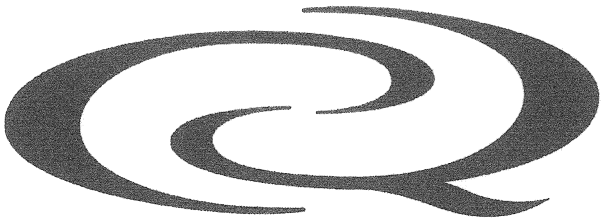
Estimating the recreational catch of blue swimmer crab in the south west of Western Australia

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



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OBJECTIVES:

1. Estimate recreational catch and effort from unsurveyed estuaries (Swan-Canning and Peel-Harvey). Note: the Leschenault Estuary was recently surveyed by a separate study (Malseed *et al.*, 2000).
2. Estimate recreational catch from (a) Geographe Bay, (b) Warnbro Sound, (c) Cockburn Sound using historical boat ramp and beach recreational survey data.
3. Compile estimates of the recreational and commercial catch share for Geographe Bay, Warnbro Sound, Cockburn Sound, Peel-Harvey Estuary, Swan-Canning Estuary and Leschenault Estuary.

NON TECHNICAL SUMMARY:

A survey of recreational boat-based and shore-based crabbing in the Peel-Harvey and Swan-Canning estuaries was conducted between August 1998 and July 1999. During the survey 3,298 interviews were conducted at boat ramps (1,996 in the Peel-Harvey and 1,302 in the Swan-Canning). An additional 1,287 shore-based fishing parties were interviewed, 909 in the Peel-Harvey and 378 in the Swan-Canning.

The bus route method, where a survey interviewer visits all boat ramps in a pre-determined area on the one day, was used to estimate the total catch and fishing effort for persons crabbing from recreational trailer boats launched at boat ramps. A roving creel survey was used to estimate the catch and fishing effort from shore-based crabbers using drop nets or wire scoop nets from the shore. For the Peel-Harvey Estuary, in conjunction with the creel surveys, houseboat and small power boat hire operators conducted a census to determine the catch and fishing effort of their clients.

Blue swimmer crabs are the key species for recreational fishers in the Peel-Harvey Estuary with 92% of boats fishing in the estuary targeting crabs. The estimated total annual boat-based recreational crabbing effort was 115,123 fisher days. The total annual shore-based recreational crabbing effort was estimated to be 160,395 fisher days.

The recreational blue swimmer crab catch from the Peel-Harvey Estuary is substantial and exceeds the reported commercial catch. The estimated total recreational catch of blue swimmer crabs was 1,360,249 crabs or 289 tonnes. This consists of a boat-based catch of 831,964 crabs and a shore-based catch of 528,285 crabs. Most crabs (86%) kept by recreational fishers were male.

Blue swimmer crabs are a key species for recreational boat-based fishers in the Swan-Canning Estuary with 53% of boats fishing in the estuary targeting crabs. The estimated total annual boat-based crabbing effort was 8,258 fisher days. There was very little shore based crabbing.

The estimated total recreational catch of blue swimmer crabs from the Swan-Canning Estuary was 20,875 crabs or 7.3 tonnes. This consisted of a boat-based catch of 20,176 crabs and a shore-based catch of 699 crabs. Almost 95% of crabs kept were male.

The estimated annual boat-based recreational crab catch for other areas in the south west of Western Australia was; Leschenault Estuary 45.7 tonnes, Geographe Bay 18.6 tonnes, Cockburn Sound 17.9

tonnes, Warnbro Sound 6.7 tonnes and other Perth marine areas 9.6 tonnes. The combined annual recreational blue swimmer crab catch for all areas surveyed in the South West is 394 tonnes.

This research has provided important catch and effort information on the recreational sector by season and location. Data were not previously available for the Peel-Harvey Estuary and Swan-Canning Estuary recreational fisheries and this study has addressed this shortfall. Catch and effort data for these and other areas of the South West of Western Australia has now been collated and presented in a single document along with the commercial catch.

Significant catch increases in most commercial sectors, coupled with high recreational pressure, indicates that all stocks of blue swimmer crabs in the South West of Western Australia are in need of careful ongoing management.

KEYWORDS: Recreational Fishing, Blue Swimmer Crabs, Peel-Harvey Estuary, Swan-Canning Estuary, Creel Survey

1. Background

Blue swimmer crabs (*Portunus pelagicus*) have a wide distribution in Australia and are found in substantial quantities in South Australia, Western Australia, Northern Territory, Queensland and New South Wales. The species has always been important to recreational fishers in those states, but in the last few years there has been increasing focus on their commercial potential.

The expansion of the commercial fishery for blue swimmer crabs has been particularly rapid in Western Australia. After many years of reported commercial catches in the order of 100 tonnes per annum, commercial catches started easing upwards in the mid-1980s and in the last few years of the 1990s the increase has been exponential. Landings in the fishery increased by over 50% between the 1995-96 and 1996-97 seasons to put the 1996-97 commercial catch at 641 tonnes. A further increase to 736 tonnes occurred in 1997/98, then the catch dropped slightly to 577 tonnes in 1998/99.

The combined recreational and commercial fishing effort is thought to be placing considerable pressure on stocks of this species in some areas of the state. It is estimated that over 76,000 recreational participants fish for crabs every summer in Western Australia (Campbell, 1997). Recent surveys of marine recreational fishers showed that blue swimmer crabs were one of the most important species for boat based fishing (Sumner and Williamson, 1999) and the second most important for shore based fishing (Ayvazian *et al.*, 1997), in terms of numbers caught. This study extends the work to estuarine areas where most of the recreational fishing for this species occurs, particularly the Peel-Harvey Estuary and Swan River. The rapid growth in commercial exploitation of crabs has led to a growing concern that resource sharing between the commercial and recreational sectors should be addressed before it becomes an issue. Steps in this regard have been taken by the recent publication of a management discussion paper outlining the issues affecting the crab fishery and calling for public comment (Campbell, 1997).

Recreational blue swimmer crab fishing also takes place in other parts of the state that have not been included in this study (e.g. King George Sound, Shark Bay and Exmouth Gulf). These areas are not of concern at present since recreational catches in these areas are considered low and unlikely to be a threat to crab stocks compared to the catches in the area covered by this study.

The Peel-Harvey, Swan-Canning and Leschenault (subject of separate study by Malseed *et al.*, 2000) estuaries are three of the most popular estuaries for recreational fishing in the south-west of Western Australia. Blue swimmer crabs are commonly caught by recreational boat-based and shore-based fishers in these estuaries.

With 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 Peel Harvey and Swan-Canning Estuaries. 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 crab catches are monitored by means of compulsory monthly returns. However, little is known about the recreational crab catch and effort. The combined catch and fishing effort for both sectors are important for managing stocks of fish and crabs. This study was

therefore undertaken to estimate the recreational catch of crabs and fishing effort for the Peel-Harvey and Swan-Canning Estuaries by means of creel surveys. The recreational catch and fishing effort for Geographe Bay, Leschenault Estuary, Cockburn Sound, Warnbro Sound and other Perth marine waters was obtained from historical survey data. Comparisons of the recreational and commercial catch are made for these areas.

The Peel-Harvey Estuary, which has a surface area of approximately 136 km^2 (Potter *et al.*, 1998), contains the circular Peel Inlet and elongate Harvey Estuary. It has a 5 km long natural entrance channel in the north-west corner of the Peel Inlet and a man-made 2 km long entrance channel (Dawesville Channel) at the northern end of the Harvey Estuary (Figure 1). There are 16 major public boat ramps within the estuary, 8 referred to as eastern ramps and 8 referred to as western ramps, three popular crab scooping areas and four bridges/jetties in the Mandurah entrance channel which are commonly used by recreational crabbers (Figure 1). Creel surveys have been conducted in the region in previous years, however, again these focussed on ocean based fishing and did not specifically take account of estuary fishing (Ayvazian *et al.*, 1997; Sumner and Williamson, 1999).

The Swan-Canning Estuary, which was surveyed from the ocean to the causeway on the Swan River and Mount Henry Bridge on the Canning River, contains eight major public boat ramps (Figure 2). Creel surveys have been conducted in the region in previous years, however, these focussed on ocean based fishing and did not specifically take account of estuary fishing (Ayvazian *et al.*, 1997; Sumner and Williamson, 1999).

2. Need

The recreational and commercial components of the blue swimmer crab fishery need to be managed jointly to ensure the total catch is sustainable. This research provides important catch and effort information on the recreational sector by season and location. Data were not available for the Peel-Harvey Estuary and Swan-Canning Estuary recreational fisheries and this study was required to address this shortfall. Catch and effort data for these and other areas of the South West of Western Australia needed to be collated and presented in a single document.

3. Objectives

The objectives of the project were to estimate the annual harvest of blue swimmer crab made by recreational fishers on the coast and in the major estuaries between Cape Naturaliste and Perth, Western Australia.
Specifically, the objectives were to:

1. estimate recreational catch and effort from unsurveyed estuaries (Swan-Canning and Peel-Harvey). Note: the Leschenault Estuary was recently surveyed by a separate parallel study (Malseed *et al.*, 2000).

2. estimate recreational catch from (a) Geographe Bay, (b) Warnbro Sound, (c) Cockburn Sound using historical boat ramp and beach recreational survey data.

3. compile estimates of the recreational and commercial catch share for Geographe Bay, Warnbro Sound, Cockburn Sound, Peel-Harvey Estuary, Swan-Canning Estuary and Leschenault Estuary.

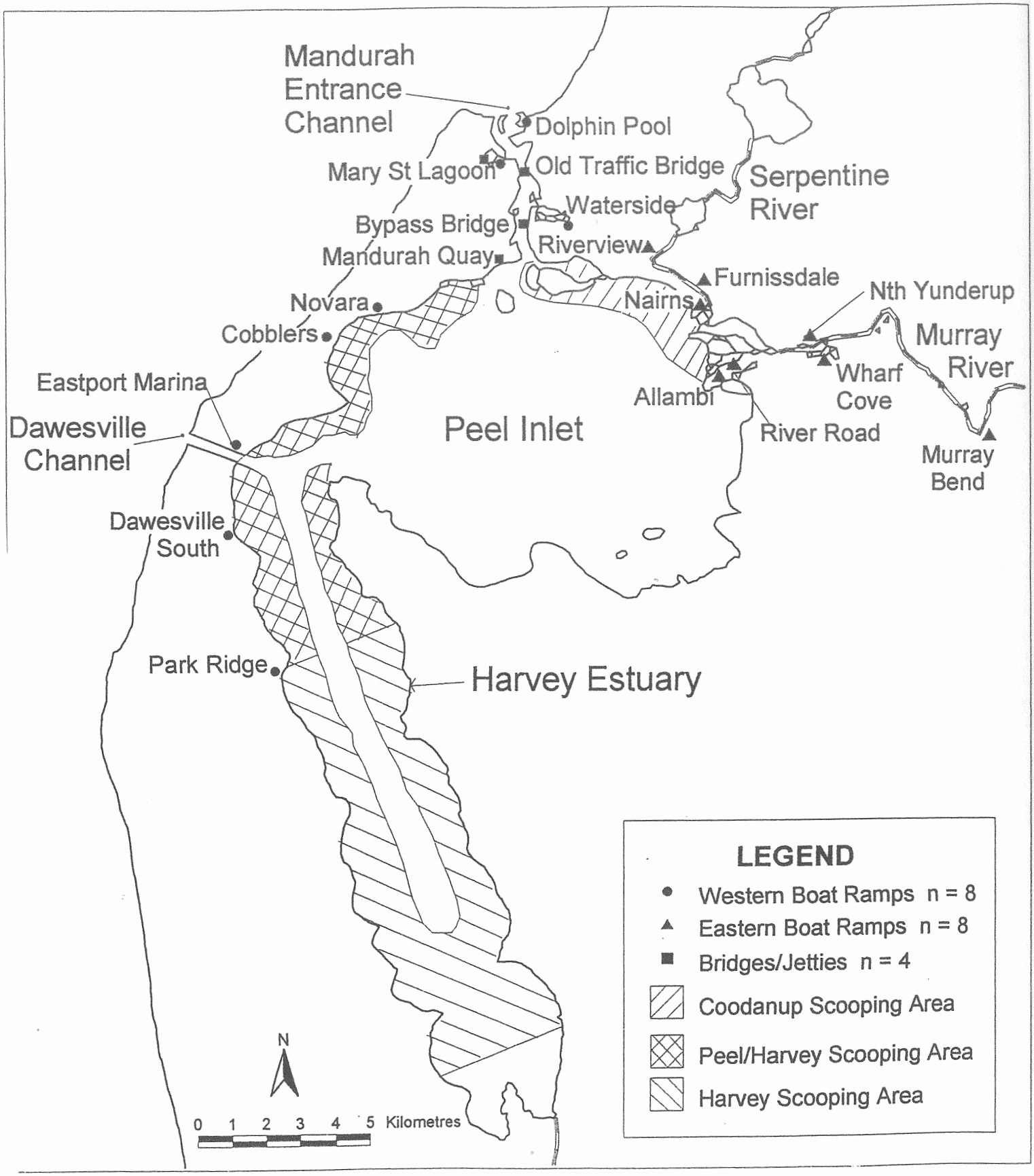

Figure 1: Peel-Harvey Estuary

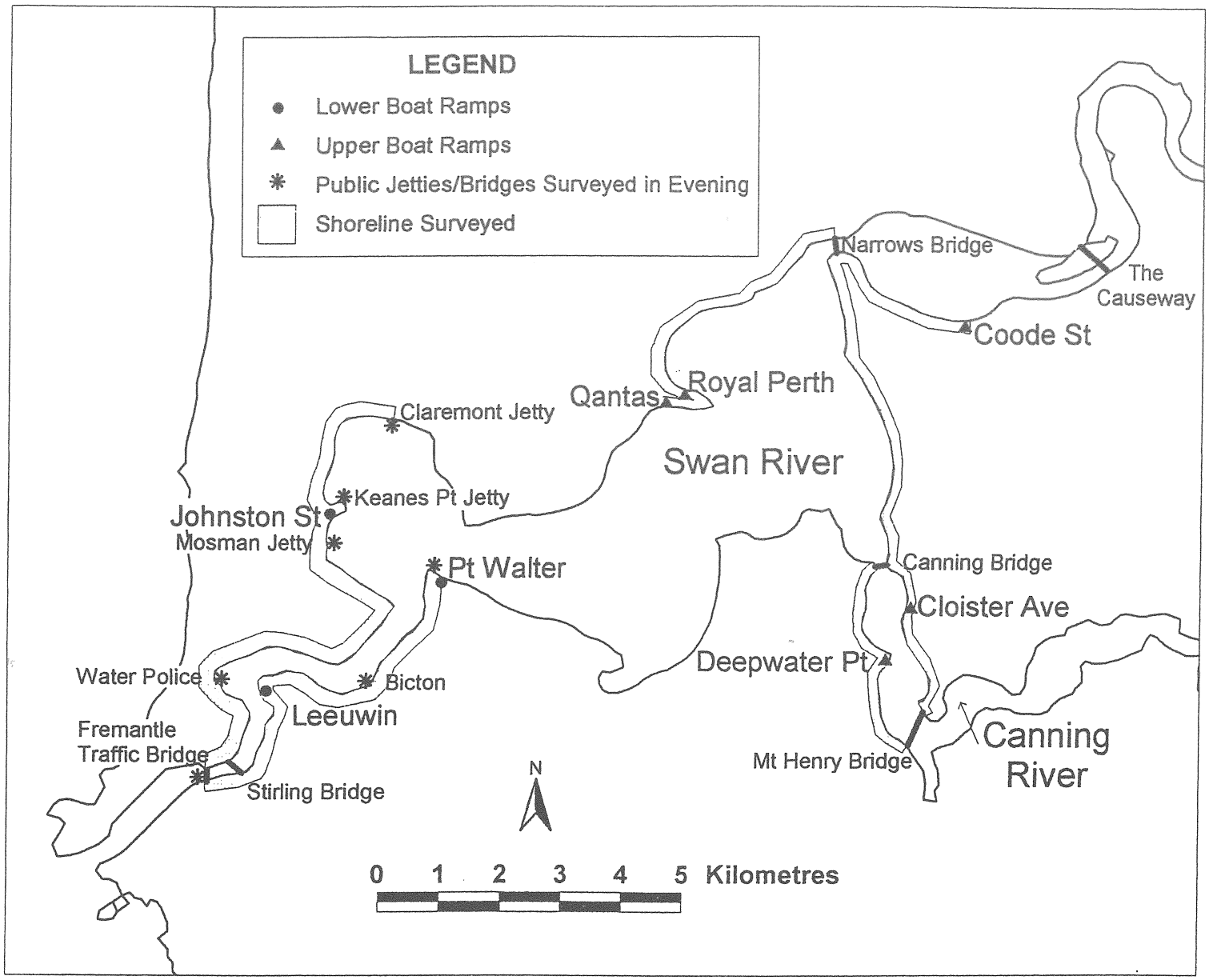

Figure 2: Swan-Canning Estuary

4. Methods

Information on the shore-based and boat-based recreational catch and fishing effort was obtained from creel surveys. Commercial catch and effort data were obtained from compulsory monthly returns provided by these fishers.

