FISHERIES RESEARCH REPORT NO. 120, 2000

A 12-month survey of recreational fishing in the Leschenault Estuary of Western Australia during 1998

B.E. Malseed, N.R. Sumner and P.C. Williamson

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Published by
Fisheries Western Australia
Perth, Western Australia
May 2000
ISSN: 1035 - 4549
ISBN: 0 7309 8437 0

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Abstract

A survey of recreational boat-based and shore-based fishing in the Leschenault Estuary was conducted between January 1998 and December 1998. The survey estimated the total annual boat-based recreational fishing effort as 33,392 fisher days, with 86% of this effort targeting blue swimmer crabs. The total annual shore-based recreational fishing effort was estimated to be 5,610 fisher days, with 88% of this effort targeting blue swimmer crabs.

The recreational blue swimmer crab catch from the Leschenault Estuary is substantial and exceeds the reported commercial catch. The estimated total recreational catch of blue swimmer crabs was 219,000 crabs or 45.7 tonnes. This consists of a boat-based catch of 179,000 crabs and a shore-based catch of 40,000 crabs. Approximately 80% of crabs kept by recreational fishers were male.

The total annual recreational catch of fish from the Leschenault Estuary is small. The estimated numbers of the most common fish species caught by anglers are (in order of number caught) 1,500 whiting other than King George (*Sillago* spp.), 1,200 (0.24 tonnes) tailor, 800 (0.11 tonnes) Australian herring and 500 (0.06 tonnes) King George whiting.

There was a very high level of compliance with fishing regulations amongst all anglers and most boat-based crabbers. However, 6.5% of shore-based crabbing parties were found to have kept undersize crabs. These were usually close to legal size.

Very few boats with two or more people on board (2.4%) achieved the daily boat limit of 48 crabs specified under present statewide recreational fishing regulations. However, a larger proportion of boats with only one person on board (29.7%) achieved their daily bag limit of 24 crabs. No anglers were recorded as catching the daily bag limit of any fish species.

Executive Summary

- The main species caught by recreational fishers in the Leschenault Estuary during 1998 were (in order of number kept) blue swimmer crabs (98%), whiting species other than King George, tailor, Australian herring, King George whiting and common blowfish.
- The recreational catch for blue swimmer crabs is substantial. The estimated recreational catch for 1998 at approximately 46 tonnes is more than ten times the annual commercial catch level over the past five years.
- The survey indicated that very few boats with two or more people on board (2.4%) achieved the daily boat limit of 48 crabs specified under current statewide recreational fishing regulations. However, a larger proportion of boats with only one person on board (29.7%) achieved their daily bag limit of 24 crabs.
- The size limits are an effective catch control measure with substantial numbers of undersize blue swimmer crabs caught subsequently being released.

- The summer months are the most popular time for both recreational crabbing and angling in the Leschenault Estuary.
- There was generally a very high level of compliance with fishing regulations amongst all anglers and boat-based crabbers. However, 6.5% of shore-based crabbing parties were found to have kept undersize crabs. Very few fishers exceeded the bag limits.
- Further monitoring of the recreational catch and effort in the Leschenault Estuary 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.

1.0 Introduction

The Leschenault Estuary, located immediately north of the city of Bunbury approximately 200 km south of Perth, is one of the most popular estuaries for recreational fishing in the south-west of Western Australia. Blue swimmer crabs (*Portunus pelagicus*) are the most common species targeted by recreational fishers in the estuary which, together with the Peel-Harvey Estuary in Mandurah, provides much of the state's focus for recreational crabbing. Boat-based fishers use drop nets while shore-based "waders" use wire scoop nets to catch crabs.

A survey by the Australian Bureau of Statistics (ABS) in July 1987 estimated that of the 284,100 persons who had participated in recreational fishing in Western Australia during the previous 12 months, 77,300 had been crabbing (Anon., 1989). A more recent survey (Anon., 1997) estimated that 636,000 persons participate in recreational fishing at least once per year.

With such high participation rates in recreational fishing and limited resources available for exploitation, it is important to know the recreational catch and fishing effort for areas of high usage such as the Leschenault Estuary. This information can be used to develop resource-sharing strategies to ensure the sustainability of fishing activities and the conservation of fish stocks and fish habitats within the estuary.

Commercial catch data and anecdotal evidence from recreational fishers suggest that fish numbers within the Leschenault Estuary are declining, while little is known about the recreational blue swimmer crab catch. This survey was undertaken to estimate the recreational catch of fish and crabs and fishing effort for the Leschenault Estuary during 1998.

The estuary, which is about 13.5 km long and between 1.5 and 2.5 km wide, contains four major public boat ramps and two popular small dinghy access channels (Figure 1). Creel surveys have been conducted in the region in previous years, however, they focused on ocean-based fishing and did not specifically take account of estuary fishing (Ayvazian *et al*., 1997; Sumner and Williamson, 1999).

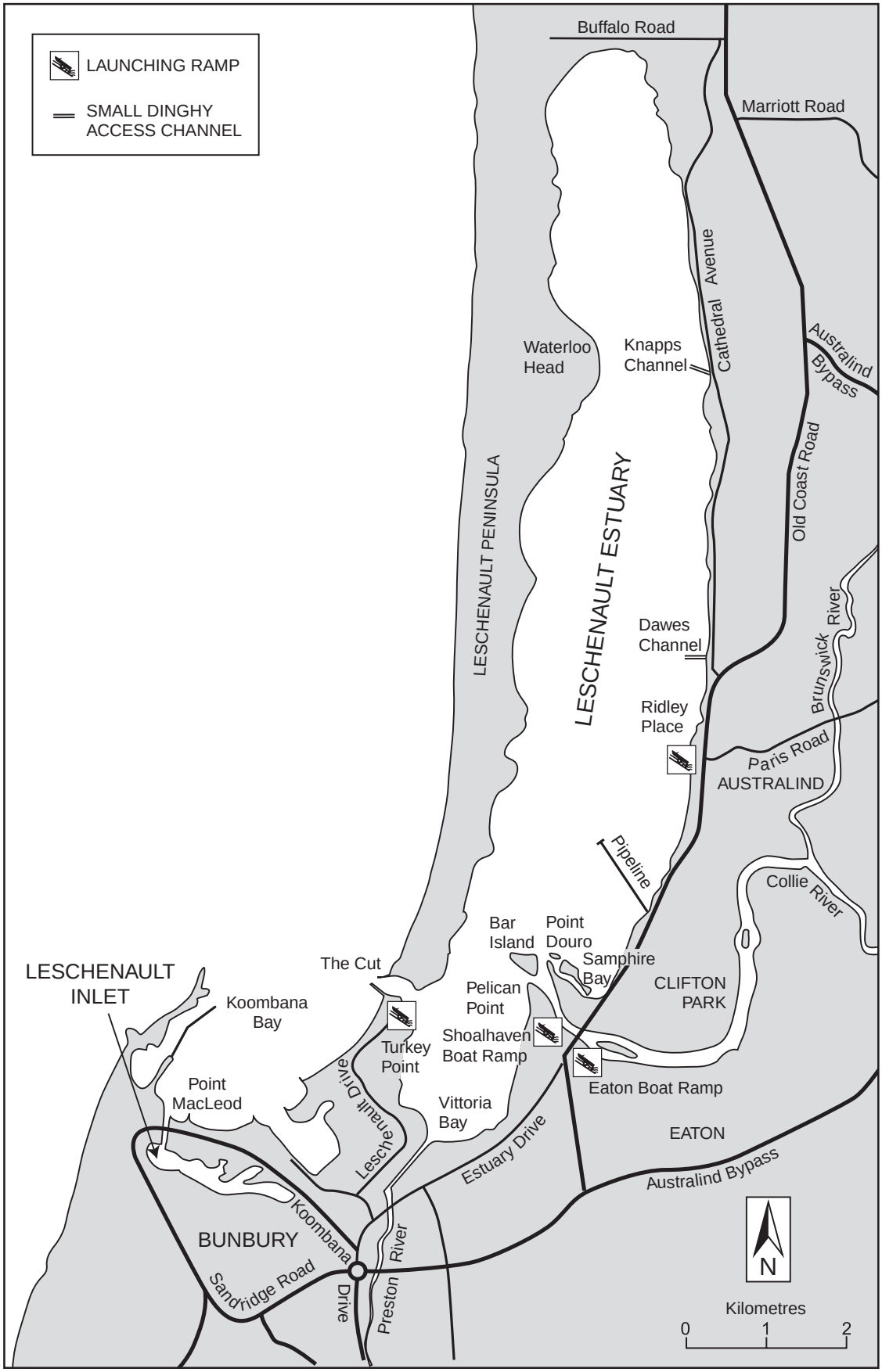

Figure 1 The Leschenault Estuary (adapted from Water and Rivers Commission).

2.0 Methods

2.1 Survey design

Catch and fishing effort information for recreational boat-based and shore-based fishing in the Leschenault Estuary was required. It was important that the data collected were comparable with catch and effort data collected for commercial fisheries.

The bus route method (Robson and Jones, 1989; Jones *et al*., 1990) was used to estimate the total catch and fishing effort for persons angling or crabbing from recreational trailer boats launched at boat ramps. A roving creel survey was used to estimate the catch and effort from shore-based anglers and crabbers wading through shallow water with scoop nets or using drop nets from the shore.

2.2 Spatial and temporal stratification

The survey spanned a 12-month period, commencing in January 1998 and concluding at the end of December 1998. Additional information on shore-based crabbing catch rates was collected during January and February 1999.

The survey was stratified by season (spring, summer, autumn or winter), time of day (morning or afternoon) and weekdays or weekends (including public holidays). Separate total catch estimates were made for each of these 16 strata (4 seasons $\times$ 2 for mornings and afternoons $\times$ 2 for weekends and weekdays). The boat fishing effort estimates were further stratified by ramp, creating 80 strata (5 ramps). This ensured that corrections could be made to account for the varying proportion of boats at each ramp which were crabbing or angling within the estuary, fishing outside the estuary or not fishing at all. These estimates were then combined to obtain the total recreational catch and effort for the estuary during 1998.

Periods of low fishing activity, such as during the night, could not be covered with the available resources. Prior information suggested that, although night fishing occurred at certain times of 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. Almost all recreational boats return to the boat ramps before dusk when the interviewer finished work at the ramp.

The two interviewers worked one shift (morning or afternoon) on each of their scheduled survey days. We chose to divide the day into two shifts so that the interviewer would not have to work longer than six hours. From January to March and November through December, shifts were six hours, either 7.00 am to 1.00 pm or 1.00 pm to 7.00 pm. This was reduced to 5.5 hours, 7.00 am to 12.30 pm or 12.30 pm to 6.00 pm, during April, May, September and October; and then further reduced to 4.5 hours, 8.00 am to 12.30 pm or 12.30 pm to 5.00 pm, during the winter months of June, July and August.

