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Determination and development of cost effective techniques to monitor recreational catch and effort in Western Australian demersal finfish fisheries

Final Report for FRDC Project 2005/034 and WAMSI Subproject 4.4.3

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Non Technical Summary

2005/034: Determination of cost effective techniques to monitor recreational catch and effort in Western Australian demersal finfish fisheries

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Objectives

1. Complete a series of concurrent catch and effort surveys of the West Coast Demersal Recreational Fishery using a variety of survey techniques.
2. Compare the precision and accuracy of estimates generated using these various techniques
3. Using cost benefit analysis, produce a series of options to monitor annual catch and effort for a range of precision levels and indicator species
4. Development of cost effective methods for monitoring the catch of the non-commercial sector.

Outcomes achieved to date

A number of independent catch and effort surveys of the West Coast Demersal Recreational Fishery were carried out concurrently in 2005/06 using a variety of survey techniques. This was followed up with an international workshop in 2010 that compared and discussed the benefits and limitations of various survey methodologies carried out in Western Australia and elsewhere.

Estimates of the catch by the boat-based recreational sector were generated, which assisted in the provision of recommendations to the Minister for Fisheries, on the appropriate integrated fisheries management (IFM) allocation of access to all sectors of the West Coast demersal scalefish fishery. This information and subsequent surveys were also critical for the establishment of appropriate management arrangements for this fishery to enable rebuilding of the West Coast demersal scalefish resources to sustainable levels and ensuring catch by the recreational sector conformed to preliminary IFM catch share allocations.

Through these analyses and the workshop, the Department of Fisheries has now adopted the most appropriate, cost effective, ongoing monitoring of recreational fishing using a state-wide integrated survey of boat fishing.

Recreational fishers are numerous, diverse and diffuse. They use multiple access points and platforms for fishing including boats launched from harbours, marinas and private docks and from the shore on piers, jetties and beaches. Their nature ranges from avid fishers to infrequent participants and different survey methods will encounter these different types of fishers in different relative proportions. This means that there is no single survey method that can be used to accurately and precisely estimate total catch and effort from all recreational fishers. Consequently, most surveys of recreational fishing have customised designs, which reflect the specific objectives of the survey, the spatial and temporal scope to be covered, the nature of the recreational fishery, and the constraints on resources that are available to conduct the survey. This project compared the efficacy and cost effectiveness of a range of survey methods.

Access point surveys are relatively expensive and the boat-ramp based creel survey was the most spatially and temporally comprehensive of all surveys conducted in 2005/06. This design produced precise estimates and the use of trained interviewers ensured accurate species identification and length measurements, and provided consistent collection of catch and effort data. Given the cost of onsite interviews, however, the survey only included major boat ramps on the West Coast Bioregion and temporal coverage was restricted to eight daylight hours. The survey did not include estimates of catch and fishing effort of boats fishing outside these hours, nor those fishing from yacht clubs, canals, private marinas moorings or those launched or retrieved from beaches. In addition, the interviews at the boat ramps were more likely to be of avid fishers.

Phone surveys are based on a sampling frame that is either a White Pages phone listing or a fishing licence database and is usually less expensive than onsite surveys. The mail-phone-diary survey carried out in 2005/06 was relatively inexpensive compared to the boat-ramp based creel survey. The use of an initial mail survey to encourage participation in the survey resulted in a low response rate. This indicates that the use of a mail component in these surveys should be avoided. The survey only included owners of registered powered boats residing in the West Coast Bioregion. Sample sizes for registered power boat owners were inadequate for estimation of catch and effort in some zones. However, bioregional estimates were possible, albeit with lower precision than those obtained from the creel survey. It was assumed that respondents accurately recalled information from past fishing trips and all fishing from the boats was reported whereby both kept and released species were correctly identified.

There is potential to employ automated counters to obtain good effort estimates at boat ramps and other access points and increase the spatial scale of surveys and precision of estimates. In 2005/06 various counter methods were compared, including; (1) video camera surveillance of boat launches and retrievals at ramps, (2) a vehicle counter system to count vehicles using the retrieval lane by their presumed type, based on the number of axles and speed, (3) camera snapshot counts of trailers and (4) counts of tickets in car parks associated with boat ramps. These methods provided various degrees of accuracy in the census of activity at boat ramps. There is a need for more research to determine the relative costs and benefits of these approaches. While the analysis takes into account missing data (i.e. it is treated as though it has not been sampled), other practical issues relating to missing data due to malfunction or vandalism, still needs to be resolved. Data from these counter methods may be integrated with the data from access point surveys using a double sampling, ratio estimation approach.

Other options considered for the collection of recreational catch and effort data was through other recreational surveys using voluntary logbooks or compulsory recruitment (i.e. by compliance officers). In 2005/06, recreational catch and effort collected by Fisheries and Marine Officers (FMOs) provided catch rates per trip, however there was no way of determining the weighting factor by which the total catch or fishing effort might be assessed. As ‘convenience’ sampling was employed in the FMO survey, sampling intensity almost certainly varied throughout each bioregion and was likely to have little spatial and/or temporal correlation with fishing activity. While the collection of catch and effort information by FMOs occurs opportunistically while conducting compliance patrols, this would be an expensive method if used as the main data collection method. The requirement that regulations remain simple may constrain approaches that compel fishers to cooperate in the provision of data. Furthermore, such regulations are likely to be expensive to enforce.

Voluntary or passive recreational surveys are becoming very popular in Australia with recreational fisher organisations. Analyses of data collected during 2005/06 were undertaken from the ongoing volunteer fisheries liaison officer (VFLO) survey and the research angler program (RAP) logbook. While these surveys provide catch rates, they are unlikely to be representative of the general population of recreational fishers and cannot be validly be used to provide estimates of catch and effort for the whole recreational fishing population. Without rigorous oversight, the data collected from these programs can be extremely misleading even when used as indices due to non-response errors and avidity bias, which can vary markedly over time.

Alternative survey methods not investigated in 2005/06 include aerial surveys, which have the potential for surveying boat-based fishing activity, such as offshore deepwater fisheries, where this method could use multiple observers and exploit distance sampling approaches. Aerial surveys may be useful for shore-based recreational fishing. Another survey method is respondent driven sampling, which may provide an alternative method to contact hard to reach fishers or rare event fisheries but it is an approach that is, as yet, untried.

Based on the understanding gained from concurrent surveys carried out in 2005/06 and the 2010 workshop, future state-wide integrated survey of boat fishing would involve the following complementary components:

1. A phone survey using the Recreational Fishing from Boat Licence (RFBL) as a sampling frame. This survey involves 3,000 randomly selected RFBL holders in which each participant asked to keep a diary/logbook of their fishing activities for a 12-month period and phoned at least monthly to obtain fishing details for the previous month. This interviewer-assisted approach minimises respondent burden, reduces recall bias and maintains respondent involvement in the survey. Post-enumeration surveys at the completion of the 12-month period are used to detect and adjust for information of new licence holders, non-respondents and participants who dropped out of the survey and included a follow-up survey to provide substantive additional information, including socio-economic data.
2. Boat ramp surveys providing on site biological information and enabled validation of information collected in the phone surveys and involves a randomly stratified survey at key boat ramps and times to carry out face-to-face interviews with boat-based fishers.
3. A remote video survey using video cameras mounted at key boat ramps to monitor launches and retrievals over a 24-hour period.
4. An integrated set of catch estimates of recreational fishing from boats generated for each of the four bioregions in Western Australia.

Keywords: West Coast Demersal Scalefish Fishery, recreational fishing, volunteers, creel survey, phone survey, logbooks, camera and road counters.

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A number of staff, who contributed to this project, are listed in Appendix 8.2. Norm Hall, Carli Telfer and Claire Smallwood also provided assistance in finalising the report. Workshop participants who provided review of sections of the document are listed in Appendix 8.10. Karina Ryan, Tim Green, Fiona Crowe, Dan Gaughan and Brett Molony reviewed the document.

1.0 Introduction

1.1 Background

This project was initially developed and funded by FRDC as a result of the research and management requirements to implement Integrated Fisheries Management (Crowe *et al.*, 2013). Integrated Fisheries Management (IFM) involves the setting of a total harvest level in each fishery and the allocation of explicit catch shares for use by each of the sectors (i.e. recreational, commercial, indigenous). It also requires the catch harvested by each sector to be monitored and broadly managed within that sector's allocated catch level. One of the first set of fisheries to undergo the IFM process was the West Coast demersal scalefish fisheries, which are offshore, boat-based fisheries. Having ongoing collection of recreational catch information for key species of this fishery is essential, both to ensure the sustainability of fish stocks and to satisfy the governance requirements associated with ensuring that the sectoral allocation decisions are appropriate and being maintained. This FRDC funded project aimed to understand the relative precision and accuracy of each approach along with their relative costs, benefits, limitations and interactions, which is essential for determining ongoing sampling methods needed to monitor the IFM outcomes for this fishery.

Subsequently, a WAMSI 3.3.4 project was funded to develop methods that allow the catch levels taken by non-commercial sectors to be monitored cost effectively at a level of precision that will be sufficient to allow the data to be used reliably to ensure the sustainability of the resource and facilitate the management of allocations to recreational and commercial fishing sectors. Initially, the funding was intended to be used for a state-wide phone survey utilising the Department of Planning and Infrastructure (DPI) database of boat licences as a sampling frame, with the results to be compared with other survey methods implemented concurrently. With the shift in government policy and the decision to introduce a Recreational Fishing from Boat Licence (RFBL) in 2010, it was clearly not logical to continue this approach. A specific requirement of the Western Australian government therefore, became how best to utilise the new framework that would become available following the introduction of the boat-based fishing licence, to produce a system to generate reliable estimates of recreational fishing effort and catch. The aim of the WAMSI funded project was to determine the appropriate sampling schemes for fisheries requiring the ongoing collection of recreational data.

1.2 Need

The need for regular monitoring of recreational fishing activity in Western Australia will increase substantially over coming years. This increase will result from the overarching requirement for better data to facilitate the management of those fish stocks where recreational fishing contributes a major proportion of the total catch. In addition, these data will also be needed as inputs to the determination of explicit sectoral allocations (i.e. between recreational, commercial and indigenous sectors) through the IFM process. Moreover, some level of monitoring will be needed to determine whether management arrangements are successful in ensuring that the catch of each sector is in accord with the IFM allocation decisions. The West Coast demersal scalefish fisheries, which are offshore and boat-based, will be the first scalefish fisheries subjected to the IFM process.

The previous methods used in Western Australia for estimating recreational catch and effort have ranged from on-site creel, and off-site phone and/or logbook surveys. These methods have differing costs and are subject to a number of different factors that introduce bias into the resulting estimates of catch and effort. Given that allocation decisions for these fisheries will be based on the estimates generated from these surveys, all stakeholder groups demanded that the accuracy and precision of any estimates produced be assessed. Such assessment is best undertaken by the simultaneous collection of data by alternative methods to allow suitable comparisons of the estimates to determine whether there are differences and, if so, to explore whether the design of the surveys can be adjusted to improve the accuracy and precision of the estimates.

Furthermore, whilst there is little doubt that intensive survey methods will need to be completed at periodic (e.g. 3 to 5 year) intervals, having information at a lower precision level between these intervals to provide an indication of whether recreational catches are remaining steady, increasing or declining within anticipated bounds of any allocation will be essential if the desired outcomes of IFM are to be delivered.

Current management of the West Coast demersal scalefish fisheries is focused on only a relatively small number of species. Ongoing surveys may be able to use different sampling strategies to those used in the standard surveys. In addition, alternative methods of data collection are now more readily available that may offer cost effective opportunities for monitoring recreational fisheries. These methods include the use of remote monitoring technology (e.g. cameras), using information already collected by other agencies (e.g. boat ramp usage rates) and the potential to use data collected by the Department’s volunteers and compliance staff.

Understanding the relative precision and accuracy of different approaches along with their relative costs, benefits, limitations and interactions will be essential for determining what ongoing sampling methods need to be used to monitor the IFM outcomes for this fishery. These techniques will assist in determining the appropriate sampling schemes for other fisheries requiring the ongoing collection of recreational data.

2.0 Catch and effort surveys of the West Coast Demersal Recreational Fishery in 2005/06

Objective 1. Complete a series of concurrent catch and effort surveys of the West Coast Demersal Recreational Fishery using a variety of survey techniques

The West Coast Bioregion extends south along the west coast from the latitude 27° S to west of longitude 115° 30’ E (Figure 2.1). The approximate 900 kilometres of coastline includes Western Australia’s capital city, Perth. The population residing adjacent to the West Coast Bioregion contains 81% of the 1.98 million Western Australia’s residents (Trewin, 2006). In 2005 an estimated 540,000 persons participated in recreational fishing at least once a year with 85% of these fishing in the West Coast Bioregion (Baharthah, 2006).

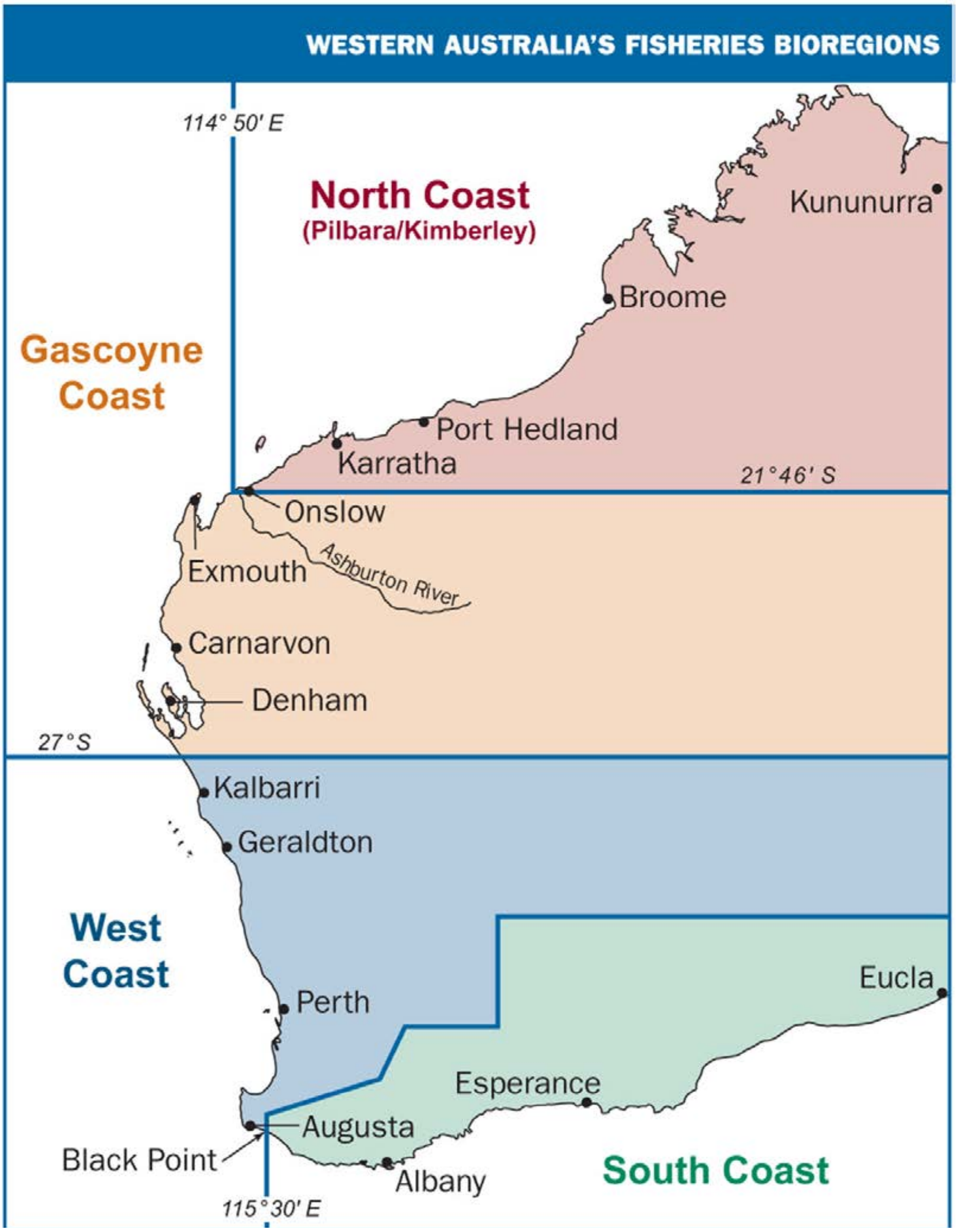

Figure 2.1 Map of Western Australia showing the Marine Bioregions and major cities/towns.

Due to the nature of the management and suite of species in each area the West Coast Bioregion is divided into the following zones (Figure 2.2):

- Kalbarri zone (26°30¢S – 28°S)
- Mid-West zone (28°S – 31°S)
- Metropolitan (Metro) zone (31°S – 33°S)
- South-West zone (33°S – 115°30¢E)
- Offshore zone (waters between 3 nm State waters boundary and the boundary of the 200 nm Economic Exclusion Zone)

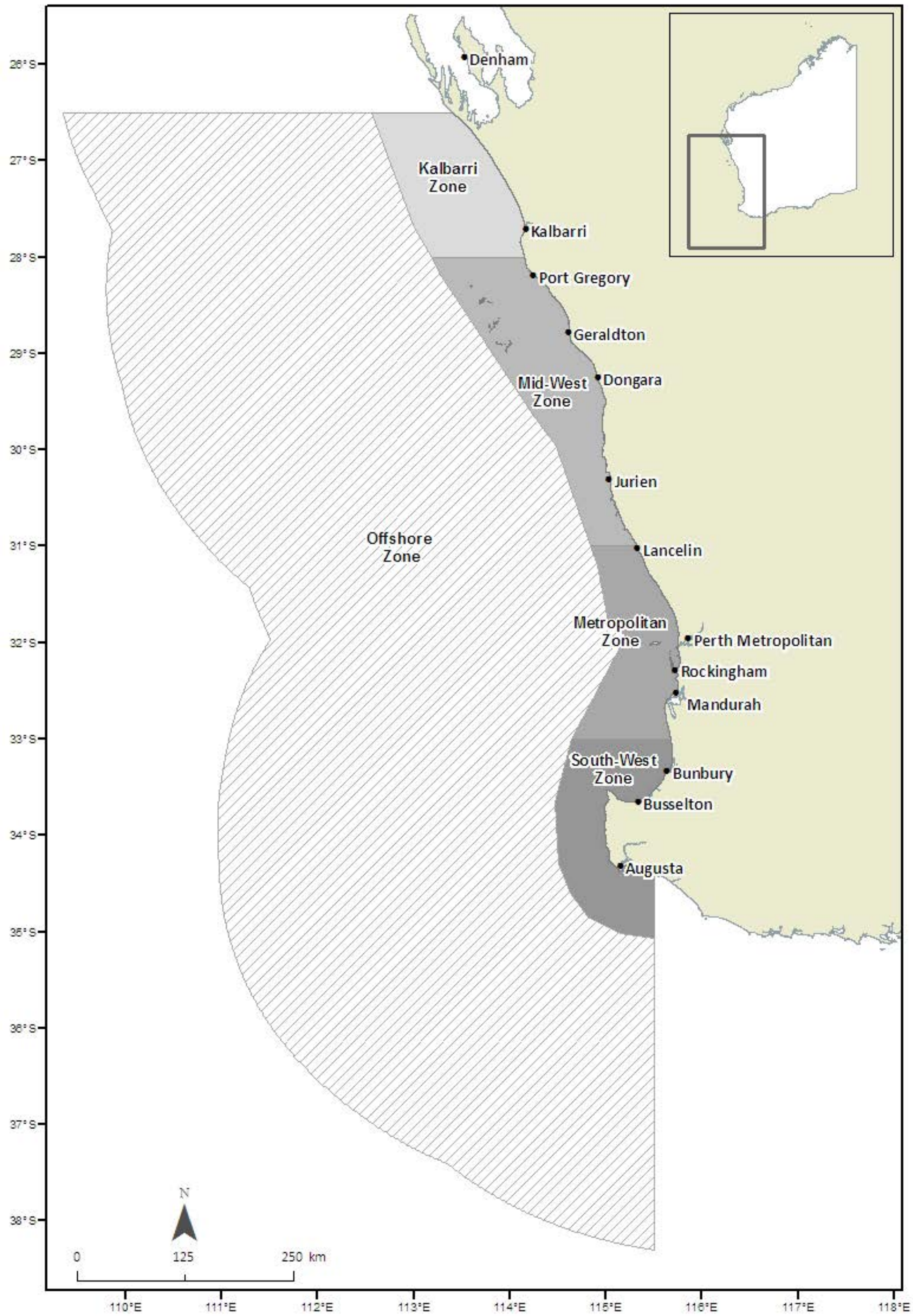

Figure 2.2 Map of Western Australia showing the West Coast Bioregion zones.

As a result of significant increases over the last decade in population size and fishing efficiency, such as through the use of Global Positioning Systems (GPS) and high quality colour sounders, there has been growing concern regarding the sustainability of these demersal stocks in the West Coast Bioregion (Wise *et al.*, 2007).

Demersal fishing activities in the West Coast Bioregion encompass recreational boat-based angling and charter operators, and commercial fisheries including the West Coast Demersal Scalefish (Interim) Managed Fishery (WCDS), West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF), Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLF), the South West Trawl Managed Fishery and the Commonwealth managed Western Deepwater Trawl Fishery. In addition, the Western Rock Lobster Fishery takes a small catch of these demersal species as a bycatch in their rock lobster pots (Department of Fisheries, 2010).

All scalefish that have been reported in catches from the West Coast Bioregion over recent years by the different sectors have been assigned to different habitats on the basis of their biology, their preferred habitat, particularly the location of the breeding stock, and the distribution of the principal catch (Figure 2.3). These habitat types essentially reflect different water depths and/or distances from the land, as follows.

- Estuarine – comprises estuaries;
- Nearshore – habitats in coastal waters of less than 20 metres deep;
- Inshore demersal – demersal habitats in waters between 20 and 250 metres deep;
- Offshore demersal – comprises demersal habitats in waters between 250 metres deep and the boundary of the 200 nm Economic Exclusion Zone;
- Pelagic – comprises the water column between the 20 metre bathymetric contour and the boundary of the 200 nm Economic Exclusion Zone but not including the demersal habitats.

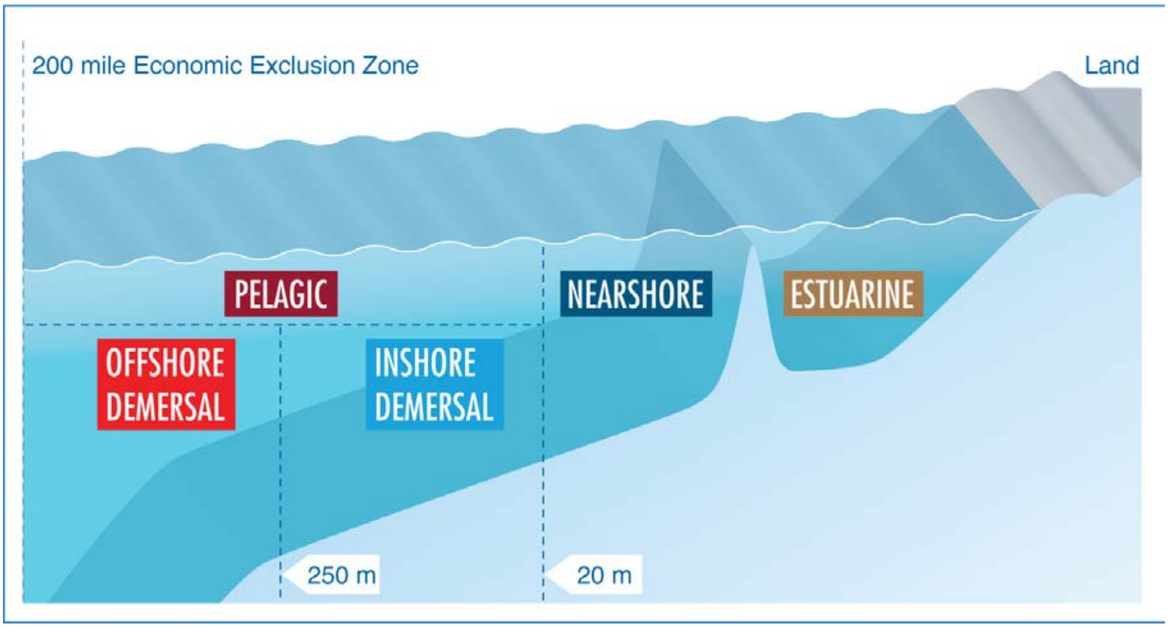

Figure 2.3 Five broad ecological depth based habitats recognised in each bioregion.

Collectively, demersal fisheries in the West Coast Bioregion include over 100 species (Fletcher and Santoro, 2007). Western Australian Dhufish (Glaucosoma hebraicum) and Pink Snapper (Pagrus auratus) had the highest demersal scalefish landings in 2005/06. This report primarily focused on the key inshore demersal species including the three 'indicator' species (Western Australian Dhufish, Pink Snapper and Baldchin Groper, Choerodon rubescens) caught by boat-based fishers in the West Coast Bioregion (Table 2.1). The management of the West Coast demersal scalefish fisheries focuses on only a relatively small number of key species, rather than attempting to manage every species directly (Wise *et al.*, 2007; Department of Fisheries, 2010). Resources and data requirements for the latter approach are well beyond those that are available to the Department of Fisheries.

Table 2.1 Key inshore demersal scalefish species caught by boat-based fishers in the West Coast Bioregion. Indicator inshore demersal scalefish species are Western Australian Dhufish, Pink Snapper and Baldchin Groper.