4.1 Survey Design

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

For the Peel-Harvey Estuary, in conjunction with the creel surveys, houseboat and small power boat hire operators conducted a census to determine the catch and fishing effort of their clients.

4.2 Spatial and Temporal Stratification

The surveys of the Peel-Harvey and Swan-Canning Estuaries spanned a 12 month period, commencing in August 1998 and concluding at the end of July 1999.

Both surveys were 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 × 2 for mornings and afternoons × 2 for weekends and weekdays). The boat fishing effort estimates were further stratified by ramp. 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 the survey period.

For the Peel-Harvey, shore-based scoopers were surveyed between December 1998 and April 1999. This is the time of year when legal size crabs are most abundant in the estuary (Potter *et al.*, 1983; 1998) and therefore available for scooping in shallow water. A survey of fishers from the bridges and jetties along the Mandurah entrance channel was conducted between November and April. There was little crabbing activity from these locations throughout the rest of the year due to the low abundance of crabs.

Periods of low fishing activity, such as during the night, could not be covered with the available resources. Anecdotal information obtained from Fisheries Officers and local recreational fishers suggested that, although night fishing occurred at certain times of year, the catch and fishing effort was insignificant and did not warrant special attention. The personal safety of interviewers at night was also a concern. The interviewers commenced work before fishers 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.

It was not feasible to include the catch and fishing effort for boats kept in canals or the usage of drop nets in the canal developments in the Peel-Harvey Estuary. The incidental night time catch by divers in the Swan-Canning estuary was not included either.

An interviewer worked one shift (morning or afternoon) on each of the scheduled survey days. We chose to divide the day into two shifts so that the interviewer would not have to work longer than 6 hours. From November to March shifts were 6 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.

For the Peel-Harvey, a roving creel survey of shore-based crabbers using wire scoop nets was conducted by the two survey interviewers from a small boat. The day was divided into 4.5 hour morning and afternoon shifts. Morning shifts were conducted randomly between 7am and 12:30pm while afternoon shifts were conducted randomly between 12:30pm and 6pm.

4.3 Sampling Design

Boat-based fishing - bus route method

The bus route method, where a survey interviewer visits all boat ramps in a pre-determined area on the one day, was used for boat-based fishing.

For the Peel-Harvey, two bus routes were set up (referred to as "eastern" and "western") to cover all major boat ramps in the Peel-Harvey Estuary. 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 crabbing patterns (Sumner, unpublished data). Prior information suggested that the boat ramps on the "western" bus route were more popular than those on the "eastern" bus route. More shifts were therefore allocated to the "western" ramps. 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 12 to 32, which is effectively six to 16 full days (Table 1).

Table 1: Monthly Allocation of Survey Shifts for Peel-Harvey Estuary

Month	Number of shifts		Total shifts
	East	West	
January	12	20	32
February	8	16	24
March	8	16	24
April	8	16	24
May	8	12	20
June	4	8	12
July	4	8	12
August	4	8	12
September	8	12	20
October	8	12	20
November	8	12	20
December	8	16	24

For the Swan-Canning, two bus routes were set up (referred to as "upper" and "lower") to cover all major boat ramps in the estuary. The number of shifts conducted per month depended upon the season. More shifts were allocated to the seasons where most effort

occurred, based on prior information on recreational crabbing patterns (Sumner, unpublished data). Prior information suggested that fishing effort varied seasonally between the upper and lower ramps. More shifts were therefore allocated to the area where most effort occurred. 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 eight to 22, which is effectively four to 11 full days (Table 2).

Table 2: Monthly Allocation of Survey Shifts for Swan-Canning Estuary

Month	Number of upper shifts	Number of lower shifts	Total number of shifts
January	12	10	22
February	10	8	18
March	8	8	16
April	6	8	14
May	6	6	12
June	4	4	8
July	4	4	8
August	4	4	8
September	4	6	10
October	4	6	10
November	6	8	14
December	8	8	16

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 interviewers followed a pre-determined schedule specifying the boat ramps to visit and the sampling time for each boat ramp. The route was chosen to minimise the distance travelled between boat ramps. 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 part way through the wait time at a ramp, although the probability of commencing at a ramp or travelling remained unchanged. On average, visits to each site were likely to occur over all daylight hours throughout 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 proportional to ramp use based on anecdotal information from fisheries officers and local fishers. This was revised after two months once data from the survey became available (Tables 3 and 4).

Table 3: Allocation of Time to Survey Ramps for Peel-Harvey Estuary

Area	Ramp	Prop. of Time	Area	Ramp	Prop. of Time
East	Nairns	0.2	West	Waterside	0.13
East	Riverview	0.13	West	Dolphin Pool	0.07
East	Furnissdale	0.25	West	Mary St Lagoon	0.08
East	North Yunderup	0.12	West	Novara	0.14
East	Murray Bend	0.04	West	Cobblers	0.01
East	Wharf Cove	0.12	West	East Port Marina	0.18
East	River Road	0.08	West	Dawesville South	0.29
East	Allambi	0.06	West	Park Ridge	0.10

Table 4: Allocation of Time to Survey Ramps for Swan-Canning Estuary

Area	Ramp	Prop. of Time	Area	Ramp	Prop. of Time
Upper	Royal Perth	0.27	Lower	Leeuwin	0.35
Upper	Qantas	0.14	Lower	Point Walter	0.35
Upper	Deepwater Point	0.27	Lower	Johnston Street	0.30
Upper	Cloister Avenue	0.05			
Upper	Coode Street	0.27			

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 and confirming that no recreational boats had been launched. On a small number of occasions, 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 were 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 3). 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 4). For boat-based fishers the catch was recorded at the completion of the day's fishing and represented the entire catch for the duration of the trip. The catch of crabs was counted, measured and where

possible the sex recorded. The carapace width (CW) from spine point to point was measured to the nearest millimetre.

Field staff were instructed, where possible, to measure all crabs that were seen during interviews. However, since it was more important to collect as much basic catch information from as many fishers as possible, when several boats returned to a ramp at the same time it was not always possible to measure all the crabs in the catch. When this happened, a random sample of the crabs kept were measured. A random sample, rather than all of the catch, was also measured when fishers were in a hurry to leave the ramp.

A simplified interview form was used to record the time spent fishing, catch and gear used by hire boats (Appendix 5).

Shore-based fishing - roving creel survey

A roving creel survey was used for the survey of shore-based crabbers. These included crabbers wading through shallow water with wire scoop nets or using drop nets from the bridges and jetties in the Mandurah entrance channel of the Peel-Harvey Estuary and lower reaches of the Swan River.

For the Peel-Harvey a small dinghy complete with outboard motor was used to count and interview crabbers wading with scoop nets to collect information on the time spent fishing and catch. The Coodanup, Peel-Harvey and Harvey areas were surveyed using the dinghy (Figure 1). The Dawesville Channel was not included in the survey. A separate interview form was used for shore-based crabbers (Appendix 6).

For the Swan-Canning, effort information for shore-based crabbers 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 schedule design allowed time for a small number of interviews between check points. This enabled shore-based fishers to be interviewed when encountered. The boat ramps were used as checkpoints along the route. Separate interviews of shore-based fishers were conducted. The interview questionnaire used for boat-based fishers (Appendix 4) was also used to record time spent fishing, catch and other information for shore-based fishers.

Anecdotal information suggested that most crabbing in the Swan-Canning Estuary occurred from jetties and bridges around dusk. For this reason, on the 'lower' bus route for the Swan Canning-Estuary, the survey of shore-based fishers was extended to include the catch and effort for fishers crabbing from jetties and bridges around dusk. At the conclusion of an afternoon shift on the lower bus route the interviewer visited each of the six jetties/bridges indicated in Figure 1. An instantaneous count of fishers was made on arrival at each bridge/jetty before interviews were undertaken using the interview questionnaire shown in Appendix 6.

4.4 Estimation of Total Catch and Effort for Boat-based Fishers

The fishing effort (boat hours) for a day was estimated from the counts of the number of trailers at the boat ramps. This was converted to fisher days by taking into account the average number of fishers per boat and average time spent fishing. Catch rates were estimated from information on the time spent fishing and catch obtained by interviewing fishers when they

returned to the boat ramp at the completion of the fishing trip. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in boat hours (Appendix 7).

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 crabbing activities. The trailer counts were multiplied by the proportion of boats used for recreational crabbing in the estuary.

Fishing effort by fishers from boats that were launched before the start of a morning shift (7:00am or 8:00am 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 7).

The whole weight of the catch, in tonnes, was estimated using the following carapace width (CW) (mm) to body weight (W) (g) relationships developed by Potter *et al.* (1983).

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

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

4.5 Estimation of Total Catch and Effort for Shore-based Fishers

For the Peel-Harvey, the hours of fishing effort for the day were calculated by multiplying the instantaneous counts by the average number of hours in the fishing day. For the Swan-Canning, the hours of fishing effort for the day were calculated by multiplying the progressive counts by the average number of hours in the fishing day. Catch rates were estimated from information on the time spent fishing and catch obtained by interviewing fishers while they were still fishing. The total catch was estimated by multiplying the catch rate by the estimate of fishing effort in fisher hours (Appendix 8).

The whole weight of the catch, in tonnes, was estimated from the length-weight relationships described in Section 4.4.

4.6 Collation of Historical Catch and Effort Data

Existing recreational shore and boat ramp survey data was collated to establish the recreational catch from (a) Geographe Bay, (b) Warnbro Sound, (c) Cockburn Sound.

Two studies that estimate the catch and effort of recreational marine boat (Sumner and Williamson 1999) and shore (Ayvazian, 1997) fishers have been undertaken in the south west region of Western Australia in recent years. Both studies were primarily concerned with marine finfish, although the incidental crab catch was recorded. The boat-based and shore-based catch for the Leschenault Estuary was estimated by a previous study (Malseed et al., 2000).

5. Results/Discussion

5.1 Peel-Harvey Estuary

During the survey 1,996 interviews were conducted at boat ramps. Of these, 1,136 boats had been crabbing and 136 angling in the estuary (43 were both crabbing and angling). A further 400 were fishing or diving in the ocean and 360 were not involved in any fishing activity.

The majority of the boat-based crabbers (57%) were residents from the greater Perth metropolitan region living within a 50 km radius of the city centre. However, more than a third of boat based fishers (36%) were local Mandurah residents living within a 20km radius of the Peel-Harvey Estuary (Figure 3).

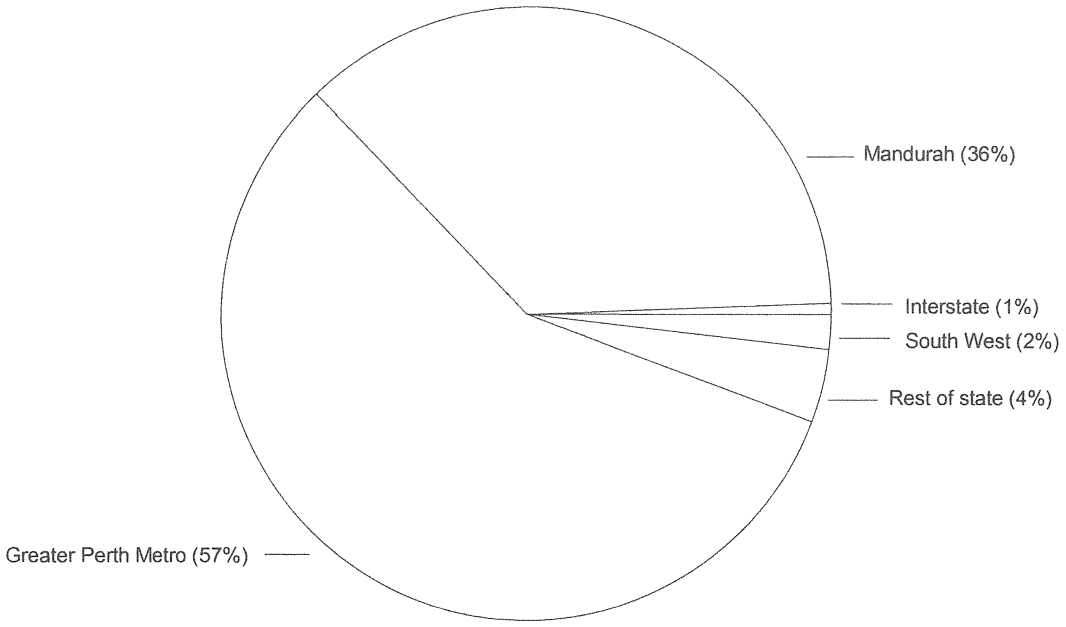

Figure 3: Boat-based crabbers' places of residence for Peel-Harvey Estuary

Blue swimmer crabs were the target species for 92% of recreational boat-based fishers interviewed in the Peel-Harvey Estuary. The remaining 8% of boat-based fishers targeted fish such as Australian herring, tailor and King George whiting.

In addition to the interviews at boat ramps, 595 shore-based fishing parties were interviewed at or in the near vicinity of the four major jetties/bridges along the main entrance to the Peel-Harvey Estuary. Of these groups, 397 were crabbing and 296 were angling (101 were both crabbing and angling).

A further 314 shore-based fishing parties targeting blue swimmer crabs with wire scoop nets were also interviewed.

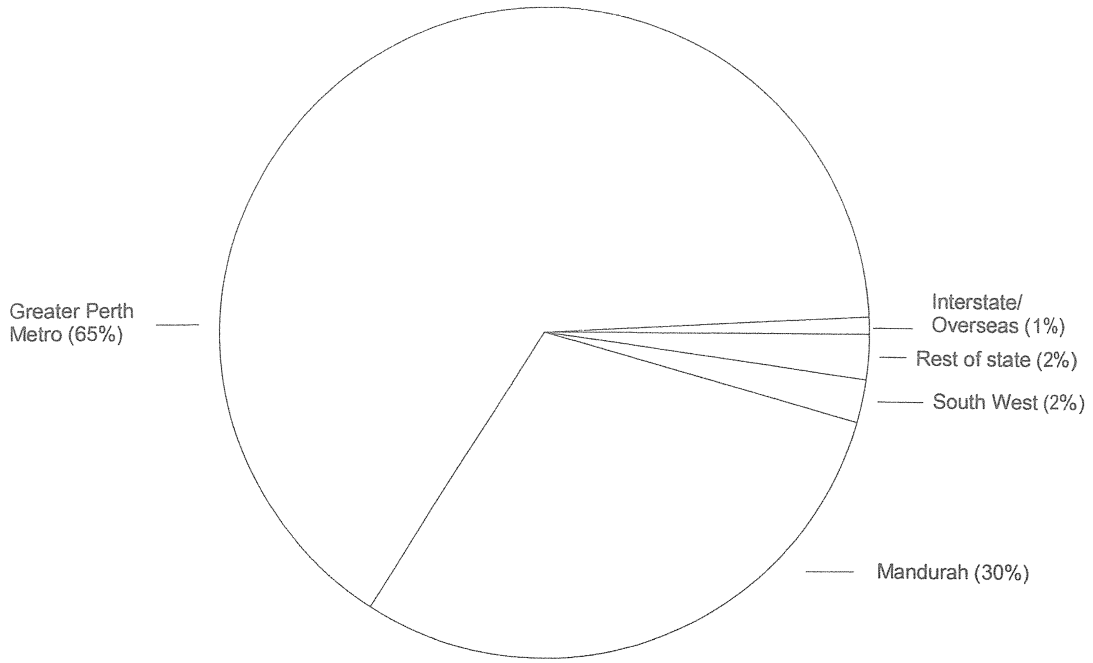

Figure 4: Shore-based crabbers' places of residence for Peel-Harvey Estuary

The majority of shore-based crabbers (65%) were residents of the greater Perth metropolitan area (Figure 4).

5.1.1 Recreational Effort

Boat-based effort

Results indicate that most fishing occurred during the two survey periods of the day referred to 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 (7:00am in spring, summer and autumn or 8:00am 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 5 and Appendix 7).

Table 5: 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	0.087	1.087
Autumn	0.044	1.044
Winter	0.078	1.078
Spring	0.026	1.026

Most boats had returned to the ramp before the end of an afternoon shift (7:00pm during January, February, March, November and December, 6:00pm during April, May, September and October and 5:00pm 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 two per ramp on average between November and March) (Figure 5).