2.3 Sampling design

Boat-based fishing - bus route method

A creel survey was used to estimate the recreational boat-based catch for all species. The bus route method, where a survey interviewer visits all boat ramps in a district on the one day, was used for boat-based fishing.

A bus route was set up to cover the entire Leschenault Estuary in one shift. The number of shifts surveyed per month depended upon the season. More shifts were allocated to the

seasons where most effort occurred, based on prior information on recreational fishing patterns. An equal proportion of shifts were allocated to mornings and afternoons and weekdays and weekends (including public holidays). The number of survey shifts allocated per month varied from 8 to 20, which is effectively 4 to 10 full days (Table 1.)

Table 1 Allocation of survey shifts.

Month	Number of shifts	Number of days
January	20	10
February	16	8
March	16	8
April	16	8
May	12	6
June	8	4
July	8	4
August	8	4
September	12	6
October	12	6
November	16	8
December	20	10

The bus route schedules were constructed as described by Pollock *et al*. (1994). The start, travel and wait time at boat ramps were rounded to the nearest minute. A Mathcad (Mathsoft 1995) worksheet was developed by the authors to generate the randomised schedules.

The survey interviewer followed a pre-determined schedule specifying the boat ramps to visit and the sampling time for each boat ramp. The starting location and direction of travel was chosen randomly. The bus route commenced either between ramps or at a ramp. The bus route method was constrained so that a shift could not commence partway through the wait time at a ramp, although the probability of commencing at a ramp or during a travel sector remained unchanged. On average, each site was likely to be visited over all daylight hours by the end of the 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 about ramp usage. This was reviewed after two months as data from the survey became available (Table 2). Then the wait time was adjusted to be proportional to the recreational fishing effort at each ramp. The route was chosen to minimise the distance travelled between boat ramps.

Table 2 Allocation of time to survey ramps.

Ramp	Type	Proportion of time
Knapps Channel	Small dinghy access channel	0.05
Dawes Channel	Small dinghy access channel	0.10
Ridley Place	Boat launching	0.40
Eaton/Shoalhaven*	Boat launching	0.30
The Cut	Boat launching	0.15

* Since the Eaton and Shoalhaven ramps were in close proximity and an interviewer could survey both at the same time they were combined.

There are four boat launching ramps within the Leschenault Estuary (Table 2). The Eaton and Shoalhaven ramps are located within close proximity of each other, on either side of the Collie River Bridge (Figure 1). For the purposes of the survey we therefore treated these two ramps as one ramp, referred to as Collie Bridge.

Prior information gained from Fisheries Officers in the region enabled the two locations where boats were commonly launched via small dinghy access channels to be included in the survey (Figure 1; Table 2).

Within each season, a random sample of survey days was chosen. When it was not possible for recreational anglers to fish due to severe weather conditions the survey was not conducted and it was assumed that there was zero catch and effort for the shift. 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 when recreational fishing was not possible due to severe weather was representative of the season.

Catch, effort, biological and demographic information was collected from boat-based fishers when they returned to the boat ramp. One form was used to record the environmental conditions, 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. The second form was used to record the time spent fishing, catch and other information from individual boats (Appendix B). For boat-based fishers 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 identified, counted, measured and, where possible, recorded by sex. For crabs the carapace width (CW) was measured to the nearest millimetre while the total length in millimetres was recorded for fish.

Field staff were instructed, where possible, to measure all fish or crabs that were seen during interviews. 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 crabs or fish of each species was measured. A random sample, rather than all of the catch, was also measured when fishers were in a hurry to leave the ramp.

Shore-based fishing - roving creel survey

A roving creel survey was used for the survey of shore-based fishers. These included anglers and crabbers wading through shallow water with scoop nets or using drop nets from the shore.

Effort information for shore-based fishers was collected during the bus route surveys. Progressive counts of shore-based fishers were made while the interviewer drove from one boat ramp to the next according to a randomised time schedule. The boat ramps were used as checkpoints along the route. Separate interviews of shore-based fishers were conducted; the interview questionnaire used for boat fishers (Appendix B) was also used to record time spent fishing, catch and other information for shore-based fishers.

The schedule allowed time for a small number of interviews between checkpoints. This enabled shore-based anglers to be interviewed when encountered. However, this method was not suitable for crabbers wading through the shallows in search of crabs. The crabbers were often 100 metres or more from the shore and the interviewer was not able to reach them within

the time allowed. For this reason a small dingy complete with outboard motor was used to interview crabbers wading with scoop nets to collect information on the time spent fishing and catch. Most interviews were obtained in this manner.

2.4 Estimation of total catch and effort for boat-based fishers

The fishing effort for a day was estimated from the 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 anglers and crabbers 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. Catch and effort calculations were performed for estuarine boat-based crabbing and angling as shown in Appendix C.

The unit of effort (number of trailers counted at the boat ramps) for each 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 in the estuary.

Fishing effort by boats that were launched before the start of a morning shift (7.00 am, or 8.00 am in winter) and returned after the start of a 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 C).

The whole weight of the catch, in kilograms, was estimated from length-to-weight relationships for each species. The total weight of blue swimmer crabs kept was calculated using the following carapace width (CW) (mm) to body weight (W) (g) relationships developed by Potter *et al.* (1983).

$$\text{males } \log_{10} W = \log_{10} 2.56\times10^{-5} + 3.260 \log_{10} CW$$

$$\text{females } \log_{10} W = \log_{10} 5.97\times10^{-5} + 3.056 \log_{10} CW$$

The total weight for tailor, Australian herring and King George whiting kept was calculated separately using the following total length (L) (mm) to weight (W) (g) relationships.

Tailor (*Pomatomus saltatrix*)	$W = 5.15\times10^{-5} L^{2.714}$	(Steckis, unpubl. data)
Australian Herring (*Arripis georgianus*)	$W = 1.022\times10^{-5} L^{3.015}$	(Fairclough, 1988)
King George Whiting (*Sillaginodes punctata*)	$W = 1.99\times10^{-6} L^{3.19}$	(McGlennon and Kinloch, 1997)

2.5 Estimation of total catch and effort for shore-based fishers

The angler hours of fishing effort for the day were calculated by multiplying the progressive counts by the number of hours in the fishing day. Catch rates were estimated from information on the time spent fishing and catch data obtained by interviewing anglers and crabbers while they were still fishing. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in fisher hours. Catch and effort calculations were performed for estuarine shore-based crabbing and angling as shown in Appendix D.

The whole weight of the catch, in kilograms, was estimated from length-to-weight relationships for each species as described in Section 2.4.

3.0 Results

During the survey 933 interviews were conducted at boat ramps. Of these, 646 boats had been crabbing and 72 had been angling in the estuary (10 were both crabbing and angling). Of the remainder, 113 were fishing or diving in the ocean and 111 were not involved in any fishing activity.

The majority of boat-based crabbers (76.9%) were local Bunbury residents living within a 12.5 km radius of the Leschenault Estuary (Figure 2).

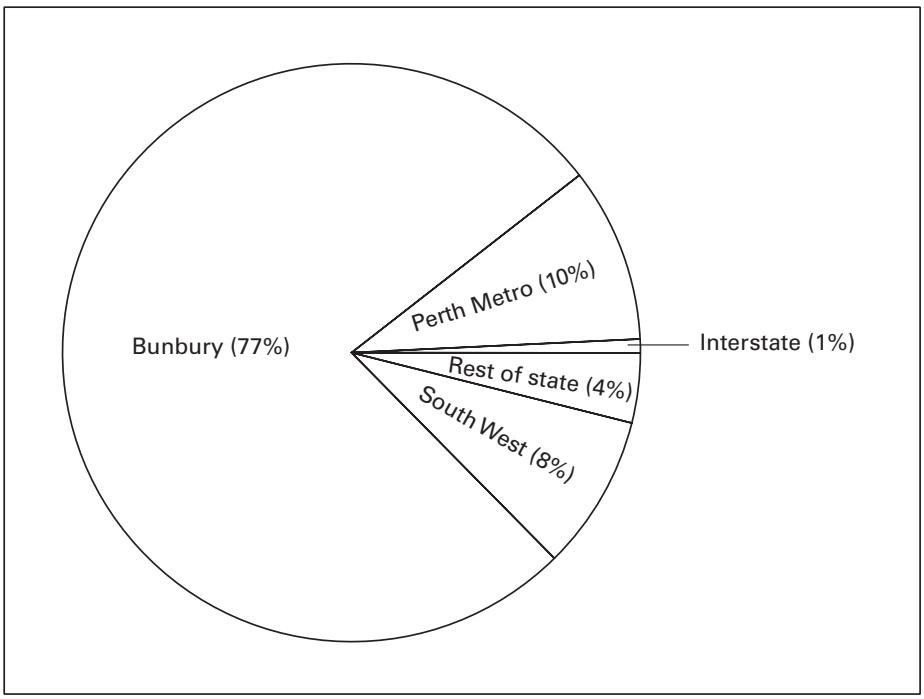

Figure 2 Boat-based crabbers' places of residence.

Blue swimmer crabs were the target species for 91% of recreational boat-based fishers in the Leschenault Estuary. The remaining 9% of boat-based fishers targeted fish such as King George whiting, tailor and herring.

In addition to the interviews at boat ramps, 117 shore-based fishing parties were interviewed. Forty of these groups were crabbing and 77 were angling in the estuary. A further 84 interviews with shore-based crabbers were conducted between December 1998 and February 1999 to provide better estimates of catch rates for shore-based crabbers during summer. Analysis of variance showed that there was no difference between the catch rates for January and February 1998 and December 1998 to February 1999 at any reasonable level of significance.

The majority of shore-based crabbers (69%) were also local Bunbury residents (Figure 3).