Common name	Scientific name
Baldchin Groper	*Choerodon rubescens*
Breaksea Cod	*Epinephelides armatus*
Grass Emperor (Black Snapper)	*Lethrinus laticaudis*
Spangled Emperor	*Lethrinus nebulosus*
Redthroat (Sweetlip) Emperor	*Lethrinus miniatus*
Yellowtail Emperor	*Lethrinus atkinsoni*
Bluespotted Emperor	*Lethrinus punctulatus*
Robinson's Seabream	*Gymnocranius griseus*
Not identified - Lethrinids	*Lethrinus spp*
Pink Snapper	*Pagrus auratus*
Blue Morwong (Queen Snapper)	*Nemadactylus valenciennesi*
Bight Redfish	*Centroberyx gerrardi*
Swallowtail	*Centroberyx lineatus*
Yelloweye Redfish	*Centroberyx australis*
Sea Sweep	*Scorpis aequipinnis*
Sergeant Baker	*Aulopus purpurissatus*
Western Australian Dhufish	*Glaucosoma hebraicum*
Western Foxfish	*Bodianus frenchii*

Information on fishing catch, effort and catch rates from all sectors are required to evaluate the status of stocks and to manage those stocks. In Western Australia, commercial and charter operators are required to provide catch and effort returns as a condition of their licence. Since there is no mandatory reporting system in place for recreational fishers, surveys must be conducted to determine the catch and fishing effort for this sector. The traditional methods for estimating recreational catch and effort have been creel, diary and/or logbook based surveys. Alternative survey methods of collecting recreational catch and effort data are now available. These include the use of remote monitoring technology (e.g. cameras), using information already collected by other agencies (e.g. boat ramp usage rates) and the potential to use data collected by the Department's volunteers and compliance staff.

All methods used to survey recreational fisheries generate estimates that are potentially subject to a number of different biases. Given that management decisions for these fisheries will be based on the estimates generated from surveys, there is a requirement that some assessment of the accuracy and precision of estimates is produced. Assessment of bias requires comparison of estimates with the unknown true values (e.g. through use of simulated data). It is possible, however, to compare the results obtained using different approaches to determine the extent to which alternative models produce results that are consistent. Such analyses are best completed by the simultaneous collection of data by alternative methods to allow suitable comparisons to be made and to reveal any differences among the estimates.

During 2005/06 a series of concurrent catch and effort surveys of West Coast demersal recreational boat-based fishers that used a variety of survey techniques were undertaken. The different methods used in this study are described in this chapter:

- Boat-ramp based creel survey
- Mail-phone-diary survey
- Counter surveys of:
    - boat launches and retrievals using video cameras
    - vehicles and boat trailers using a Vehicle Classifier System (VCS)
    - car park vehicles and boat trailers using video cameras
    - car park vehicles and boat trailers using ticketing machines
- Fisheries and Marine Officer (FMO) survey
- Volunteer Fisheries Liaison Officer (VFLO) survey
- Research Angler Program (RAP) logbook

2.1 Boat-ramp-based creel survey

2.1.1 Introduction

A 12-month recreational boat-ramp based creel survey commenced on the 1 July 2005 and concluded on the 30 June 2006. The survey was designed to provide estimates of the line fishing catch and effort in marine waters for boat-based fishers in the West Coast Bioregion.

The preliminary results of the survey was published in Sumner *et al.* (2008) and reviewed by Steffe (2009). This report provides updated results based on the review recommendations.

2.1.2 Creel survey design

The West Coast Bioregion was divided into a number of bus routes so that survey interviewers could visit all the boat ramps within a bus route during a scheduled day. A bus route constituted the base sampling unit, with boat ramps within a bus route constituting the sub-sampling units.

Thirteen geographic bus routes were defined; boundaries were chosen to minimise travel time and hence cost. The number of ramps ranged from a single boat ramp represented the entire sampling unit in Kalbarri and Dongara to nine ramps in Busselton. The bus routes and the number of boat ramps surveyed (in parentheses) for each zone was as follows:

Kalbarri zone:	Kalbarri (1)
Mid-West zone:	Port Gregory (2), Geraldton (5), Dongara (1), Jurien (5)
Metro zone:	Lancelin (4), North Perth Metropolitan (3), South Perth Metropolitan (4), Rockingham (6), Mandurah (8)
South-West zone:	Bunbury (8), Busselton (9), Augusta (5)

A total of 61 boat ramps on the West Coast Bioregion where boats are launched into marine waters were included in the survey. The survey of boat ramps was restricted to eight hours, from 9:00am to 5:00pm.

The bus route method was used for this survey. This method requires that survey interviewers visit several boat ramps each day. Whilst at each ramp the count of boat trailers are recorded and interviews of recreational fishers are undertaken (Robson and Jones, 1989; Jones *et al.*, 1990).

When the interviewers are at each boat ramp, they interview as many recreational boat parties as possible. When several boats return to the ramp at the same time, the survey interviewers randomly choose which of the boat parties will be interviewed. To increase the percentage of parties interviewed, two staff were conducted interviews at each of the busy Perth metropolitan boat ramps during 1 August 2005 to 30 April 2006. Interviewers were trained on the use of the interview data sheets (Appendix 8.3) which were slightly modified from those used in earlier surveys conducted in Western Australia (Sumner and Williamson, 1999; Sumner *et al.*, 2002).

Table 2.2 Boat ramps for each bus route and proportion of time spent at each boat ramp per bus route.

Bus route	1	2	3	4	5	6	7	8	9
Augusta	Flinders Bay 30%	Augusta 10%	Hamlin Bay 5%	Gnarabup 30%	Grace Town 25%				
Busselton	Canal Rocks 10%	Old Dunsborough 10%	Quindalup 15%	Vasse 10%	Dolphin Road 10%	Georgette St 2%	Port Geographe 36%	Wonnerup Beach 2%	Forest Beach 5%
Bunbury	Peppermint Grove 10%	Stirling St. 15%	Fishing Boat Harbour 25%	Bunbury Power Club 20%	Emu Point 5%	Eaton Bridge 10%	Australind 5%	Binningup 10%	
Mandurah	Melros 1.75%	Dawesville 10.2%	Port Bouvard Marina 27.7%	Avalon 1.75%	Mary St Lagoon 15.7%	Waterside Drive 10.2%	Ocean Marina 32.7%		
Rockingham	Bent St 17%	Carlisle St 13%	Point Peron 30%	Mangles Bay 5%	Palm Beach 25%	Kwinana Beach 10%			
South Perth Metropolitan	Sutton Rd 10%	Woodman Point 45%	Fremantle Sailing Club 15%	Leeuwin 30%					
North Perth Metropolitan	Hillarys 50%	Ocean Reef 30%	Mindarie 20%						
Lancelin	Two Rocks 35%	Seabird 15%	Ledge Point 20%	Lancelin 30%					
Jurien	Cervantes 25%	Jurien 25%	Green Head South 15%	Green Head North 10%	Leeman 25%				
Dongara	Main Ramp 100%								
Geraldton	St Georges Beach 10%	Batavia 40%	Town Ramp 30%	Point Moore 10%	South Gates 10%				
Port Gregory	Horrocks 50%	Port Gregory 50%							
Kalbarri	Main Ramp 100%								

The results of the previous recreational survey conducted in 1996/97, showed that recreational fishers ventured out more frequently on weekends and public holidays (Sumner and Williamson, 1999). Consequently, a higher level of sampling was conducted on weekend and public holidays during the 2005/06 survey. The combination of bus routes (n=13) and day-type (n=2: weekdays and non-weekdays) divisions resulted in an experimental design with 26 strata. The sample of interviews for each stratum was assumed to be sufficiently large such that the stratum represents the population of fishing boats in each stratum.

The days each bus route were surveyed was chosen randomly within each month. For each survey day, randomised schedules were then set up for each bus route. The schedules specified the order in which to visit the boat ramps and the amount of time to spend at each ramp. The survey interviewers spent more time at busy boat ramps to maximise the amount of recreational data collected. The amount of time spent at a particular boat ramp was based on prior information on ramp usage obtained during the 1996/97 survey (Sumner and Williamson, 1999) (Table 2.2).

For example based on Table 2.2 a survey interviewer's schedule in the North Perth Metropolitan bus route may be allocated to each boat ramp as follows:

- Ocean Reef - 9:00am to 11:10am (30%)
- Hillarys Marina – 11:28am to 3:05pm (50%)
- Mindarie Keys – 3:34pm to 5:00pm (20%)

The catch and effort information gathered for recreational fishers at boat ramps was recorded in 5x5 nm blocks (Appendix 8.4).

2.2 Mail-phone-diary survey

2.2.1 Introduction

A 12-month recreational mail-phone-diary survey was undertaken from 1 July 2005 to 30 June 2006. The survey was designed to provide estimates of the fishing effort and catch for ocean line fishing of 55,354 licensed recreational boat owners residing within the West Coast Bioregion.

2.2.2 Mail-phone-diary survey design

The mail-phone-diary survey was based on the survey method used by Fishcount in the Northern Territory (Coleman, 1998; Lyle *et al.*, 2002) and the National Recreational and Indigenous Fishing Survey conducted in 2,000 (Henry and Lyle, 2003). However, in the Western Australian survey, the primary sampling unit was a boat rather than a person. A Department of Primary Industries (DPI) database of registered powered boats in Western Australia was used as the sampling frame from which a random sample of boats was drawn. To satisfy a condition imposed by the DPI for permission to use these data, an initial mailout to randomly selected boat owners was undertaken seeking their agreement to participate in the subsequent phone-diary component of the survey. Based on prior information available from a creel survey conducted in 1996/97, where 99% of recreational boat-based fishers interviewed in the West Coast Bioregion lived within this part of the state (Sumner and Williamson, 1999), the sample of boats in the survey was restricted to boats where the owners resided in the West Coast Bioregion.

The survey had three phases:

1. The DPI database of licensed recreational boats in the West Coast Bioregion was used to select a random stratified sample of 2,800 boat owners, each of whom was sent a letter (Appendix 8.5) from the DPI, seeking their participation in the survey. The population of boats in the DPI database was stratified by boat size, i.e. small (length < 4 m), medium (4 ≤ length < 6 m) and large (length ≥6 m) (Table 2.3). This stratification was intended to improve the precision of catch estimates, particularly for boats used for fishing in deeper water, and where fishing parties were likely to be targeting the key demersal indicator species Dhufish, Pink Snapper and Baldchin Groper. From the 2,800 boat owners who received letters from the DPI, 336 responses were received, of which 329 (98% of respondents) owners advised they did not wish to participate in the phone-diary stages of the survey. These individuals were subsequently removed from the survey sample (Table 2.3). It was assumed that non-respondents had no objection to participating in the survey, and were therefore remain included in the sampling frame.
2. A telephone screening survey was conducted during May and June 2005 to canvas a random stratified subsample of those registered boat owners, who had not sought to be excluded from participation in the phone-diary stage of the survey (from Phase 1), and thereby to determine whether their boat was likely to be used for recreational fishing during the next 12-month period, and if so, to encourage them to participate in the next phase of the survey. Randomly selected boat owners were contacted during this screening phase until the sample sizes required for each stratum of the phone-diary phase was reached. This quota, which had been set at 500 boats (504 boats were actually included in the phone-diary phase), was stratified by boat size as in Phase 1 (Table 2.3).Boat owners were asked if their boat had been used for recreational fishing in the previous 12-months, and/or if it was likely that it would be used for recreational fishing in the next 12-months. Only respondents whose boats had been used for fishing in the previous 12-months, or were likely to be used for recreational fishing in the following 12-months, were asked to participate in the next phase. At this phase of the survey, a number of owners could not be contacted, e.g. incorrect phone number, were out of scope (e.g. had sold the boat, or were not able/willing to participate in the 12-month phone-diary phase of the survey) (Table 2.3).
3. The third phase of the study was a 12-month phone-diary survey of the owners of boats that were likely to be used for recreational fishing. Following an initial phone interview (Appendix 8.5), the 504 boat owners selected in the screening phase of the survey, i.e. Phase 2, were sent an introductory letter, species identification booklet and a diary to record all fishing activity from their boat (Appendix 8.5). Catch and effort data for individual boats were collected from the boat owner or the person using the boat. The 'phone-diary survey' was conducted from 1 July 2005 to 30 June 2006. In each month of the 12-month survey, trained interviewers called all participating boat owners and details of their fishing activity were reported over the telephone. The diary was designed to serve as a memory-prompt for the respondent, in order to improve the accuracy of recalled information. A cover sheet for each respondent was used by the interviewer to record all their contact details, the best times to contact the respondent and a history of call attempts (Appendix 8.5). Calls were made monthly except in the cases of avid fishers, where interviews were conducted fortnightly to reduce the interview call length. The best times to call were noted early in the survey to reduce the number of interview attempts. Similarly, efforts were made to schedule interview times to meet the needs of respondents and thereby to ensure that they were not lost from the survey. All fishing from boats in the sample was recorded, regardless of whether the owner

was on board. Extra diaries were sent to owners of boats that were regularly loaned to friends and family members. Where more than one person owned a boat, all owners were sent diaries and called regularly to collect the records of their fishing activity. It was important to retain all boats in the phone-diary survey. Consequently, when boats were sold, attempts were made to contact the new owners. The new owners were sent a letter from the DPI seeking their participation in the survey. If they agreed to be contacted, they were phoned and the survey's purpose and details were explained. Following this call, each new owner was sent a diary and species identification booklet and contacted monthly.

Table 2.3 Sample size from the three phases of the mail-phone-diary survey.

	Small	Medium	Large	Total
Total DPI licences in WCB	16,951	29,949	8,454	55,354
YAC	2,468			2,468
PWC	1,792			1,792
SKI	848	136		984
Mail out phase 1				
Total Mail outs	560	1,680	560	2,800
Not Fishing	10	18	11	39
Away/Sick/Unable	10	26	9	45
No Comment	53	146	46	245
Screening phase 2				
Total phoned	222	601	188	1,011
Full response	150	360	123	633
Full refusal	3		2	5
Full non-contact	29	98	31	158
Partial non-contact	4	12		16
Disconnected	21	55	19	95
Other (business, wrong number, away, sold boat, going overseas, deceased, no English, etc.)	15	76	13	104
12-month phone-diary phase 3				
Total fishing and sent diaries	102	300	102	504
Not Fishing	52	66	28	136
Not fishing due to YAC, SKI or PWC	15	6		21
Boat lost or unable to contact	7	31	10	48

2.3 Counter surveys

Several concurrent counter surveys were carried out, mainly at the Hillarys' boat ramp (one of three ramps in the North Perth Metropolitan bus route in the Metropolitan Zone, Table 2.2). The Hillarys ramp adjoins a large car park, at which the majority of the vehicles and boat trailers are parked until the boats are retrieved on their return to the ramp (Figure 2.4). Counts of the launches and retrievals at the boat ramp, boat trailers in the car park and the vehicle traffic via access-ways associated with those trailers were collected using counter surveys of four types:

- boat launches and retrievals using video cameras focused on the boat ramp
- vehicles, including those with boat trailers, using a VCS

- vehicles with boat trailers parked in the car park using video cameras
- vehicles and boat trailers parked in the car park using ticketing machines.

Figure 2.4 Aerial view of boat ramp and associated car park at Hillarys. The large building at the top left of the photograph is the Western Australian Fisheries and Marine Research Laboratories, where video cameras were mounted to survey the car park and the boat ramps (situated bottom left). The boat-retrieval access lanes are located at the bottom of the car park leading away from the boat ramps. Satellite imagery provided courtesy of Satellite Remote Sensing Services, Western Australian Land Information Authority, 2009.

2.3.1 Video camera survey of boat-ramps

2.3.1.1 Introduction

Activity at the Hillarys boat ramp was monitored using a video camera from the 3 August 2005 to 30 June 2006. The resultant data were used to calculate estimates of total retrieval activity of boats at each ramp during the period over which the ramp was monitored. Subsequently, other cameras were trialled at Woodman Point (6 December 2005 to 30 June 2006), Point Peron (10 April 2006 to 30 June 2006) and Ocean Reef (10 March 2006 to 30 June 2006). These locations were chosen as they represent the boat ramps with the greatest activity in the South Perth Metropolitan, North Perth Metropolitan and Rockingham bus routes in the Metropolitan Zone (Table 2.2). The focus of this report, however, was the comparison between the results of the counter methods employed at the Hillarys ramp.

2.3.1.2 Video camera survey design

A high resolution video camera (Axis 213 PTZ) with pan, tilt and zooming functionality (used in setting up the camera) and infrared capability for improved visibility at night was used to monitor the activity at Hillarys boat ramp. Video camera output streamed directly to a local Apple Mac computer using SecuritySpy software to control the camera recordings and storage. Infrastructure included data and electrical cabling.

Identical high resolution video cameras (Axis 213 PTZ) were mounted directly off the underside of the concrete roof structure on the guard shed at Garden Island causeway to observe the Point Peron boat ramp, and mounted on a pole attached to the roof of the Cockburn powerboat club to observe the Woodman's Point boat ramp. Data from these cameras fed into each building via cable to a network switch, which also had a mac-mini connected for video storage. The monitoring system at these sites used the DSL connection available at the location to send data back to Hillarys via the internet.

A video camera (Mobotix M10) with two fixed lenses; one with a standard field of view and a second telescopic lens was mounted on the Whitfords Sea Search & Rescue building to observe the narrow opening, through which all boats must pass to reach the Ocean Reef boat ramp. This video camera was cabled to a mac-mini and the camera recordings were collected manually each month.

Additional common infrastructure used by all cameras (except Hillarys) included the DSL link, DSL modem and secure gateway. An overlay containing details of the date, time and site of capture was embedded in the recorded video and the camera was configured to record time-lapsed video footage at the rate of one frame every 8 seconds and combined all frames over one hour duration into a Quicktime video file. The video footage was reviewed and any boat activity recorded within each minute was identified as either a launch or retrieval for entry into the database. Additionally the boat type classification (small-length < 4 m, medium – $4 \leq$ length < 6 m and large length ≥ 6 m, other), the date and time were also recorded. For the purposes of this survey, a unit of activity was deemed to be the time (to the nearest minute) at which launching of a boat was complete or at which retrieval commenced. Activity classified as 'Other' boat types included yachts, kayaks and jet skis. In addition to the records of activity, there were periods for which it was not possible to collect useful activity data. These were recorded as outage 'events' that hindered collection and included technical faults and environmental conditions (e.g. storms) that affected visibility. Details of these events were recorded for later analysis.

2.3.2 Vehicle counter survey

2.3.2.1 Introduction

Vehicles were counted using a VCS mounted across the boat-retrieval access lane for the Hillarys car park between 6 April and 27 June 2006. This collection method was employed to assess the effectiveness of vehicle counters for capturing an index of the level of retrieval activity at a boat ramp with high traffic volume. It was assumed that retrieval activity recorded by the VCS would be proportional to the total activity of the recreational fishery associated with the boat ramp. Although this was the shortest temporal coverage of the surveys considered in this project, adequate data were obtained to be analysed and compared with data collected from some other survey approaches.

2.3.2.2 Vehicle counter survey design

A MetroCount 5600 VCS unit was deployed across the boat-retrieval access lane for the Hillarys car park. This unit consisted of a pair of pneumatic rubber tubes that led to the recording unit, thereby intending to provide a count of the axles that passed over the rubber tubes. These events were assumed to relate to the passage of a vehicle through the monitored access lane to retrieve a boat from the boat ramp. As the unit monitored activity throughout the entire deployment period, it had the potential to provide comprehensive monitoring coverage for a wide temporal stratum. The data were extracted from the unit on a weekly basis to limit potential data loss.

2.3.3 Camera snapshot counter survey

2.3.3.1 Introduction

A small number of low cost and low resolution cameras were deployed at fixed locations to overlook the Hillarys boat ramp car park. These cameras were configured to take synchronised, hourly snapshots. The resulting set of images for each hourly snapshot was then examined and the number of trailers visible at that time in the car park was recorded, thereby providing an instantaneous count of boat trailers present in the car park. When trailers were not present in the captured images, no count was recorded. The resulting data were intended to provide an index of the usage of the associated boat ramp, whilst recognising that not all trailers are necessarily associated with boats being used for recreational fishing and that not all launched boats would necessarily result in a residual trailer being stationed in the car park.

2.3.3.2 Camera snapshot counter survey design

Several types of cameras were deployed at the car park adjoining the Hillarys boat ramp to allow comparison of their effectiveness. The cameras and associated methods were:

- A pan-tilt-zoom camera (Axis 213 PTZ) with infrared facility, panning across a car park once per hour. This camera was also used to capture images of boat ramp activity, i.e. launches and retrievals. The frequencies of trailer counts recorded by the panning camera for each hour of the day over all days within the 2005/06 study period and of all counts recorded within each day during the study period (in periods for which the camera functioned correctly) were calculated. The panning camera suffered occasional interruptions to its operations with consequent failure to capture images during such periods. The average of the trailer counts recorded within each hour of the day over all days within each calendar month was calculated;
- Between 1 February and 30 April 2006, a pair of low resolution cameras (Swann SW231) attached to the window sill taking synchronised snapshots every hour, facing east and west to cover the entire car park every hour downloaded to network;
- Subsequently, between 6 March and 30 April 2006, a low resolution wide angle lens (Axis 207W) attached to the window sill camera taking an individual snapshot of the car park every hour, which was downloaded to the network; and
- Between 10 March and 30 April 2006, a phone-camera (Nokia N70) taped to a window overlooking the car park, using TimedSpy and PhotoSpy software taking hourly high-resolution and low-resolution JPEG format photos every hour and storing these directly to the memory card.

2.3.4 Ticketing counter survey

2.4.1 Introduction

Details of the number of parking tickets, annual parking permits and parking infringements issued monthly may be obtained for car parks adjoining several of the boat ramps in the West Coast Bioregion. These counts aimed to provide a relative index of activity at boat ramps. Various authorities were approached and asked to supply details of the number of parking tickets, infringements and annual parking permits issued for 2005/06 financial year.

2.3.4.2 Ticketing counter survey design

Local government authorities and the DPI were contacted and requested to provide various types of parking ticket data for the car parks adjoining several of the boat ramps in the Perth Metropolitan area. The requested data included ticket sales at boat ramps for boat trailers, annual parking passes issued, and parking infringement/fine figures (Table 2.4).

Table 2.4 Summary of responsibilities (as at June 2006) for issuing parking tickets at boat ramps in the Perth Metropolitan Area.

Boat Ramp	Issuing	Responsible organisation
Hillarys	Ticketing Annual passes Fines	Department of Planning & Infrastructure
Ocean Reef	Ticketing Annual passes Fines	City of Joondalup
Leeuwin	Ticketing Annual passes Fines	Town of East Fremantle
Mindarie Keys	Ticketing Fines	Private property

2.4 Fisheries and Marine Officers (FMO) recreational fishing survey

2.4.1 Introduction

The compliance and inspection activities of its Fisheries and Marine Officers (FMOs) provided an opportunity to obtain data on recreational fishing. Accordingly, on 1 July 2005, a modified Marine Safety Inspection (MSI) Form was introduced for use by FMOs. This new form was intended to capture ancillary recreational fishing data obtained in the course of the Officers' inspection duties. FMOs completed the form in the field, recording details of the location of inspection, the number of people on board the recreational boat, whether or not the fishers had been fishing, and the catches of key recreational species. The catches of these key species differ among bioregions, so four separate bioregion-specific versions of the MSI Form were developed. The forms, developed in consultation with the FMOs, are intended to capture essential information on recreational fishing, while remaining of sufficient simplicity that they could be completed readily by the FMOs in the field, during the course of their inspection activities. Full details of the MSI Forms and instructions to FMOs on the information to be collected and recorded during inspections are described in Green and Griffiths (2005).

A detailed description of the FMO programme has been published in Smallwood *et al.* (2013), while the survey form is shown in Appendix 8.6

2.4.2 FMO survey design

In the course of daily duties, FMOs make contact with the people on board recreational boats. Such contacts with recreational boats may occur at boat ramps where boats are launched or retrieved (i.e. land patrols), or at anchorages in protected waters or at sea (i.e. boat patrols). It is the responsibility of the FMO to determine whether, for each contact that is made with a recreational boat, whether the operators of that boat are complying (or have complied) with marine safety and fishery regulations. Such FMO surveys and inspections are intended to provide incentive for compliance with regulations on each occasion on which the boat is operated. Accordingly, the sampling unit of the FMO inspection is a "trip" or "proposed trip" by a recreational boat during which either fishing activity has, is, or will be occurring, or if no fishing activity is planned. The population to be surveyed may thus be considered to be all trips by recreational boats within each bioregion within a specified year.

The spatio-temporal distribution of the population of fishing trips by recreational boats within each bioregion within a specified year is likely to be related to the spatial distribution of recreational boats, the spatial distribution of boat ramps and/or moorings, the demographic characteristics of the owners/operators of the recreational boats, and the location of fishing grounds and fish assemblages in different districts and areas within each bioregion. A well defined sampling frame to collect recreational fishing data would ensure appropriate spatial coverage of the bioregion and appropriate temporal coverage both within and among days of the year.

Survey and inspection activities of the FMOs are conducted in accordance with normal operational and compliance duties of the FMOs, and, at times, to fulfil obligations to the DPI to conduct marine safety inspections. Because it is designed to meet other objectives, the sampling design of the FMO survey was not based on a predefined sampling frame developed to collect recreational fishing data. Accordingly, the sampling method employed in the FMO surveys may be considered to be 'convenience' (i.e. opportunistic) sampling that is of a non-random nature and, therefore no weighting data are available to allow the data to be adjusted to produce unbiased estimates of recreational catch rates.

While those people operating recreational boats contacted by FMOs may have engaged, be engaged and/or may intend to engage in fishing activities, others may also be undertaking other recreational activities. If the FMO decided to conduct a recreational survey, the appropriate fields in the MSI form (Appendix 8.6) were completed, otherwise the fields were left blank. Recreational survey data stored within the resulting database included details of the date, time, location (area within district) and purpose of the contact (for example marine safety inspection and/or recreational survey), whether or not the party on the boat was engaged or intended to engage in fishing and, if fishing had occurred, the number of individuals of each of the key indicator species that was caught and retained by the fishing party.

It should be noted that the number of fish recorded for a species was frequently the number advised by the recreational fishers at the time of the interview, particularly when the species was one for which large numbers of fish may be retained, e.g. Blue Swimmer Crabs and/or Australian Herring. The number of fish recorded was generally an accurate count of the number of fish taken, but for high volume species such as crabs or herring, an exact count may only be undertaken if the FMO thinks the catch is close to the bag limit.

It was considered inappropriate to report details of the spatial and/or temporal distribution of surveys or inspections in this report, as such data may compromise the operations of the FMOs. Accordingly, data from the FMOs' Recreational Fishing Surveys have been analysed and reported at the West Coast Bioregion level, however, the majority of contacts were in the metropolitan zone.

2.5 Volunteer Fisheries Liaison Officer (VFLO) survey

2.5.1 Introduction

VFLOs are individuals who participate in volunteer activities that promote sustainable fishing amongst recreational anglers. The program was initiated in 1993, and activities undertaken during this time included shore and boat-based patrols, training, education programs (i.e. fishing clinics/workshops, learning with disabilities program), educational displays at events (i.e. boat shows, festivals), participation in fisheries research programs and presentations to schools and community groups.