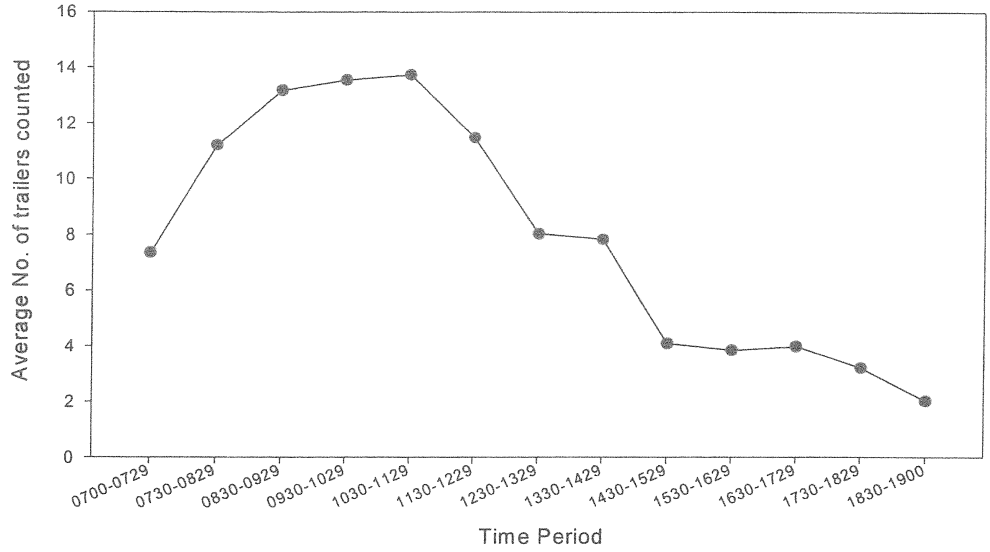

Figure 5: Average number of trailers counted on arrival/departure at all ramps

Boat-based Crabbing Effort

Most boat-based crabbers used drop nets to catch crabs, although a small number used scoop nets.

The recreational boat-based crabbing effort was greatest in summer with 72% of the annual crabbing effort occurring during this 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 6). The majority of boat-based crabbing took place from the western boat ramps (Figure 6).

The recreational crabbing effort varied from 3,214 fisher days during winter to 80,961 fisher days for summer (Figure 6).

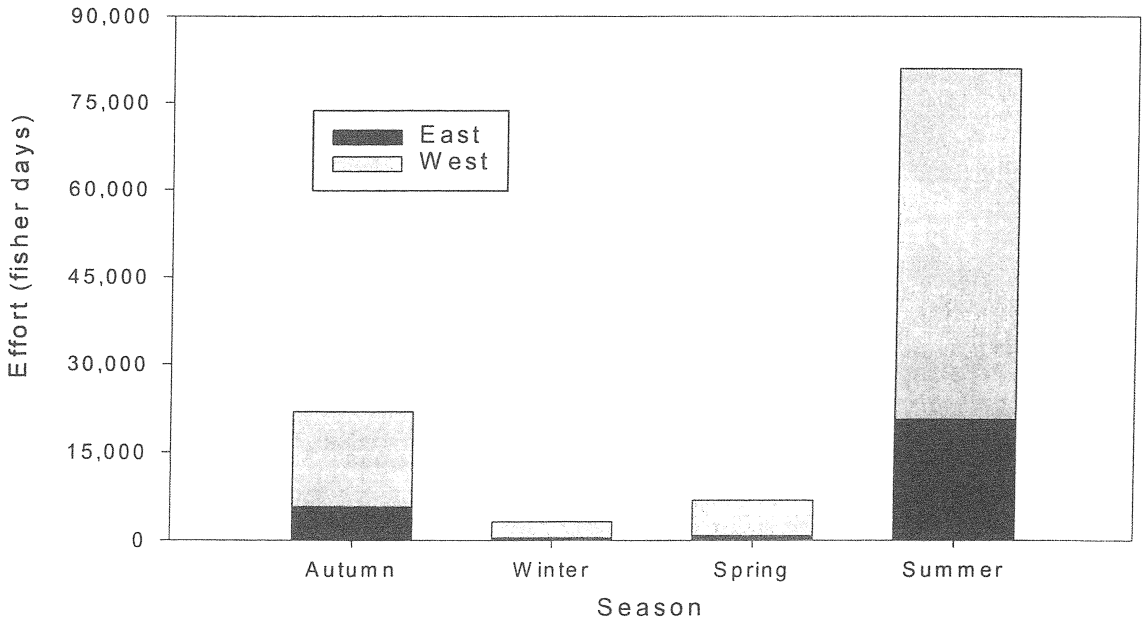

Figure 6: Recreational boat-based crabbing effort in Peel-Harvey Estuary

The estimated total annual recreational boat-based crabbing effort for the Peel-Harvey Estuary is 112,936 fisher days (123,383 boat hours). This effort does not include that of hire boats which contributed a further 2,087 boat hours of recreational crabbing effort over the 12 month period.

Shore-based Scooper Crabbing Effort

Shore-based scoopers were defined as those fishing from the shore wading through shallow water using wire scoop nets.

The effort was relatively similar for all three areas where shore-based crab scoopers were surveyed. The Peel-Harvey area had the most effort followed by the Coodanup and Harvey areas (Figure 7).

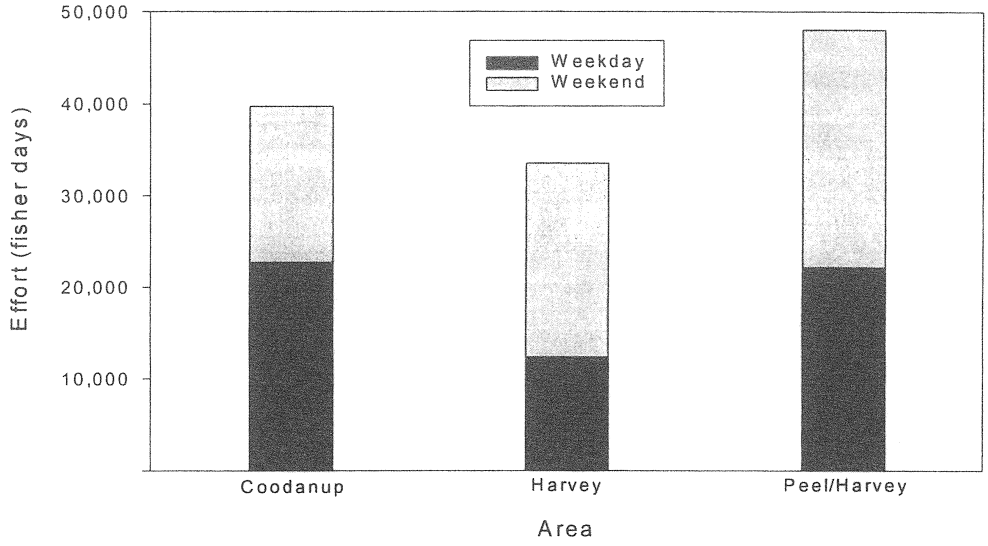

Figure 7: Recreational shore-based scooper crabbing effort in Peel-Harvey Estuary

The total fishing effort was similar for both weekdays and weekends (Figure 7).

It is estimated that the total annual recreational shore-based crab scooping effort for the Peel-Harvey Estuary is 121,323 fisher days (225,797 fisher hours).

Shore-based Bridge/Jetty Crabbing Effort

Shore-based crabbers on or in the near vicinity of bridges and jetties were defined as those fishing from the shore using either drop nets or scoop nets.

Mandurah quay was the most popular bridge/jetty location for shore based crabbers with an estimated annual fishing effort of 15,130 fisher days. The old traffic bridge and bypass bridge were also popular locations. The Mary Street area was the least popular with 2,635 fisher days (Figure 8).

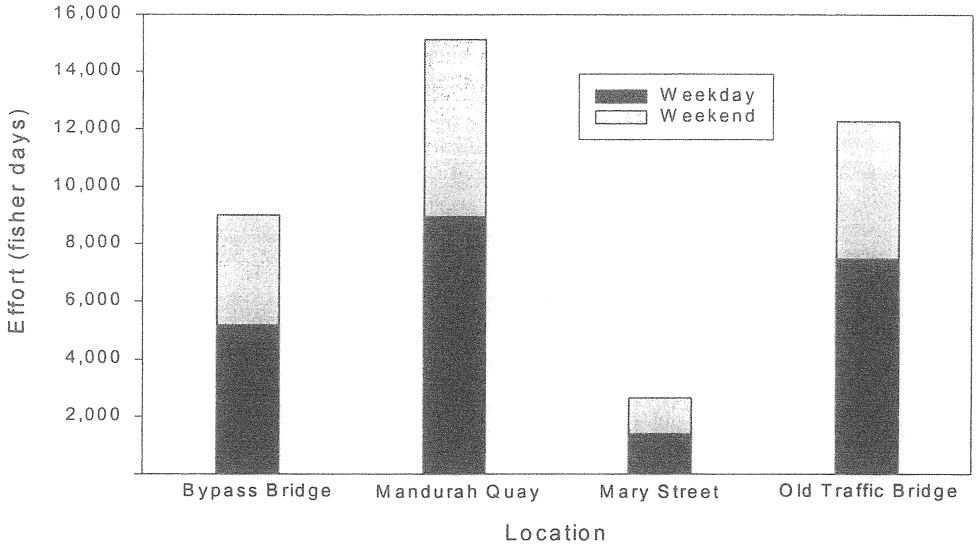

Figure 8: Recreational shore-based bridge/jetty crabbing effort in Peel-Harvey Estuary

Weekdays had a higher total fishing effort from shore-based crabbers on or in the near vicinity of bridges/jetties than weekends, due to the greater number of weekdays (Figure 8).

It is estimated that the total annual recreational shore-based crabbing effort from and in the near vicinity of the major jetties and bridges in the Peel-Harvey Estuary is 39,072 fisher days (90,058 fisher hours).

5.1.2 Recreational Catch

Size Frequency

The size frequency for blue swimmer crabs displayed in Figures 9 and 10 shows the carapace width (CW) range for crabs kept by boat and shore-based crabbers respectively.

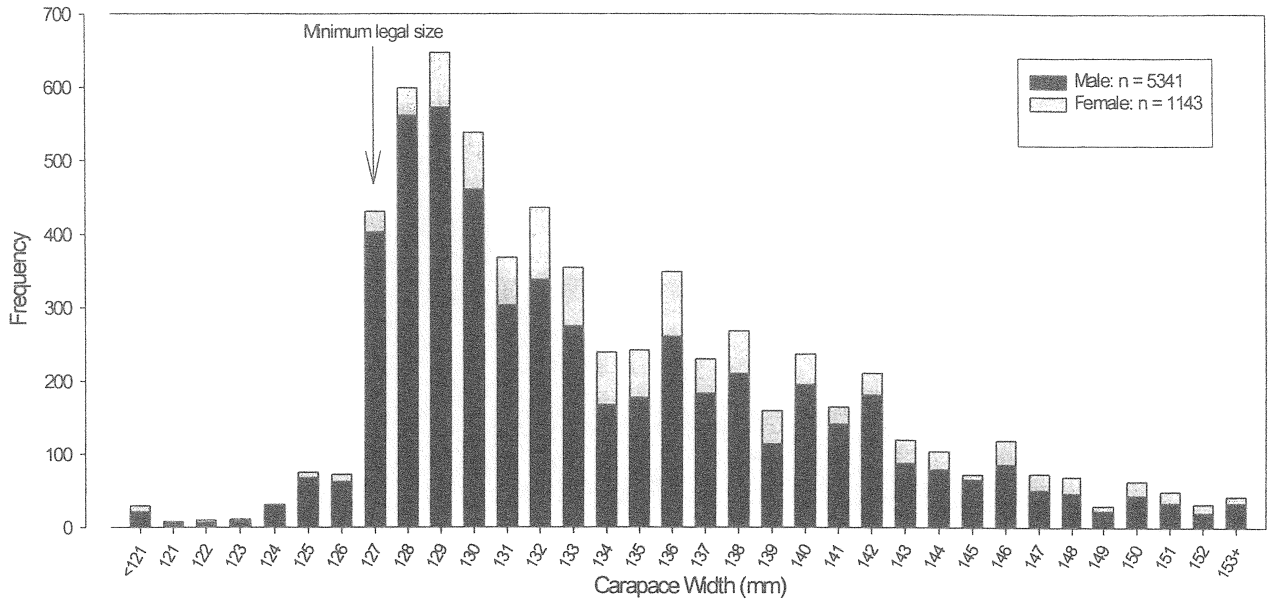

Figure 9: Size Frequency for blue swimmer crabs kept by boat-based fishers in Peel-Harvey Estuary

Approximately 50% of crabs kept by boat-based fishers have a CW between 127mm (minimum legal size) and 133mm. However, crabs as small as 98mm CW and as big as 172mm CW were kept by recreational boat-based crabbers. The distribution was similar for both male and female crabs (Figure 9), although the catch was predominantly males.

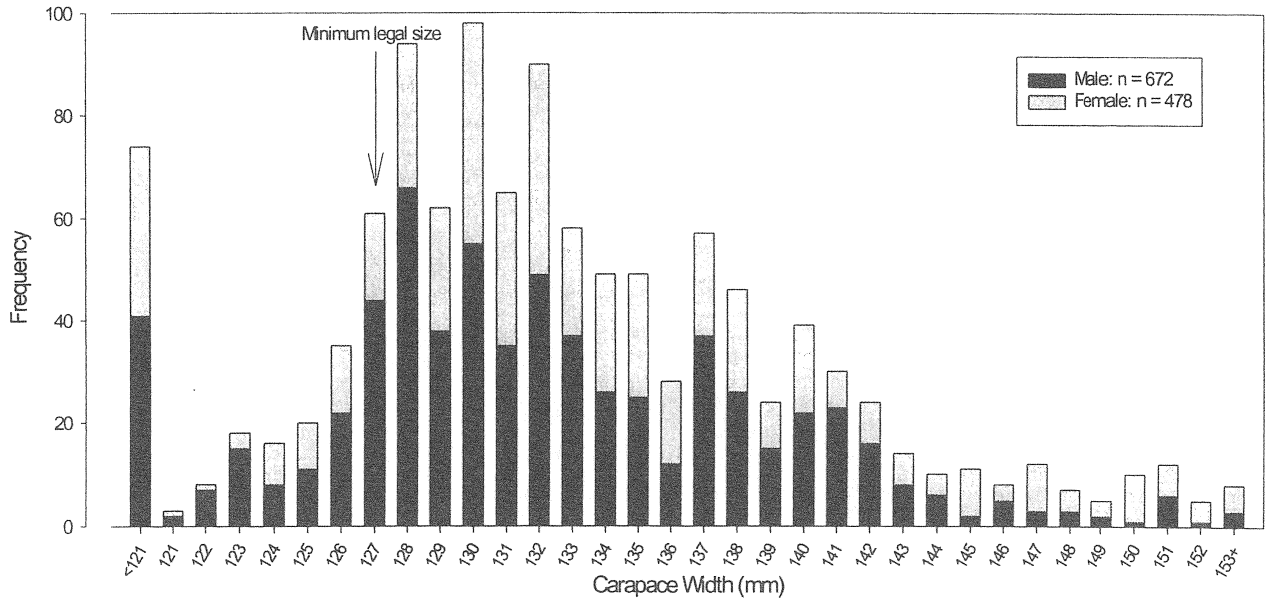

Figure 10: Size Frequency for blue swimmer crabs kept by shore-based fishers in Peel-Harvey Estuary

Approximately 50% of crabs kept by shore-based fishers have a CW between 127mm (minimum legal size) and 134mm. However, crabs as small as 93mm CW and as big as 154mm CW were kept by recreational shore-based crabbers. The distribution was similar for both male and female crabs (Figure 10).

Boat-based Catch

Of the crabs kept for which sex was recorded, 19,922 (90%) were males and 2,293 (10%) females. The sex of crabs released was also recorded where possible; of these 19,582 (78%) were males and 5,380 (22%) females.

Table 6: Estimated catch of blue swimmer crabs by recreational boat-based fishers in Peel-Harvey Estuary

	Trailer Boat	Standard Error	Hire Boat	Total
Number kept	823,742	32,582	8,222	831,964
Number released	956,406	34,146	10,492	966,898
Weight kept (tonnes)	179.9	6.5	1.8	181.7
Catch rate (crabs/boat/hour)	5.93	0.19	3.94	
Catch rate (crabs/net/trip)	2.22	0.05		
Catch rate (crabs/boat/trip)	19.54	0.40		

An estimated 823,742 crabs were kept (85,025 females and 738,717 males) and 956,406 released (206,132 females and 750,274 males) by trailer boat-based crabbers (Table 6). 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 32,582. 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).