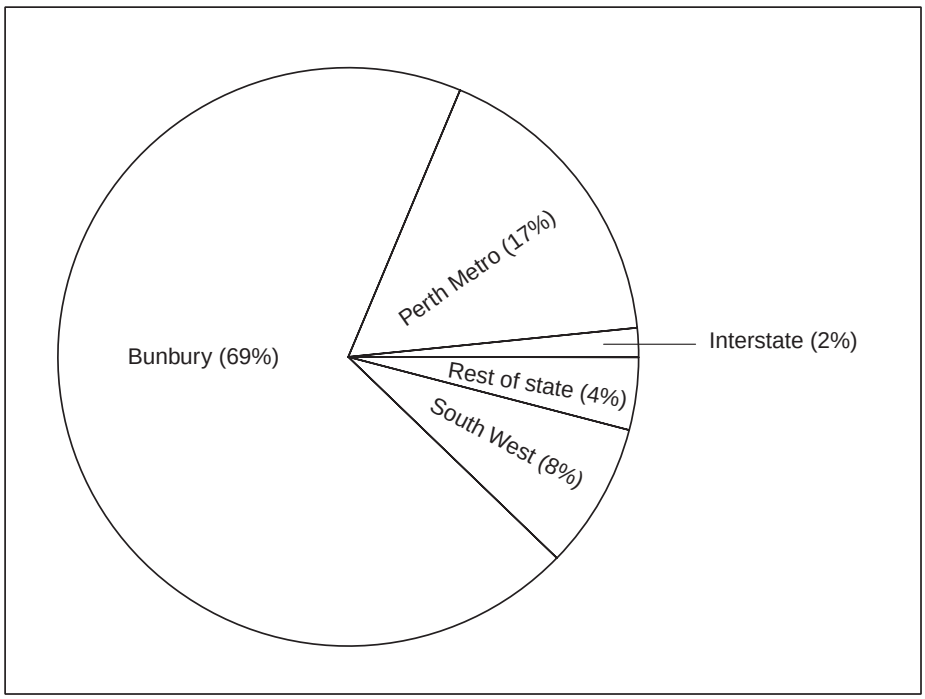

Figure 3 Shore-based crabbers' places of residence.

3.1 Recreational fishing effort

Boat-based effort

Results indicate that most fishing occurred during the two survey periods of the day known as a morning or afternoon shift. 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 the start of a morning shift (7.00 am, or 8.00 am in winter) and returned after the start of a morning shift was 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 (Table 3 and Appendix C).

Table 3 Correction factor for effort occurring before the start of a morning shift.

Season	Ratio of effort prior to start to after start	Correction factor (*f*)
Summer	0.217	1.217
Autumn	0.057	1.057
Winter	0.110	1.110
Spring	0.043	1.043

Most boats had returned to the ramp before the end of an afternoon shift (7.00 pm during January, February, March, November and December; 6.00 pm during April, May, September and October; and 5.00 pm during June, July and August). The number of boats returning after this time of the day, based on the number of trailers remaining, was relatively small (around three per ramp on average during summer) (Figure 4).

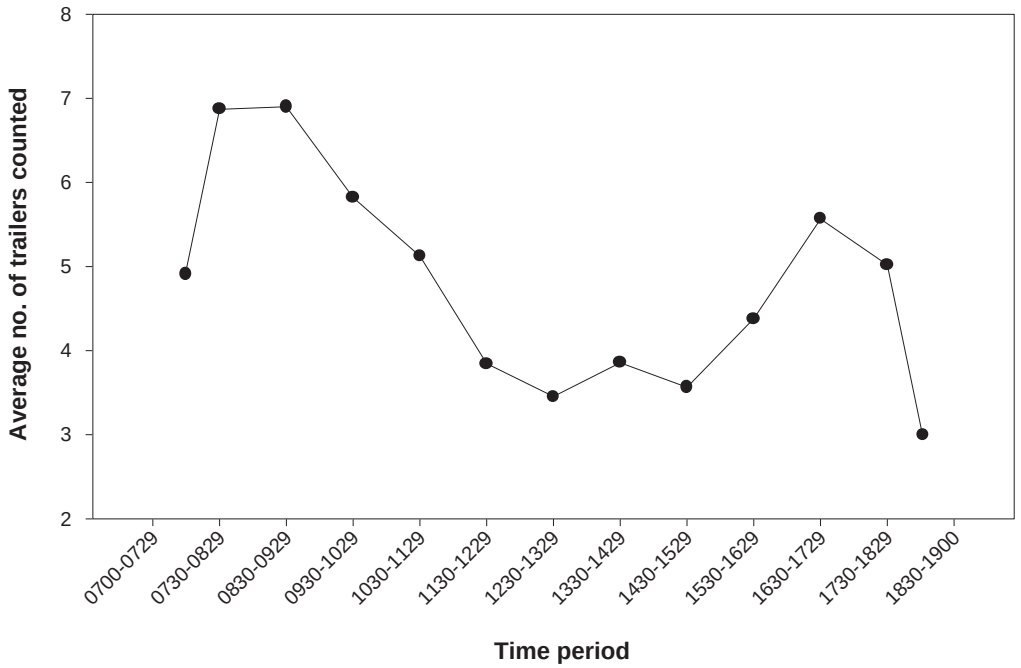

Figure 4 Average number of trailers counted on arrival/departure at all ramps (November to March).

3.1.1 Boat-based crabbing effort

Boat-based crabbers used either scoop or drop nets to catch crabs.

The recreational boat-based crabbing effort was greatest in summer with 70% of the annual crabbing effort occurring during this three-month period (December to February). Autumn was the next most popular season for boat-based crabbing, followed by spring. Very little crabbing took place during winter (Figure 5). The majority of boat-based crabbing took place from the Ridley Place boat ramp. The Collie Bridge ramps had the second greatest crabbing effort followed by the Cut and Dawes Channel. Very few people went crabbing from Knapps Channel (Figure 5).

The recreational crabbing effort varied from 432 fisher days during winter to 20,115 fisher days for summer (Figure 5).

The estimated total annual recreational boat-based crabbing effort for the Leschenault Estuary was 28,873 fisher days (31,745 boat hours).

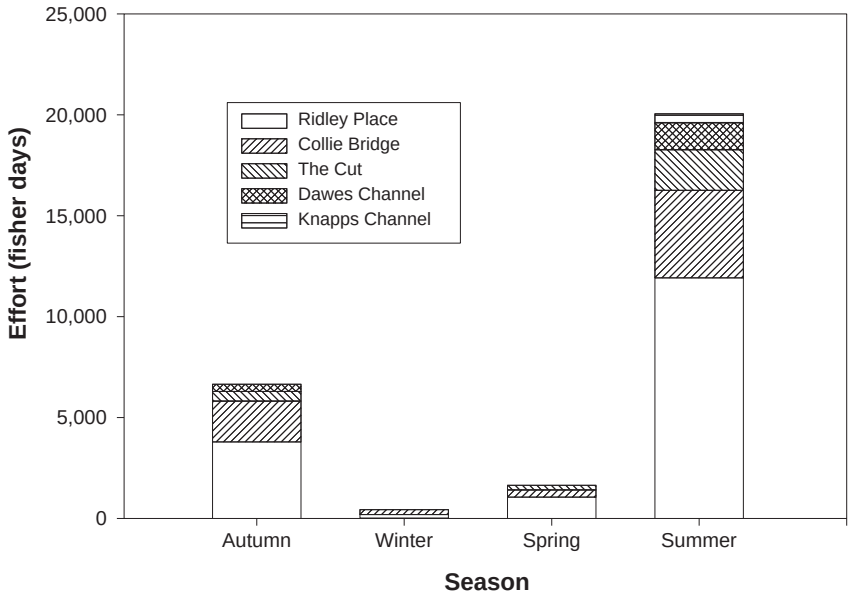

Figure 5 Recreational boat-based crabbing effort.

3.1.2 Shore-based crabbing effort

Shore-based crabbers were defined as those fishing from the shore using drop nets or wading through shallow water using scoop nets.

The majority of shore-based crabbing took place in summer, with a total of 4,033 fisher days (81.6%) followed by 887 fisher days (17.9%) in autumn. The remaining 25 fisher days (0.5%) occurred in spring. There was no shore-based crabbing during winter (Figure 6).

Afternoons were the most popular time of day for shore-based crabbers. During summer 68% of effort took place in the afternoon, while during autumn 90% of the effort occurred in the afternoon (Figure 6).

It is estimated that the total annual recreational shore-based crabbing effort for the Leschenault Estuary is 4,945 fisher days (16,004 fisher hours).

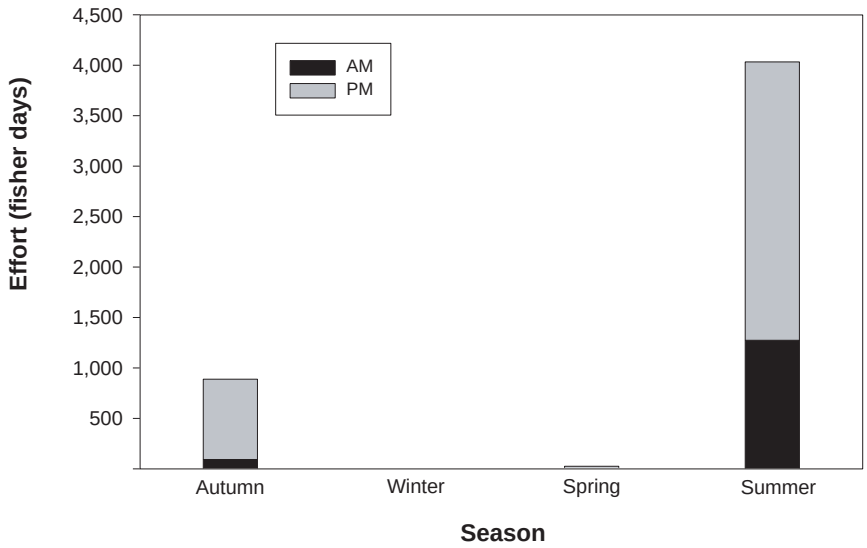

Figure 6 Recreational shore-based crabbing effort.

3.1.3 Boat-based angling effort

Anglers were considered to be people targeting fish using one or more fishing lines.

Summer is the most popular season for angling in the Leschenault Estuary. The effort is only slightly less during autumn, while winter and spring are less popular (Figure 7).

The Collie Bridge boat ramps were the most popular for estuary anglers. The Cut and Ridley Place are less popular but are also used by estuary anglers (Figure 7).

The estimated annual recreational boat-based angling effort for the Leschenault Estuary was 4,519 fisher days (5,804 boat hours).

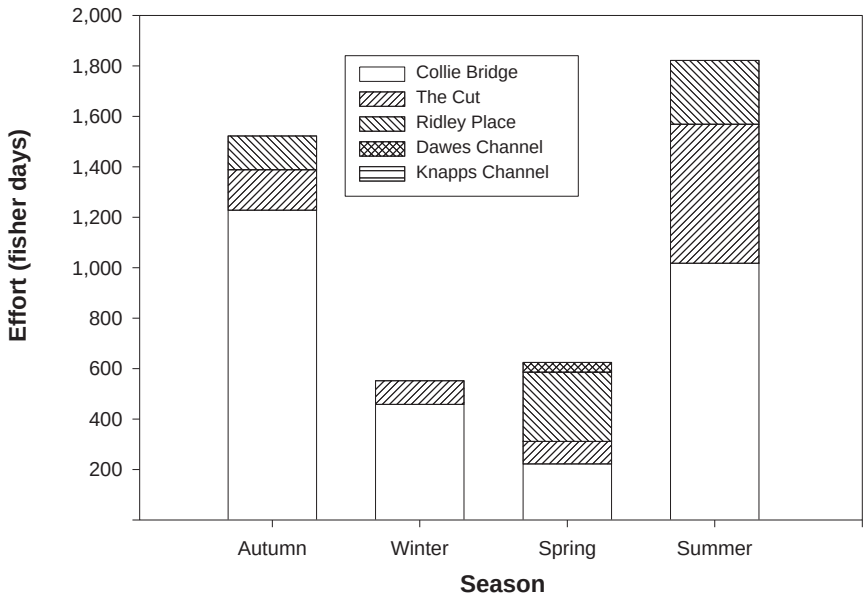

Figure 7 Recreational boat-based angling effort.