As well as a range of educational activities, volunteers conducted patrols throughout the coastal, marine and estuarine environs of Western Australia. The information collected from interviews with shore- and boat-based recreational fishers during these patrols developed a dataset from 1995 to 2007. This information has generally been distributed via the volunteer coordinator or research staff during annual general meetings, and bioregional data summaries of activities have been provided for State of the Fisheries reports (Penn *et al.*, 2005).

A detailed description of the VFLO programme has been published in Smallwood *et al.* (2010), while the survey form is shown in Appendix 8.7.

2.5.2 VFLO survey design

Information collected during patrols and interviews with recreational fishers from 1995 to 2007 was used for catch-rate analysis. Patrols were predominately conducted from the shore at locations where any type of recreational fishing (i.e. using line, scoop nets, pots) may have occurred (i.e. beaches, estuaries or rivers). The scheduling of patrols was unstructured, with the volunteers determining where and how long to patrol a particular location (i.e. no defined schedule). The numbers of recreational fishers at a particular location were counted, and a random sample interviewed by volunteers on the patrol.

2.6 Research Angler Program (RAP) Logbook

2.6.1 Introduction

The RAP commenced in March 2004 and was initially designed as a tool to maintain fishery data collection in estuaries during and after their closure to commercial fishing. However, the popularity of the RAP has seen the program expand to collect data in all bioregions of the State, during fishing competitions and for site-specific programs (e.g. monitoring of fish around Busselton Jetty).

The RAP provides data for a wide range of species and areas and is the only source of data by which to assess the status of some fish stocks. In brief, information on the majority of recreationally caught estuarine and nearshore species in the West Coast Bioregion now comes primarily or exclusively from the RAP. With the push to buying out or retiring many of the commercial licenses in estuarine areas, and closures of areas to commercial fishing the collection of recreational data will become increasingly important.

RAP data have also been used to support analyses and interpretation of trends in other fishery data, support requests for information from internal and external stakeholders and generate community involvement and support. Monthly newsletters, which are sent to all RAP log book holders, provide an outreach and extension tool to a wide audience of recreational fishers.

A detailed description of the establishment of the RAP logbook programme has been published in Smith *et al.* (2007). An example of the logbook data collection sheet is shown in Appendix 8.8.

2.6.2 RAP logbook design

Promotion of the RAP logbook program and recruitment of new anglers is ongoing via channels such as media, pamphlets, posters, and word of mouth. Any angler in Western Australia can register to complete a logbook. Anglers are encouraged to participate in the program on long-term basis.

Data collected includes the angler's registration details such as name, address, phone number, email address, whether the angler is a member of an angling club, the region registered, book number and issue date. Returns also include information on date fished, mode of fishing (boat or shore), location fished, region fished, start and finish time of fishing, gear and number used, tackle, bait, species caught, fish health, body size (total length, carapace width, etc.), retained or released and the reason for release.

Logbooks include all recreational methods (angling, trapping, netting, hand collecting). All anglers are supplied with maps of fishing regions, divided into 5x5 nm blocks, similar to those used in creel surveys (see Appendix 8.4). Catch and effort are reported by block.

3.0 Comparison of precision and accuracy of various survey estimates

Objective 2. Compare the precision and accuracy of estimates generated using these various survey techniques.

Surveys of the type used in this study provide data from which estimates of activity, nominal fishing effort (i.e. the observed or reported fishing activity), catch, and catch rate for a specified region and time period may be derived (Table 3.1). In this context, activity represents the fishing and non-fishing usage of boats, fishing effort represents the total boat-hours or fisher-hours of line fishing (i.e. directed towards one or more of the demersal species or non-directed), and the total catch and catch rate of each of the key indicator species. Note that the latter measure is unlikely to represent an index of abundance of fish of a particular species, however, provides a measure of fishing success or catch for the selected unit of effort, i.e. boat-hour or fisher-hour.

The different survey methods used in this study, which were described in Section 2, are analysed in this chapter and the activity, participation, effort, catch and catch rate estimates and their precision were calculated and compared where possible.

Table 3.1 Matrix indicating which survey estimates were possible for each given method and level of ramp (R), zone (Z) and bioregion (B) spatial extents.

Method	Activity	Estimated Total Effort	Estimated Total Catch	Catch rate
Creel survey	R	Z,B	Z,B	Z,B
Mail-phone-diary survey		B	B	B
Camera @ ramps	R			
VCS @ ramps	R			
Camera @ car parks	R			
Ticketing @ car park	R			
FMO survey				B
VFLO survey				B
RAP logbooks				B

3.1 Boat-ramp based creel survey

3.1.1 Introduction

Detailed results from the original analysis of the data collected in this survey have been presented by (Sumner *et al.*, 2008) and the analysis methods described below represent a refinement of the approaches described by these authors. The results of this survey were an important consideration between 2007 and 2009 when the future management of the WCDS fishery was being discussed. In 2009, a review of the methods used in this survey was undertaken (Steffe, 2009). A workshop to examine the results of this review was held in October 2009 to determine how its recommendations might best be implemented. A summary of the decisions resulting from that workshop and details of the revised methods are presented below. The results that are presented in this report were determined using the revised approach.

3.1.2 Workshop to implement findings of review of survey method

A workshop was held at the Western Australian Fisheries and Marine Research Laboratories from the 31 August to the 9 September 2009 to carry out an internal audit of methods used to analyse data from boat-ramp based recreational creel surveys based on the review of Sumner *et al.* (2008) by Steffe (2009). The outcomes of this workshop provided the basis for reanalysis of data collected using these types of surveys.

Consideration and decisions resulting from the workshop are listed below.

Recommendations

1. In principle, the survey should extend to cover the entire period of daylight hours. However, such extension is dependent on funding. There is a trade-off between increasing the coverage of daylight hours and decreasing the number of days surveyed per month. Decreasing the numbers of days surveyed per month will result in decreased precision in zonal and monthly catch and effort estimates, which is required by management. Past surveys were designed to ensure adequate temporal coverage with 8 to16 days surveyed per month. With such temporal coverage, available funding restricted the daily survey period to only eight hours. It should be noted that past creel surveys were designed to provide relative estimates of catch and effort during the peak fishing period of the day, which could be compared with results from subsequent surveys to determine trends over time. However, with the introduction of IFM initiative, the objective has changed and recreational fishing surveys are now required to produce a total measure of catch and effort at each zone, within the bioregion level.
2. Survey data from Sumner et al. (2008) to be reanalysed using methods consistent with the stratification employed in the survey design and with appropriate estimation of precision.
3. Where the data exist, the following additional information has been added to the report
    a. Number of days sampled in each bus route for the appropriate level of stratification (e.g. day-type within each season/month)
    b. Number of interviews conducted in each bus route for the appropriate level of stratification (e.g. day-type within each season/month)
    c. Report interview refusal rates in each bus route for the appropriate level of stratification (e.g. day-type within each season/month). A low refusal rate provides evidence of stakeholder cooperation and quality control. Note that earlier surveys did not collect this information.
    d. Raw number of fish counted by species during interviews at an appropriate level of aggregation
    e. Raw number of fish measured by species during interviews at an appropriate level of aggregation
4. An internal audit of recreational surveys had already identified the need for more detailed underlying documentation including information on project quality assurance, including pretesting of survey forms, level of training provided for survey interviewers, fish identification procedures, survey protocols, data entry and validation checks.

Conceptual Issues

1. While uncertainty increases when calculating catch and effort at individual access sites (boat ramps) and individual areas (5x5 nm blocks), there is still value in the calculation of some

spatial aspects of the survey data, however, the uncertainty of the estimates needs to be understood. The spatial distribution of the catch and effort data provides an indication at a broad subjective level how the effort is changing. In addition, it may be useful to form statistical contrasts of the data to confirm any trends in the spatial distribution of catch and effort.

2. The day length of only eight hours is restrictive, however, funding is an issue. In the past, funding was only sufficient to provide an eight hour day with 8 to 16 days surveyed per month. There is a trade-off between increasing the coverage of daylight hours and decreasing the number of days surveyed per month. Decreasing the numbers of days surveyed per month will result in deceased precision in zonal and monthly catch and effort estimates.
3. The eight hour daily survey period will cause greater under-estimation in summer than winter. Having a survey that covered all daylight hours would overcome this and provide more accurate and precise monthly, seasonal and annual totals.

Stratification

1. The stratification (bus route and day type) is appropriate.
2. Monthly or seasonal stratification is important. While not clearly presented by Sumner et al. (2008), the sampling design includes monthly stratification. Consequently, there is no incorrect application of temporal stratification. This will be clearly presented in the future reports.
3. Covered above under Conceptual Issues 1.

Estimation Issues

1. The two methods "Time Interval Count Method" and "Direct Expansion Method" are now used to estimate effort in a bus route method. The choice of appropriate methodology depends on the situation at the boat ramp, where on some days one method may be more appropriate than the other method.
2. The uncertainty around the correction factor should be included in the precision estimates.
3. The analysis can be done by season (three monthly periods) or by month. It should be noted that to continue to provide estimates at monthly stratum requires high level of sampling per month to provide an acceptable level of precision.
4. The primary sampling unit is the sampling day.
5. The uncertainty around the estimated proportion of boats ocean line fishing should be included in the precision estimates.
6. The appropriate catch rate estimator for the onsite bus route survey is the ratio of the means (Crone and Malvestuto, 1991; Pollock et al., 1997).
7. The uncertainty around the weight estimates should be included in the precision estimates.

Review summary

1. The onsite surveys methods used in these studies were appropriate for deriving estimates of catch, effort and catch rates for this type of fishery.
2. The creel survey provides an under-estimate of the total fishing effort and catch, as was stated by Sumner et al. (2008).
3. The measures of uncertainty associated with the total estimates have been under-estimated.

The survey data will be reanalysed to update the level of uncertainty associated with total estimates of catch and effort.

4. If future funding allocated for recreational fishing surveys is of a level similar to that available for past surveys, funding will be sufficient for an eight hour day with 8 to16 days surveyed per month. Consideration will be given to the trade-off between increasing the coverage of daylight hours and decreasing the number of days surveyed per month, recognising that the latter will result in deceased precision in zonal and monthly catch and effort estimates.
5. The creel survey does not provide over-estimates of total recreational catch and effort but, as stated by Sumner et al. (2008), the survey under-estimates catch and effort.
6. Voluntary or mandatory logbooks do not provide the same quality estimation of total catch and effort than a probability based survey, i.e. a recreational fishing survey based on statistically sound survey methods where the sample is representative, and can be referenced back to, the target population.

3.1.3 Boat-ramp-based creel survey analysis

The sampling frame for the creel census for the boat ramps is spatio-temporal, comprising all times of the day that are available for fishing and all access points, i.e. boat ramps, covered by a number of bus routes. The strata for each bus route are the different types of day within the different months (or seasons). The primary sampling unit (PSU) is the sampling day. The survey design has typically employed calendar month as a second level of stratification to provide balanced coverage through an entire year, and within this temporal frame, day type (weekday or weekend/public holiday) has provided a final level of temporal stratification.

Data collected at the boat ramps visited within each sampling day must be expanded to produce estimates of the total catch, fishing effort or average catch rate for the complete bus route for the day, i.e. for the PSU. The resultant data for each of the sampled days, i.e. sampled PSUs, may then be combined for each stratum, i.e. all days of the day type within month (or season). Thus, total catch and effort or average catch rate over all boat ramps in the bus route must first be calculated, before the resultant daily data for the complete bus route are combined to produce estimates of total catch, total effort, or average for all days of the day type associated with the stratum. The resulting data for the different strata may then be combined to produce estimates of the overall catch or fishing effort.

The sequence of calculations is therefore;

- For each day on which the bus route survey was undertaken, derive an estimate of total fishing effort for the day for the bus route as a whole from the data collected while the interviewer was at each of the individual boat ramps.
- Combine the daily data for the sampled PSUs within each stratum to produce an estimate of the total fishing effort over all possible sampling days (i.e. of the day type represented) within the stratum.
- Calculate the average catch rate over all possible sampling days (i.e. of the day type represented) within each stratum.
- Calculate an estimate of the total catch over all possible sampling days (i.e. of the day type represented) within each stratum.
- Combine the data for the different strata to obtain an estimate of the total catch, total effort and overall catch rate.

The bus route contains a number, R, of boat ramps (i.e. access sites) that must be sampled during the day. The starting time, position and direction of travel around the route on a sampling day were randomly selected. The West Coast Bioregion surveys were restricted to a specified period within each day i.e. from 9:00 a.m. to 5:00 p.m. from 1 July 2005 to 30 June 2006 (Sumner *et al.*, 2008). Thus, for these surveys, the starting time was randomly selected from the daily survey period allowing sufficient time for the interviewer to visit all ramps covered by the bus route. The interviewer moved around the bus route visiting each access site according to a predefined schedule, such that the time spent at each site was approximately proportional to the activity at the site, but allowing time to travel between sites. The time that the interviewer spent at boat ramp r ($1 \le r \le R$) on a sampling day d ($1 \le d \le D$) within stratum m ($1 \le m \le M$) is referred to as the wait time w_{rdm}.

Pollock *et al.* (1994) advised that the interviewer needs to adhere strictly to the schedule of visits, i.e. the time of arrival at the boat ramp and the specified wait time at that ramp. In practice, a small amount of implementation error occurred in the boat ramp surveys undertaken. Accordingly, any inconsistency between the actual scheduled times were determined from the start and end times at the boat ramp that were recorded by the interviewer rather than the scheduled times.

At the beginning and end of the visit to each boat ramp, i.e. at times t_{rdm} and $t_{rdm} + w_{rdm}$, respectively, the interviewer recorded the number of boat trailers parked at the boat ramp. The time at which each boat b was launched l_{rbdm} or retrieved r_{rbdm} during the wait time on this sampling day was recorded. Launch and retrieval times falling outside the wait time were considered missing (unknown) values. Note that each boat trailer parked at a ramp was assumed to be associated with a boat that was launched from that ramp. The boats associated with these trailers were included in the total number of boats, i.e. the boats considered include all boats launched or retrieved during the wait time as well as those boats which remained on the water throughout the entire wait time.

In addition to recording the launch and retrieval times of each boat, the interviewer attempted to interview the members of the boat parties that are aboard all boats that were retrieved from the site. If sites were very busy, interviews were not obtained from the crews of all retrieved boats. In such cases, it was assumed that the boats selected for interview were randomly selected from the boats that were retrieved. During the interviews, details of the launch time of the retrieved boat and the duration of fishing was ascertained and recorded by the interviewer, together with details of catches of the different species and, where practical, lengths of individual retained species.

3.1.3.1 Calculation of total fishing time for the whole bus route for each surveyed day

Two approaches were adopted to analyse the bus route survey data, to produce an estimate of the total fishing effort for the bus route for each sampling day on which the survey was undertaken.

A. Estimation of total boat (fishing and non-fishing) hours for bus route using the interval count (IC) method

It was assumed in this section of the analysis that all boats are included, whether involved in fishing (possibly for a specific target species or set of target species) or in non-fishing activities, and whether or not an interview was conducted.

Let X_{rbdm} be the time that boat b ($1 \le b \le B_{rdm}$) was on the water (or the trailer associated with boat b was at the ramp) while the interviewer was at ramp r on sampling day d within stratum

m. The value of x_{rbdm} was calculated as shown in Table 3.2. The estimate of the total boat time (hours) e_{dm} during the daily survey period T over all boat ramps r ($1 \le r \le R$) on day d ($1 \le d \le D_m$) in stratum m ($1 \le m \le M$) (Jones and Robson, 1991) is:

$$e_{dm} = T \sum_{r=1}^{R} \frac{1}{w_{rdm}} \sum_{b=1}^{B_{rdm}} X_{rbdm}$$

Table 3.2 Approaches used to calculate the value of X_{rbdm}, the time that boat b ($1 \le b \le B$) is on the water (or the trailer associated with boat b is at the site) while the interviewer is at site r on sampling day d within stratum m. Note that an estimate of the launch time $\hat{l}_{rbdm}$ for a boat that was launched prior to the start of the visit to the boat ramp is available only if the party on board the boat was interviewed.

		Retrieval		
		Before visit to boat ramp	**During wait time**	**After visit to boat ramp**
Launch	**Before visit to boat ramp**	No overlap with visit	$X_{rbdm} = r_{rbdm} - t_{rdm}$	$X_{rbdm} = w_{rdm}$
	During wait time	NA	$X_{rbdm} = r_{rbdm} - \hat{l}_{rdbm}$	$X_{rbdm} = t_{rdm} + w_{rdm} - \hat{l}_{rdbm}$
	After visit to boat ramp	NA	NA	No overlap with visit

This calculation assumes that the times at which all boats were launched or retrieved during the wait time were accurately recorded, that the number of trailers in the ramp at the start of the wait time was accurately recorded, and that the wait time was a random sample of duration w_{rdm} from the time period T, which was assumed to represent the total time within the sampling day during which fishing occurs. As no record was kept by the interviewer of the identities of boats that were launched during the visit to the ramp, it is not possible to determine whether a retrieved boat was launched prior to or after the start of the wait time. Accordingly, it was assumed that all boats that were retrieved during the visit were launched prior to the start of the wait time, and that all boats launched from the boat ramp during the visit were retrieved after the conclusion of the visit to the boat ramp. Thus, the number of boats that were present at the ramp for the entire duration of the visit may be calculated as the difference between the number of boat trailers present at the start of the visit and the number of retrievals (or zero, if this difference is negative).

To facilitate the calculation of the variance of total boat time for the stratum for those cases where there was a limited number of boats at a boat ramp during the bus route survey, the above equation for e_{dm} is rewritten in terms of a transformed variable, X'_{rbdm}. For boat (or trailer) b at boat ramp r on survey day d within stratum m, the boat time for each unit of survey time within the interviewer's visit may be calculated as:

$$X'_{rbdm} = \frac{X_{rbdm}}{w_{rdm}}$$

The average boat time for each unit of survey time for all boats at boat ramp r on survey day d within stratum m was then calculated as:

$$\bar{X}'_{rdm} = \frac{1}{B_{rdm}} \sum_{b=1}^{B_{rdm}} X'_{rbdm}$$

where

$$Var\left(\overline{X}'_{rdm}\right)=\frac{1}{B_{rdm}(B_{rdm}-1)}\sum_{b=1}^{B_{rdm}}\left(X'_{rbdm}-\overline{X}'_{rdm}\right)^2$$

This boat-ramp-based estimate of variance is undefined if $B_{rdm} < 2$. If the number of boats at boat ramp *r* on survey day *d* within stratum *m* is insufficient to allow calculation of the variance using the above equation, a stratum-based estimate of the variance for this ramp, day and stratum was obtained by calculating the variance over all boats, ramps and survey days within the stratum: Thus, in this case,

$$Var\left(\overline{X}'_{rdm}\right)=\frac{1}{\left(\sum_{d=1}^{d_m}\sum_{r=1}^{R}B_{rdm}\right)\left(\sum_{d=1}^{d_m}\sum_{r=1}^{R}B_{rdm}-1\right)}\sum_{d=1}^{d_m}\sum_{r=1}^{R}\sum_{b=1}^{B_{rdm}}\left(X'_{rbdm}-\frac{1}{\left(\sum_{d=1}^{d_m}\sum_{r=1}^{R}B_{rdm}\right)}\sum_{d=1}^{d_m}\sum_{r=1}^{R}\sum_{b=1}^{B_{rdm}}X'_{rbdm}\right)^2$$

where d_m is the number of survey days within the stratum on which the bus route survey was undertaken, and where it is assumed that the values of X'_{rbdm} are random variates sampled from the stratum. As previous studies of recreational boat survey data within Western Australia applied a stratum-wide estimate of variance rather than a boat-ramp-based estimate, the analyses undertaken in this report considered the cases where the stratum-based estimates of variance were used (a) only for those boat ramps and sampling days on which the number of boats was less than 2, and (b) where the stratum-based estimates of variance are used for all boat ramps and sampling days.

The total boat time of the boats at site *r* on sampling day *d* within stratum *m* during the wait time at this site may be calculated as $TB_{rdm}\overline{X}'_{rdm}$, and the variance of this variable can be estimated as $\left(TB_{rdm}\right)^2 Var\left(\overline{X}'_{rdm}\right)$.

The total boat time over all boat ramps on day *d* in stratum *m* is:

$$e_{dm}=T\sum_{r=1}^{R}B_{rdm}\overline{X}'_{rdm}$$

with variance

$$Var\left(e_{dm}\right)=T^2\sum_{r=1}^{R}B_{rdm}^2 Var\left(\overline{X}'_{rdm}\right)$$

where it is assumed that the estimates of $\overline{X}'_{rdm}$ for the different boat ramps are independent.

The equations presented above describe how estimates of total boat time may be calculated for the various strata. For fishing time, it is necessary to adjust the equations to allow for boats that were not occupied in fishing activity, noting that discrimination of whether or not a boat was engaged in fishing is based on the results of the interviews that were conducted.

For sampling day *d* within stratum *m*, the proportion of boats that were fishing (or fishing for the targeted species), p_{dm}, may be estimated as the ratio of the total over all boat ramps of the number of boats for which interviews reported (targeted) fishing for the day to the total over all boat ramps of the number of boats for which successful interviews were conducted.

The proportion p_{dm} of boats that were fishing on day *d* in stratum *m* was estimated as:

$$p_{dm}=\frac{n_{dm}^{Fishing}}{n_{dm}}.$$

The variance of the proportion p_{dm} was calculated as:

$$Var(p_{dm}) = \frac{p_{dm}\ 1 - p_{dm}}{n_{dm}}$$

where n_{dm} is the total number of interviews over all boat ramps for sampling day d within stratum m. If no boats were successfully interviewed on day d within stratum m, it was assumed that $p_{dm} = p_m$, where p_m is calculated as the proportion of boats fishing over all ramps and days within the stratum (see next section). In this case, $Var(p_{dm})$ was assumed to be equal to $Var(p_m)$.

The total fishing time (hours of boat time) within the daily time period surveyed for day d within stratum m over all access sites included in the bus route, e^f_{dm}, may then be estimated as:

$$e^f_{dm} = p_{dm} e_{dm}$$

The variance of e^f_{dm} is calculated using the formula for the variance of a product presented by Goodman (1960,Eq. 5)

$$Var(e^f_{dm}) = (p_{dm} e_{dm})^2 \left[\frac{Var(p_{dm})}{p^2_{dm}} + \frac{Var(e_{dm})}{e^2_{dm}} - \frac{Var(p_{dm})Var(e_{dm})}{(p_{dm} e_{dm})^2} \right]$$

which has been employed in similar boat ramp studies of recreational fishing (e.g. Steffe *et al.*, 2008).

B. Estimation of total fishing hours for bus route for the sampling day using the direct expansion (DE) method

This approach used the information on fishing effort collected from the parties that were interviewed at the times at which their boats were retrieved, thereby providing a direct estimate of the hours spent fishing. Thus, there was no need to first estimate total boat time and then use the proportion of boats that were fishing to derive an estimate of fishing time.

If Y_{rbdm} is the reported fishing or trip time (set to zero if the boat was not fishing or was fishing but not for the requisite species and/or using the requisite fishing method) of boat b ($1 \le b \le N_{rdm}$) that is retrieved during the wait time at site r on sampling day d within stratum m, where n_{rdm} is the number of boats that were retrieved and the occupants of which were successfully interviewed during this wait time, then

$$e^f_{dm} = T \sum_{r=1}^{R} \frac{N_{rdm}}{n_{rdm}} \frac{1}{w_{rdm}} \sum_{b=1}^{n_{rdm}} Y_{rbdm}$$

where $\frac{n_{rdm}}{N_{rdm}}$ is the (known) proportion of the N_{rdm} boats retrieved at the boat ramp. That is, $\sum_{b=1}^{n_{rdm}} Y_{rbdm}$ is the total fishing time recorded from interviews of the parties in the n_{rdm} of the N_{rdm} boats that were retrieved within the randomly selected period w_{rdm} within the total period T.

The average fishing time of the interviewed boats at site r on sampling day d within stratum m is

$$\bar{Y}_{rdm} = \frac{1}{n_{rdm}} \sum_{b\ 1}^{n_{rdm}} Y_{rbdm}$$

An estimate of the total fishing time of the boats retrieved at site r on sampling day d within stratum m may now be calculated as

$$\frac{N_{rdm}}{n_{rdm}}\sum_{b=1}^{n_{rdm}} Y_{rbdm}\ \left(i.e., N_{rdm}\overline{Y}_{rdm}\right)$$

Since the wait time at the site was randomly selected from the daily survey period T, an estimate of the total fishing time for all boats retrieved at site r on sampling day d within stratum m during the daily survey period was calculated as:

$$\frac{T}{w_{rdm}}\frac{N_{rdm}}{n_{rdm}}\sum_{b=1}^{n_{rdm}} Y_{rbdm}\ (i.e., \frac{T}{w_{rdm}}N_{rdm}\overline{Y}_{rdm})$$

Finally, by combining over all boat ramps in the bus route, the total fishing time of all boats retrieved on sampling day d within stratum m was calculated as:

$$e^{f}_{dm} = T\sum_{r=1}^{R}\frac{N_{rdm}}{n_{rdm}}\frac{1}{w_{rdm}}\sum_{b=1}^{n_{rdm}} Y_{rbdm} = T\sum_{r=1}^{R}\frac{N_{rdm}}{w_{rdm}}\overline{Y}_{rdm}$$

This calculation assumes that the fishing time of all occupants of boats interviewed was accurately reported during the interview (occupants of boats that are not fishing will report zero fishing time, and it is possible to identify reliably those interviewed boats that were fishing for the requisite species and/or using the requisite fishing method) and that the numbers of boats that are retrieved and for which occupants were interviewed were accurately recorded.

