) \qquad (17)$$

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

$$SE(\hat{C}) = \sqrt{Var(\hat{C})} \qquad (18)$$

APPENDIX F - Spatial distribution of fishing effort



APPENDIX G - Recreational catch for all species - trailered boats

Common name	Scientific name	No. kept	SE kept	No. released
Whiting, other		548,741	35,263	110,165
Australian herring	*Arripis georgianus*	416,657	26,621	18,102
Trevally, skipjack	*Pseudocaranx dentex*	120,439	15,665	28,380
Whiting, King George	*Sillaginodes punctata*	93,982	9,168	17,754
Squid, general		87,149	8,593	1,411
Garfish, southern sea	*Hyporhamphus melanochir*	77,868	8,961	4,294
Wrasse/groper, general		65,252	5,219	79,811
Western Australian dhufish	*Glaucosoma hebraicum*	28,967	1,928	13,991
Snook, general	*Sphyraena novaehollandiae*	28,067	7,595	4,415
Tailor	*Pomatomus saltatrix*	26,627	3,962	3,798
Mackerel, blue	*Scomber australasicus*	26,441	3,909	6,015
Mussels	*Mytilus edulis*	19,448	19,535	0
Snapper, pink	*Pagrus auratus*	18,077	1,653	9,303
Cod, breaksea (black-arse cod)	*Epinephelides armatus*	15,883	1,264	1,982
Cod, other		13,035	2,721	7,405
Butterfish, western	*Pentapodus vitta*	10,567	2,468	2,496
Trumpeter, general		10,229	2,388	13,207
Groper, baldchin	*Choerodon rubescens*	8,466	1,169	660
Abalone, roe's	*Haliotis roei*	8,428	3,217	252
Yellowtail scad	*Trachurus novaezelandiae*	8,307	2,546	3,302
Flathead, general	Platycephalidae	8,187	1,150	40,708
Snapper, queen (blue morwong)	*Nemadactylus valenciennesi*	7,386	1,100	0
Abalone, green lip	*Haliotis laevigato*	6,712	2,318	0
Sweep, sea	*Scorpis aequipinnis*	6,534	1,278	668
Bream, silver (tarwhine)	*Rhabdosargus sarba*	6,083	1,219	6,111
Sweep, banded	*Scorpis geogianus*	5,913	1,929	141
Samsonfish	*Seriolahippos*	5,687	629	2,934
Mullet, general		5,290	2,522	1,537
Leatherjacket, general		3,691	676	3,158
Australian salmon	*Arripis truttaceus*	3,241	991	1,281
Shark, general		2,741	373	2,888
Goatfish, general		2,685	730	1,491
Flounder, general		2,553	476	459
Octopus	*Octopus* spp	2,413	708	94
Sergeant Baker	*Aulopus purpurissatus*	2,138	404	1,016
Trout, coral	*Plectropus leopardus*	2,114	526	464
Mackerel, narrow barred spanish	*Scomberomorus commerson*	2,025	508	154
Cuttlefish	*Sepia* spp	1,786	529	150
Foxfish, western	*Bodianus frenchii*	1,780	431	17
Harlequin fish	*Othos dentex*	1,666	307	296
Snapper, red	*Centroberyx gerradi*	1,293	262	184
Sweetlip, general		1,237	257	103
Gurnard, general		1,070	275	3,086
Garfish, robust	*Hemiramphus robustus*	1,011	676	85
Toadfish, other		1,000	456	19,333
Wobbegong/catshark, general	*Orectolobus* spp	1,000	241	590

APPENDIX G - Recreational catch for all species - trailered boats (continued)