Census information on catch and fishing effort was provided by the four hire boat companies operating in the estuary (Table 6). This includes small power boats and houseboats.

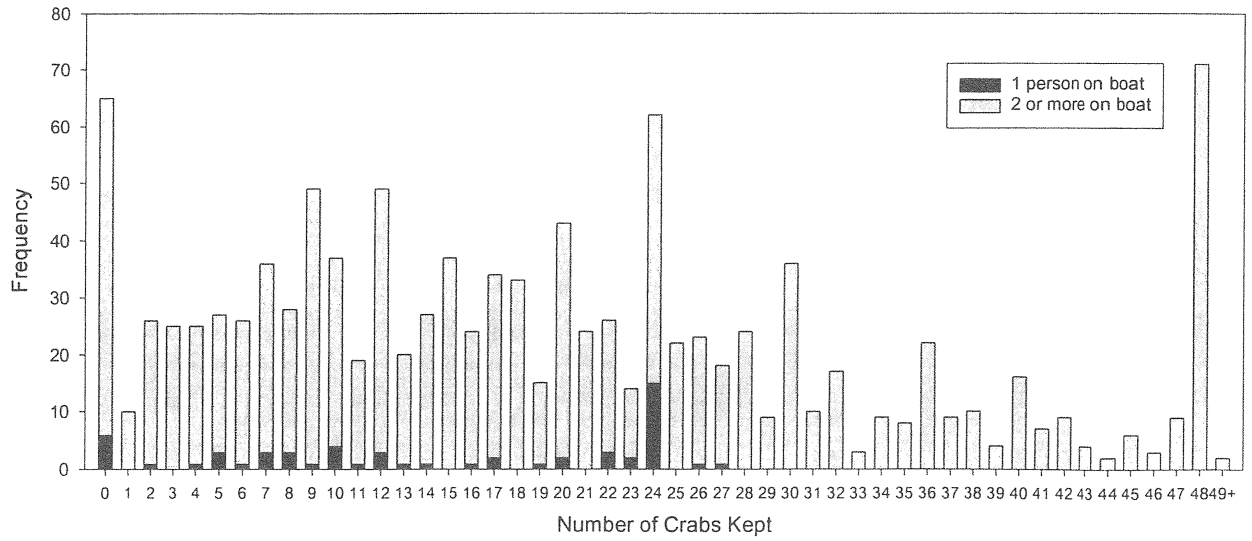

Figure 11: Frequency of crabs kept per boat in Peel-Harvey Estuary

Only 7% of boats with two or more on board achieved or exceeded the boat limit of 48 crabs. However, 30% of boats with only one person on board achieved or exceeded the bag limit of 24 crabs. Six percent of boats targeting crabs did not keep any crabs at all (Figure 11).

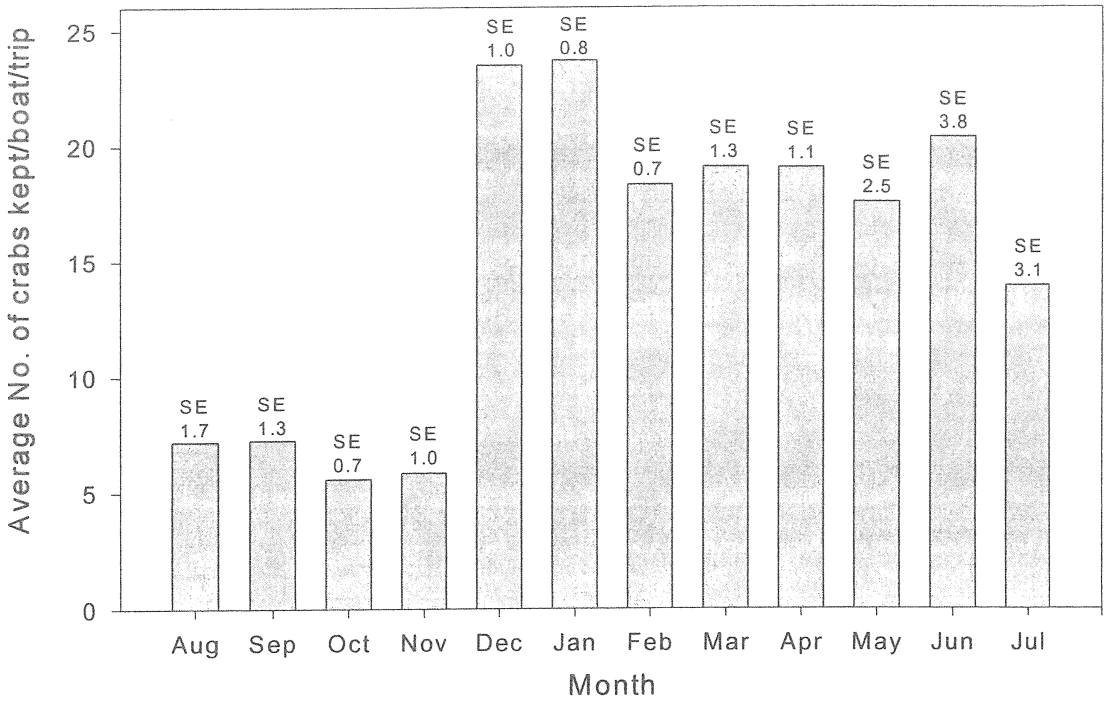

Figure 12: Crab catch rates per month for boat-based fishers in Peel-Harvey Estuary

Catch rates peaked at just over 23 crabs per boat per trip during December and January. Catch rates were slightly lower but steady at between 17 and 20 crabs per boat per trip from February to June. Catch rates then fell away to less than 6 crabs per boat per trip during October and November before peaking in December (Figure 12).

Most (75%) of the recreational crab catch taken by boat-based fishers occurred in the summer months, 19% was caught during autumn and only 6% of the catch was taken during winter and spring (Figure 13).

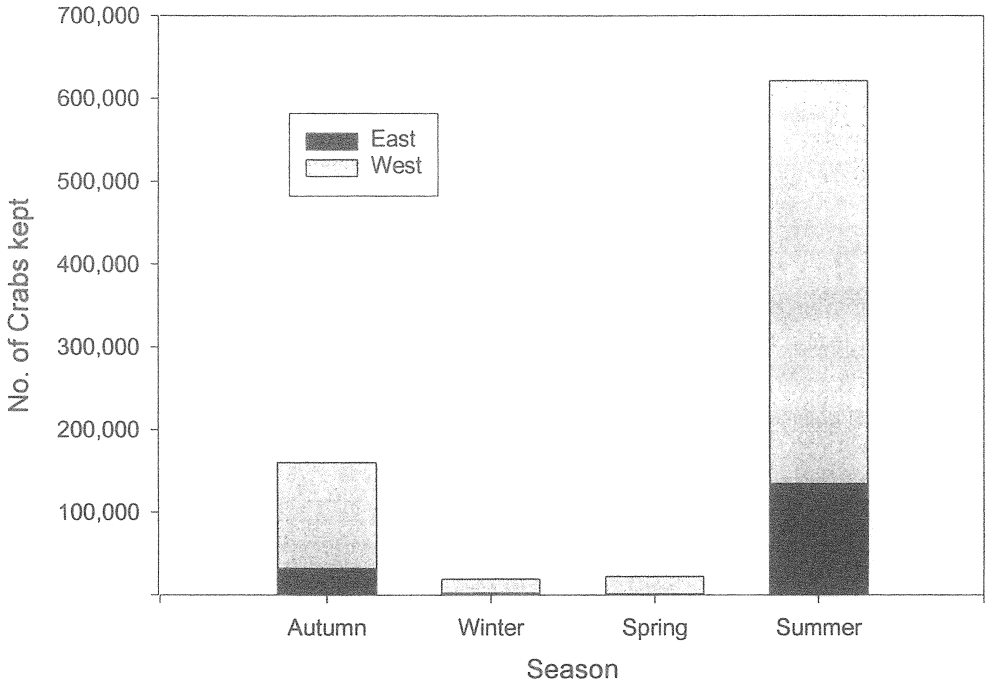

Figure 13: Estimated number of crabs kept per season from Peel-Harvey Estuary

The majority of crabs kept were from boats launched from the western boat ramps (Figure 13).

Female crabs comprised 26% of the crabs kept during autumn but only 5% of the crabs kept during summer. However, of the crabs released, a similar proportion were females during both summer (23%) and autumn (19%) (Figure 14).

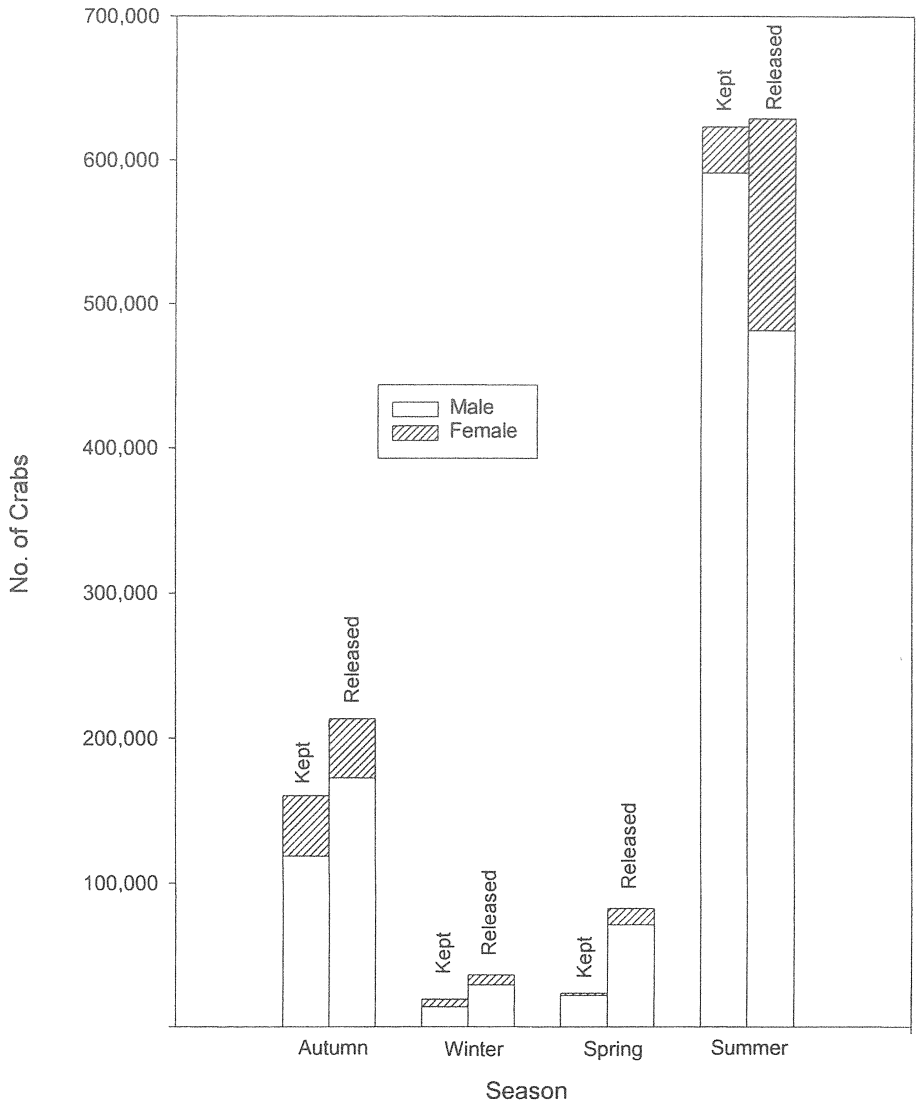

Figure 14: Estimated number of crabs kept and released per season by boat-based crabbers in Peel-Harvey Estuary

During autumn for every crab kept by recreational boat-based crabbers there were 1.3 crabs released. However, during summer there was an equal proportion of crabs kept and released (Figure 14).

The total annual weight of crabs kept by recreational trailer boat and hire boat-based crabbers in the Peel-Harvey Estuary was estimated to be 181.7 tonnes (164.7 tonnes of males and 17 tonnes of females) (Table 6).

Shore-based Scooper Catch

Of the crabs kept for which sex was recorded, 1190 (60%) were males and 796 (40%) females. The sex of crabs released was also recorded where possible; of these 739 (61%) were males and 479 (39%) females.

Table 7: Estimated catch of blue swimmer crabs by recreational shore-based scoopers in Peel-Harvey Estuary

	Total	Standard Error
Number kept	445,291	53,045
Number released	302,508	39,834
Weight kept (tonnes)	89.9	7.8
Catch rate (crabs/person/trip)	3.95	0.35
Catch rate (crabs/person/hour)	1.93	0.21
Catch rate (crabs/party/trip)	13.00	1.03

An estimated 445,291 crabs were kept and 302,508 released by shore-based scoopers (Table 7).

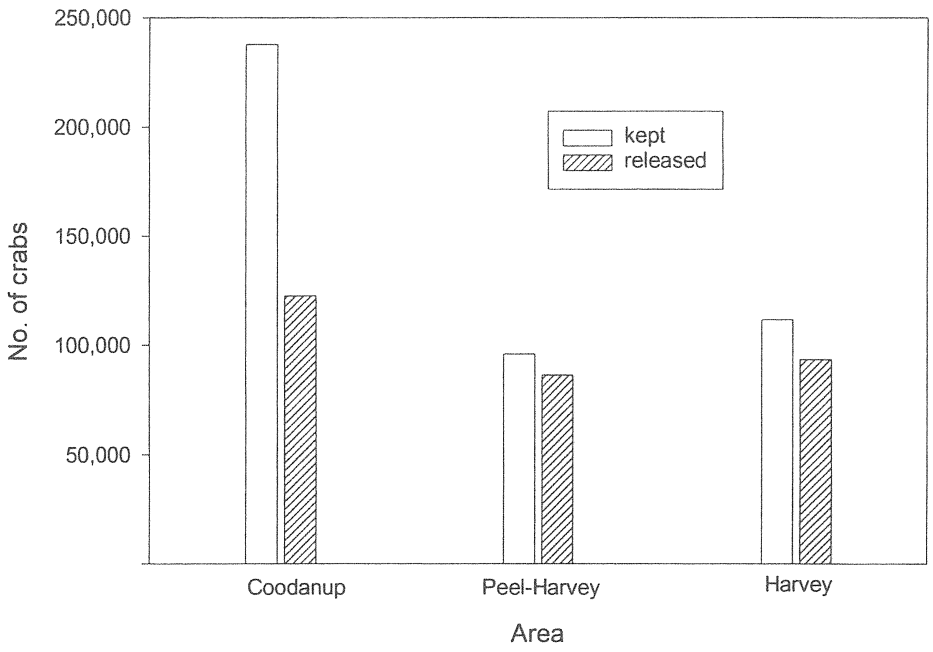

Figure 15: Estimated number of crabs kept and released per area by shore-based scoopers in Peel-Havey Estuary

Over half (53%) of the crabs kept by shore-based scoopers were caught at Coodanup (Figure 15). At Coodanup there were 0.52 crabs released for every one kept. In the other areas there were similar numbers of crabs both kept and released (Figure 15).

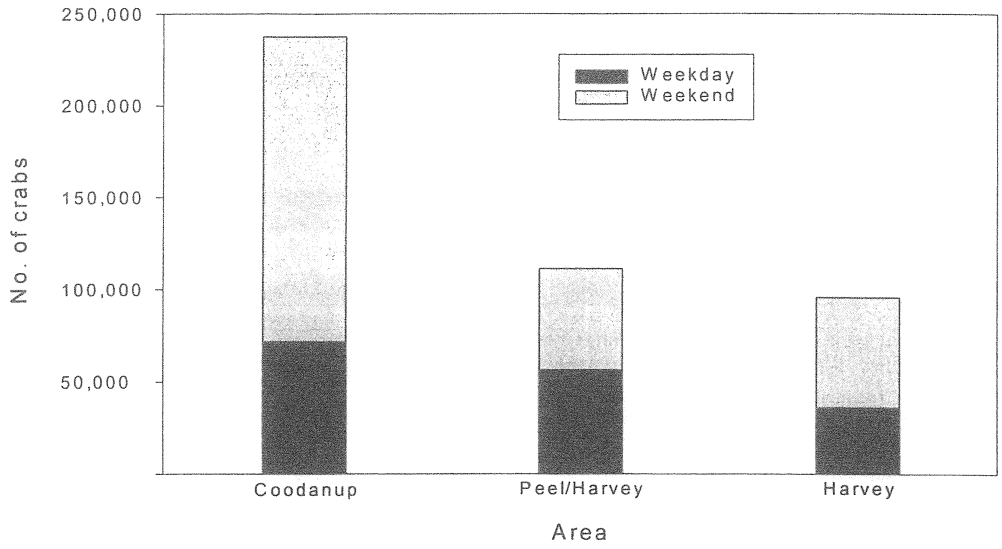

Figure 16: Estimated number of crabs kept per area on weekday/weekend by shore-based scoopers in Peel-Harvey Estuary

Despite the greater number of weekdays, 70% of crabs kept at Coodanup were caught on weekends. There were also more crabs caught on weekends (62%) in the bottom of the Harvey. A similar number of crabs were caught on weekdays and weekends in the Peel-Harvey area (Figure 16).