Note that the proportion $\frac{n_{rdm}}{N_{rdm}}$ is indeterminate if no boats were retrieved at the boat ramp, and that the estimate of fishing effort cannot be determined from the above formulae if there were no interviews for the boats that were retrieved at the boat ramp. In the case where boats were retrieved but no interviews were conducted, the value of $\overline{Y}_{rdm}$ in the equation for e^{f}_{dm} was estimated using a stratum-wide average over all interviews rather than the above boat ramp-based average, i.e.,

$$\overline{Y}_{rdm} = \overline{Y}_{m} = \frac{1}{\sum_{d=1}^{d_m}\sum_{r=1}^{R} n_{rdm}}\sum_{d=1}^{d_m}\sum_{r=1}^{R}\sum_{b=1}^{n_{rdm}} Y_{rbdm}$$

The variance of the reported fishing times Y_{rbdm} for the boats retrieved and interviewed during the wait time at ramp r on sampling day d within stratum m was calculated as

$$Var\left(Y_{rbdm}\right) = \frac{1}{n_{rdm}-1}\sum_{b=1}^{n_{rdm}}\left(Y_{rbdm} - \overline{Y}_{rdm}\right)^2$$

where $\overline{Y}_{rdm}$ is the mean of the reported fishing times for that day d, boat ramp r and stratum m, i.e.

$$\overline{Y}_{rdm} = \frac{1}{n_{rdm}}\sum_{b=1}^{n_{rdm}} Y_{rbdm}$$

The variance of the mean reported fishing time for boat ramp r on day d within stratum m is

$$Var\left(\overline{Y}_{rdm}\right) = \frac{1}{n_{rdm}} Var\left(Y_{rbdm}\right)$$

Again the finite population correction was not applied as it is assumed that the reported values of Y_{rbdm} were derived from a random sample from the population (of unknown size) of the boats that fished at boat ramp r on sampling day d within stratum m, where the sample size was determined by the wait time at the ramp and the proportion of boat parties willing to be interviewed.

If the number of interviews n_{rdm} was less than two for any boat ramp on any surveyed day, the above boat-ramp-based formulae for the estimation of $Var\left(\overline{Y}_{rdm}\right)$ cannot be applied. In such cases, an estimate of $Var\left(\overline{Y}_{rdm}\right)$ is calculated using a stratum-based estimate, i.e.

$$Var\left(\overline{Y}_{rdm}\right)=\frac{1}{\left(\sum_{d=1}^{d_m}\sum_{r=1}^{R}n_{rdm}\right)\left(\sum_{d=1}^{d_m}\sum_{r=1}^{R}n_{rdm}-1\right)}\sum_{d=1}^{d_m}\sum_{r=1}^{R}\sum_{b=1}^{n_{rdm}}\left(Y_{rbdm}-\frac{1}{\sum_{d=1}^{d_m}\sum_{r=1}^{R}n_{rdm}}\sum_{d=1}^{d_m}\sum_{r=1}^{R}\sum_{b=1}^{n_{rdm}}Y_{rbdm}\right)^2$$

Two approaches were used to calculate the variance when analysing the bus route survey data and employing the direct expansion method. In the first, the variance was calculated by using the boat-ramp-based estimates of $Var\left(\overline{Y}_{rdm}\right)$ when $n_{rdm} > 1$, but employing the stratum-based estimate of this variable when $n_{rdm} < 2$. In the second case, values of the stratum-based estimate of $Var\left(\overline{Y}_{rdm}\right)$ are used for each boat ramp and surveyed day for the stratum.

From the above, it follows that the variance of e_{dm}^{f} may be calculated as:

$$Var\left(e_{dm}^{f}\right)=T^2\sum_{r=1}^{R}\left[\left(\frac{N_{rdm}}{w_{rdm}}\right)^2 Var\left(\overline{Y}_{rdm}\right)\right]$$

where it was assumed that the variables $\overline{Y}_{rdm}$ at the different boat ramps are independent.

The direct estimation method produced a slightly different estimate from that produced by the IC methods. Rather than estimating the fishing time within the daily survey period, it estimated the fishing time for boats retrieved during the daily survey time.

3.1.3.2 Extrapolation of the effort from the daily sampling period to the full day

The interval count (IC) method of analysis of the data collected in the bus route survey provided estimates of the effort within the daily survey period T for the boat ramps covered by the bus route during the total period covered by the survey. To ensure IC method estimates were comparable with direct expansion (DE) method – which provides estimates of the total catch and effort prior to the daily survey period – extrapolation beyond the daily sampling period was required. Extrapolation beyond the daily sampling period introduces further imprecision, however, and relies upon the assumptions under which the extrapolated estimates were calculated. The reliability and precision of the extrapolated values depend on the distribution of fishing activity within each day and the proportion of the total fishing activity that lies within the daily survey period. The extrapolation is constrained to the period for which data collected in the daily survey period and did not necessarily provide "coverage" of the full period over which fishing activity occurred.

Extrapolation using interval count method

A correction factor f_m was calculated using the data on launch times reported by the boat parties that were interviewed when their boats were retrieved at the boat ramps. The times at which boat *b* was launched and retrieved at boat ramp *r* on sampling day *d* in stratum *m* were denoted previously by l_{rbdm} and r_{rbdm}, respectively, and the starting time of the wait time at the ramp was denoted by t_{rdm}. The factor by which the fishing effort (or catch) within the daily survey period was multiplied to include the additional boat time expended by fishers (who subsequently retrieved boats within the wait period) before the start of the daily survey period was estimated as:

$$f_m = \frac{\sum_d \sum_r \sum_b \left(r_{rbdm} - l_{rbdm}\right)}{\sum_d \sum_r \sum_b \min\left(r_{rbdm} - l_{rbdm}, r_{rbdm} - t_{rdm}\right)}$$

No variance estimate was calculated for this factor, and it was therefore assumed that $Var(f_m) = 0$, which is clearly an underestimate.

3.1.3.3 Calculating the fishing time over all possible sampling days within each stratum

The methods described above produced estimates over all boat ramps in the bus route for each sampling day *d* within each stratum *m*, i.e. for each sampled PSU, of the total fishing time within the daily survey period, for the interval count and average count methods, or fishing time (or catch) for boats retrieved during the daily survey time, for the direct expansion method. The daily samples were combined to produce estimates for each stratum.

A. Interval count (IC) method

The total fishing time within the daily survey period for stratum m over all possible sampling days was calculated from the data for the days that were sampled as:

$$\begin{aligned}\hat{E}_m &= \frac{D_m}{d_m}\sum_{d=1}^{d_m} e_{dm}^f \\ &= \frac{D_m}{d_m}\sum_{d=1}^{d_m} p_{dm}e_{dm}\end{aligned}$$

where the proportions of boats fishing were calculated over all boat ramps for the sampling day within the stratum.

The variance associated with $\hat{E}_m$ was estimated using

$$Var\left(\hat{E}_m\right) = \left(\frac{D_m}{d_m}\right)^2 Var\left(\sum_{d=1}^{d_m} p_{dm}e_{dm}\right) = \left(\frac{D_m}{d_m}\right)^2 Var\left(d_m\left[\frac{1}{d_m}\sum_{d=1}^{d_m} p_{dm}e_{dm}\right]\right)$$

where $Var\left(\sum_{d=1}^{d_m} p_{dm}e_{dm}\right)$ comprised a combination of both the variability among days and the imprecision of each product $p_{dm}e_{dm}$. The variability among days was estimated as the variance of the mean of $p_{dm}e_{dm}$., where it was assumed that each observation $p_{dm}e_{dm}$. had no error. The additional variability of the sum, $\sum_{d=1}^{d_m} p_{dm}e_{dm}$, that is associated with the error in the individual estimates of $p_{dm}e_{dm}$. was considered to be the sum of the variances of those individual estimates, i.e. the sum of the values of $Var\left(p_{dm}e_{dm}\right)$.

Thus, correcting for the finite population over which the mean was estimated, the first term in the expression below represents the variability among the daily estimates, while the second term represents the variability associated with the imprecision of the products.

$$Var\left(\sum_{d=1}^{d_m} p_{dm}e_{dm}\right) = d_m^2\left[\frac{1}{d_m\left(d_m - 1\right)}\left[\sum_{d=1}^{d_m}\left(p_{dm}e_{dm} - \frac{1}{d_m}\sum_{d=1}^{d_m} p_{dm}e_{dm}\right)^2\right]\left[\frac{D_m - d_m}{D_m}\right] + \left(\frac{1}{d_m D_m}\right)\sum_{d=1}^{d_m}\left[Var\left(p_{dm}e_{dm}\right)\right]\right]$$

and where it was assumed that the products $p_{dm}e_{dm}$. are independent.

The standard error was calculated by the usual method:

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

B. Direct expansion (DE) method

The total fishing time within the daily survey period for stratum m over all possible sampling days was calculated from the data for the days that were sampled as:

$$\hat{E}_m = \frac{D_m}{d_m}\sum_{d=1}^{d_m} e^{f}_{dm} = D_m \bar{e}^{f}_{dm}$$

Once again, it was necessary to extrapolate from the days that were sampled to the total over all possible sampling days. Thus, again, it was necessary to consider both the variability about the mean and the additional variability associated with the imprecision of the values from which the mean was derived. Thus,

$$Var\left(\hat{E}_m\right) = D_m^2 Var\left(\bar{e}^{f}_{dm}\right)$$

where,

$$Var\left(\bar{e}^{f}_{dm}\right) = \frac{1}{d_m\left(d_m - 1\right)}\left[\sum_{d=1}^{d_m}\left(e^{f}_{dm} - \bar{e}^{f}_{dm}\right)^2\right]\left[\frac{D_m - d_m}{D_m}\right] + \frac{1}{d_m D_m}\sum_{d=1}^{d_m} Var\left(e^{f}_{dm}\right)$$

and where $Var\left(e^{f}_{dm}\right)$ was calculated as described earlier in this report and it was assumed that the variables e^{f}_{dm} for the different sampling days were independent.

The standard error is calculated by the usual method

$$SE(\hat{E}_m) = \sqrt{Var(\hat{E}_m)}.$$

3.1.3.4 Calculating the average catch rate over all possible sampling days within each stratum

The catch rate for each stratum *m* was estimated by the ratio of the means (Crone and Malvestuto, 1991)

$$\hat{R}_m = \frac{\bar{c}_m}{\bar{L}_m} = \frac{\sum_{b=1}^{n_m} c_{bm}/n_m}{\sum_{b=1}^{n_m} L_{bm}/n_m}$$

where n_m was the number of interviewed boats in stratum m, and c_{bm} was the catch and L_{bm} is the length of trip, i.e. fishing effort, in hours on the water (i.e. the difference between launch and retrieval times), reported for interviewed boat *b*.

An estimate of catch rate calculated as the ratio of mean catch to mean effort represents a measure of the weighted average of the catch rate for individual sampling units, where the fishing effort of each sampling unit is used as a weighting factor. The ratio of means is the appropriate estimator when the probability of interviewing a fisher is independent of fishing trip duration (e.g. when used for data from completed trips collected in an access-point survey, such as the boat ramp-based surveys) (Pollock *et al.*, 1994).

The variances for $\bar{c}_m$ and $\bar{L}_m$ were calculated by the usual method for the calculation of the variance of a mean of values within a sample (without the finite population correction factor). The variance for $\hat{R}_m$ was then estimated using the formula described in Kendall and Stuart (1969)

$$Var(\hat{R}_m) = \hat{R}_m^2 \left(\frac{Var(\bar{c}_m)}{\bar{c}_m^2} + \frac{Var(\bar{L}_m)}{\bar{L}_m^2} - \frac{2Cov(\bar{c}_m, \bar{L}_m)}{\bar{c}_m \bar{L}_m} \right)$$

The covariance term in this equation was assumed to be zero.

3.1.3.5 Estimation of total catch for the bus route for the sampling day using the direct estimation (DE) method

The method described above to calculate the total fishing effort of all boats retrieved within the daily sampling period on sampling day *d* within stratum *m* may be applied to calculate the total catch, c_{km}, of all boats retrieved within the daily sampling period on sampling day *d* within stratum *m*. Thus,

$$c_{dm} = T \sum_{r=1}^{R} \frac{N_{rdm}}{n_{rdm}} \frac{1}{w_{rdm}} \sum_{b=1}^{n_{rdm}} C_{rbdm}$$

where C_{rbdm} is the reported catch of boat *b* that is retrieved during the wait time at site *r* on sampling day *d* within stratum *m*. The variance of this estimate is calculated by

$$Var(c_{dm}) = T^2 \sum_{r=1}^{R} \left[\left(\frac{N_{rdm}}{w_{rdm}} \right)^2 Var(\bar{C}_{rdm}) \right]$$

where $\bar{C}_{rdm}$ is the average of the reported catches of boats at boat ramp *r* on sampling day *d* within stratum *m* for which successful interviews were conducted, i.e.

$$\bar{C}_{rdm} = \frac{1}{n_{rdm}} \sum_{b=1}^{n_{rdm}} C_{rbdm}$$

3.1.3.6 Total catch for the stratum within the daily period surveyed

A. Interval count (IC) method

To estimate the total catch, the estimated total fishing effort (boat-hours) must be multiplied by the average daily catch rate. Thus, the total catch for stratum m is estimated as

$$\hat{C}_m = \hat{E}_m \hat{R}_m$$

And, using the formula presented by Goodman (1960, Eq.5), variance as

$$Var(\hat{C}_m) \approx \hat{C}_m^2 \left(\frac{Var(\hat{E}_m)}{\hat{E}_m^2} + \frac{Var(\hat{R}_m)}{\hat{R}_m^2} - \frac{Var(\hat{E}_m) Var(\hat{R}_m)}{\hat{E}_m^2 \hat{R}_m^2} \right)$$

B. Direct expansion (DE) method

The total catch for the stratum is calculated as

$$\hat{C}_m = \frac{D_m}{d_m} \sum_{d=1}^{d_m} c_{dm} = D_m \bar{c}_{dm}$$

and, allowing for both the variability among days and the imprecision of the estimates, the variance as

$$Var\left(\hat{C}_m\right) = D_m^2\left\{\frac{1}{d_m\,(d_m-1)}\left[\sum_{d=1}^{d_m}\left(c_{dm}-\bar{c}_{dm}\right)^2\right]\left[\frac{D_m-d_m}{D_m}\right]+\frac{1}{d_m D_m}\sum_{d=1}^{d_m}Var\left(c_{dm}\right)\right\}$$

The values of $Var(c_{dm})$ in the last term of this equation are calculated using the equation presented in Section 3.1.3.5. It is assumed in this term that the daily estimates of total catch, i.e. c_{dm}, are independent.

The standard error is calculated by the usual method

$$SE(\hat{C}_m) = \sqrt{Var(\hat{C}_m)}.$$

3.1.3.7 Combining the data over strata to produce estimates for the total fishery

The total catch is estimated by summing the catch over all strata as follows

$$\hat{C} = \sum_{m=1}^{M}\hat{C}_m$$

The variance and standard error of $\hat{C}$ are estimated respectively as

$$Var(\hat{C}) = \sum_{m=1}^{M}Var(\hat{C}_m)$$

where the catches within the different strata are independent. The standard error of the total catch is

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

3.1.4 Boat-ramp based creel survey results

Estimates of the total boat-based fishing effort between 1 July 2005 and 30 June 2006, i.e. the total of the times (boat hours) between launch and retrieval, that were calculated for each management zone, and combined over zones to give a total for the West Coast Bioregion, are presented in Table 3.3. Fishing effort for the Metropolitan zone was approximately three times greater than that for the South-West zone, which, in turn, was approximately double that for the Mid-West zone. Only a small amount of fishing effort was estimated to have occurred at the boat ramps in the Kalbarri management zone.

Table 3.3 The estimated boat-based fishing effort (and standard errors SE) between 1 July 2005 and 30 June 2006, i.e. time (boat hours) between launch and retrieval, by zone for the West Coast Bioregion using each estimation technique.

	Interval Count	SE	Direct Expansion	SE	Combined	SE
Kalbarri	9,062	683	7,858	648	8,429	470
Mid-West	82,261	7,186	68,621	5,283	73,406	4,256
Metro	475,879	12,114	425,656	11,889	450,298	8,485
South-West	147,153	7,936	190,779	11,807	160,729	6,587
West Coast Bioregion	714,356	16,181	692,914	17,581	692,861	11,564

Estimates of the total numbers of individuals of key demersal fish species, which were caught between 1 July 2005 and 30 June 2006 by boat-based recreational fishers operating from the boat ramps that were included in the bus route surveys, and which were kept and released, are reported in Table 3.4 and Table 3.5, respectively. Of the species listed in these tables, Western Australian Dhufish was dominant in both the kept and released categories of catch, with Breaksea Cod and Pink Snapper ranking as the second and third most abundant species, respectively, in numbers of fish that were kept and as the third and second most abundant species, respectively, in the numbers of fish that were released.

Table 3.4 The estimated total catches (number of individual fish) of key demersal fish species, which were caught by boat-based recreational fishers between 1 July 2005 and 30 June 2006, that were kept within each of the four management zones of the West Coast Bioregion, and the combined retained catch for the West Coast Bioregion. Standard errors (SE) of kept catches are also recorded.

Common name	Kalbarri		Mid-West		Metro		South-West		West Coast	
	Kept	SE	Kept	SE	Kept	SE	Kept	SE	Kept	SE
Baldchin Groper	414	61	5,834	674	2,832	270	48	20	9,128	729
Blue Morwong (Queen Snapper)	21	6	90	22	2,472	204	1,971	198	4,554	285
Breaksea Cod	187	32	1,703	167	11,829	593	4,847	408	18,567	740
Grey-banded Rockcod					85	27			85	27
Grass Emperor (Black Snapper)	307	51	19	7					3,26	51
Spangled Emperor	131	49	117	25					2,48	55
Redthroat (Sweetlip) Emperor	1,101	152	5,914	677	13	9			7,029	694
Yellowtail Emperor	6	3							6	3
Bluespotted Emperor	22	12	27	13					48	18
Robinson's Seabream	2	1							2	1
Lethrinids Not identified	5	3							5	3
Pink Snapper	1,054	133	4,432	652	5,864	375	5,824	923	17,173	1198
Bight Redfish					2,155	278	2,216	272	4,371	389
Swallowtail					411	135	463	95	874	165
Yelloweye Redfish										
Sea Sweep			7	3	1,873	252	1,040	145	2,919	291
Sergeant Baker	6	3	261	49	1,315	143	2,303	236	3,886	280
Western Australian Dhufish	275	49	11,158	927	12,351	760	9,985	876	33,770	1,485
Western Foxfish			23	7	1,662	185	878	113	2,564	217

Table 3.5 The estimated total catches (number of individual fish) of key demersal fish species, which were caught by boat-based recreational fishers between 1 July 2005 and 30 June 2006, that were released within each of the four management zones of the West Coast Bioregion, and the combined retained catch for the West Coast Bioregion. Standard errors (SE) of released catches are also recorded.

Common name	Kalbarri		Mid-West		Metro		South-West		West Coast	
	Released	SE	Released	SE	Released	SE	Released	SE	Released	SE
Baldchin Groper	124	30	1,229	163	386	85			1,739	186
Blue Morwong (Queen Snapper)			13	6	610	376	200	77	823	384
Breaksea Cod	173	31	602	106	7,283	549	1,818	276	9,875	625
Grey-banded Rockcod					45	21			45	21
Grass Emperor (Black Snapper)	403	102	28	16					432	104
Spangled Emperor	178	57	113	30					291	65
Redthroat (Sweetlip) Emperor	1,598	259	4,330	716					5,927	761
Yellowtail Emperor	2	1							2	1
Bluespotted Emperor	14	11							14	11
Robinson's Seabream										
Lethrinids Not identified	21	12	10	7					31	14
Pink Snapper	955	111	1740	208	7,351	570	2,861	612	12,907	869
Bight Redfish					295	88	324	79	619	118
Swallowtail					118	48	31	13	149	50
Yelloweye Redfish					66	35			66	35
Sea Sweep			12	5	1,000	186	1,042	336	2,053	384
Sergeant Baker	46	12	452	58	2,277	236	3,828	401	6,604	469
Western Australian Dhufish	78	17	3,905	389	7,545	468	5,127	515	16,655	797
Western Foxfish			9	4	473	87	260	49	742	100

3.2 Mail-phone-diary of boat-based fishing survey

3.2.1 Introduction

The mail-phone-diary survey conducted in 2005/06 employed the DPIs database of registered power boats in Western Australia as its sampling frame, restricting the population to be surveyed to those boats for which the registered owner resided in a region of the State adjacent to the West Coast Bioregion (Figure 2.2). This latter region extends over approximately 900 km of coastline and includes the following management zones:

- Kalbarri zone (26–30°S – 28°S)
- Mid-West zone (28°S – 31°S)
- Metropolitan (Metro) zone (31°S – 33°S)
- South-West zone (33°S – 115°30'E)
- Offshore zone (waters between 3 nm State waters boundary and the boundary of the 200 nm Economic Exclusion Zone)

Primary sampling units were the registered boats, i.e. the owners of those boats. Accordingly, recreational fishing data derived from the survey represent estimates of the catch taken and fishing effort associated with recreational fishing activity in 2005/06 using powered boats registered to owners residing in the West Coast Bioregion. As noted in Section 2.2.2, the survey involved three phases, namely (1) a "mail out" by DPI to a sample of registered owners from the sampling frame seeking permission for contact by the Department of Fisheries, (2) a screening survey of a randomly selected subset of the registered owners, who were willing to be contacted by the Department of Fisheries, to determine eligibility for inclusion and selection of participants in the phone-diary phase of the survey, and (3) regular telephone interviews in 2005/06 of the selected registered owners who agreed to participate in the phone-diary phase of the survey.

It should be noted that the initial "mail out" by DPI, seeking approval for the Department of Fisheries to contact registered boat owners in the subsequent screening and phone-diary components of the survey, may have introduced a bias that is not taken into account in the analysis and results described below. That is, the boat owners, who declined contact by the Department of Fisheries, may not have represented a random sample of the registered boat owners in the sampling frame, e.g. there would possibly have been a greater tendency for those owners, who were not intending to engage in fishing activity, to refuse permission for contact.

3.2.2 Mail-phone-diary survey analyses

The methods used when analysing the mail-phone-diary survey data (based on the approach described by Tara Baharthah, Department of Fisheries, unpublished manuscript) are presented below.

Subsequent to the screening interview and following preliminary analysis, it was decided that powered yachts, jet skis and personal water craft (PWC) should be considered outside the survey scope, requiring an adjustment to the size of the population within each boat length stratum of the sampling frame (Table 2.3 and Table 3.6).

While the possibility of determining the total catch and fishing effort for the Kalbarri, Mid-West, Metropolitan and South-West management zones was also explored when analysing the data collected during the mail-phone-diary survey, the survey design and sampling intensity were inadequate to allow precise estimation of these variables for zones other than the Metropolitan zone. The Metropolitan zone (67%) had the most boat-based fishing in the West Coast Bioregion, with much less fishing in the South-West (19%), Mid-West (12%) and Kalbarri (1%) zones (Baharthah, Western Australian Department of Fisheries, unpublished manuscript). Accordingly, because of the dominance of the Metropolitan zone and the imprecision of estimates for the other management zones, details of this aspect of the analysis are not presented in this report. To produce reliable estimates of total catch and fishing effort by management zone, it would be necessary to take this into account when designing the survey, with consideration being given to further stratifying the sampling frame into sub-region within the region of residence that is considered to be associated with the West Coast Bioregion. It would also be necessary to increase the sampling intensity within the resulting strata, taking into account the numbers of registered boat owners within each stratum and the proportions of sampled boats that would be expected to participate in fishing activity during the survey period.

Table 3.6 Original and revised numbers of registered powered boats in each boat length stratum (k) of the sampling frame for the mail-phone-diary survey, following exclusion of (powered) yachts, surf skis and personal water craft.

	Vessel length			Total
	Small (length < 4 m)	**Medium (4 ≤ length < 6 m)**	**Large (length ≥ 6 m)**	
Original population	16,951	29,949	8,454	55,354
New population N_k	11,843	29,813	8,454	50,110

The numbers of registered boat owners within each boat length stratum, who agreed to participate in the phone-diary phase of the mail-phone-diary survey, do not represent the full sample from the stratum. The sample size must be supplemented by the numbers of registered boat owners, who had not fished in the previous year and/or had advised in the screening survey that they would not be fishing during the 12-month survey period, and who were therefore excluded from participation in the phone-diary phase (Table 3.7). The sample sizes must also be reduced to account for (a) the exclusion of powered yachts, surf skis and personal water craft, and (b) the numbers of registered boat owners who "dropped out" of the phone-diary phase during the course of the year, and those that could not be contacted (Table 3.7).

Table 3.7 Sample sizes in each stratum after adjusting for the numbers of boats excluded at the screening survey phase due to the likelihood that these boats would not be used for fishing during the survey period, the numbers of yachts, surf skis and personal water craft that were out of scope due to the decision that these should be excluded from the survey, and the numbers of registered boat owners who dropped out of the phone-diary phase or who could not be contacted.

	Vessel length			Total
	Small (length < 4 m)	Medium (4 ≤ length < 6 m)	Large (length ≥ 6 m)	
Original sample size	102	300	102	504
Not fishing (c.f. non-fishers (a) in Table 2.3)	52	66	28	146
Not fishing due to yacht, ski or PWC	15	6		21
Boats not in survey, *i.e.* "lost" during year (c), or non-contacts (d) (Table 2.3)	7	31	10	48
Sold boats			32	32
Adjusted sample size	132 (=102+52-15-7)	329 (=300+66-6-31)	120 (=102+28-0-10)	581

Estimation of participation

The participation, i.e. fraction of population participating in fishing, for each stratum k was estimated as follows

$$q_k = \frac{p_k}{n_k}$$

where n_k is the sample size in each stratum k and p_k is the total number of boats used for fishing.

The estimated variance for participation within stratum k with finite population correction was calculated as

$$Var(q_k) = \frac{q_k(1-q_k)}{n_k}\frac{(N_k - n_k)}{(N_k - 1)}$$

where n_k is the sample size and N_k is the population size for stratum k.

The total number of boats used for fishing in stratum k was estimated by

$$f_k = N_k q_k$$

The variance for the total number of boats used for fishing within stratum k was estimated as

$$Var(f_k) = N_k^2 Var(q_k)$$

Estimation of Total Effort

The mean fishing effort for each stratum k was estimated as follows

$$\bar{e}_k = \frac{\sum_{i=1}^{p_k} e_i}{p_k}$$

where p_k is the participation in each stratum k and e_i is the total number of hours fished by each boat i. $\bar{e}_k$ is the average effort that is expended by those boats in the sample that had reported fishing activity. Since other boats in the sample did not report fishing activity or, in the case of those excluded in the screening survey, were assumed not to have fished, it is also an estimate of the total effort for all boats in the sample.

The estimated variance within stratum k is

$$Var(e_k) = \frac{p_k \sum_{i=1}^{p_k} e_i^{\,2} - \left(\sum_{i=1}^{p_k} e_i\right)^2}{p_k\,(p_k - 1)}$$

where p_k is the participation for stratum k and e_i is the total number of hours fished by each boat i. The above is the estimate of the variance of individual boat effort for those boats in the sample that were fishing. If it is known with absolute certainty that the other boats in the sample did not fish, then this will also be the variance of the effort for all boats in the sample.