3.1.4 Shore-based angling effort

Summer is the most popular season for shore-based estuary angling, followed by autumn. There was minimal angling during spring and none recorded in winter (Figure 8).

The estimated annual recreational shore-based angling effort for the Leschenault Estuary was 666 fisher days (1,765 fisher hours).

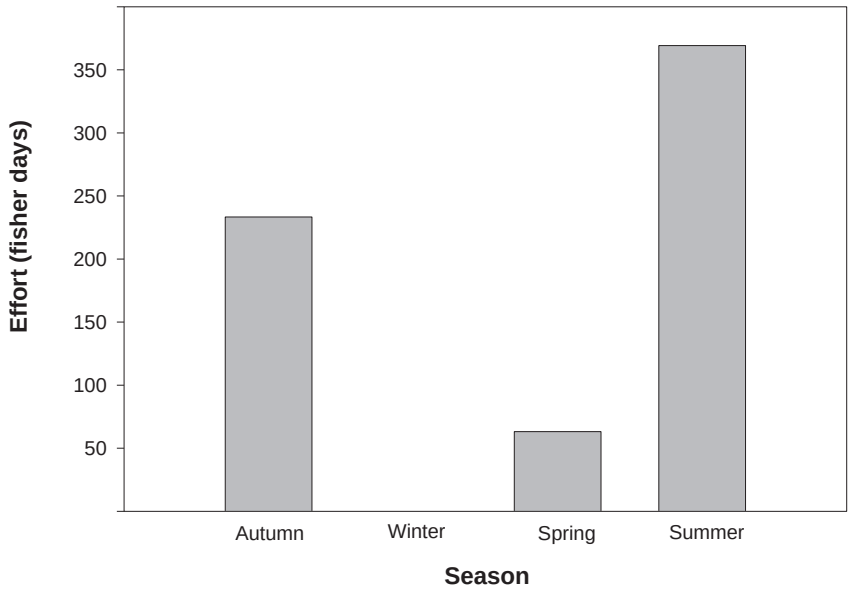

Figure 8 Recreational shore-based angling effort.

3.2 Recreational catch of blue swimmer crabs

The size frequency for blue swimmer crabs displayed in Figure 9 shows the carapace width (CW) range for crabs kept by both boat- and shore-based crabbers.

Approximately 50% of crabs kept have a CW between 127mm (minimum legal size) and 132mm. However, crabs as small as 118mm CW and as big as 158mm CW were kept by recreational crabbers. The distribution was similar for both male and female crabs (Figure 9).

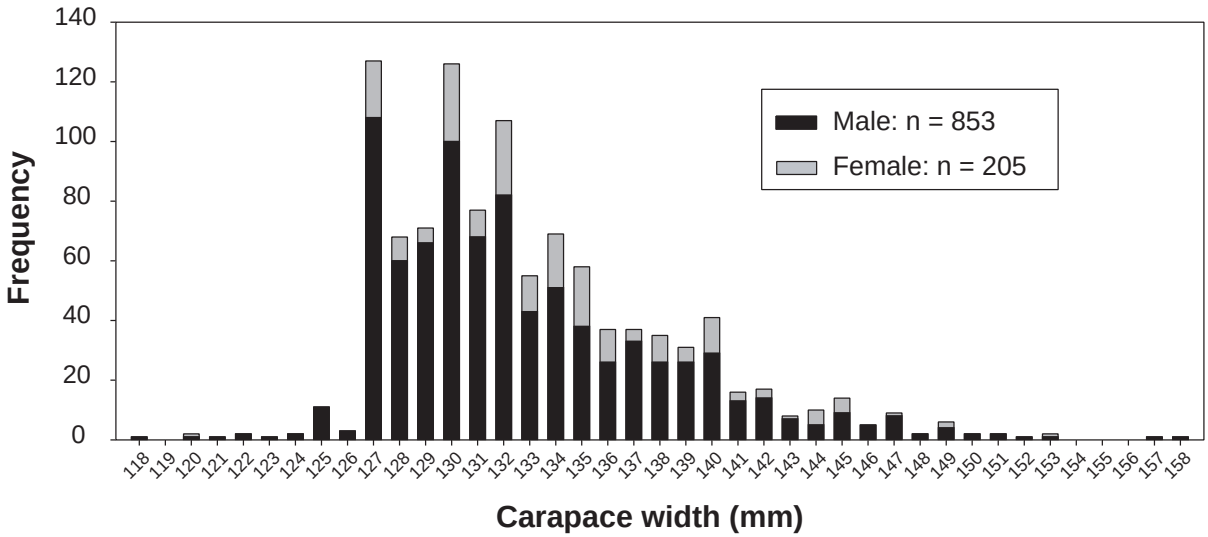

Figure 9 Size frequency for blue swimmer crabs kept (minimum CW 127 mm).

3.2.1 Boat-based catch

Of the crabs kept for which sex was recorded, 7,998 (82%) were males and 1,725 (18%) females. The sex of crabs released was also recorded where possible; of these 23,007 (77%) were males and 7,018 (23%) females.

An estimated 179,140 crabs were kept (32,951 females and 146,189 males) and 600,125 released (141,057 females and 459,068 males) by boat-based crabbers during 1998 (Table 4). The error associated with the estimate of the number of crabs kept was calculated; the standard error for the estimated number kept $SE(\hat{c})$ was 8,575. If we assume a student *t* distribution, the (1-α) percent confidence interval for the number kept $(\hat{c})$ can be calculated from the standard error

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

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

Table 4 Estimated recreational boat-based catch of blue swimmer crabs.

	Total	Standard error
Number kept	179,140	8,575
Number released	600,125	30,289
Weight kept (tonnes)	37.80	1.60
Catch rate (crabs/boat/hour)	5.53	0.17
Catch rate (crabs/net/trip)	1.66	0.05
Catch rate (crabs/boat/trip)	15.53	0.43

Only 2.4% of boats with two or more on board achieved or exceeded the boat limit of 48 crabs. However, 29.7% of boats with only one person on board achieved or exceeded the bag limit of 24 crabs. Of all boats targeting crabs, 4.6% did not keep any crabs at all (Figure 10).

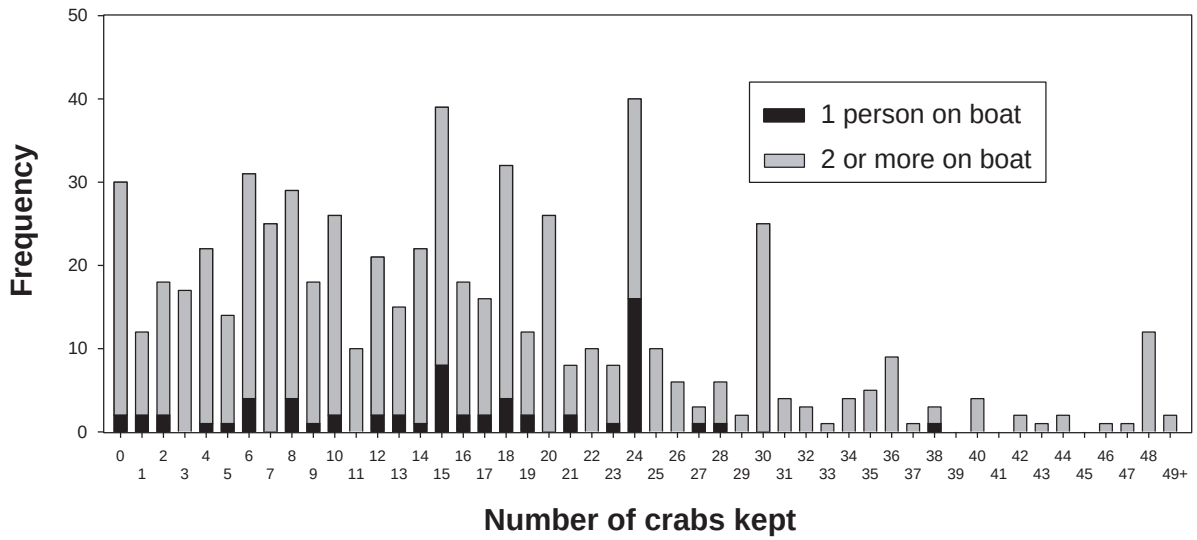

Figure 10 Frequency of crabs kept per boat.

Catch rates peaked at 20.6 crabs per boat per trip during autumn 1998. During summer when the majority of effort occurred, the catch rate was slightly lower at 14.8 crabs per boat per trip (Figure 11).

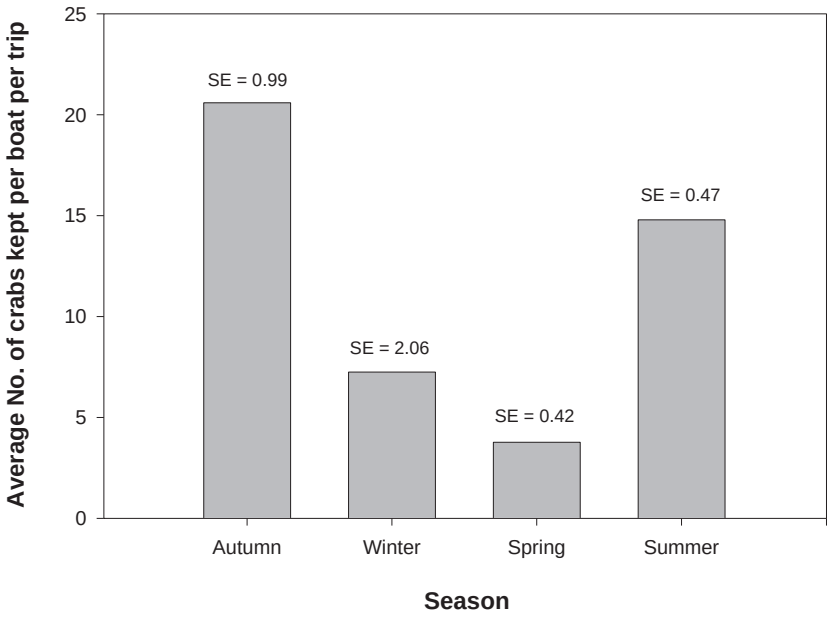

Figure 11 Crab catch rates per season for boat-based fishers.