The total annual weight of crabs kept by recreational shore-based scoopers in the Peel-Harvey Estuary was estimated to be 89.9 tonnes (56.4 tonnes of males and 33.5 tonnes of females) (Table 7).

Shore-based Bridge/Jetty Catch

Of the crabs kept for which sex was recorded, 885 (65%) were males and 484 (35%) females. The sex of crabs released was also recorded where possible; of these 867 (57%) were males and 642 (43%) females.

Table 8: Estimated catch of blue swimmer crabs by recreational shore-based bridge/jetty fishers in Peel-Harvey Estuary

	Total	Standard Error
Number kept	82,994	8,005
Number released	96,967	10,801
Weight kept (tonnes)	17.0	1.2
Catch rate (crabs/person/trip)	1.60	0.14
Catch rate (crabs/person/hour)	0.57	0.06
Catch rate (crabs/party/trip)	6.75	0.49

An estimated 82,994 crabs were kept and 96,967 released by shore-based crabbers from bridges and jetties (Table 8).

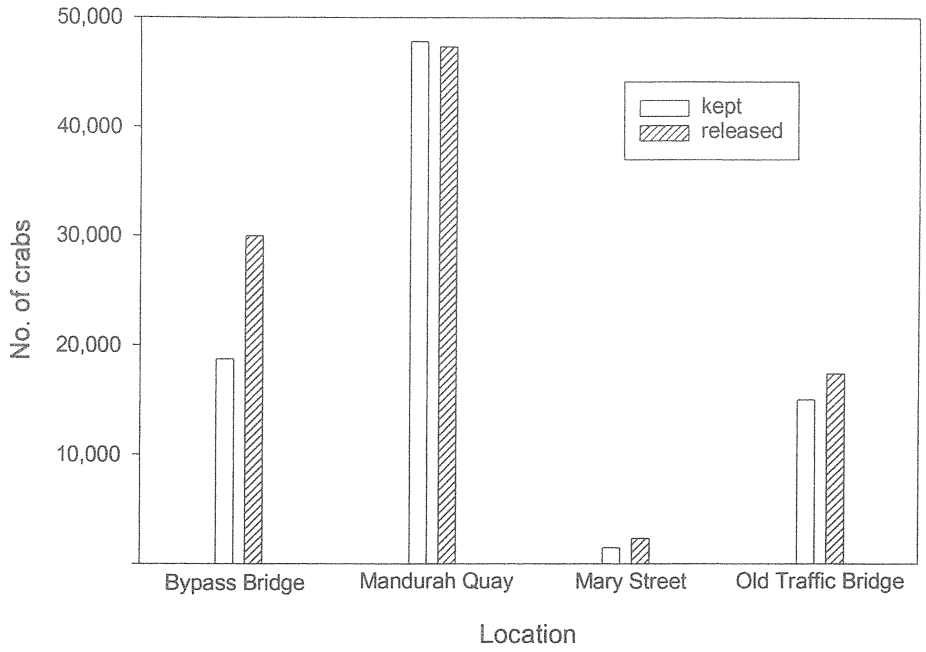

Figure 17: Estimated number of crabs kept and released per season by shore-based crabbers in Peel-Harvey Estuary

Over half (58%) of the crabs kept by shore-based crabbers from and in the close vicinity of the major bridges and jetties were caught at Mandurah Quay (Figure 17). Similar numbers of crabs were kept and released from all locations except for the bypass bridge where there were 1.6 crabs released for each one kept (Figure 17).

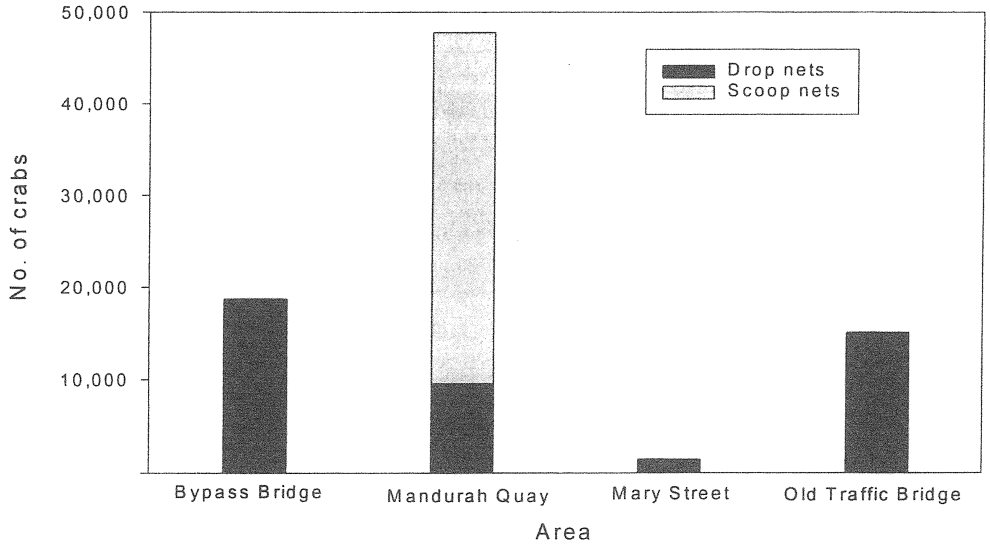

Figure 18: Estimated number of crabs kept per area by drop nets and scoop nets in Peel-Harvey Estuary

The majority of the Mandurah Quay catch was made by people scooping in the near vicinity of the quay. In all other areas the catch by scoopers was negligible (Figure 18).

The total annual weight of crabs kept by recreational shore-based crabbers from bridges and jetties in the Peel-Harvey Estuary was estimated to be 17.0 tonnes (11.6 tonnes of males and 5.4 tonnes of females) (Table 8).

Total Catch of Blue Swimmer Crabs

The total recreational harvest of blue swimmer crabs from the Peel-Harvey Estuary between August 1998 and July 1999 is estimated to have been 1,360,249 crabs (or 288.6 tonnes). It is also estimated that 1,366,373 crabs were released by recreational fishers over this same period (Table 9).

Table 9: Estimated total recreational catch of blue swimmer crabs from Peel-Harvey Estuary

	Boat	Scoopers	Jetties	Total	Standard Error
Number kept	831,964	445,291	82,994	1,360,249	62,765
Number released	966,898	302,508	96,967	1,366,373	53,566
Weight Kept (tonnes)	181.7	89.9	17.0	288.6	10.2

5.1.3 Commercial Catch and Effort

During 1998-99 the Peel-Harvey commercial blue swimmer crab catch (Penn, 1999), of 65.5 tonnes, was 23% of the recreational catch and 18% of the combined catch. The crabbing effort was 1,577 boat days during this period.

The annual commercial crab catch between 1991-92 and 1998-99 ranged from a high of 83.2 tonnes in 1996-97 to only 11.2 tonnes in 1992-93 (Figure 19). The mean annual crab catch for these years was 46.2 tonnes. The annual crabbing effort in boat days per year ranged from 1,702 days in 1997-98 to 714 days in 1991-92 (Figure 19).

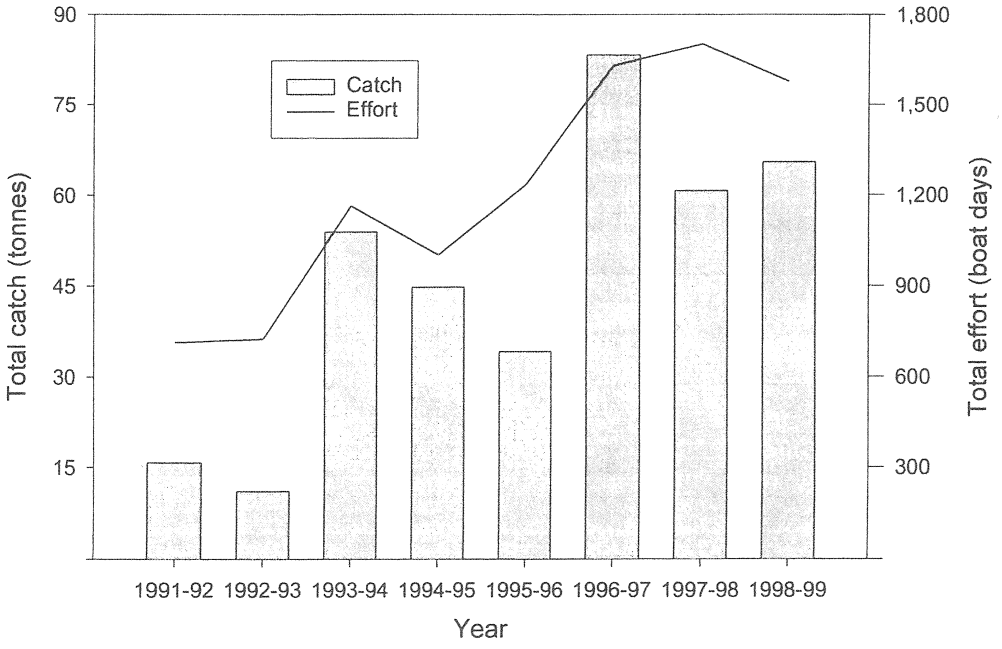

Figure 19: Annual commercial catch and effort for blue swimmer crabs in the Peel-Harvey Estuary (1991-92 to1998-99)

5.2 Swan-Canning Estuary

During the survey 1,302 interviews were conducted at boat ramps. The majority of these (61%) were not involved in fishing or crabbing activities, with a further 18% fishing in the adjacent ocean. Of the remainder, 139 boats had been crabbing and 154 angling in the estuary (29 were both crabbing and angling).

Blue swimmer crabs were targeted by 53% of recreational boat-based fishers interviewed in the Swan-Canning Estuary. Boat-based fishers also targeted fish species such as tailor, black bream and flathead.

In addition to the interviews at boat ramps, 378 shore-based fishing parties were interviewed. Thirty seven of these groups were crabbing and 374 were angling (33 were both crabbing and angling).

5.2.1 Recreational Effort

Boat-based Crabbing Effort

Boat-based crabbers used drop nets to catch crabs. No boat-based divers targeting crabs were recorded.

The recreational boat-based crabbing effort was greatest in summer with 63% of the annual crabbing effort occurring during this 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 20). The majority of boat-based crabbing took place from the lower boat ramps, although during summer more of the crabbing effort (57%) was from the upper boat ramps. Very few people went crabbing from the upper boat ramps during the remainder of the year (Figure 20).

The recreational crabbing effort varied from 455 fisher days during winter to 5,209 fisher days for summer (Figure 20).

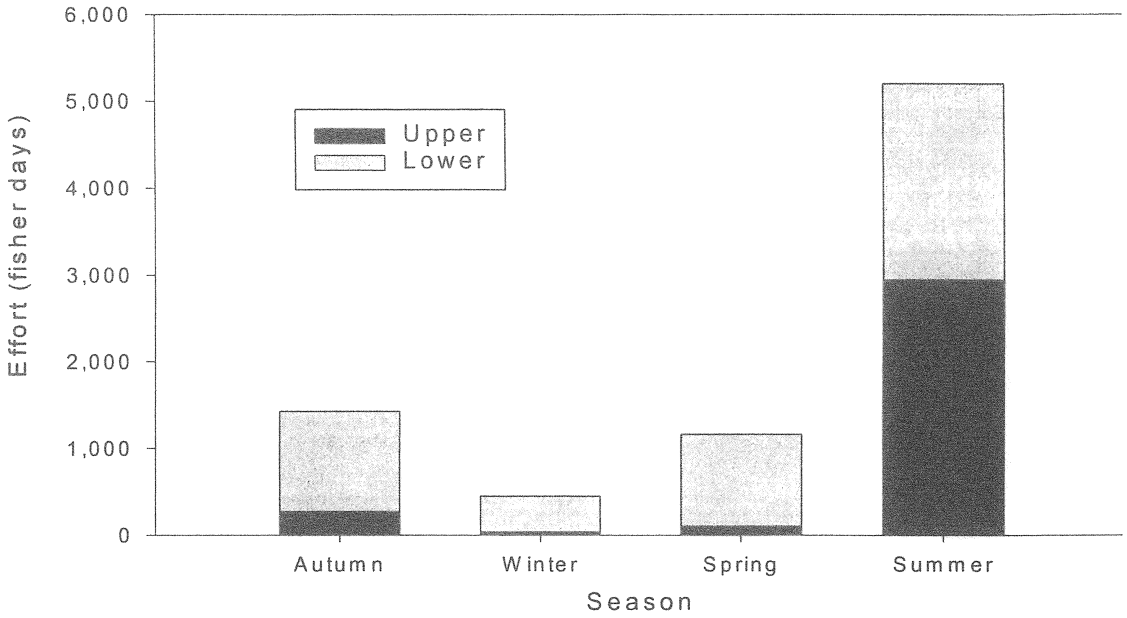

Figure 20: Recreational boat-based crabbing effort in Swan-Canning Estuary

The estimated total annual recreational boat-based crabbing effort for the Swan-Canning Estuary is 8,258 fisher days (15,402 boat hours).

Shore-based Crabbing Effort

All shore-based crabbers encountered were fishing from jetties and bridges using drop nets. No shore-based crabbers with scoop nets or divers targeting crabs were recorded.

The majority of shore-based crabbing (52%) took place in spring, with a total of 382 fisher days. There was a similar amount of effort in both autumn and summer and no shore-based crabbing recorded during winter (Figure 21).

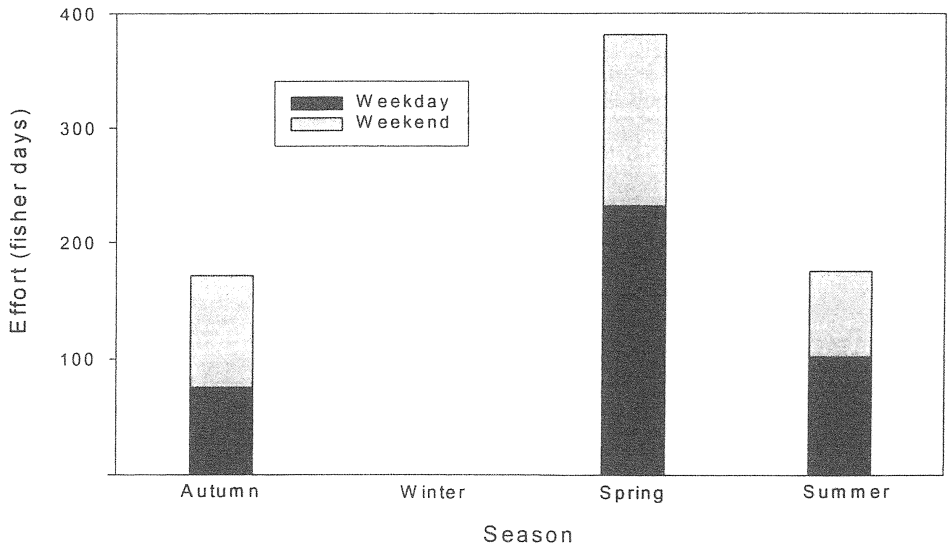

Figure 21: Recreational shore-based crabbing effort in Swan-Canning Estuary

It is estimated that the total annual recreational shore-based crabbing effort for the Swan-Canning Estuary is 728 fisher days (1,583 fisher hours).

5.2.2 Recreational Catch

Size Frequency

The size frequency for blue swimmer crabs displayed in Figure 22 shows the carapace width (CW) range for crabs kept by both boat and shore-based crabbers.