The variance associated with the estimate of the mean, with finite population correction (Neter *et al.*, 1988) is

$$V\hat{a}r(\bar{e}_k) = \left(\frac{N_k - p_k}{N_k - 1}\right)\frac{s_k^2}{p_k}$$

where s_k is the calculated as the square root of $Var(e_k)$

The total effort for stratum k was estimated as

$$\hat{E}_k = f_k \bar{e}_k$$

where f_k is the total number of boats in stratum k. $\hat{E}_k$ is an estimate of the total effort for stratum *k*, and may also be calculated by direct expansion. First, the sum of the fishing efforts reported for the sample was calculated, and this was then multiplied by the ratio of the number of boats in the population to the number in the sample, i.e.

$$\hat{E} = f_k\,\bar{e}_k = N_k\,q_k\,\frac{\sum_{i=1}^{p_i} e_i}{p_k} = N_k\,\frac{p_k}{n_k}\,\frac{\sum_{i=1}^{p_i} e_i}{p_k} = \left(\frac{N_k}{n_k}\right)\sum_{i=1}^{p_i} e_i$$

The variance associated with $\hat{E}_k$ was calculated using the formula for the variance of a product presented by Goodman (1960, Eq. 5), i.e.

$$Var\left(\hat{E}_k\right) = (f_k\bar{e}_k)^2\left[\frac{Var\,(f_k)}{f_k^2} + \frac{Var\,(\bar{e}_k)}{\bar{e}_k^2} - \frac{Var\,(f_k)\,Var\,(\bar{e}_k)}{(f_k\bar{e}_k)^2}\right]$$

The total effort was calculated by summing the effort for the strata, i.e.

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

where n is the number of strata. The variance was estimated as

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

The standard error was calculated by the usual method

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

Estimation of Total Catch

The mean catch $\bar{c}_k$ for each stratum k was estimated as

$$\bar{c}_k = \frac{\sum_{i=1}^{p_k} c_i}{p_k}$$

where c_i is the catch by each boat i in stratum k, and $\bar{c}_k$ is the average catch by those boats in the sample that were fishing. Since other boats in the sample were not fishing, it is also an estimate of the total catch for all boats in the sample.

The estimated variance within stratum k was calculated as

$$Var(c_k) = \frac{p_k \sum_{i=1}^{p_k} c_k{}^2 - (\sum c_k)^2}{p_k \ (p_k - 1)}$$

The above is the estimate of the variance of individual boat catch for those boats in the sample that were fishing. If it is assumed that the other boats in the sample did not fish, then this will also be the variance of the individual catches for all boats in the sample.

The variance associated with the estimate of the mean, with finite population correction (Neter *et al.*, 1988) is

$$Var(\bar{c}_k) = \left(\frac{N_k - p_k}{N_k - 1}\right) \frac{Var(c_k)}{p_k}$$

The total catch $\hat{C}_k$ for stratum k was estimated as

$$\hat{C}_k = N_k \bar{c}_k q_k$$

$\hat{C}_k$ may also be calculated by direct expansion. First, by calculating the sum of the catches reported for the sample, then by multiply this by the ratio of the number of boats in the population to the number in the sample. Thus,

$$\hat{C} = N_k \ \bar{c}_k \ q_k = N_k \ q_k \frac{\sum_{i=1}^{p_i} c_i}{p_k} = N_k \frac{p_k}{n_k} \frac{\sum_{i=1}^{p_i} c_i}{p_k} = \left(\frac{N_k}{n_k}\right) \sum_{i=1}^{p_i} c_i$$

The variance associated with $\hat{C}_k$ was estimated using the formula for the variance of a product presented by Goodman (1960, Eq. 5)

$$Var(\hat{C}_k) = N_k^2 \bar{c}_k^2 q_k^2 \left(\frac{Var(\bar{c}_k)}{\bar{c}_k^2} + \frac{Var(q_k)}{q_k^2} - \frac{Var(\bar{c}_k)Var(q_k)}{(\bar{c}_k \ q_k)^2} \right)$$

The total catch was calculated by summing the catch for the strata as follows

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

where n is the number of strata.

The variance was estimated as

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

The standard error was calculated by the usual method as

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

3.2.3 Mail-phone-diary results

3.2.3.1 Estimated fishing effort

The number of registered boats from the sample for each boat length stratum that engaged in fishing during the 12-month period is presented in Table 3.8.

Table 3.8 Number of boats in the sample for each boast length stratum k that fished and estimate of the proportion of the population participating in the recreational fishery in 2005/06.

	Vessel length			Total
	Small (length < 4 m)	Medium (4 ≤ length < 6 m)	Large (length ≥ 6 m)	
Adjusted sample size n_k	132	329	120	581
Boats that fished p_k	36	169	64	269
Participation rate q_k	0.27	0.51	0.53	0.46
SE of participation rate	0.04	0.03	0.04	0.02

The estimated total time spent fishing was 444,350 boat hours or 1,263,113 fisher hours (Table 3.9). These values exclude non-fishing time, i.e. time between launch and retrieval that was not spent fishing. The corresponding estimates of fishing effort, i.e. time between launch and retrieval, were 649,602 boat hours and 1,888,284 fisher hours, respectively.

Table 3.9 Estimates of the total time spent fishing and total time between launch and retrieval, with associated standard errors (SE), for boats registered to owners living in the region adjacent to the West Coast Bioregion that fished between 1 July 2005 and 30 June 2006. Two measures of time are used, i.e. the total time measured in fisher hours, which takes the numbers of fishers into account, and the total time measured in boat hours, which considers only the activity of the boats.

		Vessel length			Total
		Small (length < 4 m)	Medium (4 ≤ length < 6 m)	Large (length ≥ 6 m)	
Time spent fishing	Fisher hours	66,482	949,487	247,144	1,263,113
	SE of fisher hours	15,847	263,870	43,219	267,855
	Boat hours	34,004	319,777	90,569	444,350
	SE of boat hours	8,487	35,551	14,184	39,206
Time between launch and retrieval	Fisher hours	85,286	1,408,545	394,453	1,888,284
	SE of fisher hours	19,073	398,244	62,737	403,607
	Boat hours	43,275	462,440	143,887	649,602
	SE of boat hours	9,918	49,778	21,299	55,045

3.2.3.2 Estimated catch

Estimated total numbers of caught individuals of key demersal species that were kept or released are presented in Table 3.10.

Table 3.10 Estimated numbers of fish (± SE) that were caught and kept or released in 2005/06 during fishing trips on boats registered by owners residing in the region adjacent to the West Coast Bioregion in Western Australia.

Common name	Kept	SE	Released	SE
Baldchin Groper	19,609	5,127	9,352	4,486
Blue Morwong (Queen Snapper)	10,367	4,658	4,329	3,407
Breaksea Cod	19,514	4,314	11,120	4,221
Grass Emperor (Black Snapper)	393	239	362	361
Spangled Emperor	5,193	2,716	3,462	1,948
Redthroat (Sweetlip) Emperor	10,820	4,767	7,156	3,923
Pink Snapper	22,275	5,780	15,895	5,155
Bight Redfish	10,736	6,568	3,534	2,579
Sea Sweep	4,541	2,504	1,621	776
Sergeant Baker	2,647	1,084	6,663	2,776
Western Australian Dhufish	41,847	7,602	22,027	4,712
Western Foxfish	1,510	545	705	636

3.3 Counter surveys

3.3.1 *Video camera survey of boat-ramps*

3.3.1.1 Introduction

Launching and retrieval activity at the Hillarys and Woodman Point boat ramps was monitored using video cameras during periods within the 2005/06 year. These locations were chosen as they represent the boat ramps with the greatest activity in the South Perth Metropolitan and North Perth Metropolitan regions, respectively, in the Metropolitan Zone. Note that the Metropolitan zone is one of four zones in the West Coast Bioregion.

Analysis was restricted to the retrieval data for the Hillarys ramp, however, as (1) comparisons with data from other counter methods were only available at this boat ramp, (2) the launch and retrieval data were highly correlated (Section 4), and (3) onsite surveys were based primarily on retrievals. The data obtained from examination of the video camera recordings were used to calculate estimates of total retrieval activity of motor boats at each ramp for each month monitored.

Although it was possible to distinguish motor boats from yachts, jet skis, kayaks, etc. from captured video, no information could be ascertained from the video to determine the type of activity to be undertaken by launched boats or that had been undertaken by retrieved boats. While it was therefore not possible to obtain estimates of the numbers of boats involved in fishing activity, the data obtained in this survey could potentially produce valuable data on boating activity to augment the data obtained during a creel or phone-diary census.

3.3.1.2 *Video camera survey analysis*

The launching and retrieval of boats at boat ramps has a marked temporal distribution, varying both within a day and among days of the year. As with creel census survey design, it is useful to recognise that such activity depends on the day of the week, and is influenced by public holidays and by season. It is also likely to be affected by seasonal fishing closures. While activity will also be affected by the introduction of daylight saving, the period over which this study was undertaken, i.e. 2005/06, preceded the daylight saving trial that was subsequently conducted in Western Australia.

Although, in theory, video monitoring should capture a full census of boat ramp activity for a given month, data collection by the camera was hindered occasionally by events such as technological faults. Thus, methods to analyse the data needed to accommodate such data loss and to take into account the temporal distribution of activity for the time period over which the loss occurred. That is, extrapolation of data to cover periods of loss was based on data from periods (i.e. strata) in which the characteristics of collected data were likely to be similar to those expected to have been experienced in the missing data period.

Sampling at the Hillarys and Woodman Point boat ramps extended from 3 August 2005 to 30 June 2006 and 6 December 2005 to 30 June 2006, respectively. The data for each boat ramp were stratified by hour of day h ($0 \leq h \leq 23$), day type (day of week or public holiday t ($0 \leq t \leq 7$, where 0=Sunday, 1=Monday, …, 6=Saturday, 7=public holiday) by month m ($1 \leq m \leq 12$) within month, and month (1=July, 2=Aug, …, 12=June) within those months of the 12-month period from 1 July 2005 to 30 June 2006. For each stratum, there are $D_{t,m}$ possible days d ($0 \leq d \leq D_{t,m}$) on which data could have been recorded, where $0 \leq D_{t,m} \leq 5$. Note that, for some months, there was no public holiday, hence the possibility that $D_{t,m} = 0$. The number of days on which data were actually recorded, i.e. $n_{t,m}$, depended on whether or not the camera had been deployed and was operating and was affected by events during which the camera failed to record activity. This stratification by day type allows for the possibility that the activity patterns recorded for each day of the week and for public holidays may differ. This differed from stratification typically used in other studies of recreational fishing. In these cases, Saturday, Sunday and public holidays were classified as weekend days, and Monday through Friday as weekdays (e.g. Steffe *et al.*, 2008). The primary sampling units within the same hour of day and each day within the same day type and month were assumed to be random samples from a common distribution.

Estimation of total monthly and annual retrievals

In general terms, the analysis of data collected using stratified sampling and employing random sampling within each stratum, proceeds as follows. Assume that a sample of size n_h is collected from the population of N_h individuals (objects, elements, etc.) from stratum h ($1 \leq h \leq H$) of the H strata into which the overall population has been divided. The j'th observation within this stratum is denoted by $x_{j,h}$, where $1 \leq j \leq n_h$.

The sample mean of the n_h individuals in stratum h is $\bar{x}_h$, where $\bar{x}_h = \frac{1}{n_h}\sum_{j=1}^{n_h} x_{j,h}$.

The sample estimate of the population standard deviation in stratum h is s_h, where

$$s_h^2 = \frac{1}{n_h - 1}\sum_{j=1}\left(x_{j,h} - \bar{x}_h\right)^2$$

The variance of the mean for stratum h is $\mathrm{Var}\left(\bar{x}_h\right) = \frac{1}{n_h} s_h^2$ or, when sampling a fraction greater than approximately 5% of the N_h individuals, is

$$\mathrm{Var}\left(\bar{x}_h\right) = \frac{1}{n_h} s_h^2 \frac{N_h - n_h}{N_h - 1}.$$

The latter formula employs the finite population correction (e.g. Steffe *et al.*, 2008).

To analyse the boat ramp data, an estimate was first made of the mean count of retrieval activities per hour for each hour *h* within each day type *t* (over all days of this day type) within each month *m*. Thus, the stratum was considered to be the combination of hour, day type and month.

For each day *d* within each stratum, missing data were imputed by replacing the missing value with the mean count of activities that had been calculated for the hour, day type and month. The variance of the value was set equal to the variance of the mean count. For data that had actually been recorded for the hour, the variance of the observed count per hour was set to zero. This procedure produced values of the observed or imputed count per hour $X_{d,h,t,m}$, and its variance $Var\ (X_{d,h,t,m})$, for each day *d* within the stratum for hour *h*, day type *t* and month *m*.

The observed and imputed counts of activities for each hour of each day *d* were accumulated to produce an estimate of the total count of activities for that day $X_{d,t,m}$. Thus,

$$X_{d,t,m} = \sum_{h=0}^{23} X_{d,h,t,m}$$

where

$$Var\left(X_{d,t,m}\right) = \sum_{h=0}^{23} Var\left(X_{d,h,t,m}\right)$$

The total count of activities over all days *d* within each day type *t* and month *m*, and the variance of this total count, were then calculated as follows

$$X_{t,m} = \frac{D_{t,m}}{n_{t,m}} \sum_{d=1}^{n_{t,m}} X_{d,t,m}$$

$$Var\left(X_{t,m}\right) = D_{t,m}^2 \left[\frac{1}{n_{t,m}\left(n_{t,m}-1\right)} \left[\sum_{d=1}^{n_{t,m}} \left(X_{d,t,m} - \frac{1}{n_{t,m}} \sum_{d=1}^{n_{t,m}} X_{d,t,m} \right)^2 \right] \left[\frac{D_{t,m}-n_{t,m}}{D_{t,m}-1} \right] + \left(\frac{1}{n_{t,m}\, D_{t,m}} \right) \sum_{d=1}^{n_{t,m}} \left[Var\left(X_{d,t,m}\right) \right] \right]$$

Subsequently, estimates of the total counts of activities over all day types for month *m*, and variances of these total counts, were obtained using

$$X_m = \sum_{t=0}^{7} X_{t,m}$$

$$Var\left(X_m\right) = \sum_{t=0}^{7} Var\left(X_{t,m}\right)$$

Finally, an estimate of the total activity over all months for the 12-month period could have been obtained, if data had been collected within each of those months, using

$$X = \sum_{m=1}^{12} X_m$$

$$Var\left(X\right) = \sum_{m=1}^{12} Var\left(X_m\right)$$

However, as the camera at the Hillarys boat ramp was only deployed in August 2005, no data were available for July 2005, and thus, while monthly estimates of activity for the camera data could be calculated, no estimate of the total activity could be obtained without extrapolation from the results for other months.

A clear seasonal trend was found to be present in the number of boats retrieved each month, with a maximum in December 2005 and a minimum in August 2005 (see Section 4). The actual minimum could have been in July 2005, but the camera was only deployed in August of that year. Extrapolation to estimate the retrievals in July 2005 was therefore undertaken using four different approaches: (1) It was assumed that the values for June 2005 were the same as for June 2006, and thus the number of boats retrieved in July 2005 could be interpolated as the average of the monthly values for Aug 2005 and June 2006; (2) the number of boats operating in July 2005 (and the variance of this estimate) was assumed to be the same as in August 2005; (3) the number of boats operating in July 2005 was assumed to be the same as in August 2005, but the SE of the estimate was doubled to account (to some extent) for the uncertainty associated with the assumption; and (4) The July 2005 estimate was calculated by extrapolating linearly from the September 2005 estimate back through the August 2005 estimate.

Estimation of total time that boats spent at sea

Analyses of the trailer counts obtained using the camera snapshot method (described later in this report) demonstrated that there were very rarely any trailers left in the Hillarys car park between 23:00 and 04:00. Therefore, midnight was used as a calibration point for estimation of the periods over which boats were at sea, i.e. the car park was assumed to be empty at midnight, the start of each day and, initially, the number of boats at sea was also assumed to be zero at this time.

The boats that were at sea at a particular time on a day may be obtained by subtracting the sum of all retrievals, from the sum of all launches to that time, i.e. since midnight. That is, if Y_t is the difference between the sum of all launches and the sum of all retrievals from midnight to time *t*, then Y_t is an estimate of the number of boats that are at sea at time *t*. The total duration that these boats are at sea between time *t* and the next time $t + \Delta t$ is Δt, which, in the case of the camera survey, was 1 minute. Thus, an estimate of the total at-sea boat time for the interval may be calculated as $Y_t \Delta t$. The total at-sea boat time for a specific hour, *h*, within a specific day *d* and month *m* may be calculated as $y_{h,d,m} = \sum_{t \in h,d,m} Y_t \Delta t$. Data for days in which camera events resulted in loss of video were excluded from this analysis, results of which are presented in Chapter 4 when comparing estimates obtained using different counter techniques.

Initially, the number of boats at the start of the day was set to zero. However, examination of the resulting estimates of the hourly total time at sea during the 24 hours of the day revealed that, on occasion, retrievals occurred prior to the first launch of the day or that, at times during the day, a greater number of retrievals than launches had occurred, yielding values that were negative. Such retrievals indicate, however, that the number of boats retrieved in excess of those launched must have returned from a launch at another boat ramp or from an anchorage, e.g. Rottnest Island. A method was explored that would account for such boats by resetting the count of boats to zero if the cumulative number of boats retrieved exceeded the cumulative number of launches. The resulting estimate of boat time at sea is likely to underestimate the true time, as it ignores boats launched from other sites or returning from other anchorages. An alternative approach was also explored to obtain an upper estimate of the total boat time at sea. For this, the number of boats at sea at midnight, i.e. at the start of the day, was reset for days on which the count of retrievals exceeded that of launches to the difference between those counts. It is recognised, however, that this assumes that the additional boats were at sea from midnight, a period that is likely to be considerably over-estimated.

The methods used to calculate the total number of launches or retrievals for the various strata, which were described above, could be employed to estimate the total at-sea boat time (and variance) for each hour of each day type, for each day type and each month.

3.3.1.3 Video camera survey results

The video camera survey commenced at the Hillarys boat ramp on 3 August 2005 and at the Woodman Point boat ramp on 6 December 2005. The cameras and their associated infrastructure were deployed and configured to capture a full census of launch and retrieval activity at the ramps they were placed to monitor.

There were three data collection mechanisms deployed:

- For some deployments, the footage was buffered to a local storage and then sent back to a remote media server across the internet on an automated schedule;
- For areas where internet access was not possible, a long range microwave communications link was deployed to stream the footage directly to another monitored site with the linking site used for internet transmission of multiple sets of video feeds;
- For sites that did not have internet access available and did not have convenient line-of-site to another monitored ramp, local storage was used to hold the captured video and the site's footage was manually copied off once a month by survey staff.

The cameras were used to monitor boat ramp activity from the date of deployment through 30 June 2006, providing data on activity within each minute of operation, 24 hours a day. Although coverage was excellent, capture of video at the Hillarys boat ramp failed on occasions, resulting in the loss of 32.84 hours, distributed over 54 days (a period of 0.57 hours from midnight on the first day of deployment was excluded from this calculation). Thus, video problems were encountered on 14.9% of the total number of days and 0.38% of the total number of hours in the period over which the camera at the Hillarys boat ramp monitored launching and retrieval activity.

Analysis of the video camera recordings revealed that a total of 25,692 boats were launched and 24,798 boats were retrieved at the Hillarys boat ramp during the period when the camera was operating (Table 3.11). Strong daily trends were evident in the plots of hourly launches and retrievals (Figure 3.1 and Figure 3.2). A strong seasonal trend in boating activity was also present in the data (Figure 3.3).

Table 3.11 Numbers of launches and retrievals of power boats recorded by the video camera at the Hillarys boat ramp, numbers of pulses recorded by the VCS that was deployed across the retrieval lane at this ramp, and total number of trailers counted in video snapshots of the car park at the Hillarys boat ramp. Note that trailers parked in the car park will have been counted multiple times in successive snapshots.

Calendar month	Launches (boats)	Retrievals (boats)	VCS (pulses)	Car park trailer count
7				
8	996	1,055		715
9	981	1,016		1,648
10	1,424	1,392		3,207
11	2,183	2,132		6,005
12	4,540	4,145		9,660
1	3,873	3,698		10,585
2	2,947	2,795		11,856
3	2,937	2,804		12,518
4	2,965	2,919	13,386	11,983
5	1,887	1,891	11,172	7,715
6	959	951	10,318	3,797
Total	25,692	24,798	34,876	79,689

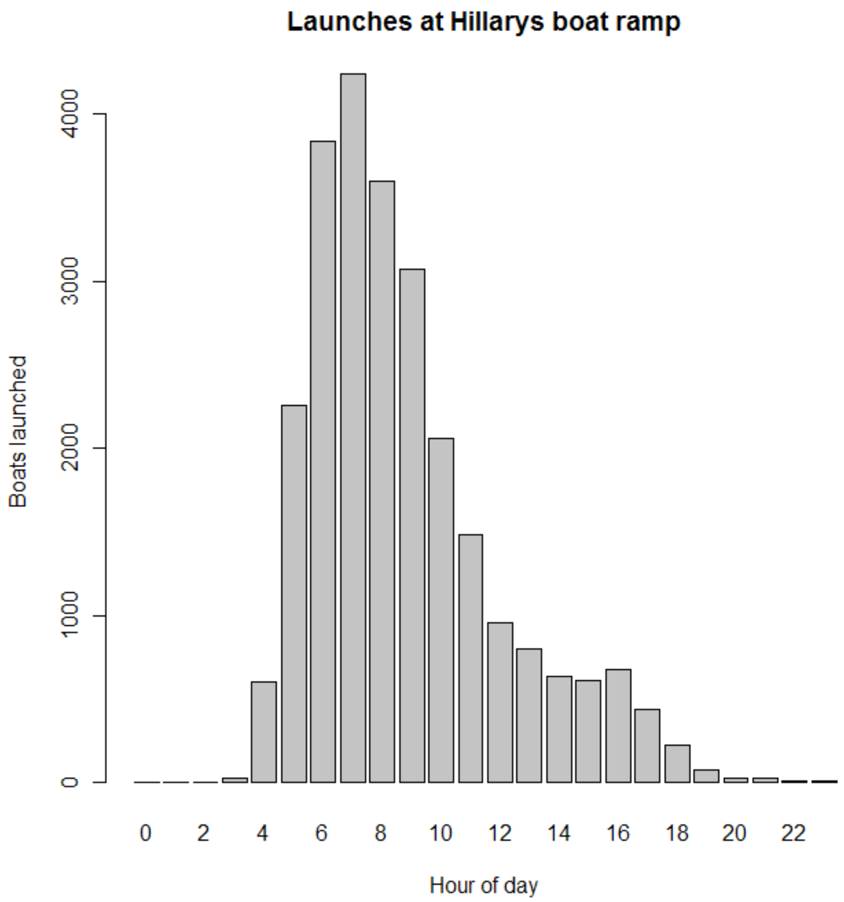

Figure 3.1 Total number of boats launches within each hour, as recorded by the video camera at the Hillarys boat ramp.

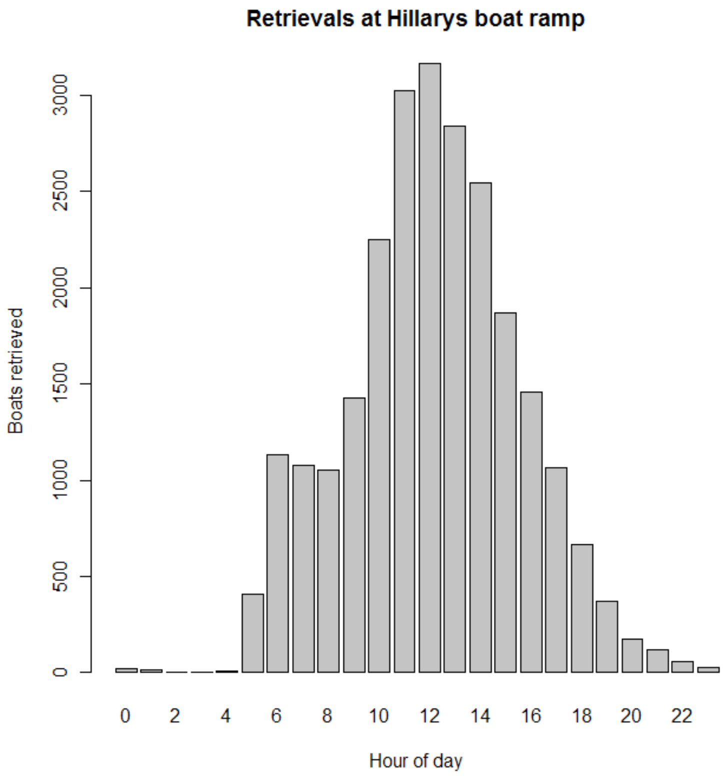

Figure 3.2 Total number of boats retrieved within each hour, as recorded by the video camera at the Hillarys boat ramp.

Estimated activity

Estimates of the total monthly counts of retrievals are presented in Table 3.12. A strong seasonal pattern is evident in the data (Figure 3.3). If it was assumed that the number of retrievals in July 2005 was equal to the average of the number of retrievals in August 2005 and June 2006 (i.e. 1,490), then the number of retrievals at the Hillarys boat ramp between 1 July 2005 and 30 June 2006 was estimated to be 28,397.

Table 3.12 Estimates of the total number (and standard error) of power boats retrieved each month at the Hillarys boat ramp between 1 August 2005 and 30 June 2006, i.e. the period over which the video camera operated.