Most (65%) of the recreational crab catch made by boat-based fishers was made in the summer months, 32% was caught during autumn and only 3% of the catch was taken during winter and spring (Figure 12).

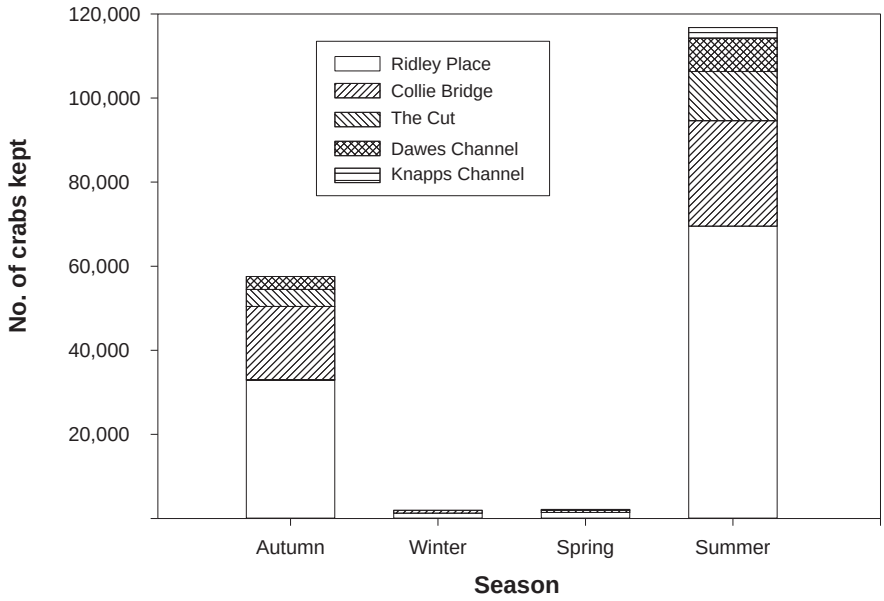

Figure 12 Estimated number of crabs kept per ramp per season.

The majority of crabs kept were from boats launched at the Ridley Place boat ramp. Reasonable numbers of crabs were kept from boats launched at the Collie Bridge boat ramps. The catch was comparatively less from the Cut, Dawes Channel and Knapps Channel (Figure 12).

Female crabs comprised 37% of the crabs kept during autumn but only 9% of the crabs kept during summer. However, of the crabs released, 23% were females during both summer and autumn (Figure 13).

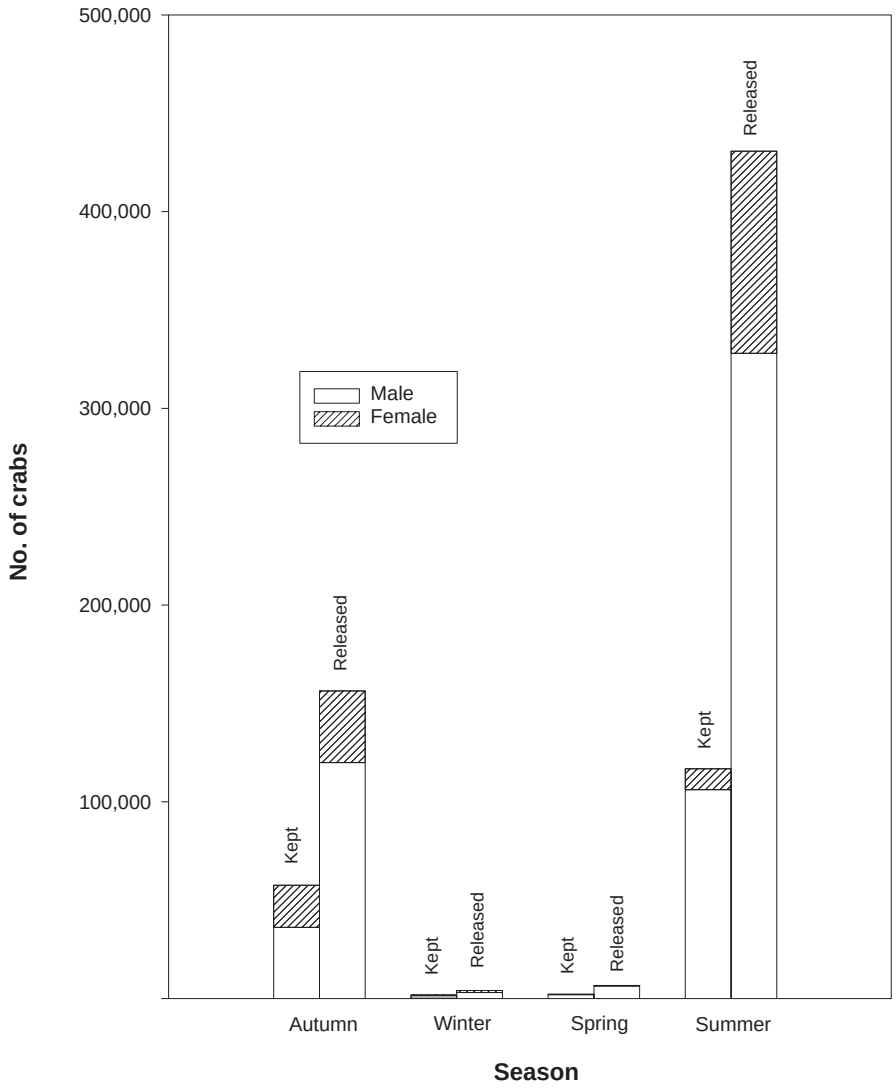

Figure 13 Estimated number of crabs kept and released per season by boat-based crabbers.

During autumn, for every crab kept by recreational boat-based crabbers there were 2.7 crabs released. However, during summer there were 3.7 crabs released for every crab kept (Figure 13).

The total annual weight of crabs kept by recreational boat-based crabbers in the Leschenault Estuary was estimated to be 37.8 tonnes (31.6 tonnes of males and 6.2 tonnes of females) (Table 4).

3.2.2 Shore-based catch

Of the crabs kept for which sex was recorded, 608 (68%) were males and 281 (32%) females. The sex of crabs released was also recorded where possible; of these, 1,570 (58%) were males and 1,126 (42%) females.

An estimated 39,897 crabs were kept and 130,313 released by shore-based crabbers during 1998 (Table 5).

Table 5 Estimated recreational shore-based catch of blue swimmer crabs.

	Total	Standard error
Number kept	39,897	5,583
Number released	130,313	17,958
Weight kept (tonnes)	7.90	0.80
Catch rate (crabs/person/trip)	5.89	0.79
Catch rate (crabs/person/hour)	2.73	0.22
Catch rate (crabs/party/trip)	14.77	1.90

Most (90%) of the crabs kept by shore-based crabbers in 1998 were caught in summer (Figure 14). During summer there were also large numbers of crabs released, with 3.2 crabs released for every one kept. During autumn a lot fewer crabs were kept than in summer, however, only 0.4 crabs were released for every crab kept (Figure 14).

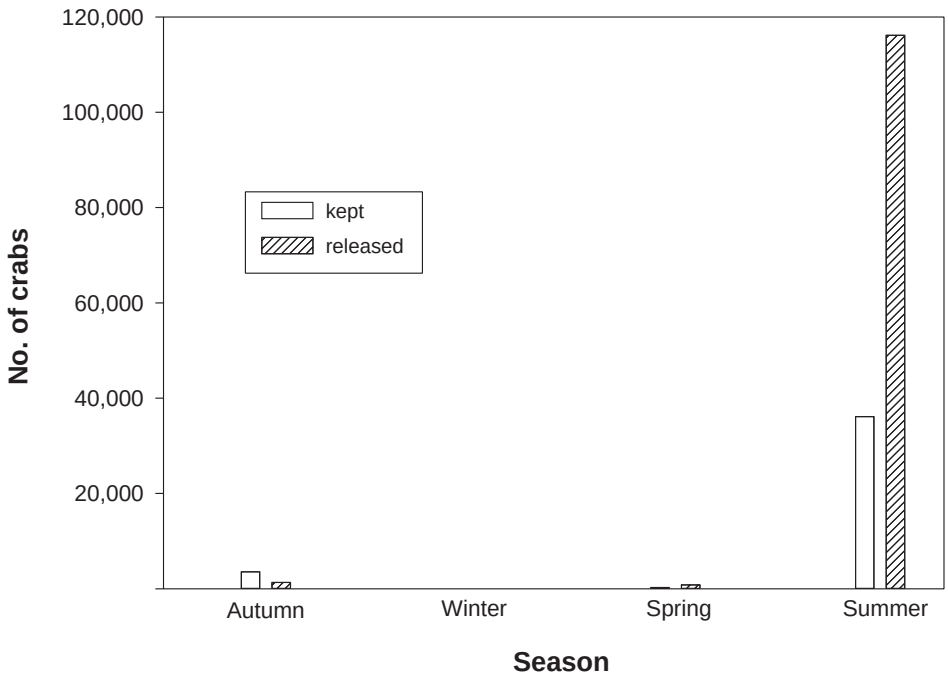

Figure 14 Estimated number of crabs kept and released per season by shore-based crabbers.

A similar proportion of the crabs kept by shore-based fishers were caught on weekdays and weekends. The majority of the catch, however, was caught during the afternoon (Figure 15), which corresponds with fishing effort (see Figure 6).

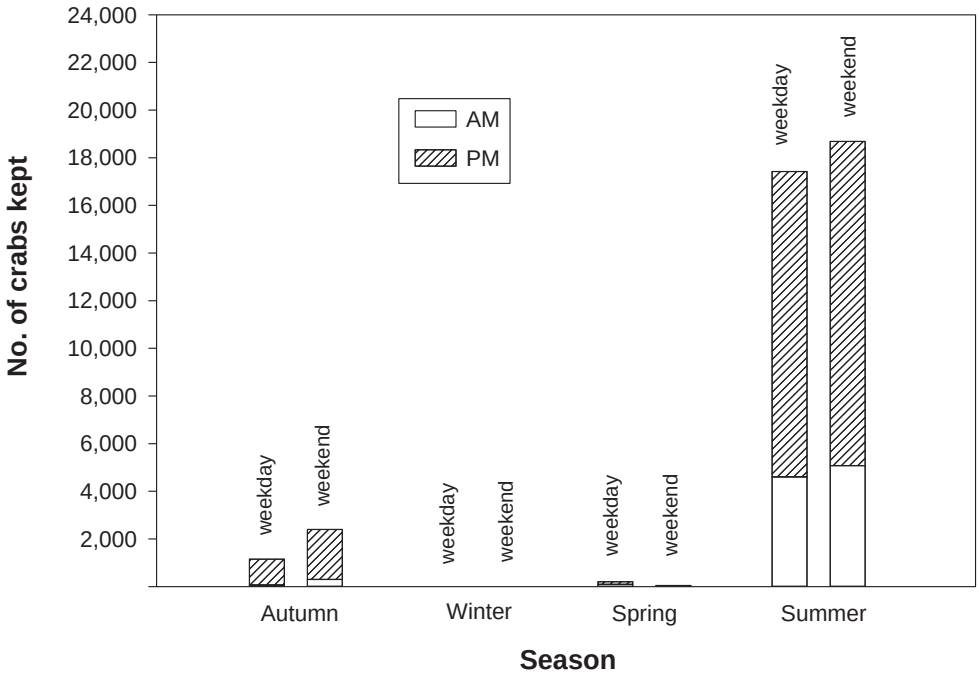

Figure 15 Estimated number of crabs kept per season, by weekday/weekend and morning/afternoon, by shore-based fishers.