Common name	Scientific name	No. kept	SE kept	No. released
Amberjack	*Seriola domerili*	811	523	130
Yellowtail kingfish	*Seriola lalandi*	804	363	153
Cod, chinaman	*Epinephelus rivulatus*	749	271	200
Morwong, general		732	218	0
Parrotfish, general		724	311	395
Emperor, sweetlip (red throat)	*Lethrinus miniatus*	641	199	0
Bonito, general	Scombridae	570	212	261
Groper, western blue	*Achoerodus gouldic*	557	180	0
Toadfish, silver	*Lagocephalus scleratus*	555	358	6,338
Mackerel, scaly	*Sardinella lemuru*	516	290	119
Wirrah, western	*Acanthistius serratus*	416	139	105
Blue devil (western)	*Paraplesiops meleagris*	348	112	63
Bream, black	*Acanthopagrus butcheri*	347	184	531
Mackerel, Australian spotted	*Scomberomorus munroi*	326	109	0
Sea perch, general		317	191	148
Tuna, yellowfin	*Thunnus albacares*	310	127	124
Dolphinfish, common	*Coryphaena hippurus Linaeus*	308	165	0
Scorpioncod, western red	*Scorpaena sumptuosa*	304	133	266

* The standard error (SE) associated with the estimate of the number of fish kept was calculated for each species. The 95% confidence interval is the number of fish kept ±1.96×SE (see Section 4.4).

APPENDIX H - Recreational catch for all species - non-trailered boats

Common name	Scientific name	No. kept	SE kept*	No. released
Whiting, other		15,647	1,308	2,432
Australian herring	*Arripis georgianus*	8,243	800	501
Trevally, skipjack	*Pseudocaranx dentex*	2,217	242	54
Garfish, southern sea	*Hyporhamphus melanochir*	1,323	237	215
Cod, other		644	113	447
Whiting, King George	*Sillaginodes punctata*	447	56	18
Squid, general		393	53	18
Wrasse/groper, general		393	71	215
Western Australian dhufish	*Glaucosoma hebraicum*	304	49	161

* The standard error (SE) associated with the estimate of the number of fish kept was calculated for each species. The 95% confidence interval is the number of fish kept ±1.96×SE (see Section 4.4).

APPENDIX I - Bag and size limits at time of survey

Common name	Scientific name	Bag limit	Size limit (mm) [1]
PRIZE FISH (4 of each species, total mixed bag of 8)			
Billfish	*Xiphiidae* and *Istiophoridae* spp	mixed bag of 4	
Cobia	*Rachycentron canadus*	4	
Cods	*Serranidae* family	mixed bag of 4	1200 (max. size)
Coral trout	*Plectropomus* spp	4	450
Dhufish, WA	*Glaucosoma hebraicum*	4	500
Mackerel, wahoo	*Acanthocybium solandri*	4	750
Mackerel, spanish	*Scomberomorus* spp	4	750
Mackerel, shark	*Grammatorcynus bicarinatus*	4	500
Mackerel, spotted & old school	*Scomberomorus* spp	4	500
Mahi mahi (dolphin fish)	*Coryphaena hippurus*	4	
Mulloway Northern mulloway	*Argyrosomus hololepidotus* *Protonibea diacanthus*	combined bag of 4	450
Queenfish	*Scomberoides commersonnianus*	4	
Salmon, Australian	*Arripis truttaceus*	4	300
Samson fish	*Seriola hippos*	4	600
Sharks	all species except whale shark	mixed bag of 4	
Trout, brown & rainbow combined	*Salmo trutta* and *Oncorhynchus mykiss*	4 (1 May to 31 August closed season most areas)	300
Tuna, southern bluefin & yellowfin	*Thunnus maccoyii* and *Thunnus albacares*	4	
Yellowtail kingfish	*Seriola lalandi*	4	
REEF FISH (mixed bag of 8)			
Emperor, red	*Lutjanus sebae*	8	410
Groper & tuskfish	*Choerodon* spp	8	400
Snapper, pink	*Pagrus auratus*	8 - special rules apply in Shark Bay and Perth metro[2] area	410
Spangled emperor	*Lethrinus nebulosus*	8	410
Snapper, north-west	*Lethrinus* spp (limits apply to all other *lethrinus* spp)	8	280
Snapper, queen	*Nemadactylus valenciennesi*	8	410

[1] Size limits refer to minimum sizes unless stated otherwise.
[2] Between Halls Head and Two Rocks a maximum of two (2) pink snapper over 70 cm per person and a boat limit of four (4) pink snapper over 70 cm applied between 1 September and 31 December.