Calendar month	Total retrievals	SE of total retrievals
7		
8	1,141	83
9	864	137
10	1,686	387
11	2,209	182
12	4,145	0
1	3,919	151
2	2,940	66
3	2,846	67
4	2,919	0
5	2,398	222
6	1,840	121
Total	26,907	551

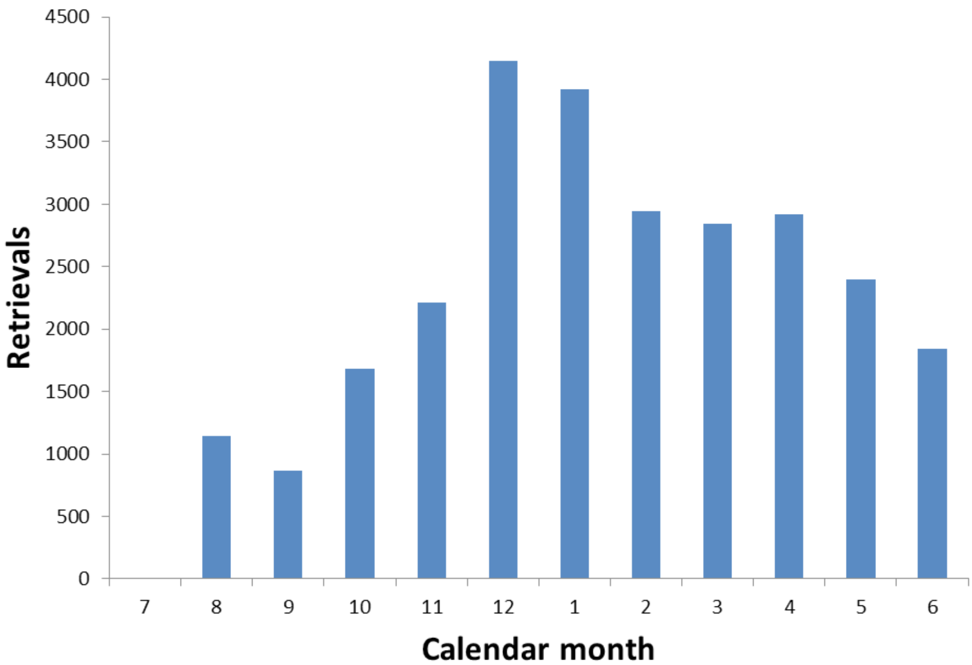

Figure 3.3 Estimates of the total number of power boats retrieved each month at the Hillarys boat ramp between 1 August 2005 and 30 June 2006, i.e. the period over which the video camera operated.

Note that only motorised boats were included in this analysis, i.e. jet skis, kayaks, yachts, were excluded from the data. Not all of these boats would have been fishing, as some would have been used for other recreational activity. Note also that the data relate only to retrievals at the Hillarys boat ramp. To determine the fishing time, it would be necessary to first estimate the proportion of the retrievals that were associated with fishing rather than other recreational activity, the proportion of the total boats fishing that were retrieved at the Hillarys boat ramp, the average number of hours over which each boat was used for fishing on each trip, and the average number of fishers on board each boat during each fishing trip.

In conclusion, it should be noted that there are 61 boat ramps in the West Coast Bioregion, from which boats may be launched and retrieved. Of these, only the Hillarys and Woodman Point boat ramps were monitored using video cameras during the current survey. Although these represent the boat ramps with the greatest activity in the South Perth Metropolitan and North Perth Metropolitan regions, respectively, of the Metropolitan Zone, the ramps cannot be considered representative of the ramps in the Bioregion as a whole. The study thus represents a pilot study to test the approach and assess the potential of the technique as a tool for obtaining information from recreational fishers.

3.3.2 Vehicle counter survey

3.3.2.1 Introduction

This collection method assessed whether vehicle counters could be employed to capture an index of the level of retrieval activity at a boat ramp with high traffic volume, where this traffic was directly related to access to the fishery to be observed. The data were collected from 6 April to 27 June 2006. Although this was the shortest temporal coverage of the surveys trialled in this project, the data collected are of sufficient resolution to allow direct comparison with those collected using other survey techniques.

3.3.2.2 *Vehicle counter survey design*

A MetroCount 5600 VCS unit was deployed across the boat-retrieval access lanes for the Hillarys car park. This unit consisted of a pair of pneumatic rubber tubes that led to the recording unit, thereby providing a count of the axles that passed over the rubber tubes. These events were assumed to relate to the passage of a vehicle through the monitored access lane to retrieve a boat from the boat ramp. When combined with other data on the proportion of retrieved boats that had participated in fishing, the resulting data would allow estimation of the number of boats fishing within various periods. Note that the use of induction loop sensors to detect and count vehicles and trailers was not attempted. Only pneumatic sensors were used in the trial.

The spatial resolution of the data produced by the VCS is at boat ramp level. As the recorder monitors activity automatically through the entire day, it has the potential to provide comprehensive monitoring coverage for a wide temporal stratum. Accordingly, VCS systems to monitor levels of boat retrieval activity can be very easily deployed at other boat ramps to supplement existing survey methods and thereby increase precision and accuracy.

3.3.2.3 *Vehicle counter survey analysis*

The use of a VCS to provide data to supplement the data produced by other recreational fishing survey techniques has been described by Steffe *et al.* (2008).

The data exported from the VCS at the Hillarys boat ramp were binned counts of axles on an individual tube within each minute. These data were then expanded to remove the binning, such that each individual hit on each pneumatic tube could be treated as a discrete event for each minute.

The count of hits on the first pneumatic tube (leg A) were used in the analysis, as the second tube (leg B) had exhibited greater susceptibility to being vandalised in an earlier trial period between 27 January and 30 March 2006.

The methods of analysis used for the video camera retrieval data could be employed to obtain monthly estimates of pulses recorded by the VCS. However, due to the short period of operation of the VCS, analysis was restricted to comparing the results obtained from the VCS with those obtained using other counter techniques (see Section 4).

3.3.2.4 *Vehicle counter survey results*

Following initial trials conducted between 27 January and 30 March 2006, the MetroCount 5600 VCS unit was deployed from 6 April to 27 June 2006. A total of 34,876 pulses were recorded by the VCS during this period (Table 3.11). A plot of the total number of pulses recorded within each hour for the period over which the VCS was deployed exhibited a strong temporal trend in activity (Figure 3.4).

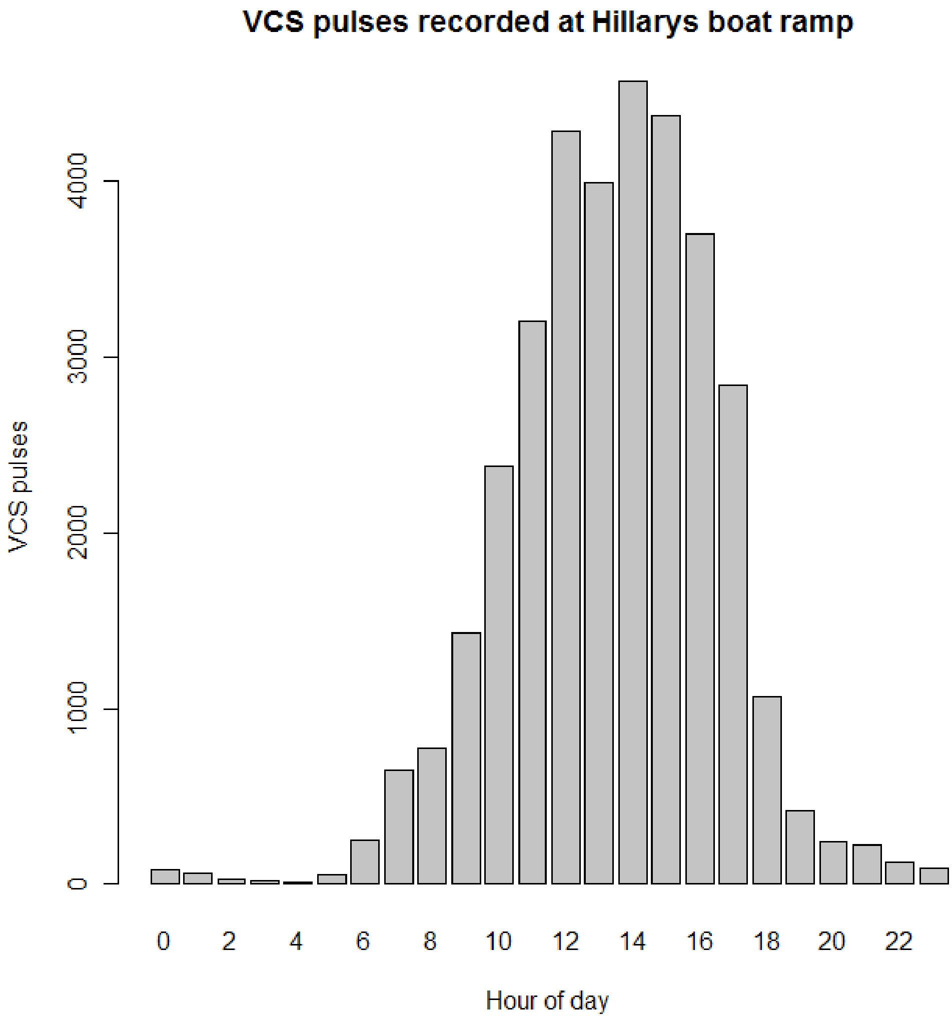

Figure 3.4 Total number of pulses within each hour, as recorded by the VCS, which was deployed over the retrieval lane at the Hillarys boat ramp between 6 April and 27 June 2006.

The VCS data were assumed to represent an index of the number of boats being retrieved from the boat ramps in the corresponding time periods. However, only a proportion of the boats associated with these trailers was likely to be associated with fishing, and this proportion will vary with time of day, day type (day of week or weekend, or public holiday), month and year. Sufficient supplementary data on the numbers of fishing boats that have been retrieved in the corresponding time periods must be collected to allow determination of the relationship of the VCS data to the numbers of boats that have been used for fishing and are retrieved from the boat ramp and the precision of estimates of the numbers of such boats to be assessed. Steffe *et al.* (2008) discuss the need to validate VCS data against true retrieval activity, and provide details of the methods used to determine the relationship between the VCS data and fishing activity.

3.3.3 Camera snapshot counter survey

3.3.3.1 Introduction

Low cost, low resolution cameras that provided a view of the Hillarys car park were deployed at fixed locations overlooking the car park. These cameras were configured to take a synchronised, hourly snapshot. The resulting images were stored on a media server located at the Western

Australian Fisheries and Marine Research Laboratories at Hillarys. The resulting set of images for each hourly snapshot was then examined and, when boat trailers were present in the car park, the number of trailers visible in the car park at that point in time was recorded and entered into a database. When trailers were not present in the captured images, no record was entered in the database. The data were intended to provide an index of the usage of the associated boat ramp, while recognising that not all trailers are associated with boats that are being used for recreational fishing.

3.3.3.2 Camera snapshot counter survey analysis

Trailer counts recorded by the panning camera for each hour of the day over all days within the 2005/06 study period and within each day during the study period (in periods for which the camera functioned correctly) were calculated and plotted. As noted previously, the panning camera suffered occasional interruptions to its operations with consequent failure to capture images during such periods.

To account for records with zero observations, which had not been entered into the database, an estimate of the maximum number of days for which trailer counts were obtained during the month was calculated as the maximum number of counts recorded for any hour of the day for that month. An estimate of the average number of trailers present within the car park for each hour within each month was calculated as the sum of all trailers counted for that hour within that month divided by the estimated maximum number of days during that month on which trailer counts were collected.

Other analyses undertaken when comparing data from different counter techniques are described in Section 4.

3.3.3.3 Camera snapshot counter survey results

The panning camera was first deployed in August 2005, initially as a pilot study to determine whether the technique was likely to be effective. From mid September, it operated almost continually to 31 May 2006, capturing images at hourly intervals within each of the 24 hours of the day during those periods in which the camera was operational. Camera problems resulted in a gap in the data from the panning camera for early June. The other types of cameras were deployed shortly after the initial deployment of the panning camera, and were operated for a period of approximately three months. Counts could be made only during the hours of daylight from the snapshots produced by cameras other than the panning camera. The latter was fitted with an infrared facility that allowed images to be recorded at night. The majority of non-zero counts of trailers in the car park were recorded between 5 am and 6 pm, during the period in which the other cameras would have been reasonably effective.

Comparison of the counts obtained from images captured by the other cameras with those of the panning camera demonstrated that the latter camera was situated in a location that allowed greater visibility of the trailers in the car park. It was more difficult to distinguish and count the trailers in the images taken by the low resolution cameras, but counts obtained using the phone-camera taking timed high resolution images in periods when the car park was lightly occupied were similar to those obtained using the panning camera. At higher densities of car park occupancy, the view of the trailers by the phone camera, which was located at a slightly lower elevation than the panning video camera, was more obscured than the view by the panning camera resulting in discrepancies between counts. The phone camera also suffered from a slightly more restricted field of view than the panning camera.

For high densities of car park occupancy, a high vantage point is highly desirable for the location of the camera.

Images were examined by a recorder and, when trailers were present in the car park, those trailers were counted and the resulting counts were entered into an Access database. Typically, and with relatively few exceptions, zero counts were not entered into the database when no trailers were present in the car park. Images of the car park were typically captured once during each hour of each day during the period from 3 August 2005 to 30 June 2006, except for the periods 12 August to 13 September and 27 May to 11 June.

Clear temporal signals were evident in plots of total recorded counts of trailers in the car park within each month (Table 3.11, Figure 3.5) and within each hour of the day (Figure 3.6). Plots of the average hourly (non-zero) counts of trailers in the car park, and of average hourly counts adjusted to account for non-recording of zero counts, demonstrate that the temporal pattern of boating activity varies with month (Figure 3.7 and Figure 3.8).

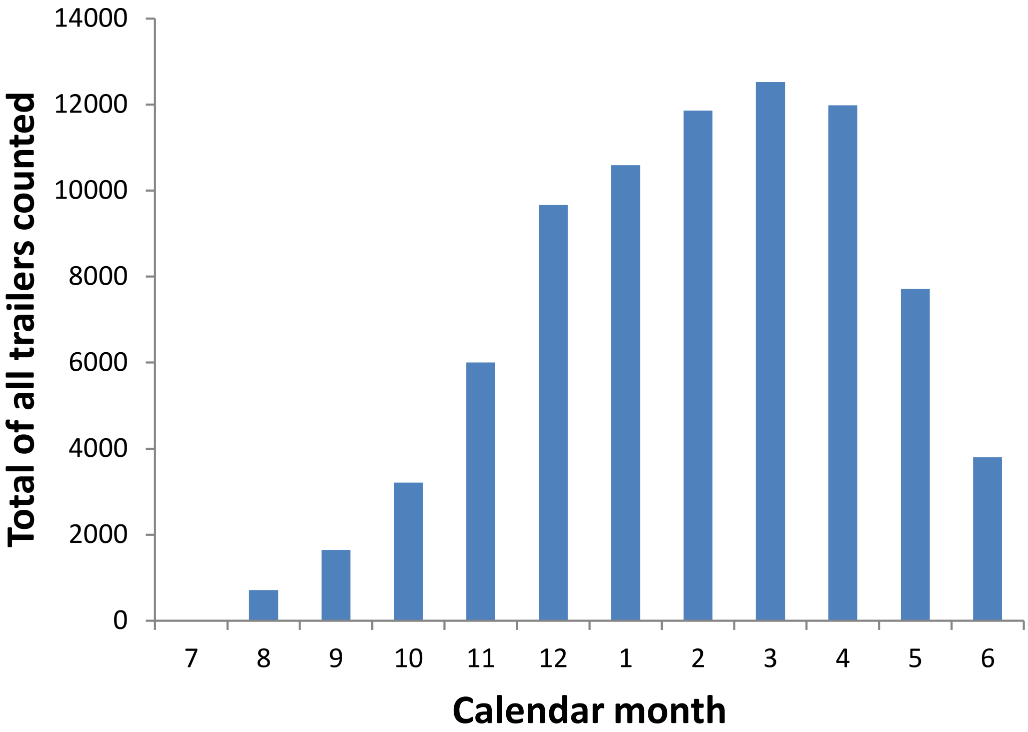

Figure 3.5 Total number of trailers counted within each month in video camera snapshots of the car park at the Hillarys boat ramp. Note that trailers parked at the ramp will be counted multiple times as they will appear in successive snapshots. Note also that camera malfunctions in June will have produced a negative bias in the trailer count.

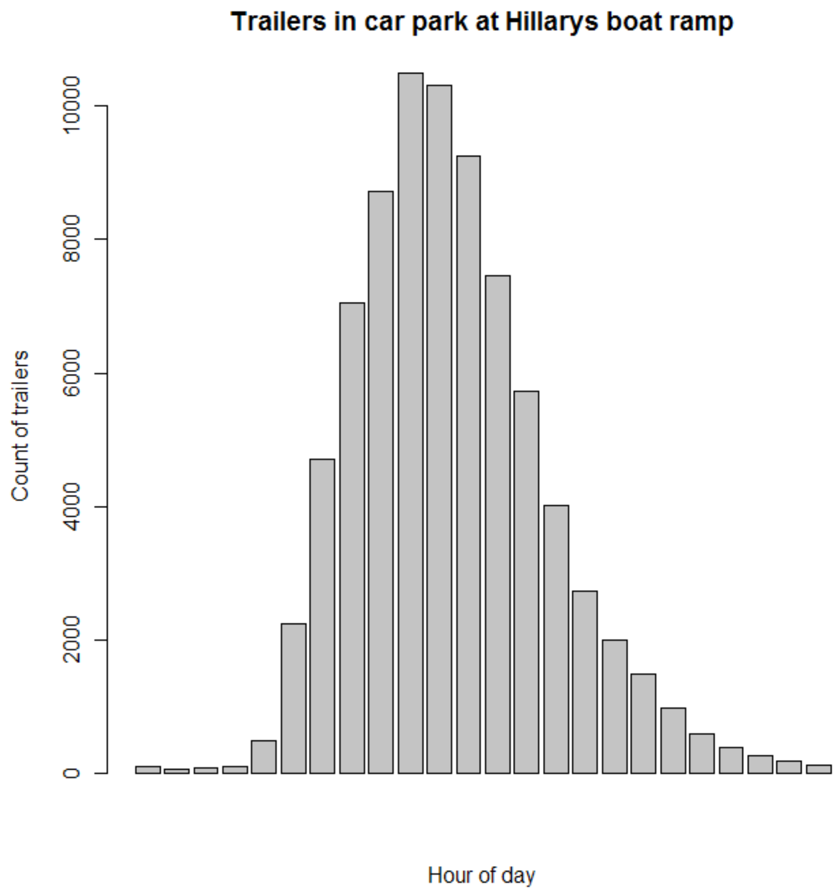

Figure 3.6 Total number of trailers counted within each hour in video camera snapshots of the car park at the Hillarys boat ramp. Note that trailers parked at the ramp will be counted multiple times as they will appear in successive snapshots.

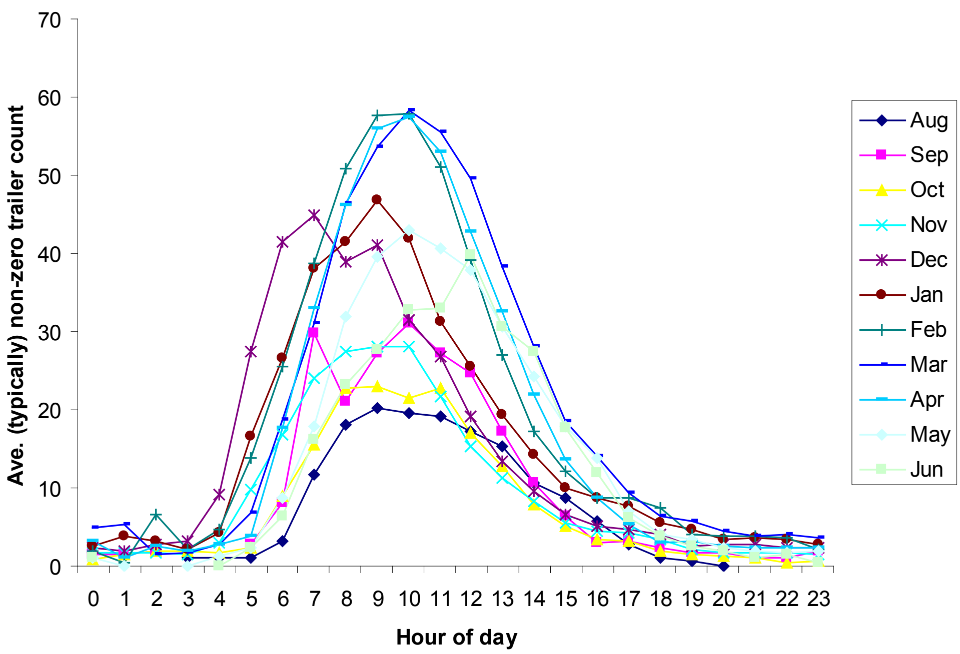

Figure 3.7 Average number of trailers present in the Hillarys car park, calculated using the (typically) non-zero records within the database. The values shown are over-estimates of the true average number of trailers present as the database contains relatively few records for the images in which no trailers were present.

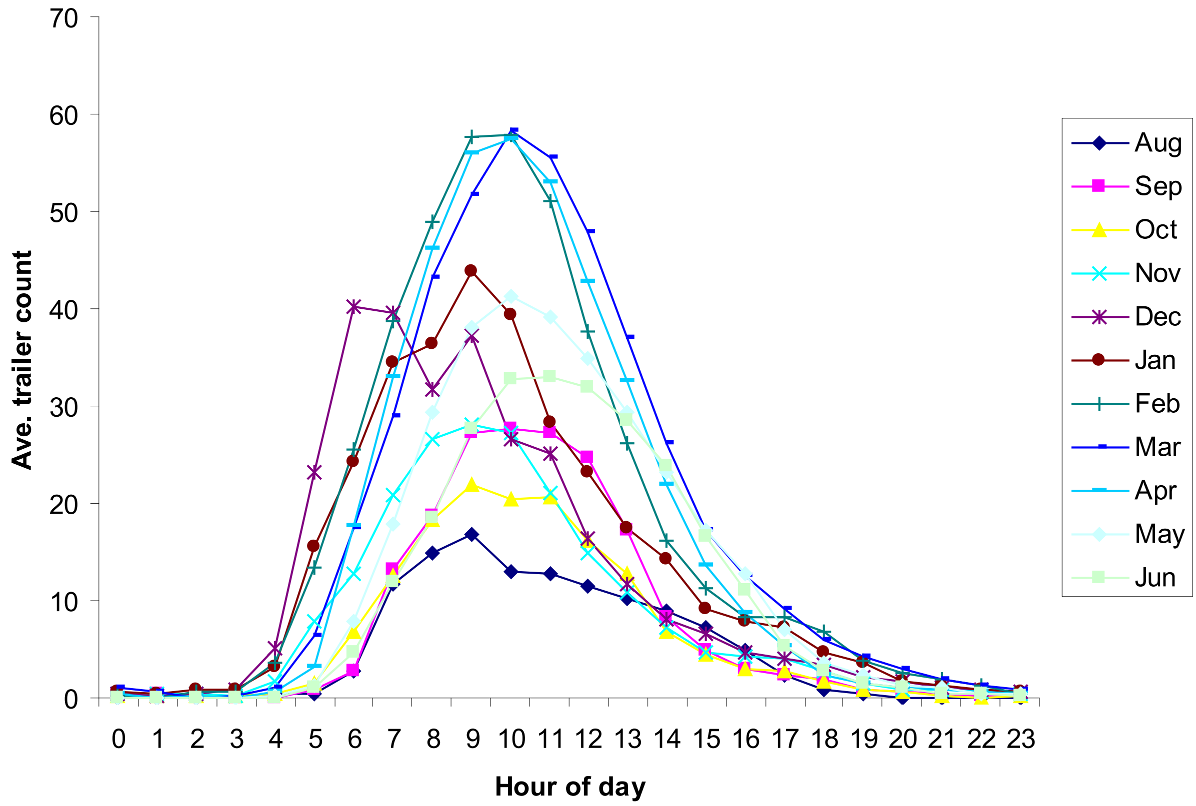

Figure 3.8 Average number of trailers present in the Hillarys car park, adjusted to allow for the zero-count records that were not entered into the database.

3.3.4 Ticketing counter survey

3.3.4.1 Introduction

Details of the number of parking tickets, parking infringements and annual parking permits issued monthly may be obtained for the car parks adjoining several of the boat ramps in the West Coast Bioregion. The potential exists for these numbers to be used to assess the accuracy of the counts from the camera snapshot survey and to provide a relative index of activity at boat ramps.

3.3.4.2 Ticketing counter survey analysis

There appears to be a strong correlation between the camera ramp activity figures and the standard ticket sales.

3.3.4.3 Ticketing counter survey results

There are four boat ramps in the Perth Metropolitan Area that have a system for parking ticketing and issuing infringements to users. These ramps are at Leeuwin, Mindarie Keys, Hillarys and Ocean Reef. The ticketing and issuing of fines and annual passes at these locations is the responsibility of local councils and/or the DPI. A summary of the systems in place and the responsibilities of each organisation at each boat ramp are provided in Table 2.4.

The ticketing counter survey was restricted to the Hillarys and Ocean Reef boat ramps, as data were not available for the other two locations. In the case of Leeuwin boat ramp, residents of the Town of East Fremantle are permitted to park at this location at no charge. It was thus impossible to use the data from tickets or fines to estimate the number of car park users, the frequency of visits or when these residents are using the boat ramp. At the time of the survey, no parking tickets or fines were being issued at Mindarie Keys due to redevelopment of the boat ramp and surrounding area.

The data available for the car parks at the Hillarys and Ocean Reef boat ramps represented a complete census of the parking tickets, infringements/fines, and annual parking permits issued each month in 2005/06 (Table 3.13 and Table 3.14).

The total number of vehicles using the car park each month at the Hillarys and Ocean Reef boat ramps were difficult to determine due to the annual pass system. Annual passes are valid for 12-months from the date of purchase at both these boat ramps, but the number of visits each month by holders of these passes cannot be determined from the available data.

Table 3.13 Number of tickets and infringements issued at Hillarys boat ramp in 2005/06.

Month	Tickets	Infringements	Annual passes issued
July 05	620	56	6
August 05	534	46	17
Sept 05	514	37	11
October 05	820	30	35
November 05	1,237	62	105
December 05	1,610	255	101
January 06	2,132	415	48
February 06	1,450	119	31
March 06	1,684	41	26
April 06	1,346	33	12
May 06	1,329	0	19
June 06	1,365	0	6
Total	14,641	1,094	417

Table 3.14 Number of tickets and infringements issued at Ocean Reef boat ramp in 2005/06.