The total annual weight of crabs kept by recreational shore-based crabbers in the Leschenault Estuary was estimated to be 7.9 tonnes (5.5 tonnes of males and 2.4 tonnes of females) (Table 5).

3.2.3 Total catch of blue swimmer crabs

The total recreational harvest of blue swimmer crabs from the Leschenault Estuary is estimated to be 219,037 crabs kept or 45.7 tonnes. It is also estimated that 730,438 crabs were released by recreational fishers during 1998 (Table 6).

Table 6 Estimated total recreational catch of blue swimmer crabs.

	Boat	Shore	Total	Standard error
Number kept	179,140	39,897	219,037	10,232
Number released	600,125	130,313	730,438	35,212
Weight kept (tonnes)	37.8	7.9	45.7	1.8

3.3 Recreational catch of fish

A total of 17 species of fish were kept by recreational anglers in the Leschenault Estuary (Appendix E). Of these, only five species were caught in sufficient numbers for the annual catch to be estimated.

3.3.1 Boat-based catch

Tailor were the fish most commonly kept by boat-based anglers with an estimated annual catch of 1,046 fish (Table 7). Whiting other than King George (*Sillago* spp.) were the next most common fish kept with an estimated annual catch of 843 fish. It was also estimated that 1,625 whiting were released by recreational anglers annually. Other important species were Australian herring, with an estimated annual catch of 822 fish kept, and King George whiting, with an annual estimate of 502 fish kept. The number of silver bream (tarwhine) and black bream kept was not large enough to determine an accurate estimate of the annual catch. It was, however, estimated that 494 silver bream and 474 black bream were released annually by boat-based anglers.

Table 7 Estimated recreational boat-based fish catch.

Common name	Scientific name	Number kept	Standard error kept	Number released	Standard error released
Tailor	*Pomatomus saltatrix*	1,046	368	610	220
Whiting, other	*Sillago* spp.	843	171	1,625	432
Australian herring	*Arripis georgianus*	822	454	566	235
Whiting, King George	*Sillaginodes punctata*	502	124	779	180
Bream, silver (tarwhine)	*Rhabdosargus sarba*	*	*	494	315
Bream, black	*Acanthopagrus butcheri*	*	*	474	216

* Number kept could not be estimated within a reasonable precision due to the small number recorded.

Small quantities of blue mackerel (*Scomber australasicus*), skipjack trevally (*Pseudocaranx dentex*), Australian salmon (*Arripis truttaceus*), wrasse (Labridae family), yellowtail scad (*Trachurus novaezelandiae*), flounder (*Pseudorhombus* spp.), and southern sea garfish (*Hyporhamphus melanochir*) were also kept by recreational boat-based anglers.

Different fish species dominate the catch during different seasons throughout the year. Australian herring was the most commonly caught fish species in autumn, King George whiting was the most common species caught during spring, while tailor was the most common species during summer. No fish catches were recorded during winter (Figure 16).

The best catch rate for a single fish species of just over 0.5 fish kept/boat/hour was found for both King George whiting during spring and tailor during summer. With the exception of winter when no fish species were recorded, whiting other than King George had the most consistent catch rate throughout the year (Figure 17).

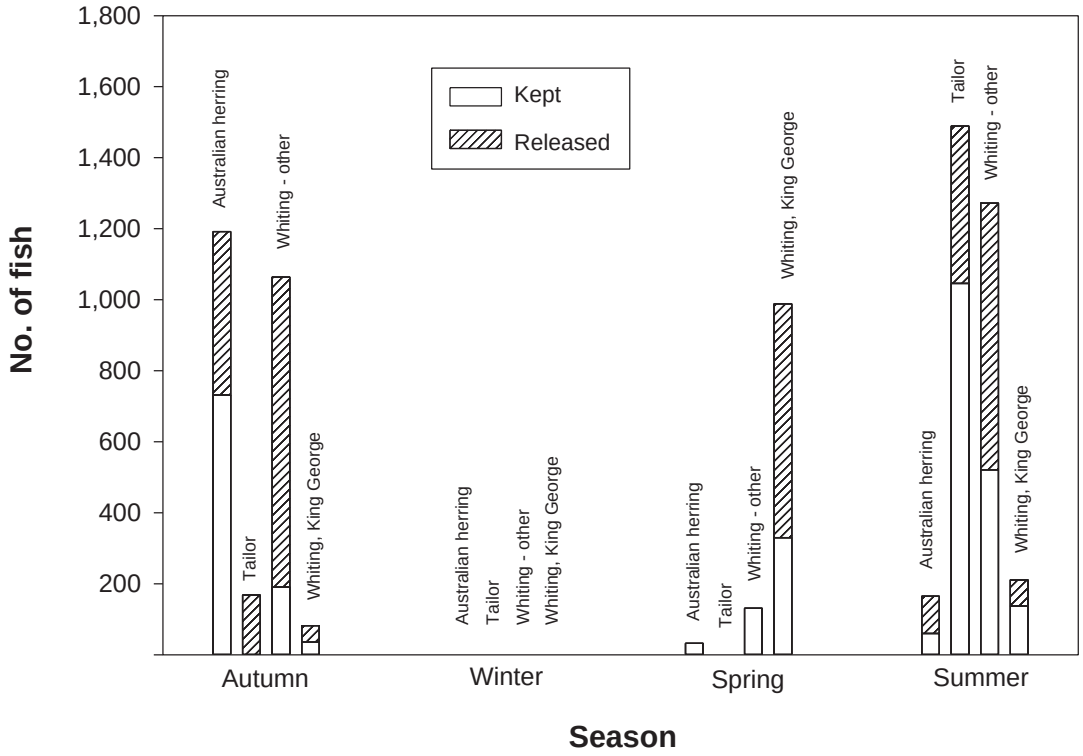

Figure 16 Estimated catch of predominant fish species per season.

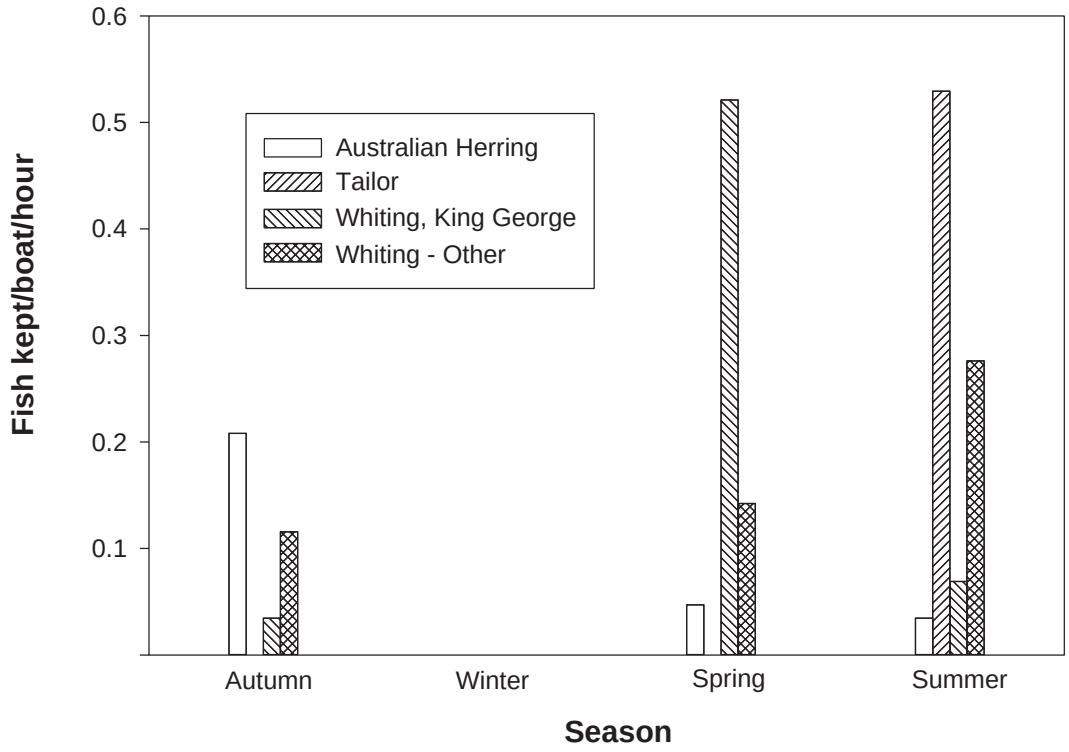

Figure 17 Angling catch rates per season (fish kept/boat/hour).

Catch rates in fish kept/person/trip (Figure 18) follow the same trend as fish kept/boat/hour.

The total weight of tailor kept was estimated at 0.21 tonnes (standard error = 0.07 tonnes), followed by 0.11 tonnes (standard error = 0.06 tonnes) of Australian herring and King George whiting at 0.06 tonnes (standard error = 0.01 tonnes).