APPENDIX I - Bag and size limits at time of survey (continued)

Common name	Scientific name	Bag limit	Size limit (mm) [1]
KEY ANGLING & SPORT FISH			
Bonito	*Sarda orientalis*	8	
Cobbler	*Cnidoglanis macrocephalus*	8	430
Tailor	*Pomatomus saltatrix*	8	250
Mangrove Jack	*Lutjanus argentimaculatus*	8	
Fingermark bream	*Lutjanus russelli*	8	
Giant threadfin salmon	*Eleutheronema tetradactylum*	8	
TABLE FISH			
Bream, black, Northwest black and yellowfin	*Acanthopagrus butcheri*, *A. palmaris* and *A. latus*	20	250
Flathead & flounder	*Platycephalus* spp and *Pseudorhombus* spp	20 (combined)	250
Leatherjackets	*Monacanthidae* family	20	250
Pike and snook	*Dinolestes lewini* and *Sphyraena novaehollandiae*	20 (combined)	330
Skipjack trevally	*Pseudocaranx* spp	20	200
Snapper, red	*Centroberyx* spp	20	230
Tarwhine	*Rhabdosargus sarba*	20	230
Threadfin, northern, Gunther's and black-finned salmon	*Polydactylus* spp	20	
Whiting, King George	*Sillaginodes punctata*	20	250; 280 (sth coast east of Pt D'Entrecasteaux)
BREAD AND BUTTER FISH			
Garfish	*Hyporhamphus* spp	40	
Herring, Australian	*Arripis georgianus*	40	
Mackerel, blue	*Scomber australasicus*	40	
Mullet, sea & yelloweye	*Mugil cephalus* and *Aldrichetta forsteri*	40	
Whiting, western sand, school and yellowfin	*Sillago* spp	40	
SPECIAL BAG LIMITS			
Barramundi	*Lates calcarifer*	possession limit 5	550
Groper, western blue	*Achoerodus gouldii*	daily bag limit 1	400
SHELLFISH (total mixed bag of 2 litres)			
Abalone, greenlip and brownlip	*Haliotis laevigata* and *Haliotis conicopora*	bag & possession limit 10; boat limit 30 (combined)	140
Abalone, roe's	*Haliotis roei*	bag & possession limit 20	60
Mussels	*Mytilus* spp	bag limit 9 litres	

[1] Size limits refer to minimum sizes unless stated otherwise.

APPENDIX I - Bag and size limits at time of survey (continued)

Common name	Scientific name	Bag limit	Size limit (mm) [1]
CEPHALOPODS			
Squid, octopus, cuttlefish		combined bag limit 15 per fisher; boat limit 30	
CRUSTACEA			
Crab, mud	*Scylla serrata*	bag limit 10 combined	green [150]; brown [120]
Crab, blue swimmer	*Portunus pelagicus*	bag limit 24; boat limit 48 [min. 2 people]	Carapace 127
Cherabin		bag limit 9 litres	
Marron	*Cherax tenuimanus*	bag limit 10	carapace 76
Prawns, king and school	*Penaeus latisulcatus* and *Metapenaeus dalli*	bag limit 9 litres	closed season Swan River & Mandurah
Rock lobster, southern, western and tropical	*Jasus edwardsii*, *Panulirus cygnus* and *Panurilis* spp	combined bag limit 8; boat limit 16	98.5; 77 [15 Nov-31 Jan]; 76 [1 Feb-30 June]
PROTECTED SPECIES (these species are totally protected and may not be taken)			
Potato cod	*Epinephelus tukula*		
Leafy seadragon	*Phycodurud eques*		
Whale shark	*Rhiniodon typus*		
Great white shark	*Caracharodon carcharias*		
Hump head maori wrasse	*Cheilinus undulatus*		

[1] Size limits refer to minimum sizes unless stated otherwise.