Month	Tickets	Infringements	Annual passes issued
July 05	10	5	0
August 05	17	0	2
Sept 05	22	2	7
October 05	15	3	5
November 05	17	55	15
December 05	20	8	10
January 06	25	37	6
February 06	28	33	6
March 06	37	4	5
April 06	21	9	1
May 06	10	0	2
June 06	15	12	0
Total	237	168	59

3.4 Fisheries Marine Officer (FMO) recreational fishing survey

3.4.1 Introduction

Fisheries and Marine Officers had a total 1,127 Marine safety patrols state-wide between the 1 July 2005 and 30 June 2006 where recreational fishing surveys were undertaken during 782 of these patrols in the West Coast Bioregion. From these patrols there were 9,301 (or 23.3% of all recreational contacts) recreational fishing interviews either on the water and/or at boat ramps. 5,452 of those contacted parties were either fishing or had fished in the West Coast bioregion at the time of the inspection. Participation in the survey was 100%, as parties cannot refuse a marine safety inspection by an FMO.

The catches of key recreational species that were included on the MSI form for the West Coast Bioregion include: Pink Snapper, Dhufish, Breaksea Cod, Baldchin Groper, Australian Herring, Tailor, Blue Swimmer Crab and Western Rock Lobster, refer to Appendix 8.6.

3.4.2 FMO survey analysis

Recreational angler information collected through the marine safety inspection in the West Coast Bioregion during 2005/06 has been used as a basis for analysis. Catch rates (calculated as fish per trip) of kept fish was calculated from recreational boat-based interviews carried out on patrols. It should be noted that the analysis contains incomplete fishing trip information as interviews were undertaken whilst parties were still fishing.

Catch rates were calculated for complete and incomplete fishing trips (Pollock *et al.*, 1994)

$$\hat{R} = \sum_{i=1}^{n} c_i / \sum_{i=1}^{n} T_i$$

Where C_i the total is catch per species and T_i is the fishing trip.

The sample variance was calculated by:

$$Var(\hat{R}) = \frac{\sum_{i=1}^{n} (c_i - \bar{c})^2}{n - 1}$$

The standard error was calculated by the usual method

$$SE(\hat{R}) = \sqrt{Var(\hat{R})}$$

The proportion of boats engaged in fishing was estimated as the ratio of the count of boats that had been fishing, or intended to fish, to the total number of such boats combined with those had not been and did not intend to fish, i.e. excluding those records for which insufficient data were recorded to discriminate whether or not fishing had or was likely to occur.

The records from the FMO database were filtered to select only those records for which the inspection was conducted by the FMO and for which fishing was reported to be occurring or to have occurred, i.e. excluding those records for boat trips for which fishing had not yet commenced, were selected for catch rate per trip analysis. The common fishing code (i.e. “Y”) is used to identify both completed and incomplete fishing trips, therefore calculating catch rates per trip may result in an underestimate. As the duration of fishing time is not collected by FMO it is not possible to calculate catch rates per hour.

It should be noted that fishing trips recorded in the FMO database may be associated with a number of different target species, including Western Rock Lobster or Blue Swimmer Crabs, which may not relate specifically to key demersal finfish species. However, the analysis of boat ramp creel survey data has demonstrated that boats fishing for rock lobster or crabs frequently undertake line fishing as well, so it is therefore inappropriate to restrict catch rates per trip analysis to boats that only reported key demersal species. The estimate of catch rate per trip is biased as all fishing trips were included in the analysis. Modifications have since been made to the MSI form to improve future analysis and remove some of the inherit biases which occurred in the analysis of the 2005/06 data. The catch rate per trip and the standard error were calculated for each species using the selected records.

3.4.3 FMO survey results

The proportion of boats that had fished, intended to fish or had not fished were calculated from the data for those boats contacted by FMOs between 1 July 2005 to 30 June 2006 (Table 3.15). In total, 58.6% of the total proportion of boats interviewed by FMOs were fishing or had fished, 19.7% were not fishing and had no intension of fishing, whilst 16.7% of interviews intended to fish that trip. The remaining 5.0% of data was incomplete.

Estimates of the catch rates (catch per trip) of the key demersal species for the West Coast Bioregion derived from the FMO data are presented in Table 3.16.

Table 3.15. Proportion of the boats contacted by FMOs that reported that they had fished or was fishing, intended to fish, had not fished and had no intention to fish during that trip.

	Intend to fish that trip	Have been fishing or is fishing	Not fishing for all of that trip	Incomplete records
Proportion	16.7%	58.6%	19.7%	5.0%

Table 3.16. Catch rate per trip for boats contacted by FMOs where the parties on board the boats advised that fishing had or were fishing.

Common name	West Coast Bioregion
	Catch rate (SE)
Baldchin Groper	0.034 (0.280)
Breaksea Cod	0.035 (0.252)
Pink Snapper	0.032 (0.361)
Western Australian Dhufish	0.087 (0.487)

3.5 Volunteer Fisheries Liaison Officer (VFLO) survey

3.5.1 Introduction

The VFLO program was initiated in 1993 and a total 6,603 state-wide shore and boat-based patrols had been carried out up to 30 June 2006. Of these, 5,931 (90%) were patrols in the West Coast bioregion. During 2005/06, 740 patrols were conducted in the West Coast Bioregion, leading to 1,454 incomplete trip interviews with shore-based fishers and 256 complete trip interviews with boat-based fishers. Of these boat-based interviews, 77 were involved with fishing activity using rods and handlines to target finfish species.

3.5.2 VFLO survey analyses

Angler information collected from boat-based fishing in the West Coast Bioregion during 2005/06 was used as a basis for analysis. Catch rates (calculated as fish per hour) of kept and released fish were calculated from interviews carried out on patrols.

The catch rate for boat-based fishers was calculated for each stratum *m* by the ratio of the means (Crone and Malvestuto, 1991)

$$\hat{R}_m = \frac{\sum_{i=1}^{n_m} C_{mi} / n_m}{\sum_{i=1}^{n_m} p_{mi} L_{mi} / n_m},$$

where C_{mi} is the catch, L_{mi} is the fishing effort (in person hours) and p_{mi} is the number of persons fishing per party *i*.

The variance for the ratio of the means $\hat{R}_m$ can then be estimated using the formula described in Kendall and Stuart (1969)

$$Var(\hat{R}_m) \approx \hat{R}_m^2 \left(\frac{Var(\overline{C}_m)}{\overline{C}_m^2} + \frac{Var(\overline{L}_m)}{\overline{L}_m^2} - \frac{2Cov(\overline{C}_m, \overline{L}_m)}{\overline{C}_m \overline{L}_m} \right)$$

where the covariance term was assumed to be zero.

The standard error is calculated by the usual method

$$SE(\hat{R}_m) = \sqrt{Var(\hat{R}_m)}$$

3.5.3 VFLO survey results

Although was ascertained that 77 boat-based fishing parties were using rods or handlines to target finfish species, it could not be determined if this activity occurred in the marine or estuarine environment. This, combined with the small number of interviews, prohibited the calculating of fishing effort using VFLO data for this time period from 1 July 2005 to 30 June 2006 (inclusive).

A total of 22 finfish species were recorded during VFLO interviews with boat-based fishers as well as 10 general categories of finfish. Although this catch included 6 of the 18 key inshore demersal scalefish species, the numbers of kept and released fish were too low to calculate catch rate (Table 3.17).

Table 3.15 Reported catch of key inshore demersal scalefish species for boat-based fishers in the West Coast Bioregion based on data collected by VFLOs in 2005/06, where n = number of interviews.

Common name	n	Kept	Released
Breaksea Cod	9	10	3
Blue Morwong (Queen Snapper)	1	3	0
Pink Snapper	5	6	0
Bight Redfish	6	6	2
Sea Sweep	4	5	1
Western Australian Dhufish	13	16	11

3.6 Research Angler Program (RAP) Logbook

3.6.1 Introduction

The RAP commenced in March 2004 and a total 383 anglers had been given logbooks up to 30 June 2006; 166 (43%) of these anglers fished at least once during this period. During 2005/06 financial year there were 146 active anglers (i.e. fished at least once during the period) in the RAP. Of these anglers, 52 provided complete information for boat-based fishing in the ocean for 256 fishing trips in the West Coast Bioregion.

3.6.2 RAP logbook analysis

Angler information collected from ocean boat-based fishing in the West Coast Bioregion during 2005/06 was used as a basis for analysis. Catch rates (calculated as fish/boat hour) of kept and released fish were calculated from the logbook data.

The catch rate for ocean boat-based fishers was calculated for each stratum m by the ratio of the means for individual fishers averaged over all fishers (Crone and Malvestuto, 1991).

$$\hat{R}_m = \sum_{i=1}^{n_{mi}} \hat{R}_m^* / n_{mi} = \sum_{i=1}^{n_{mi}} \frac{\overline{C}_m}{\overline{L}_m} / n_{mi} = \sum_{i=1}^{n_{mi}} \frac{\sum_{j=1}^{n_{mj}} C_{mij} / n_{mj}}{\sum_{j=1}^{n_{mj}} L_{mij} / n_{mj}} / n_{mi} ,$$

where C_{mij} is the catch and L_{mij} is the fishing effort for fisher i on trip j.

The variance for $\hat{R}_m$ was then be estimated using the formula described in Kendall and Stuart (1969)

$$Var(\hat{R}_m) \approx \sum_{i=1}^{n_{mi}} \hat{R}_m^{*2} \left(\frac{Var(\overline{C}_m)}{\overline{C}_m^2} + \frac{Var(\overline{L}_m)}{\overline{L}_m^2} - \frac{2Cov(\overline{C}_m, \overline{L}_m)}{\overline{C}_m \overline{L}_m} \right) / n_{mi}^2$$

where the covariance term was assumed to be zero.

The standard error was calculated by the usual method

$$SE(\hat{R}_m) = \sqrt{Var(\hat{R}_m)}.$$

3.6.3 RAP logbook results

The ocean boat-based fishing information for the key demersal species collected from the logbooks is presented in Table 3.16. Catch rate information is presented in Table 3.17.

Table 3.16 Ocean boat-based fishing information for the key demersal species collected through the RAP logbook during 2005/06.

Fishers	52	
Fishing trips	256	
Common name	**Kept**	**Released**
Baldchin Groper	29	9
Blue Morwong (Queen Snapper)	7	1
Breaksea Cod	33	16
Redthroat (Sweetlip) Emperor	11	9
Yellowtail Emperor	1	1
Pink Snapper	24	11
Bight Redfish	6	
Swallowtail	2	2
Sea Sweep	6	2
Sergeant Baker	11	7
Western Australian Dhufish	48	41
Western Foxfish	3	

Table 3.17 Ocean boat-based fishing catch rate (fish per boat hour) for the key demersal species collected through the RAP logbook during 2005/06. NA represents where the sample size was inadequate.

Common name	Kept	SE	Released	SE
Baldchin Groper	0.037	0.010	0.009	0.003
Blue Morwong (Queen Snapper)	0.009	0.002	NA	NA
Breaksea Cod	0.053	0.007	0.015	0.005
Lethrinus species	0.027	0.008	0.028	0.012
Pink Snapper	0.041	0.006	0.017	0.008
Redfish species	0.023	0.004	NA	NA
Sea Sweep	0.011	0.006	NA	NA
Sergeant Baker	0.023	0.011	0.008	0.004
Western Australian Dhufish	0.044	0.007	0.060	0.008
Western Foxfish	0.015	0.002	NA	NA

3.7 Activity comparisons

3.7.1 Overview

None of the counting methods used in this study can be assumed to produce absolutely accurate instantaneous counts of the number of boats at sea or the total boat time at sea (boat hours) during any specified period. Each method is constrained to either a time period of operation, by the temporal resolution of data that are recorded, or may be affected by factors that affect the quality of the data that are collected. Recognising this, however, it was possible to explore the extent to which the different counting methods employed in this study produced consistent and well-correlated data and thereby facilitate assessment of the relative effectiveness and value of each method.

Fundamentally, each of the various counting methods was intended to facilitate production of an instantaneous measure of boating activity that was representative of the average boating activity over a specified period of time. In this study, boating activity was taken to mean the total time that power boats launched from the boat ramp have been at sea, and is measured in "boat-hours". This definition was intended to exclude vessels other than power boats and vessels launched from the shore or from moorings. The number of power boats (both fishing and non-fishing), which have been launched from the boat ramp and which are at sea, may be considered to be an index of boating activity if it is assumed that the average duration of a trip is constant.

For a number of data collection methods, the number of boat trailers parked in the car park at the Hillarys boat ramp has been employed as a proxy of the number of boats at sea at the time of the trailer count. Thus, estimates of boating activity derived from car park counts, whether based on counts of trailers in camera snapshots of the trailer park or on counts made at the start and end of onsite survey visits, assume that this proxy was an accurate estimate of the number of boats at sea. The data recorded by car park ticketing machines represented an alternative measure, which was assumed to be a proxy for the total number of boats that were launched (or retrieved) during the day, and which remained at sea for a period that overlapped with the period requiring the purchase of a parking ticket or possession of a long term parking permit. Launches and retrievals of boats at the boat ramp, for which details of time of launch or retrieval activity are recorded together with, in the case of video camera or onsite survey data, details of boat type, represent changes in boating activity. VCS counts of retrievals, which measure pulses on the pneumatic tube laid across the retrieval lane at the boat ramp, are assumed to be a proxy for launches and retrievals of power boats, but are affected by traffic of cars without trailers and by cars with trailers carrying boats other than power boats.

In the subsequent analysis, comparisons have been made between different measures of the following;

- Estimates of numbers of trailers in the Hillarys boat ramp car park.
- Estimated counts of launches and retrievals from the Hillarys boat ramp.
- Estimated total daily boating activity from the Hillarys boat ramp.
- Car park tickets for the Hillarys boat ramp car park.

3.7.2 Estimated numbers of trailers in the Hillarys boat ramp car park

3.7.2.1 Ramp video camera counts versus camera snapshot counts

Counts of the number of trailers in the car park associated with the Hillarys boat ramp were derived from the camera snapshots (Figure 3.9). Estimates of the number of trailers that would be expected to be present in the car park at the times corresponding to those snapshots were calculated from the launches and retrievals recorded by the video camera focussed on the boat ramp. For this, it was assumed that zero trailers would be present at midnight, i.e. the start of the 24 hour period. Subsequently, one trailer was added at the time of each launch and one subtracted at the time of each retrieval, thus providing an estimate of the number of trailers estimated to be present at the time of each snapshot that could be compared with the snapshot-derived count. A robust linear regression model, with zero intercept, fitted to the ramp camera-based estimate versus snapshot count, produced a very highly significant fit (P<0.001), with a coefficient of 1.002 (SE=0.005) and with 297 points being considered outliers.

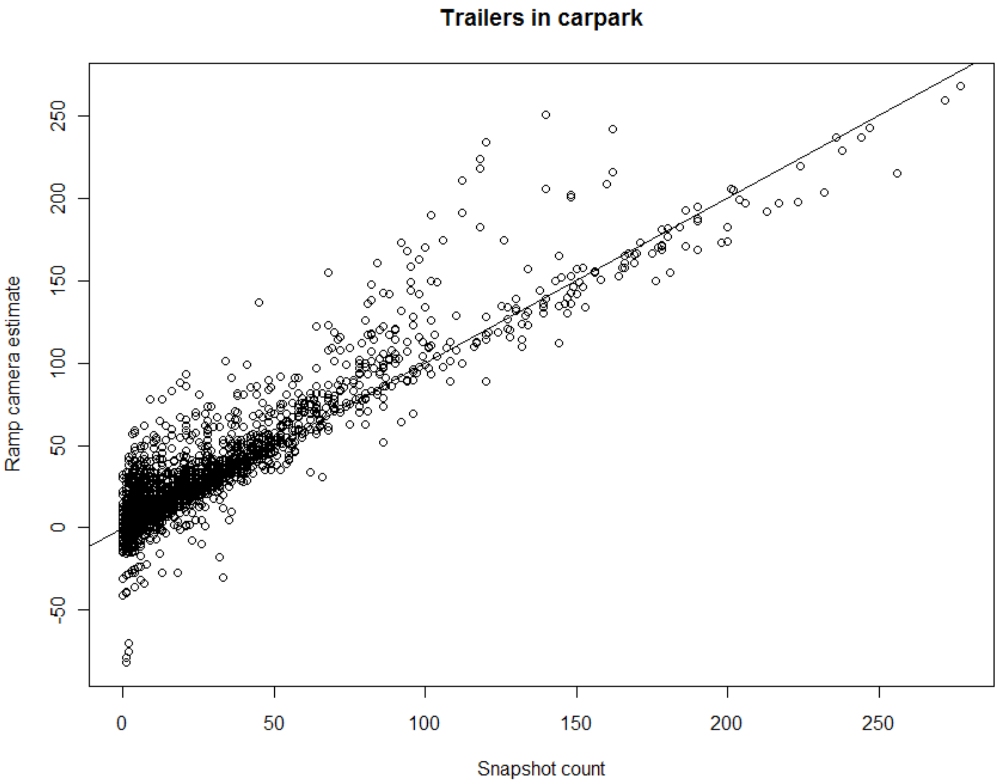

Figure 3.9 Ramp camera activity since midnight versus snapshot count at the Hillarys boat ramp car park.

3.7.2.2 Ramp video camera counts versus counts from boat-ramp based creel survey

The count of trailers in the car park undertaken by the survey team at the start of each visit to the boat ramp was also compared with the estimate of the number of trailers that was expected to be in the car park based on the difference between the numbers of launches and retrievals recorded since midnight by the ramp video camera (Figure 3.10). A robust linear regression model with zero intercept fitted to the ramp camera estimates versus the counts at the start of the survey visits produced a very highly significant fit (P< 0.001). The coefficient was estimated to be 0.99 (SE=0.02), with five points considered to be outliers.

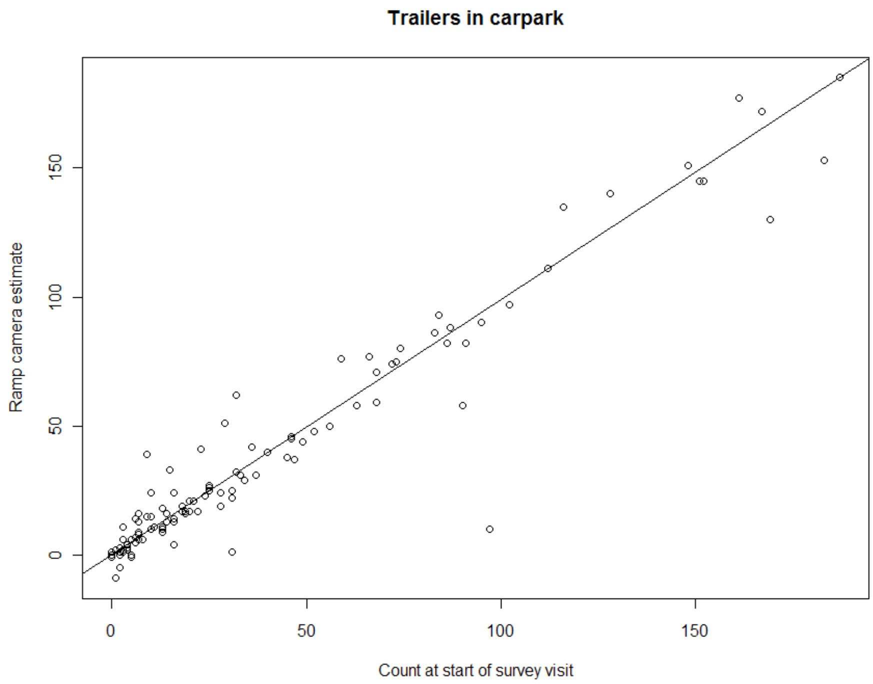

Figure 3.10 Ramp camera activity since midnight versus starting count for survey visit at the Hillarys boat ramp car park

Following the same approach as the previous analysis, the count of trailers in the car park undertaken by the survey team at the end of each visit to the boat ramp was also compared with the ramp camera-based estimate of the expected number of trailers (Figure 3.11). A robust linear regression model with zero intercept fitted to the ramp camera estimates versus the counts at the end of the survey visits produced a very highly significant fit ($P < 0.001$). The coefficient was estimated to be 1.09 (SE=0.02), with eight points considered to be outliers.

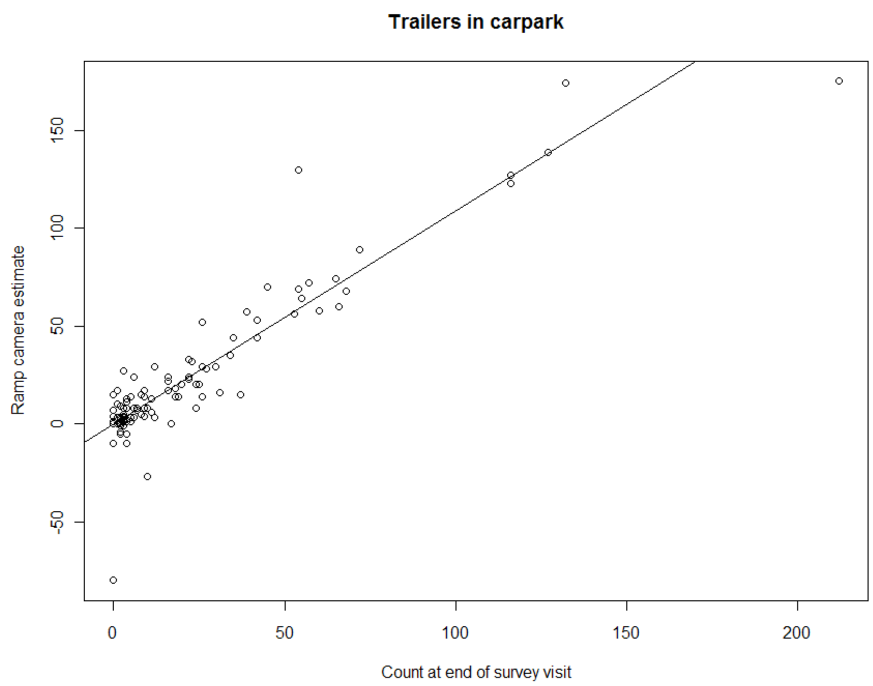

Figure 3.11 Ramp camera activity since midnight versus final count for survey visits at the Hillarys boat ramp car park.

3.7.2.3 Counts from boat-ramp based creel survey versus camera snapshot counts

The counts of boat trailers in the car park at the Hillarys boat ramp recorded at the start of their visits to the site by the creel census interviewers were matched with the closest (in time) corresponding counts determined from snapshots of the car park that were taken by the video camera within one hour of associated interviewer count (Figure 3.12). Only those interviewer counts that could be paired with such camera snapshot-based counts were considered in the subsequent analysis. A robust linear regression model of interviewer count versus snapshot count, assuming a zero intercept, yielded a coefficient of 1.09 (SE: 0.01), and the fitted relationship was highly significant ($P < 0.001$). That is, the interviewers counted approximately 9% more trailers, on average, than were counted in the associated camera snapshots, but the two counts were highly correlated. Although the robust regression analysis identified 17 points that were considered to be outliers, the pattern of residuals revealed no consistent trend, and it appears likely that these outliers were due to a combination of observation errors in both interviewer and camera snapshot counts, coupled with the fact that differences between counts could have been the result of the difference between the number of trailers in the car park at the two times for which the counts were made.

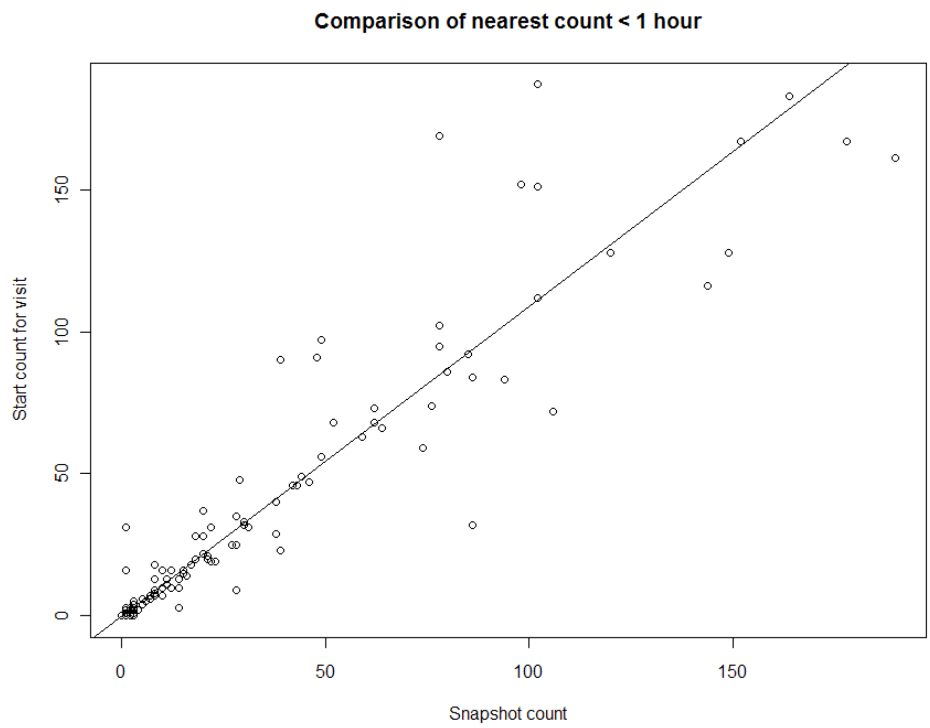

Figure 3.12 Start count for survey visit versus snapshot count at the Hillarys boat ramp car park.

Similarly, the numbers of trailers in the car park determined from the snapshots were matched to the numbers of trailers counted by the survey staff at the end of their visits to the boat ramp (Figure 3.13). Again, matching was based on the closest snapshot to the time at which the survey visit finished, and matched records were included in the analysis only if the counts were separated by one hour or less. The fit of the robust linear regression model of interviewer count related to snapshot count, assuming a zero intercept, was again highly significant ($P < 0.001$), with seven observations considered to be outliers. For these data, the estimated value of the coefficient of 1.16 (SE: 0.04), indicating that, at the end of their visits to the ramp, the interviewers counted approximately 16% more trailers, on average, than were counted in the associated camera snapshots, however the two counts were highly correlated.