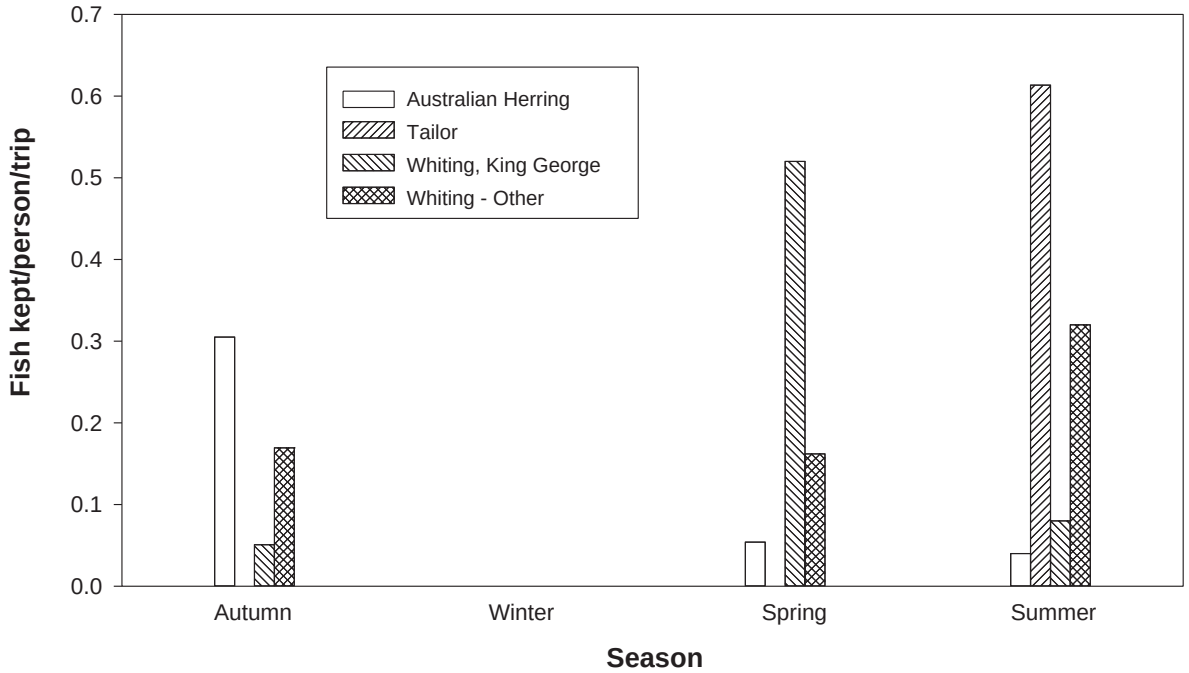

Figure 18 Angling catch rates per season (fish kept/person/trip).

3.3.2 Shore-based catch

Whiting other than King George (*Sillago* spp.) were the fish most commonly kept by shore-based anglers with an estimated annual catch of 640 fish. Common blowfish were the next most common species with an estimated annual catch of 428 fish kept or not returned to the water alive. It is also estimated that 137 tailor were kept by shore-based anglers annually (Table 8).

Table 8 Estimated recreational shore-based fish catch.

Common name	Scientific name	Number kept	Standard error kept	Number released	Standard error released
Whiting, other	*Sillago* spp.	640	256	376	147
Blowfish, common	*Torguigener pleurogramma*	428	236	302	99
Tailor	*Pomatomus saltatrix*	137	49	339	107

Small quantities of tarwhine (*Rhabdosargus sarba*), skipjack trevally (*Pseudocaranx dentex*), mulloway (*Argyrosomus hololepidotus*), flounder (*Pseudorhombus* spp.), southern fiddler ray (*Trygonorhina fasciata*) and Australian herring (*Arripis georgianus)* were also kept by recreational shore-based anglers.

The total weight of tailor kept was estimated to be 0.03 tonnes (standard error = 0.01 tonnes).

3.3.3 Total fish catch

Whiting, other than King George

Whiting other than King George (*Sillago* spp.) are the fish most commonly kept by recreational anglers in the Leschenault Estuary. The total catch of whiting was estimated to have been 1,483 fish (843 from boats and 640 from shore).

Tailor

Tailor are the fish most commonly kept by boat-based anglers with an estimated catch of 1,046 fish. Shore-based fishers are estimated to catch a further 137 fish. The total catch of tailor was therefore estimated to have been 1,183 fish or 0.24 tonnes.

Australian herring

The catch of Australian herring from the shore was negligible. The total catch was therefore estimated to be the 822 fish caught from boats. The total weight kept was estimated to have been 0.11 tonnes.

King George whiting

King George whiting were only kept by boat-based anglers in the Leschenault Estuary. The estimated total number kept was 502 fish or 0.06 tonnes.

Common blowfish

Common blowfish were not kept by any boat-based fishers. The total catch was therefore the 428 fish estimated to have been kept by shore-based fishers.

3.4 Commercial catch and effort for blue swimmer crabs

During 1998 the commercial blue swimmer crab catch of 2.8 tonnes was less than 10% of the recreational catch. The crabbing effort was 70 boat days.

The annual commercial crab catch between 1988 and 1998 ranged from 7.3 tonnes in 1990 to only 1.6 tonnes in 1994 (Figure 19). The mean annual crab catch for these years was 4.2 tonnes. The annual crabbing effort in boat days per year ranged from 274 days in 1989 to 70 days in 1998. Crabbing effort was consistently above 200 boat days per year from 1989 to 1993 but since 1994 has declined to less than 100 boat days per year (Figure 19).

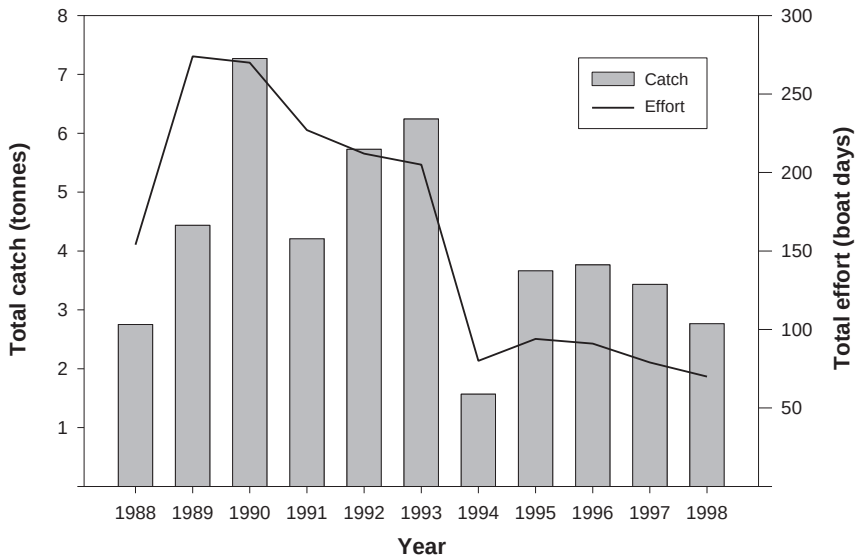

Figure 19 Annual commercial catch and effort for blue swimmer crabs in the Leschenault Estuary (1988 to 1998).

3.5 Commercial catch and effort for fish

During 1998 the commercial fish catch in the Leschenault Estuary was 85.3 tonnes. This consisted of 11 species (Appendix F). The catch was predominantly sea mullet (36.3 tonnes) and yellow-eye mullet (32.3 tonnes). The next biggest catch was of whiting other than King George (13.3 tonnes). The fishing effort was 689 boat days.

The annual commercial fish catches in the Leschenault Estuary between 1988 and 1998 ranged from 72.1 tonnes in 1996 to 126.7 tonnes in 1990 (Figure 20) with a mean annual catch of 90.4 tonnes. The annual commercial effort in days spent fishing per year ranged from 1034 days in 1990 to 524 days in 1993 (Figure 20).

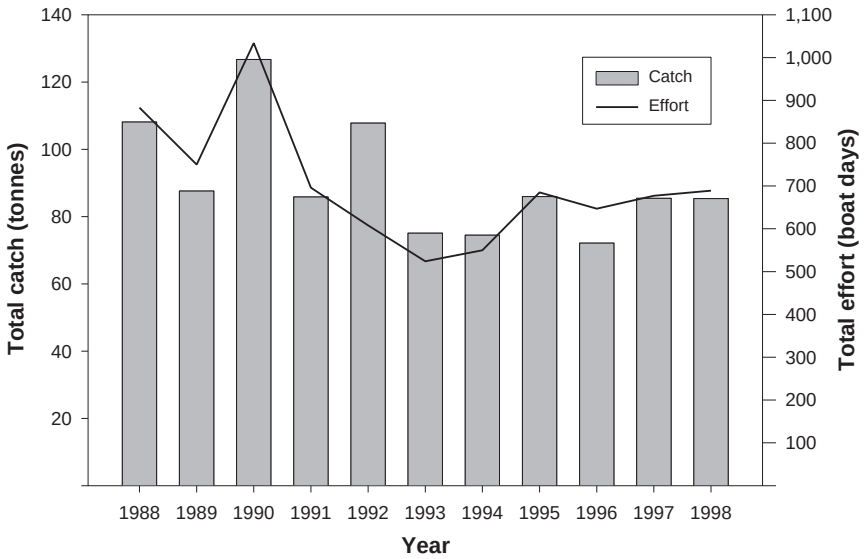

Figure 20 Annual commercial catch and effort for all fish species in the Leschenault Estuary (1988 to 1998).

3.6 Fishing regulations

Only 14 (2.4%) of the 582 boats interviewed that had been crabbing with more than one person on board achieved or exceeded the boat limit of 48 crabs. However, 19 (29.7%) of the 64 boats interviewed with only one person on board achieved or exceeded the bag limit of 24 crabs per person.

Three (4.7%) of the 64 boats with only one person on board exceeded the daily bag limit of 24 crabs. Only 2 (0.3%) of the 582 boats with 2 or more on board exceeded the daily boat limit of 48 crabs.

There was a very high level of compliance with the size limits amongst boat-based fishers. Only 11 (1.7%) of the 646 boats crabbing had kept undersize crabs and less than 1% of boats angling had kept undersize fish.

Of the 11 boats which had kept undersize crabs, 10 were local Bunbury residents and one was from elsewhere in the south-west.

Compliance rates were lower amongst shore-based crabbers with eight (6.5%) of the 124 shore-based crabbing parties interviewed having kept marginally undersize crabs. No shore-based anglers were found to have kept undersize fish.

Of the eight shore-based crabbing parties which kept undersize crabs, five were from Bunbury and two were from Perth; one party did not indicate where they were from.

4.0 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. In an estuary where the travelling time is small there will be close agreement between the effort estimated from the bus route method and the actual fishing time.

The bus route method, with adaptations, proved to be a suitable approach for estimating the recreational catch and effort for the Leschenault Estuary. The survey method proved to be robust and was readily adapted to the area surveyed. The roving creel survey conducted while the interviewer was travelling from one boat ramp to the next also worked well. Combining the two methods resulted in a significant saving of data collection costs.

The collection of effort information on shore-based fishers while the interviewer was driving between ramps had two advantages over using separate surveys for boat-based and shore-based fishing. Firstly, effort information on shore-based fishing could be collected while an interviewer drove from one ramp to the next during the bus route method reducing the data collection cost. Secondly, the schedule and checkpoints reduced bias normally associated with "count-while-interviewing" methods. Without checkpoints, the movement of the interviewer slows down during busy times and speeds up when few fishers are encountered. This approach produces an under-count of anglers since, while a fisher is being interviewed, the interviewer is unable to count or interview another angler elsewhere (Wade *et al*., 1991).