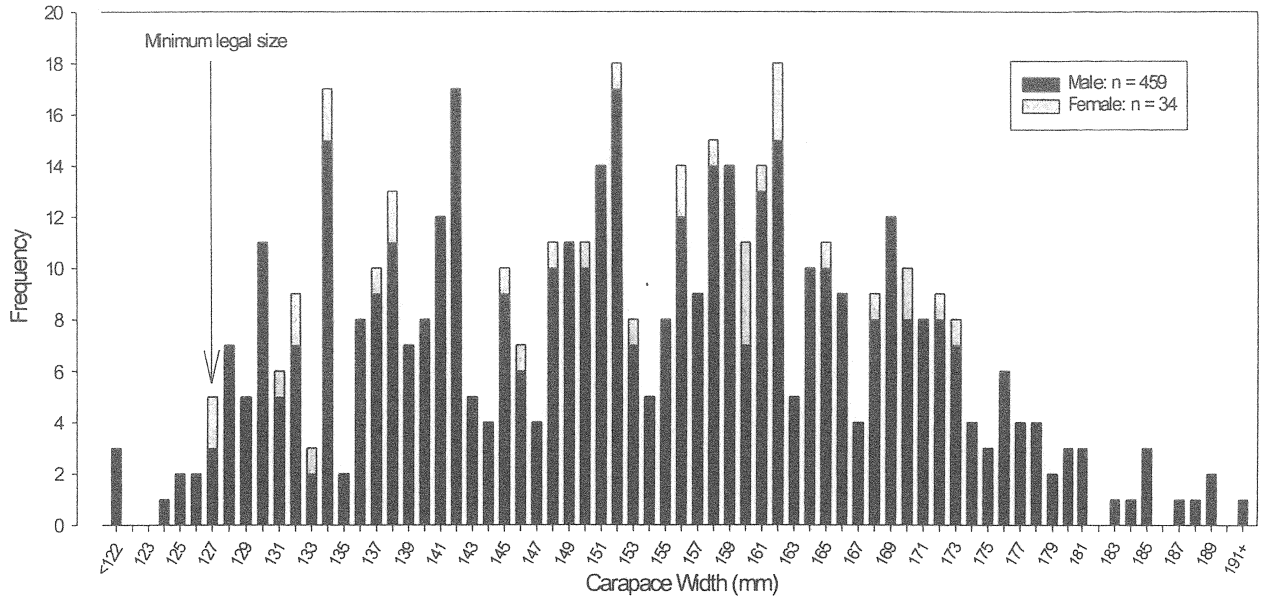

Figure 22: Size frequency for blue swimmer crabs kept from Swan-Canning Estuary

There was a relatively even distribution of crabs from the legal size of 127mm up to 173mm. Crabs as small as 120mm CW and as big as 194mm CW were kept by recreational crabbers. No female crabs larger than 173mm were recorded (Figure 22).

Boat-based Catch

Of the crabs kept for which sex was recorded, 745 (95%) were males and 40 (5%) females. The sex of crabs released was also recorded where possible; of these 265 (70%) were males and 112 (30%) females.

Table 10: Estimated catch of blue swimmer crabs by recreational boat-based fishers in Swan-Canning Estuary

	Total	Standard Error
Number kept	20,176	1,674
Number released	9,952	1,296
Weight kept (tonnes)	7.1	565
Catch rate (crabs/boat/hour)	1.36	0.19
Catch rate (crabs/net/trip)	0.68	0.08
Catch rate (crabs/boat/trip)	5.86	0.71

An estimated 20,176 crabs were kept (1,028 females and 19,148 males) and 9,952 released (2,957 females and 6,995 males) by boat-based crabbers during 1998 (Table 10). 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 1,674.

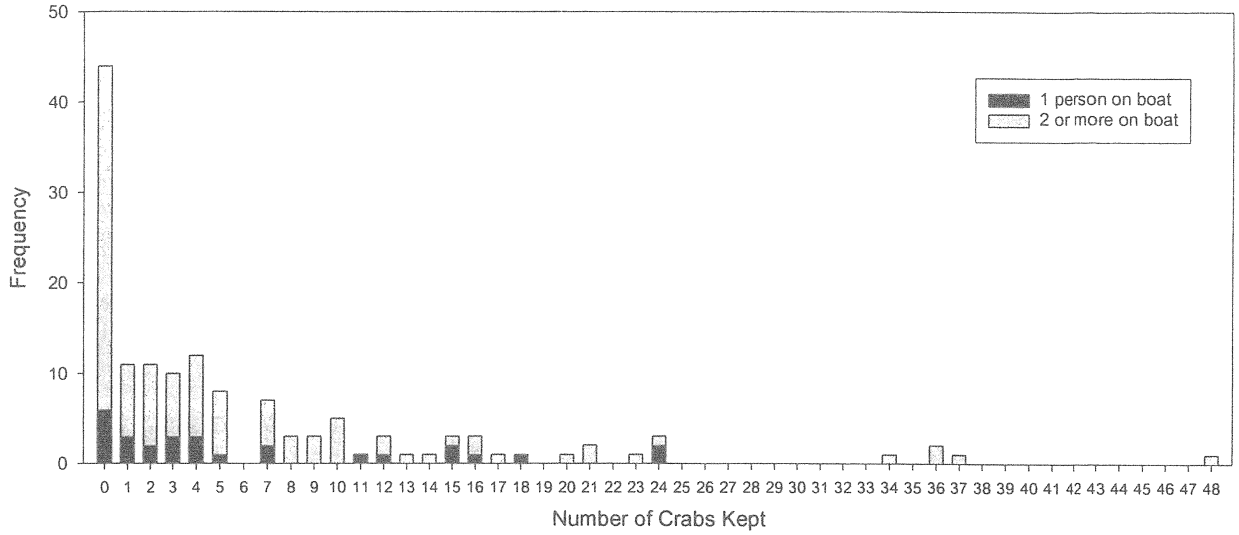

Figure 23: Frequency of crabs kept per boat in Swan-Canning Estuary

Only one of the 112 boats interviewed with two or more on board achieved the boat limit of 48 crabs. However, two of the 28 boats with only one person on board achieved the daily bag limit of 24 crabs. The majority of boats targeting crabs (69%) caught five or less crabs, with 31% of boats not keeping any crabs at all (Figure 23).

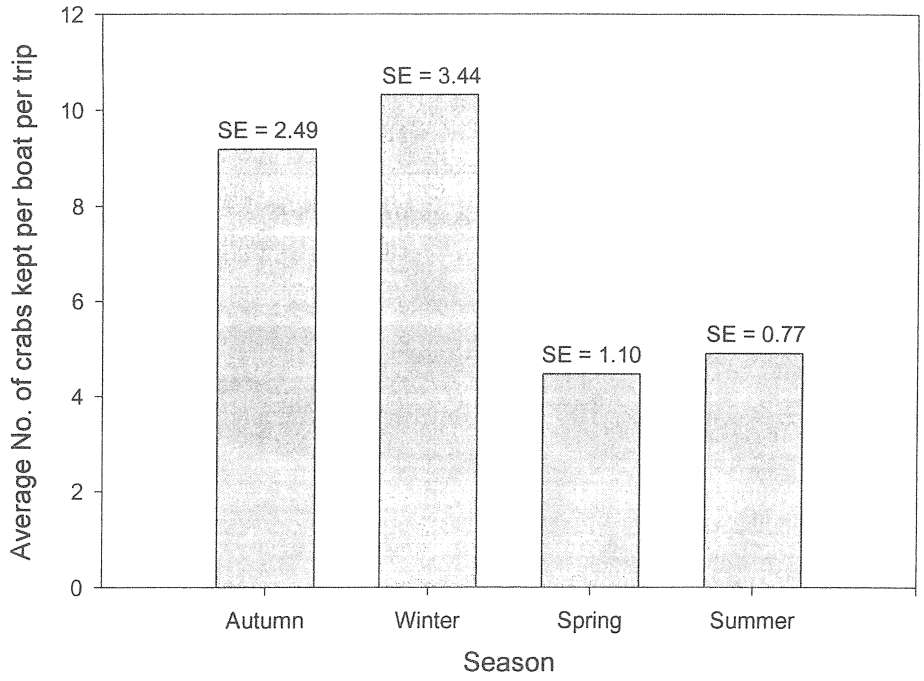

Figure 24: Crab catch rates per season for boat-based fishers in Swan-Canning Estuary

Catch rates peaked at 10.3 crabs per boat per trip during winter. During summer when the majority of effort occurred, the catch rate was only 4.9 crabs per boat per trip (Figure 24).

Most (44%) of the recreational crab catch made by boat-based fishers was made in the summer months, 31% was caught during autumn, 13% in winter and 12% during spring (Figure 24).

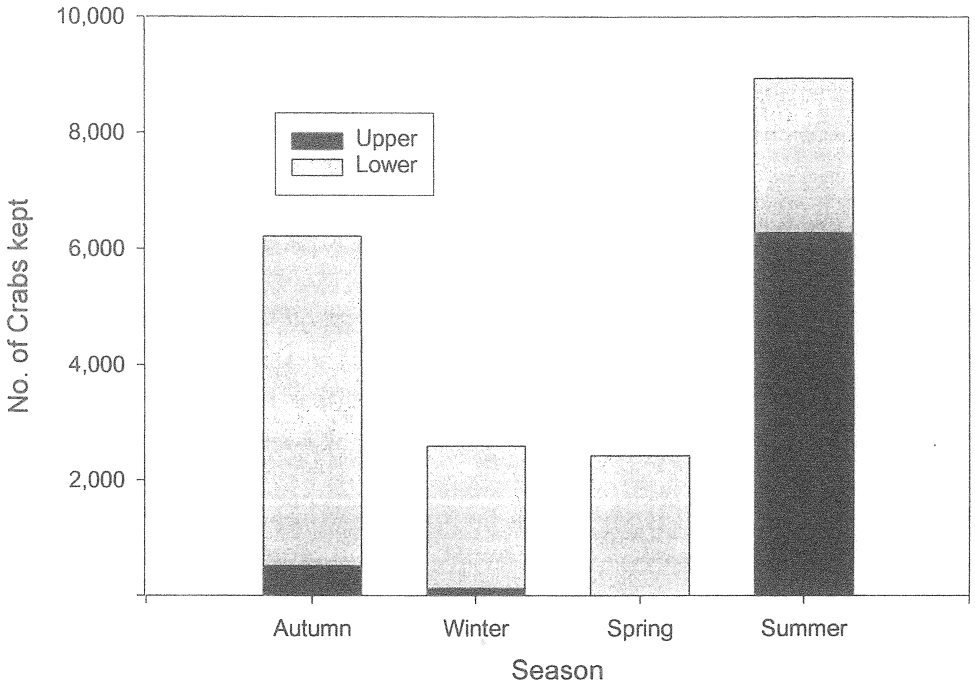

Figure 25: Estimated number of crabs kept per ramp per season from Swan-Canning Estuary

The majority of crabs kept were from boats launched from the boat ramps in the lower reaches of the Swan River. Almost all crabs were landed from the lower boat ramps during autumn, winter and spring. However, in accordance with the effort most crabs were landed at the upper ramps during summer (Figure 25).

Female crabs comprised 26% of the crabs kept during winter but less than 10% of the crabs kept during summer, autumn and spring. However, of the crabs released, 55% were females during winter and around 30% were females during summer, autumn and spring (Figure 26).

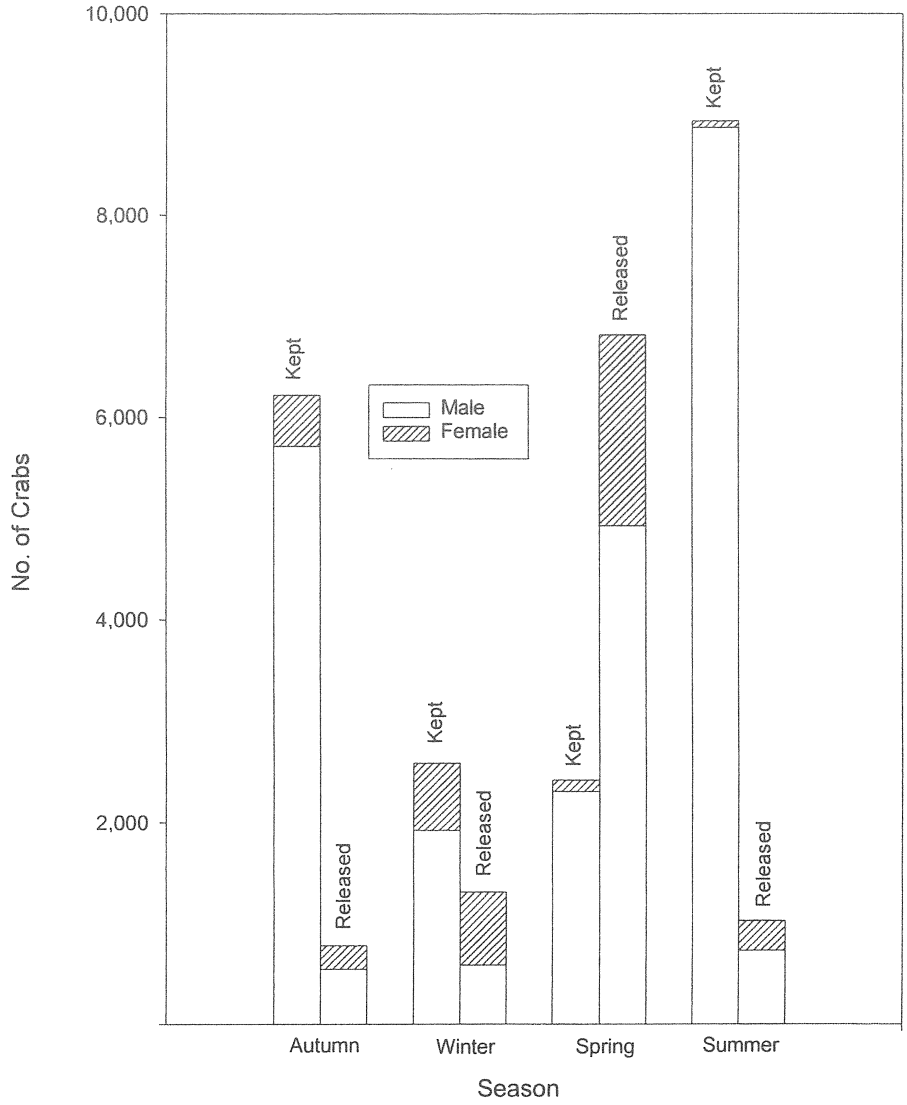

Figure 26: Estimated number of crabs kept and released per season by boat-based crabbers in Swan-Canning Estuary

During autumn and summer for every crab released by recreational boat-based crabbers there were eight crabs kept. However, during spring there were almost three crabs released for each one kept (Figure 26).

The total annual weight of crabs kept by recreational boat-based crabbers in the Swan-Canning Estuary was estimated to be 7.1 tonnes (6.8 tonnes of males and 0.3 tonnes of females) (Table 10).

Shore-based Catch

Of the crabs kept for which sex was recorded, 20 (65%) were males and 11 (35%) females. The sex of crabs released was also recorded where possible; of these 21 (46%) were males and 25 (54%) females.

Table 11: Estimated catch of blue swimmer crabs by recreational shore-based fishers in Swan-Canning Estuary

	Total	Standard Error
Number kept	699	166
Number released	651	111
Weight kept (tonnes)	0.19	0.04
Catch rate (crabs/person/trip)	0.57	0.19
Catch rate (crabs/person/hour)	0.27	0.10
Catch rate (crabs/party/trip)	1.57	0.51

An estimated 699 crabs were kept and 651 released by shore-based crabbers (Table 11).

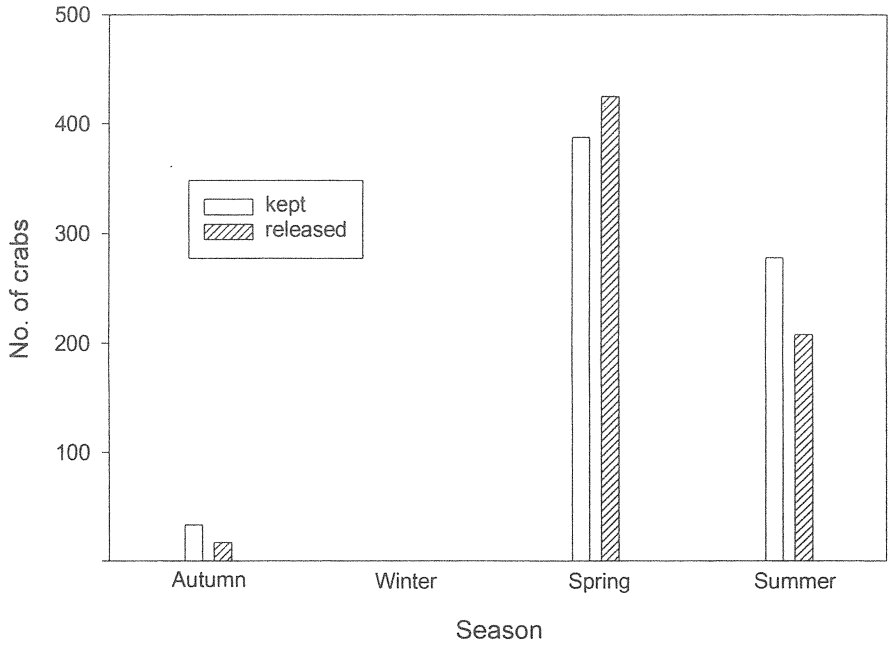

Figure 27: Estimated number of crabs kept and released per season by shore-based crabbers in Swan-Canning Estuary

Most (56%) of the crabs kept by shore-based crabbers were caught in spring (Figure 27). A further 40% of the catch was made in summer. During both spring and summer there were similar numbers of crabs kept and released. Very few crabs were caught in autumn and no crabs were recorded during winter (Figure 27).