The results may slightly understate the recreational boat-based catch since the survey could not include any boats fishing after 7.00 pm (6.00 pm in April, May, September and October and 5.00 pm in June, July and August), or any boats that had finished fishing and returned to the boat ramp before 7.00 am (8.00 am in winter). It is likely that most of the boats remaining at the end of an afternoon shift would return to the ramp before nightfall although this could vary depending on the time of the year. It was not, however, possible to account for boats that returned to the ramp after the end of an afternoon shift since no catch and effort information was collected beyond this time. Similarly the shore-based catch will also be slightly underestimated as any shore-based fishing which was completed prior to the start of a morning shift or commenced after the completion of an afternoon shift could not be accounted for.

4.1 Blue swimmer crabs

The level of sampling (number of days worked by interviewers) gave estimates of the total recreational catch of blue swimmer crabs with an acceptable level of precision. The standard error was only five per cent of the estimated catch for boat-based crabbers and 15 per cent for shore-based crabbers.

The seasonal fluctuations in crabbing effort and catch rates for recreational boat and shore-based crabbers are explained by the biology of blue swimmer crabs in the Leschenault Estuary. Potter and de Lestang (in press) found that crab numbers in the estuary reach maximum levels from late spring through summer and into early autumn when salinities and water temperatures are at their highest. Crab numbers then decline from late autumn when the majority of crabs move out of the estuary as the salinity and water temperature drop. Recreational catch rates peaked during autumn due to the increasing abundance of crabs over the minimum legal size limit (CW = 127 mm) at this time of year (Potter and de Lestang, in press).

The large difference in the proportion of male to female crabs caught is also supported by the findings of Potter and de Lestang (in press). The overall sex ratio of females to males for crabs caught (both kept and released) by recreational boat-based crabbers using drop nets was 1:3.5. Potter and de Lestang (in press) found the sex ratio of females to males for crabs caught in pots in the Leschenault Estuary to be 1:3.8.

Blue swimmer crabs are the key species for recreational fishermen in the Leschenault Estuary with 86 per cent of boat-based fishing effort and 88 per cent of shore-based fishing effort targeting crabs. The estimated recreational catch for 1998 of 45.7 tonnes is substantial. It represents 94 per cent of the total catch for 1998 and is over 10 times the recent annual commercial catch between 1994 and 1998.

4.2 Fish

The estimates of recreational catch were less precise for fish species since they were caught in much smaller quantities than crabs. The standard error relative to the estimated catch for the key species caught by boat-based anglers was tailor 35 per cent, Australian herring 55 per cent, general whiting 20 per cent and King George whiting 25 per cent.

The recreational fish catch from the Leschenault Estuary during 1998 was relatively small compared with the recreational crab catch. The overall combined catch of the four key species (whiting other than King George, tailor, Australian herring and King George whiting) was estimated to be less than one tonne.

The commercial catch during 1998 was much greater, around 85 tonnes, but was predominantly made up of mullets (sea and yellow-eye) which were not recorded in catches of recreational anglers, although they may have been taken by recreational netters at night.

The commercial and recreational catches of tailor, Australian herring and King George whiting were of similar magnitude. The commercial catch of whiting other than King George was, however, significantly larger than the recreational catch.

5.0 Conclusions

The study has provided information on the extent and distribution of recreational fishing effort. In the Leschenault Estuary, recreational fishing effort is directed towards blue swimmer crabs with most effort occurring during the summer months.

The results clearly show the importance of recreational “crabbing” in the Leschenault Estuary. It is suggested that further creel surveys are required on a regular basis, about every five years, to monitor the recreational catch for both the Leschenault Estuary and all other estuaries throughout the state and to study long-term trends in catch and catch rates.

6.0 Acknowledgments

The project was funded by the following organisations: Natural Heritage Trust, Fisheries WA, South West Recreational Fishing Advisory Committee, South West Development Commission, Minister for Primary Industry & Fisheries, SCM Chemicals and Dardanup Shire. The authors acknowledge many people who assisted with the creel survey. We especially wish to thank our interviewers Lloyd Goodlad, Jocelyn Morris and David Pyke for their dedication and commitment which made completion of the project possible. Norm Hall, Rod Lenanton, Roy Melville-Smith and Mervi Kangas reviewed the draft manuscript and provided many useful comments.

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Appendix A: Boat ramp form

LESCHENAULT ESTUARY RECREATIONAL FISHING SURVEY

BOAT RAMP FORM

Interviewer's Name: _____

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

Boat Ramp Location: _____

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

Total Number of Boats **Total Number of Trailers**

Boat Launches				Boat Retrievals				On Arrival	On Departure
Time	Type	Time	Type	Time	Type	Time	Type		

Number of Shore Fishers Sighted Between Last Ramp and This Ramp

Appendix B: Interview form

LESCHENAULT ESTUARY RECREATIONAL FISHING SURVEY

INTERVIEW QUESTIONNAIRE

Date: _____ Location: _____ Boat Reg. No.: _____

Interview Time	Boat (Pwr/Ycht/Othr), Shore	Start Time	Fish/Dive/Other	Number in Party	No. of Females in Party	Age Group of Interviewee	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,Gill,Scoop), Pots	Times Interviewed Before

FISHERS ONLY

Species	Number Kept	Number Released	Undersize Kept	Measurements (mm)
Blue Swimmer Crab (M)				
Blue Swimmer Crab (F)				

Appendix C: Catch and effort calculations for boat-based fishers

Estimation of total effort

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

$$e = f\,T\sum_i\left[\left(\frac{1}{w_i}\right)\sum_j X_{ij}\right] \qquad (1)$$

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. A correction factor $f \geq 1$ was used to adjust the effort for fishing that occurred before the morning shift commenced at time t.

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

where

$$b_i = \begin{cases} r_j - t, & l_j < t \\ r_j - l_j, & l_j \geq t \end{cases}$$

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 2.1). 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

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

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

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

and the standard error is calculated by the usual method

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

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

$$\hat{E} = \sum_{i=1}^{n} \hat{E}_i \tag{8}$$

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

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

and 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 1 is estimated by (Crone and Malvestuto, 1991)

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

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)

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

The total catch for stratum 1 is estimated as

$$\hat{C}_1 = \hat{E}_1 \hat{R}_1 \qquad (13)$$

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

$$Var(\hat{C}_1) \approx \hat{C}_1^2 \left(\frac{Var(\hat{E}_1)}{\hat{E}_1^2} + \frac{Var(\hat{R}_1)}{\hat{R}_1^2} + \frac{2Cov(\hat{E}_1, \hat{R}_1)}{\hat{E}_1 \hat{R}_1} \right) \qquad (14)$$

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

$$\hat{C} = \sum_{i=1}^{n} \hat{C}_i \qquad (15)$$

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

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

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

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

Appendix D: Catch and effort calculations for shore-based fishers

Estimation of total effort

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

$$e = \frac{IT}{2} \qquad (1)$$

where I is the count of anglers and T is the length of the shift. For this survey the numerator is divided by two since the interviewer traversed the fishery twice during the shift. The estimated variance within stratum 1 is (Pollock *et al*., 1994)

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

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

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

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

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

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

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

and the standard error is calculated by the usual method

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

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

$$\hat{E} = \sum_{i=1}^{n} \hat{E}_i \tag{7}$$

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

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

and 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 1 is estimated by (Pollock *et al*., 1994)

$$\hat{R}_1 = \frac{\sum_{i=1}^{n_1} \frac{w_i c_i}{L_i}}{\sum_{i=1}^{n_1} w_i} \tag{10}$$

where c_i is the total catch and L_i the total effort, in person hours, for party i with w_i fishers, n_1 is the number of shore-based parties where the catch was recorded. The variance for $\hat{R}_1$ can be estimated using the formula

$$Var(\hat{R}_1) \approx \frac{1}{\sum_{i=1}^{n_1} w_i \left(\sum_{i=1}^{n_1} (w_i - 1) \right)} \sum_{i=1}^{n_1} w_i \left(\frac{c_i}{L_i} - \hat{R}_1 \right)^2 \tag{11}$$

The total catch for stratum 1 is estimated as

$$\hat{C}_1 = \hat{E}_1 \hat{R}_1 \tag{12}$$

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

$$Var(\hat{C}_1) \approx \hat{C}_1^2 \left(\frac{Var(\hat{E}_1)}{\hat{E}_1^2} + \frac{Var(\hat{R}_1)}{\hat{R}_1^2} + \frac{2Cov(\hat{E}_1, \hat{R}_1)}{\hat{E}_1 \hat{R}_1} \right) \tag{13}$$

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

$$\hat{C} = \sum_{i=1}^{n} \hat{C}_i \qquad (14)$$

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

$$Var(\hat{C}) = \sum_{i=1}^{n} Var(\hat{C}_i) \qquad (15)$$

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

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

Appendix E: Fish species kept by recreational anglers in the Leschenault Estuary during 1998

Common name	Scientific name	Kept by boat-based anglers	Kept by shore-based anglers
Whiting, other	*Sillago* spp.	Yes	Yes
Tailor	*Pomatomus saltatrix*	Yes	Yes
Australian herring	*Arripis georgianus*	Yes	Yes
Whiting, yellow-finned	*Sillago schomburgkii*	Yes	Yes
Whiting, King George	*Sillaginodes punctata*	Yes	No
Blowfish, common	*Torguigener pleurogramma*	Yes	Yes
Mackerel, blue	*Scomber australasicus*	Yes	No
Trevally, skipjack	*Pseudocaranx dentex*	Yes	Yes
Australian salmon	*Arripis truttaceus*	Yes	No
Black bream	*Acanthopagrus butcheri*	Yes	No
Wrasse	Labridae family	Yes	No
Yellowtail scad	*Trachurus novaezelandiae*	Yes	No
Bream, silver (tarwhine)	*Rhabdosargus sarba*	Yes	Yes
Flounder	*Pseudorhombus* spp.	Yes	Yes
Garfish, southern sea	*Hyporhamphus melanochir*	Yes	No
Mulloway	*Argyrosomus hololepidotus*	No	Yes
Ray, southern fiddler	*Trygonorhina fasciata*	No	Yes

Appendix F: Fish species kept by commercial fishermen in the Leschenault Estuary during 1998

Common name	Scientific name
Mullet, sea	*Mugil cephalus*
Mullet, yellow-eye	*Aldrichetta forsteri*
Whiting, other	*Sillago* spp.
Mullet, other	Mugilidae family
Cobbler	*Cnidoglanis macrocephalus*
Whiting, King George	*Sillaginodes punctata*
Rays and skates	Rhinobatidae, Dasyatididae, Urolophidae, Myliobatididae and Rajidae families
Tailor	*Pomatomus saltatrix*
Australian herring	*Arripis georgianus*
Garfish, southern sea	*Hyporhamphus melanochir*
Australian salmon	*Arripis truttaceus*