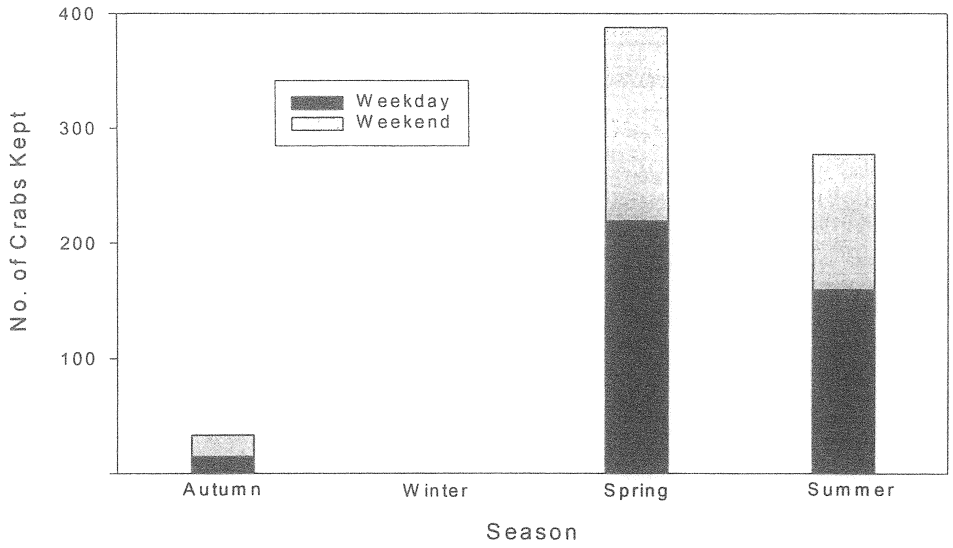

Figure 28: Estimated number of crabs kept per season on weekday/weekend by shore-based fishers in Swan-Canning Estuary

A similar proportion of the crabs kept by shore-based fishers were caught on weekdays and weekends (Figure 28).

The total annual weight of crabs kept by recreational shore-based crabbers in the Swan-Canning Estuary was estimated to be 0.19 tonnes (0.13 tonnes of males and 0.06 tonnes of females) (Table 11).

Total Recreational Catch of Blue Swimmer Crabs

The total recreational harvest of blue swimmer crabs from the Swan-Canning Estuary during 1998-99 is estimated to have been 20,875 crabs (or 7.3 tonnes). It is also estimated that 10,603 crabs were released by recreational fishers during the 12 month period (Table 12).

Table 12: Estimated total recreational catch of blue swimmer crabs from Swan-Canning Estuary

	Boat	Shore	Total	Standard Error
Number kept	20,176	699	20,875	1,682
Number released	9,952	651	10,603	1,301
Weight kept (tonnes)	7.1	0.2	7.3	0.6

5.2.3 Commercial Catch and Effort

During 1998-99 the commercial blue swimmer crab catch, of 24.0 tonnes, was more than three times the recreational catch. The commercial crabbing effort was 557 boat days during this period.

The annual commercial crab catch between 1991-92 and 1998-99 ranged from 30.6 tonnes in 1997-98 to only 8.6 tonnes in 1991-92 (Figure 29). The mean annual crab catch for these years was 18.8 tonnes. The annual crabbing effort in boat days per year ranged from 825 days in 1997-98 to 492 days in 1993-94 (Figure 29).

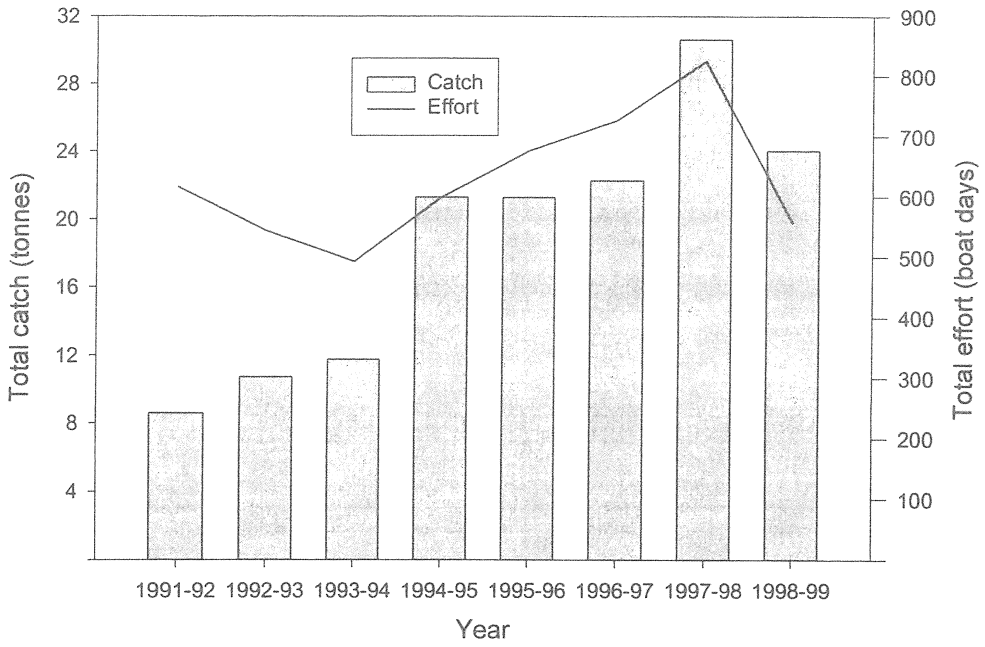

Figure 29: Annual commercial catch and effort for blue swimmer crabs in the Swan-Canning Estuary (1991-92 to 1998-99)

5.3 Other Areas in South West of State

5.3.1 Recreational Catch and Effort

Leschenault Estuary

The boat-based and shore-based crab catch for the Leschenault Estuary was estimated by a previous study (Malseed *et al.* 2000). This study estimated that 179,140 crabs (or 37.8 tonnes) were kept and 600,125 released by boat-based crabbers during 1998 (Table 13).

Table 13: Estimated catch of blue swimmer crabs by recreational boat-based fishers in Leschenault Estuary

	Total	Standard Error
Number kept	179,140	8,575
Number released	600,125	30,289
Weight kept (tonnes)	37.8	1.6
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

A further 39,897 crabs (or 7.9 tonnes) were estimated to have been kept and 130,313 released by shore-based crabbers during 1998 (Table 14).

Table 14: Estimated catch of blue swimmer crabs by recreational shore-based fishers in Leschenault Estuary

	Total	Standard Error
Number kept	39,897	5,583
Number released	130,313	17,958
Weight kept (tonnes)	7.9	0.8
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

The total recreational harvest of blue swimmer crabs from the Leschenault Estuary was 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 15).

Table 15: Estimated total recreational catch of blue swimmer crabs from Leschenault Estuary

	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

Marine Areas

The total boat-based crab catch and fishing effort for marine areas including Geographe Bay, Cockburn Sound, Warnbro Sound and other Perth areas (which includes the area to the north of Cockburn Sound as well as west of Garden Island) were estimated by a previous study during 1996-97 (Sumner and Williamson, 1999). Of these areas, Cockburn Sound had the largest recreational crab catch of 18.8 tonnes closely followed by Geographe Bay with 17.5 tonnes. A further 6.3 tonnes from Warnbro Sound and 9.6 tonnes from other Perth marine waters was estimated to be taken during 1996-97 (Table 16).

Table 16: Recreational boat-based catch and effort for blue swimmer crabs in marine areas of the South West

	Geographe Bay	Cockburn Sound	Warnbro Sound	Perth other
Effort (boat hours)	13,830	19,048	6,461	12,184
Standard Error	(1,150)	(1,042)	(345)	(1,740)
Number Kept	85,380	91,775	30,530	46,951
Standard Error	(14,179)	(11,980)	(4,834)	(8,462)
Weight Kept (tonnes)	17.5	18.8	6.3	9.6
Standard Error	(2.9)	(2.5)	(1.0)	(1.7)
Catch Rate (crabs/boat/hour)	6.8	5.6	5.7	5.2
Standard Error	(0.7)	(0.7)	(0.9)	(0.4)
Catch rate (crabs/net)	2.3	2.6	1.3	2.0
Standard Error	(0.4)	(0.8)	(0.4)	(0.4)
Catch rate (crabs/boat)	18.2	16.4	17.8	11.2
Standard Error	(1.8)	(1.9)	(2.5)	(1.0)

The shore-based catch of blue swimmer crabs for these areas, especially Geographe Bay, is likely to be significant and must also be considered. However, the data collected incidentally during a shore-based survey of recreational salmon and herring fishing (Ayvazian *et al.*, 1997) was not adequate to estimate the total shore based catch of crabs since the Busselton jetty was the only location where the shore-based catch was recorded.

The catch estimates for Cockburn Sound are not directly comparable with those provided by Dybdahl (1979). The earlier study includes crabs caught outside Cockburn Sound and landed at a boat ramp in the Sound, among other differences. However, the trend of a declining recreational catch and greatly expanding commercial catch is probably realistic.

5.3.2 Commercial Catch and Effort

Leschenault Estuary

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 1.6 tonnes in 1994 to a high of 7.3 tonnes in 1990 (Figure 30). The mean annual crab catch for these years was 4.2 tonnes. The annual crabbing effort in boat days per year ranged from 70 days in 1998 to 274 days in 1989. 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.

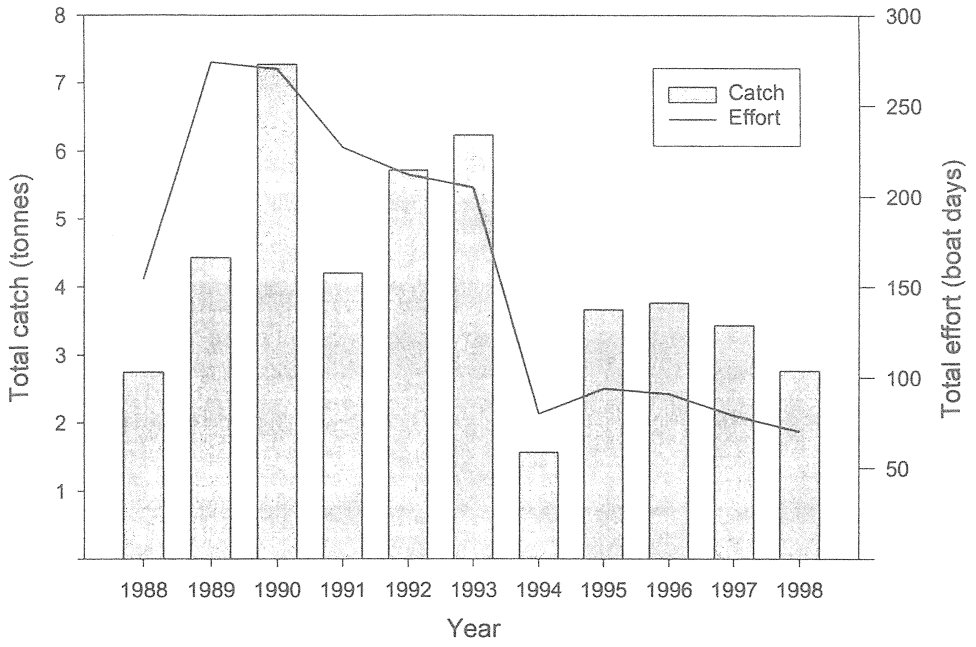

Figure 30: Annual commercial catch and effort for blue swimmer crabs in the Leschenault Estuary (1988 to 1998)

Cockburn Sound

The annual commercial crab catch (Penn, 1999) has steadily increased from 97.9 tonnes in 1991-92 to 346.9 tonnes in 1996-97 (Figure 31). The annual crabbing effort in boat days per year has also increased from 2,206 in 1991-92 to 3,415 in 1997-98. The efficiency of the commercial fishing increased substantially with the change from nets to pots in 1994.

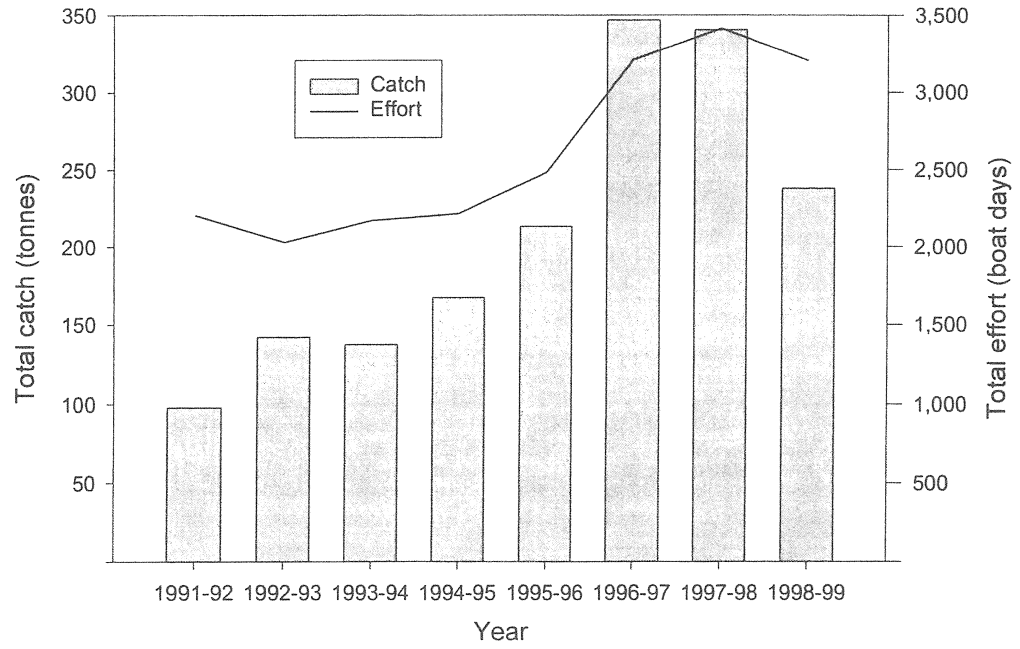

Figure 31: Annual commercial catch and effort for blue swimmer crabs in Cockburn Sound (1991-92 to 1998-99)

Geographe Bay

The annual commercial crab catch has increased from 0.6 tonnes in 1993-94 to 18.5 tonnes in 1996-97 (Figure 32). The annual crabbing effort in boat days per year has also increased from 36 in 1993-94 to 392 in 1996-97.

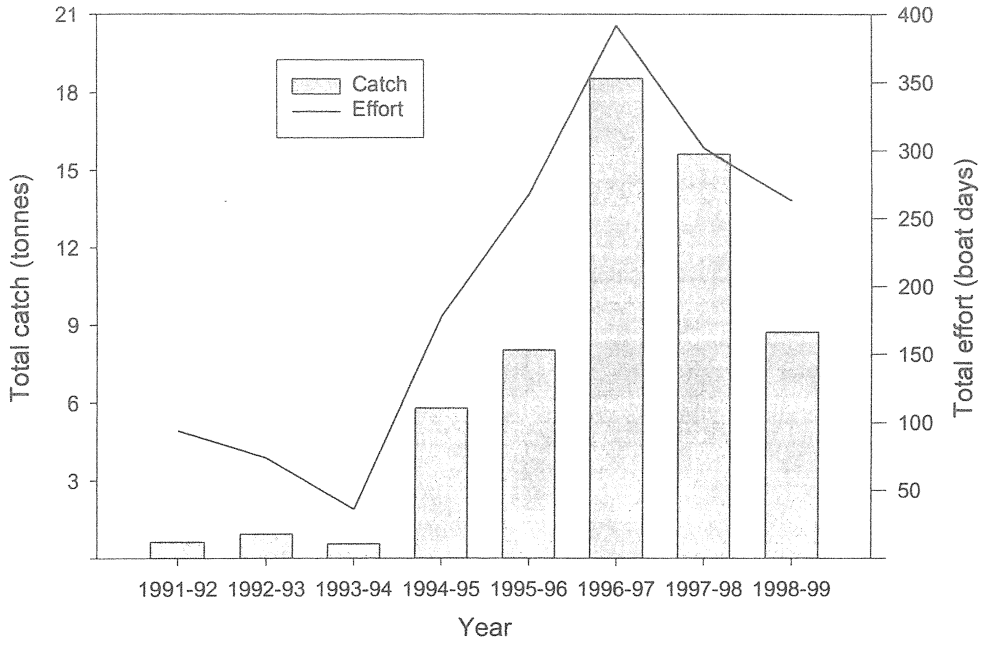

Figure 32: Annual commercial catch and effort for blue swimmer crabs in Geographe Bay (1991-92 to 1998-99)

Warnbro Sound and marine waters around Perth other than Cockburn Sound

This area includes Warnbro Sound and Comet Bay.

The annual commercial crab catch between 1991-92 and 1998-99 ranged from 24.8 tonnes in 1998-99 to a high of 57.8 tonnes in 1997-98 (Figure 33). The mean annual crab catch for these years was 36.0 tonnes. The annual crabbing effort in boat days per year ranged from 834 days in 1998-99 to 1,434 days in 1997-98.

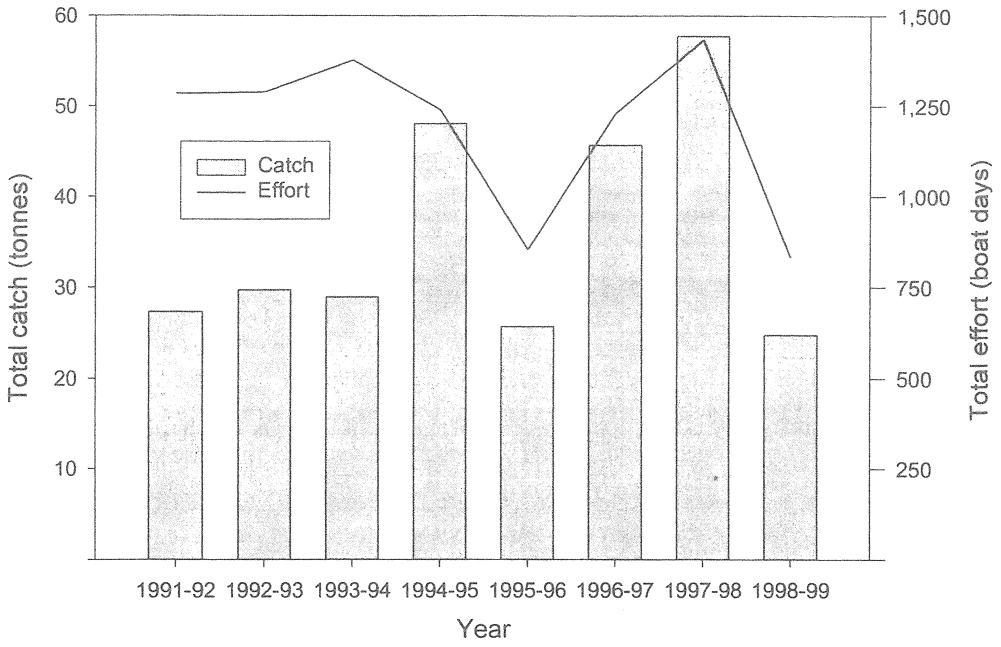

Figure 33: Annual commercial catch and effort for blue swimmer crabs from marine waters around Perth other than Cockburn Sound (1991-92 to 1998-99)

5.4 Recreational and Commercial Catch For All Areas

The combined annual recreational blue swimmer crab catch for all areas surveyed in the South West is 394 tonnes. Most of the recreational catch (289 tonnes or 73%), is taken from the Peel-Harvey Estuary, followed by the Leschenault Estuary (46 tonnes), Cockburn Sound (19 tonnes), Geographe Bay (18 tonnes), the Swan-Canning Estuary (7 tonnes), Warnbro Sound (6 tonnes) and 10 tonnes from other Perth areas (Figure 34 and Table 17). The majority of the catch in estuaries and marine areas is taken by boat-based crabbers, however, the shore-based catch from marine areas has not been estimated.

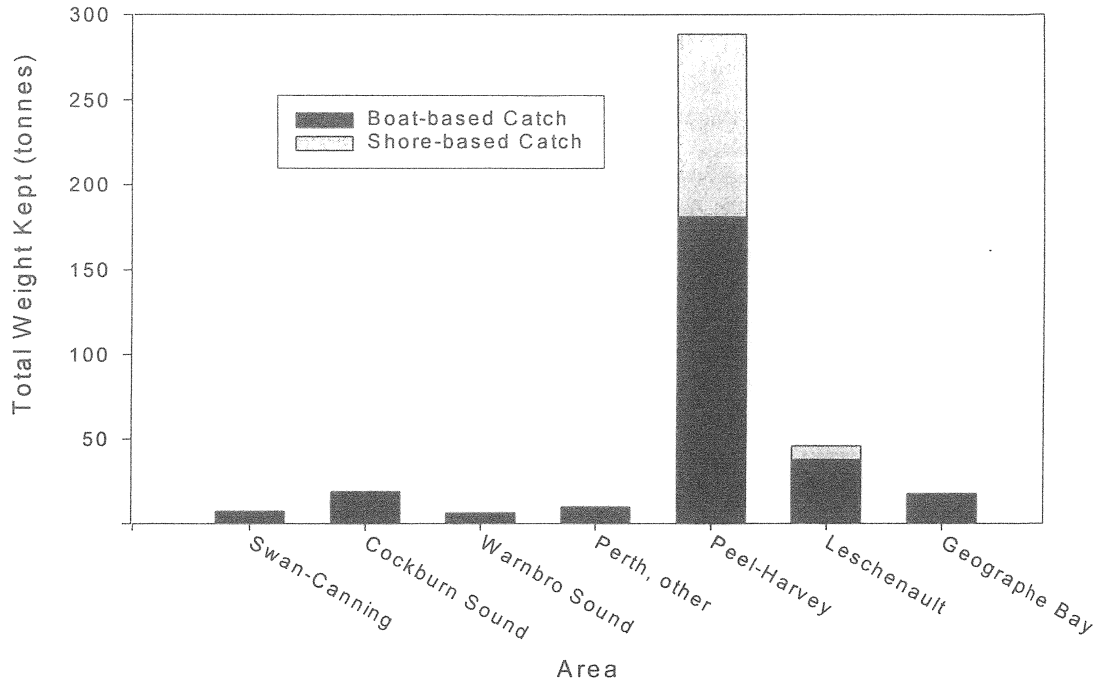

Figure 34: Estimated recreational crab catch for all areas surveyed in the south west of Western

Cockburn Sound has the largest commercial catch followed by the Peel-Harvey Estuary. In terms of total catch the Peel-Harvey Estuary and Cockburn Sound are similar. However, the share of the catch between the commercial and recreational sectors is quite different in these areas (Table 17). The Peel-Harvey and the Leschenault Estuaries are predominantly recreational fisheries while Cockburn Sound, the Swan-Canning Estuary and other Perth marine areas are predominantly commercial fisheries.

Table 17: Comparison of recreational and commercial catch of blue swimmer crabs in the south west of Western Australia

Region	Year	Recreational Catch (tonnes)	Commercial Catch (tonnes)
Geographe Bay	1996/97	18*	19
Leschenault Estuary	1998	46	3
Peel-Harvey Estuary	1998/99	289	66
Cockburn Sound	1996/97	19*	347
Swan-Canning Estuary	1998/99	7	24
Other Perth (marine)	1996/97	16*	46

* Boat-based catch only

5.5 Compliance with Recreational Fishing Regulations

Peel-Harvey Estuary

Only 7% of the 1,077 boats interviewed, with more than one person on board, that had been crabbing achieved or exceeded the boat limit of 48 crabs. However, 17 of the 57 boats interviewed (30%), with only one person on board, achieved or exceeded the bag limit of 24 crabs per person.

Two (3.5%) of the 57 boats with only one person on board exceeded the daily bag limit of 24 crabs. A further two (0.2%) of the 1,077 boats with 2 or more on board exceeded the daily boat limit of 48 crabs.

There was a fair level of compliance with the size limits amongst boat-based crabbers. One hundred and five (9.2%) of the 1136 boat crews crabbing had kept undersize crabs.

Of the 105 boat crews which had kept undersize crabs, 69 (66%) were residents from the greater Perth metropolitan region living within a 50 km radius of the city centre and 30 (29%) were local Mandurah residents living within a 20 km radius of the Peel-Harvey Estuary.

Compliance rates were lower amongst shore-based crabbers with 92 (13%) of the 711 shore-based crabbing parties interviewed having kept undersize crabs.

Of the 92 shore-based crabbing parties which kept undersize crabs, 71 (77%) were residents from the greater Perth metropolitan region living within a 50 km radius of the city centre and 15 (16%) were local Mandurah residents living within a 20 km radius of the Peel-Harvey Estuary.

Swan-Canning Estuary

Only one of the 112 boats interviewed (0.9%), with more than one person on board, that had been crabbing achieved the boat limit of 48 crabs specified under current statewide recreational fishing regulations. However, two of the 28 boats interviewed (7.1%), with only one person on board, achieved the bag limit of 24 crabs per person.

No crabbers interviewed exceeded their bag or boat limit of crabs.

There was a very high level of compliance with the size limits amongst boat-based crabbers. Only 3 (2.2%) of the 139 boats crabbing had kept undersize crabs.

Compliance rates were slightly lower amongst shore-based crabbers with two (5.4%) of the 37 shore-based crabbing parties interviewed having kept undersize crabs.

6. Benefits

Industry and recreational fishers will both benefit from the improved quality of management that will be possible with a clearer understanding of recreational catch and effort in Western Australia. Fisheries managers in some other states will find the results of comparative value.

7. Further Development

The results show the importance of recreational fishing in the Peel-Harvey and Swan-Canning Estuaries. It is suggested that further creel surveys are required on a regular basis, about every five years, to monitor the recreational catch for both of these estuaries and other areas throughout the south west of the state and to study long-term trends in catch and catch rates.

8. Conclusions

The study has provided information on the extent and distribution of recreational crabbing effort in the south west of Western Australia. The combined annual recreational blue swimmer crab catch for all areas surveyed in the South West is 394 tonnes. Most of the recreational catch (289 tonnes or 73%), is taken from the Peel-Harvey Estuary followed by the Leschenault Estuary (46 tonnes). The majority of the catch in estuaries and marine areas is taken by boat-based crabbers, however, the shore-based catch from marine areas has not been estimated.

Cockburn Sound has the largest commercial catch followed by the Peel-Harvey Estuary. In terms of total catch the Peel-Harvey Estuary and Cockburn Sound are similar. However, the share of the catch between the commercial and recreational sectors in these areas is quite different. The Peel-Harvey and the Leschenault Estuaries are predominantly recreational fisheries while Cockburn Sound, the Swan-Canning Estuary and other Perth marine areas are predominantly commercial fisheries.

Blue swimmer crabs are the key species for recreational fishers in the Peel-Harvey Estuary with 92% of boats fishing in the estuary targeting crabs. The estimated recreational catch for 1998-99 of 288.6 tonnes is substantial and almost five times the 1998-99 commercial catch in the estuary of 65.5 tonnes. The recreational catch for the Peel-Harvey Estuary was slightly underestimated since fishing effort for boats kept in canals and the usage of drop nets in the canal developments was not included.

Blue swimmer crabs are a key species for recreational boat-based fishers in the Swan-Canning Estuary with 53% of boats fishing in the estuary targeting crabs. The estimated recreational catch for 1998-99 of 7.3 tonnes is significant and makes up almost a quarter of the combined recreational and commercial catch of 31.3 tonnes.

Significant catch increases in most commercial sectors, coupled with high recreational pressure, indicates that all stocks of blue swimmer crabs in the South West of Western Australia are in need of careful ongoing management.

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Appendix 1: Intellectual Property

Based on the share of funding, the proportion of ownership of the project intellectual property is Fisheries WA 52.8% and FRDC 47.2%.

Appendix 2: Staff

Principal Investigator	Neil Sumner
Project Coordinator	Ben Malseed
Database Administrator	Peta Williamson
Data Entry	Maria Tassone
Casual Survey Interviewers	Peter Powell
	Frank Newland
	Michael Ward

Appendix 3: Boat Ramp Form

BOAT RAMP FORM

Interviewer's Name: _____

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

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

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

Shore Fishers Sighted Between Last Ramp & This Ramp

Boat Types

P: Power boat

Y: Yacht

O: Other

Appendix 4: Interview Form

INTERVIEW QUESTIONNAIRE

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

Interview Time	Boat (Pwr/Yacht/Other)	Start Time	Fish/Dive/Snorkel/Other	Number in Boat	Number of Females in Boat	Age of Interviewee	Home Postcode of Interviewee	Length of Boat (ft/m)	Member Angling Club (Yes/No)	Time Spent Fishing (decimal hrs)	Block Number or Estuary	Number of Lines Used	Number and type of nets - Crab, Gill, Scoop, Pots	Number of Times Interviewed Before
				FISHERS ONLY										

Species	Number Kept	Number Released	Undersize Kept	Species Targeted_____ Measurements (mm)
Blue Swimmer Crab (Male)				
Blue Swimmer Crab (Female)				
Blue Swimmer Crab (Sex Unknown)				

Appendix 5: Hire Boat Form

Mandurah Hire Boat Survey

Company Name:_____

Date	Hire Time (Hours)	Time Spent Fishing (Hours)	Number of Crab Nets Used	Number of Crabs Kept	Number of Crabs Released	Number of Lines Used	Number and Type of Fish Kept

Appendix 6: Bridge/Jetty/Shore Interview Form

FISHERIES
WESTERN AUSTRALIA

Bridge / Jetty / Shore Survey 1998/99

Officers 'Names: _____

_____

Location: _____

Date: ____/____/____

Time (24hr): _____

Number boats fishing: _____

Number shore fishers: _____

WIND

Direction: _____

Calm	Light	Mod	Strong	Gale
1	2	3	4	5

WATER

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

CLOUD COVER & RAINFALL

Cloud %	Nil	Light	Moderate	Heavy
	1	2	3	4

LENGTHS OF RANDOM SAMPLE (mm)

Blue Swimmer Crabs

Length	Male		Female	
(mm)	No.	Total	No.	Total
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				
141				
142				

Other Species

Species: .....

Lengths: .....

Species: .....

Lengths: .....

Fisher Number	1	2	3	4
Home postcode				
Number in group				
Times interviewed before				
Boat/Shore/Dive/sNorkel				
Number persons fishing				
Time spent fishing (decimal hours)				
Number of lines used				
Nets (Crab, Gill, Scoop), Pots				
Species Targeted				
Male Crabs	Blue swimmer crab - male	Blue swimmer crab - male	Blue swimmer crab - male	Blue swimmer crab - male
Total number kept				
Number released				
Under size kept				
Female Crabs	Blue swimmer crab - female	Blue swimmer crab - female	Blue swimmer crab - female	Blue swimmer crab - female
Total number kept				
Number released				
Under size kept				
Berried females kept				
Crabs (Sex unknown)	Blue swimmer crab	Blue swimmer crab	Blue swimmer crab	Blue swimmer crab
Total number kept				
Number released				
Under size kept				
Species 2				
Total number kept				
Number released				
Under size kept				
Species 3				
Total number kept				
Number released				
Under size kept				
Species 4				
Total number kept				
Number released				
Under size kept				
Species 5				
Total number kept				
Number released				
Under size kept				

Appendix 7: Catch and Effort Calculations for Boat-based Fishers

Estimation of Total Effort

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

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

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.

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

where

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

r_j is the retrieval time for boat j and ℓ_j is the launch time for boat j. The fishing effort was estimated for a random sample of days in each stratum (see Section 2.1). The estimated variance within stratum k is (Pollock *et al.*, 1994)

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

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

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

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

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

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

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

and the standard error is calculated by the usual method

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

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

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

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

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

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 k is estimated by (Crone and Malvestuto, 1991)

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

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

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

The total catch for stratum k is estimated as

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

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

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

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

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

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

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

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

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

Appendix 8: Catch and Effort Calculations for Shore-based Fishers

Estimation of Total Effort

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

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

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

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

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

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

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

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

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

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

and the standard error is calculated by the usual method

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

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

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

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

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

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

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

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

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

The total catch for stratum k is estimated as

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

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

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

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

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

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

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

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

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