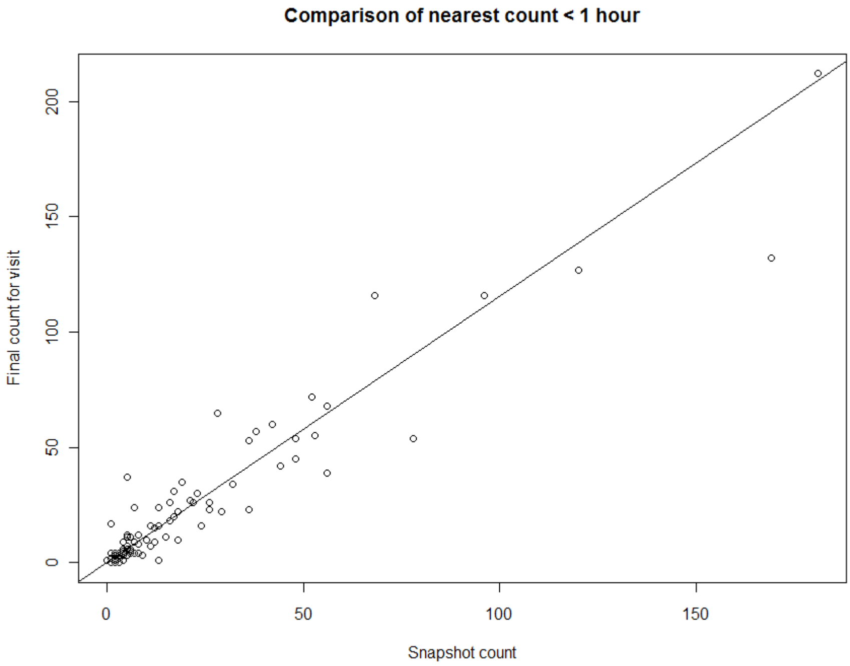

Figure 3.13 End count for survey visit versus snapshot count at the Hillarys boat ramp car park.

The matched data for the comparisons of the counts obtained from the snapshots of the car park and both the start and end of the visits by the survey team to the Hillarys boat ramp were pooled. Again, a robust linear regression model with zero intercept produced a highly significant fit ($P<0.001$), with the results indicating that 24 points had been considered to be outliers (Figure 3.14). The coefficient for the pooled data was 1.09 (SE=0.02), indicating that the counts by the interviewers produced estimates of the number of trailers in the car park that, on average, exceeded those obtained from counts derived from camera snapshots of the car park by 9%.

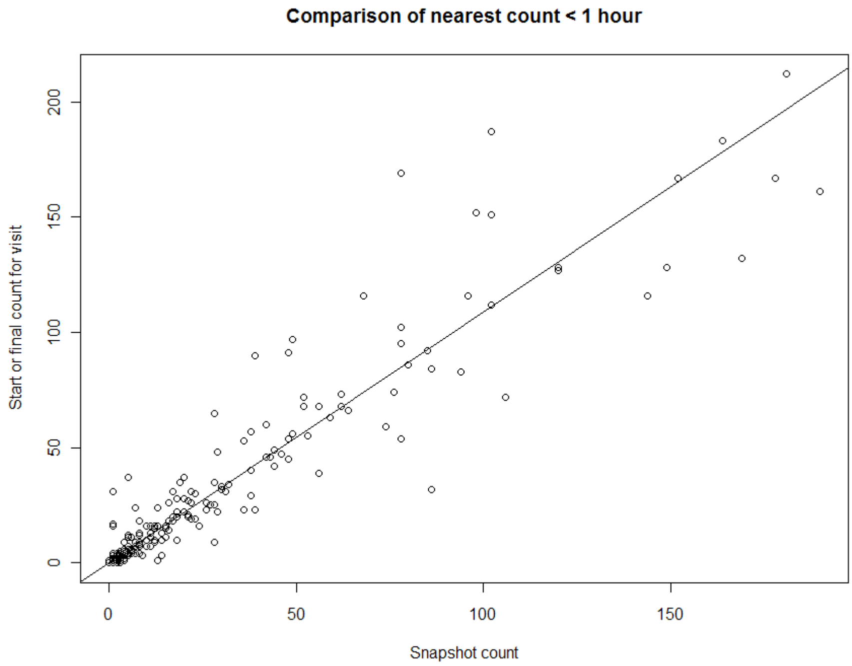

Figure 3.14 Start and end counts for survey visit versus snapshot count at the Hillarys boat ramp car park.

Trailer counts from camera snapshots of the Hillarys car park, taken in those periods in which interviewers were at the boat ramp conducting the onsite survey, were also compared with estimates of the number of trailers in the car park at the time of the snapshot, where these estimates were derived from the number of trailers in the car park counted by the interviewers at the start of their visit and the numbers of launches and retrievals that had subsequently occurred until the time at which the snapshot was taken. For this, the estimate of the number of trailers in the car park was obtained by adding the number of launches less the number of retrievals, which had occurred between the start of the visit and the time of the snapshot survey, to the number of trailers in the car park at the start of the onsite survey visit, where this last value was the count recorded by the interviewers at that time. Two estimates of trailer counts were obtained, firstly by employing launches and retrievals, which were recorded by the interviewer during the onsite survey visit, and secondly, by employing launches and retrievals derived from the video camera focussed on the boat ramp. The data on launches and retrievals recorded by the interviewers were restricted to records for power boats that were not launched or retrieved from the shore or from a mooring. For the video camera data, only those records obtained when the camera operated reliably were employed. That is, the estimate was considered to be missing if a camera event that affected the data overlapped the period between the start of the onsite visit to the ramp to the time at which the snapshot was taken.

A robust linear regression model, with zero intercept, relating the estimate of trailers in the car park derived using the count at the start of the visit and subsequent launches and retrievals recorded by the interviewers to that derived from the car park snapshot, produced a very highly significant fit ($P<0.001$) (Figure 3.15). The estimated coefficient was 1.06 (SE=0.01), and 29 points were taken to be outliers.

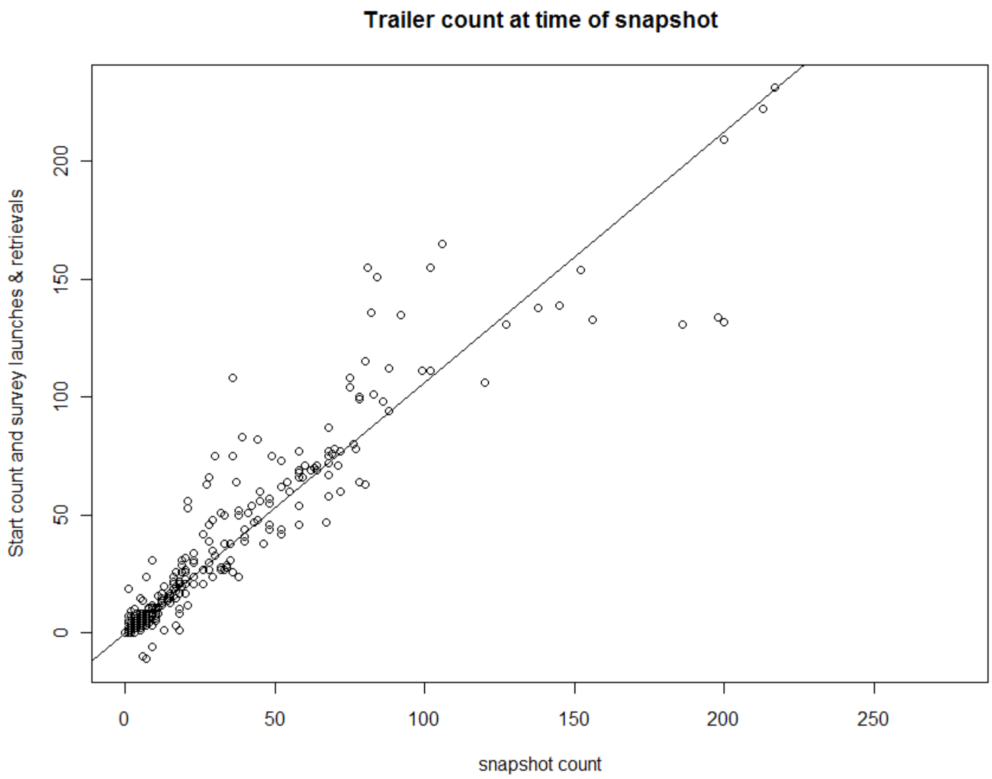

Figure 3.15 Estimates of trailers in the car park at the Hillarys boat ramp derived from start count, launches and retrievals from onsite survey versus snapshot count.

A robust linear regression model, with zero intercept, relating the estimate of trailers in the car park derived using the count at the start of the visit and subsequent launches and retrievals recorded by the ramp camera to that derived from the car park snapshot, produced a very highly significant fit ($P < 0.001$) (Figure 3.16). The estimated coefficient was 1.07 (SE=0.01), and 49 points were taken to be outliers.

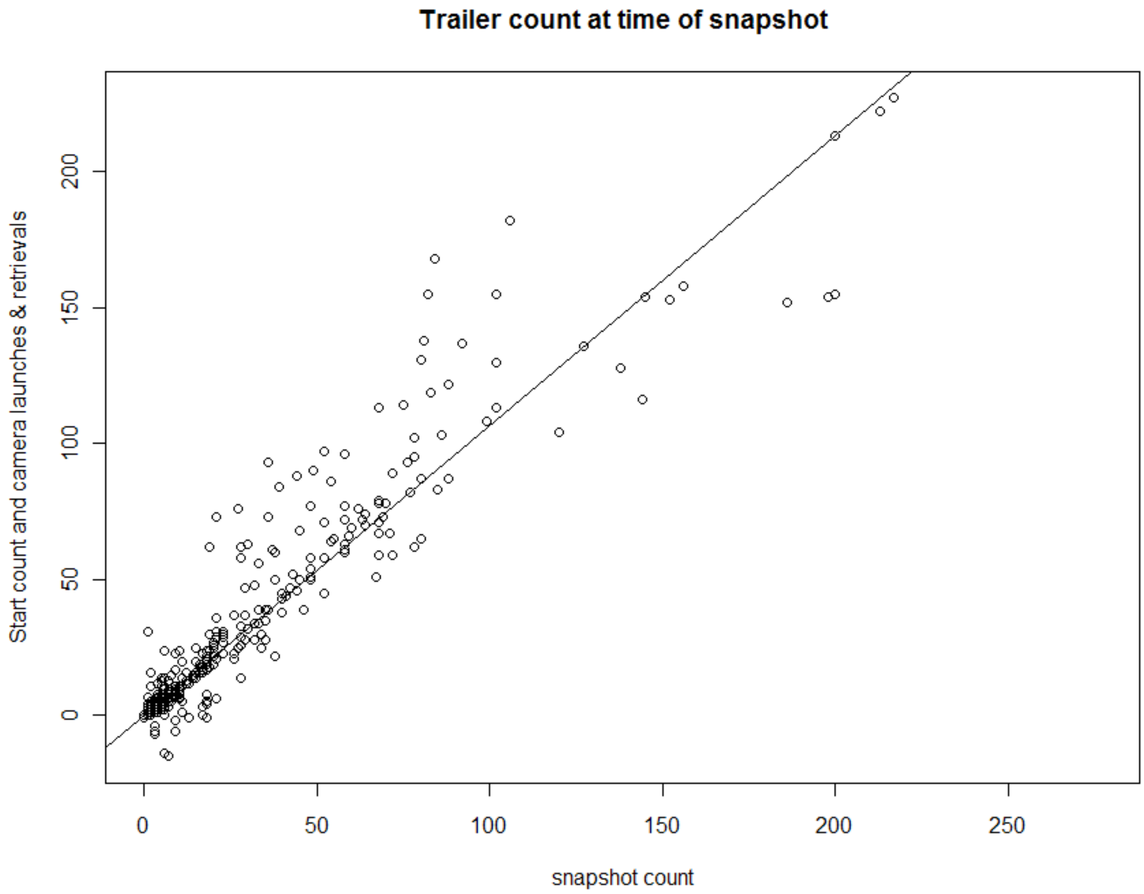

Figure 3.16 Estimate of trailers derived from start count, launches and retrievals from boat ramp camera versus snapshot count.

3.7.3 Estimated counts of launches and retrievals from Hillarys boat ramp

3.7.3.1 Ramp video camera counts versus counts from boat-ramp based creel survey

The numbers of launches recorded by the video camera focussed on the boat ramp during each of the periods that interviewers were conducting their visits to the Hillarys boat ramp were compared with the count of launches of power boats that were recorded during those visits by the survey team (Figure 3.17). A robust linear regression model with zero intercept was fitted to the resulting data. The fitted relationship was again highly significant ($P<0.001$). The estimated value of the coefficient was 1.19 (SE=0.04), with five observations considered to be outliers. This result suggests that, on average, the ramp camera recorded 19% more launches than were recorded by the interview team in the periods while the survey was being undertaken at the boat ramp.

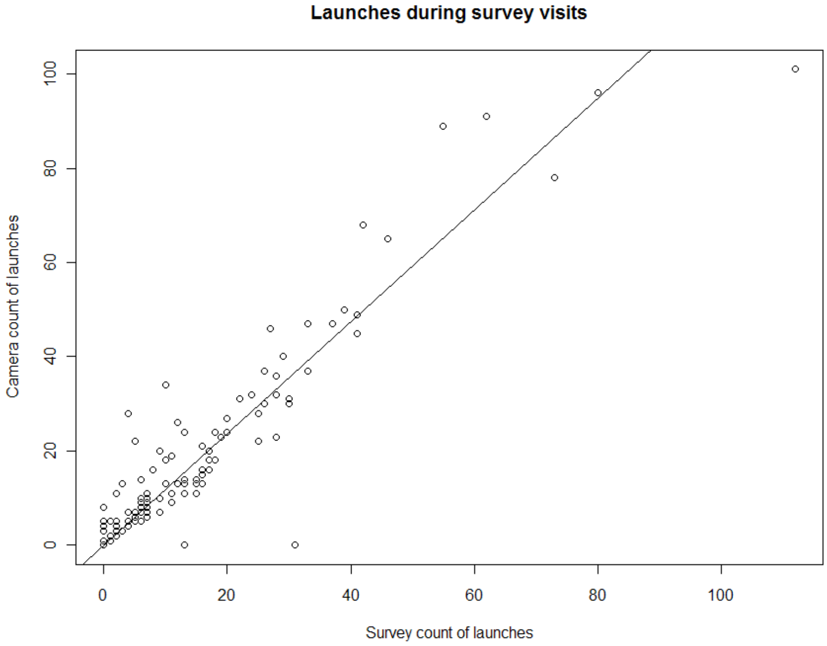

Figure 3.17 Count of launches at the Hillarys boat ramp during survey visits from ramp camera versus interviewers' count.

The numbers of retrievals recorded by the video camera focussed on the boat ramp during each of the periods that interviewers were conducting their visits to the Hillarys boat ramp were also compared with the count of retrievals of power boats that were recorded during those visits by the survey team. A fitted robust linear regression model with zero intercept was highly significant ($P<0.001$) (Figure 3.18). The estimated value of the coefficient was 1.06 (SE=0.03), with the results indicating that eight observations were taken to be outliers. This result suggests that, on average, the ramp camera recorded 6% more retrievals than were recorded by the interview team in the periods while the survey was being undertaken at the boat ramp.

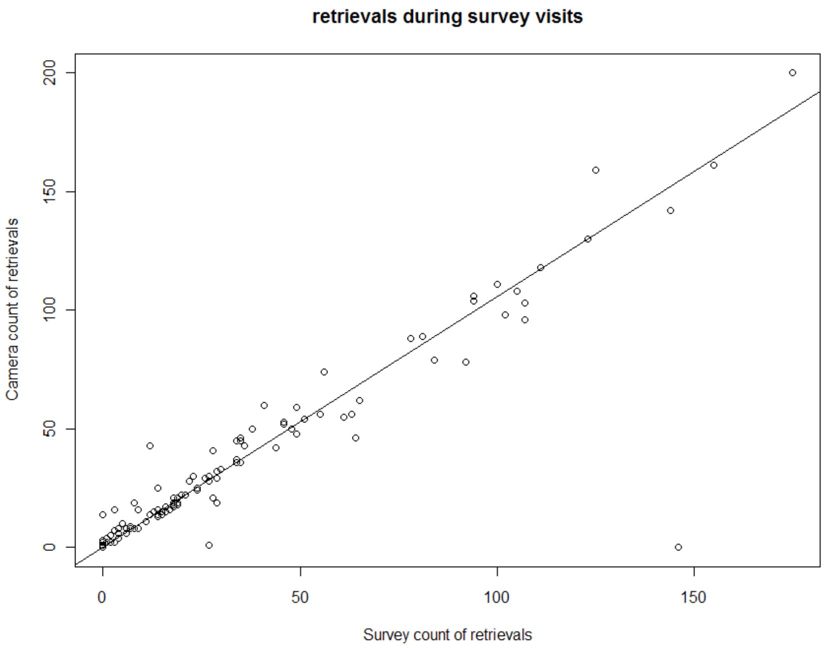

Figure 3.18 Retrievals at the Hillarys boat ramp during survey visits from ramp camera versus interviewers' count.

3.7.3.2 VCS counts versus ramp video camera counts

The number of pulses that were recorded on Leg A of the VCS mounted across the retrieval lane at the Hillarys boat ramp during each period in which the interview team was visiting the car park was also compared with the count of retrievals derived from the recordings from the video camera focussed on the boat ramp. A fitted robust linear regression model of the VCS count versus the camera count indicated that the relationship was highly significant ($P<0.001$), and produced a coefficient of 5.51 (SE=0.14), thus indicating that, for every retrieval recorded by the video camera, there were, on average, 5.51 pulses recorded on the VCS (Figure 3.19). No outliers were reported.

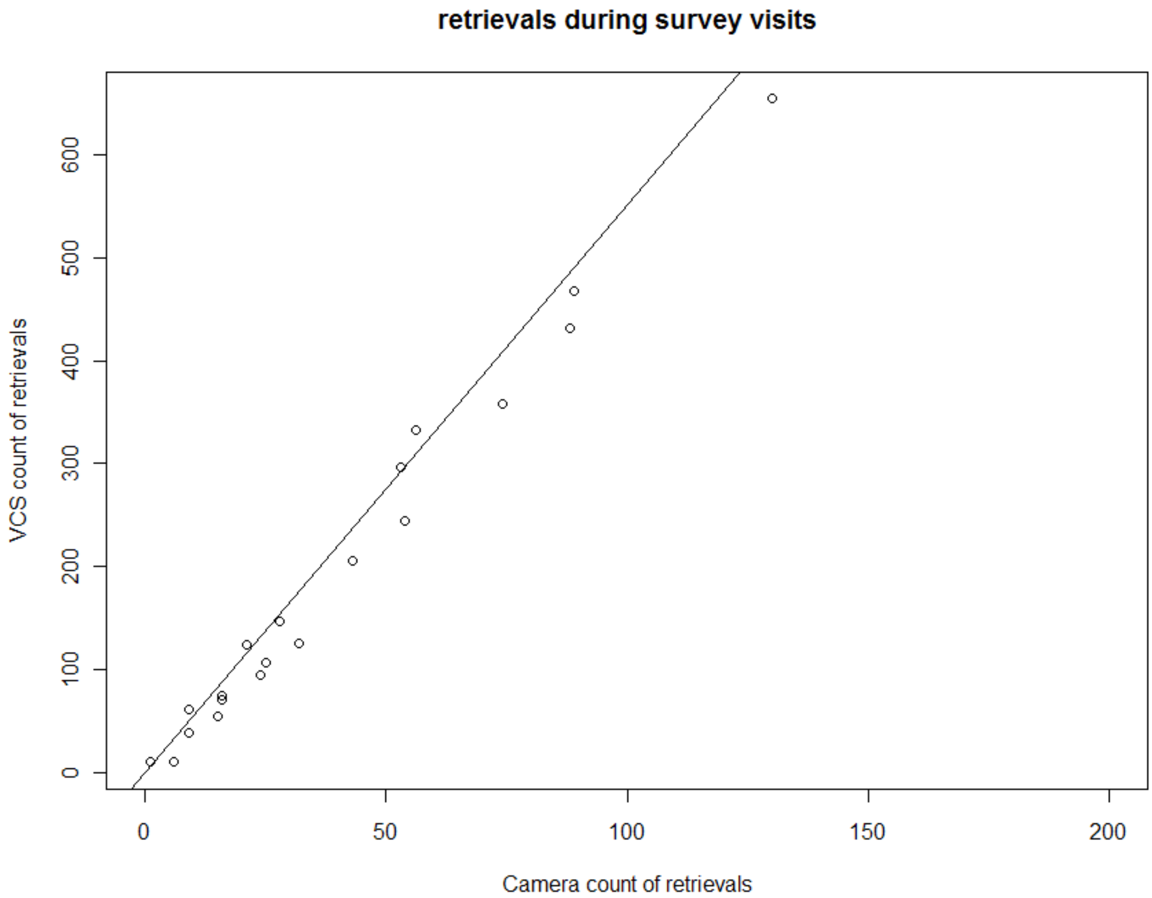

Figure 3.19 Pulses recorded by VCS on retrieval lane during survey visits versus retrievals from the Hillarys boat ramp camera in the same period.

The numbers of pulses recorded on the retrieval lane of the Hillarys boat ramp by the VCS during each hour from midnight to midnight was calculated (Figure 3.20). This was compared with the number of retrievals recorded within each hour by the camera focussed on the boat ramp. A robust linear regression model fitted to the VCS count versus the camera count, with zero intercept, indicated that the relationship was very highly significant ($P<0.001$). For every retrieval recorded by the camera, the VCS recorded 4.53 (SE=0.08) pulses. The analysis suggested that 12 points were outliers.

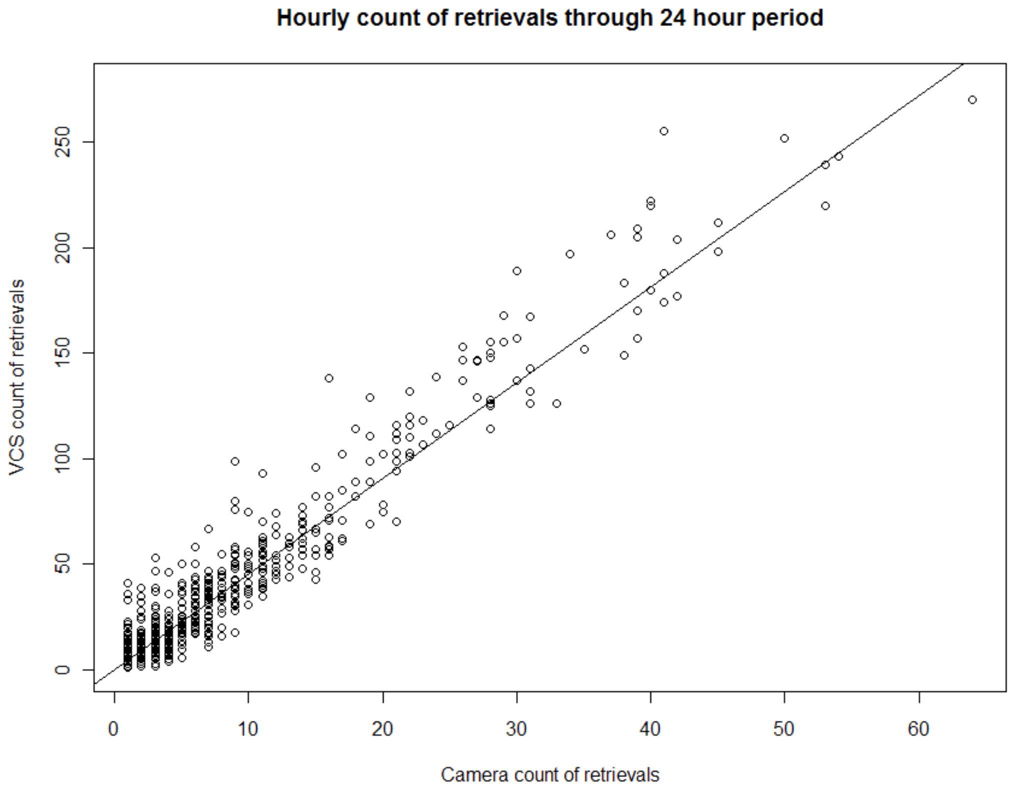

Figure 3.20 VCS count of retrievals versus camera count of retrievals at Hillarys boat ramp car park.

A preliminary exploration of the count of retrievals recorded by the ramp camera and pulses recorded by the VCS affixed to the retrieval lane of the Hillarys boat ramp suggested that the majority of activity was recorded between 6 am and 6 pm (Figure 3.21).

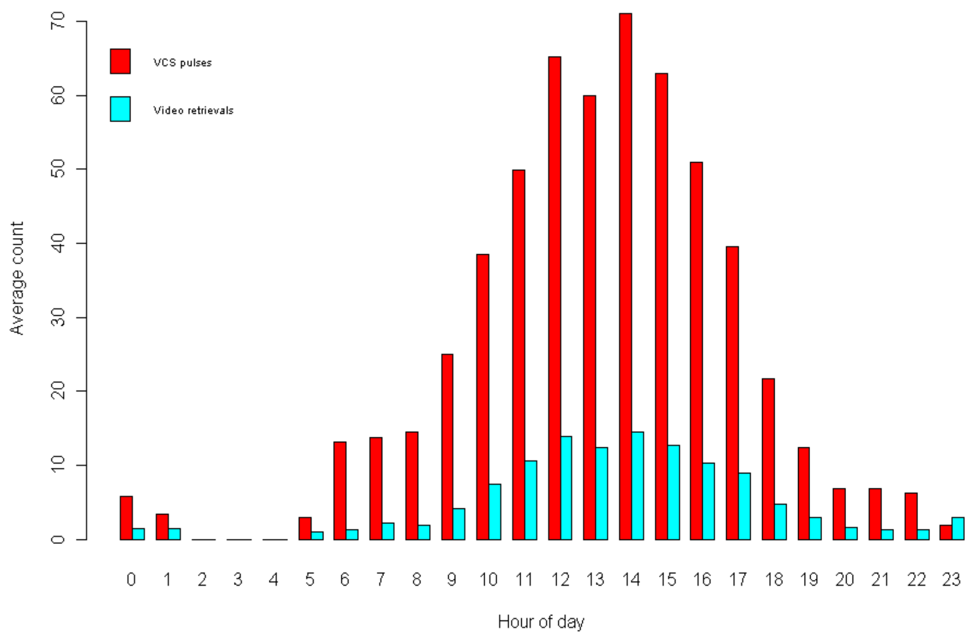

Figure 3.21 Average count of boat trailers across a 24 hr day at Hillary boat ramp car park using VCS pulses and video.

Accordingly, the comparison of the VCS' pulse data with the ramp camera' retrieval data was repeated using only the data recorded between 6 am and 6 pm. The robust linear regression model with zero intercept that was fitted to these data was again very highly significant ($P<0.001$) (Figure 3.22). It was estimated that, for every retrieval recorded by the ramp camera, 4.53 (SE=0.08) pulses would be recorded, on average, by the VCS. Twelve observations were considered to be outliers.

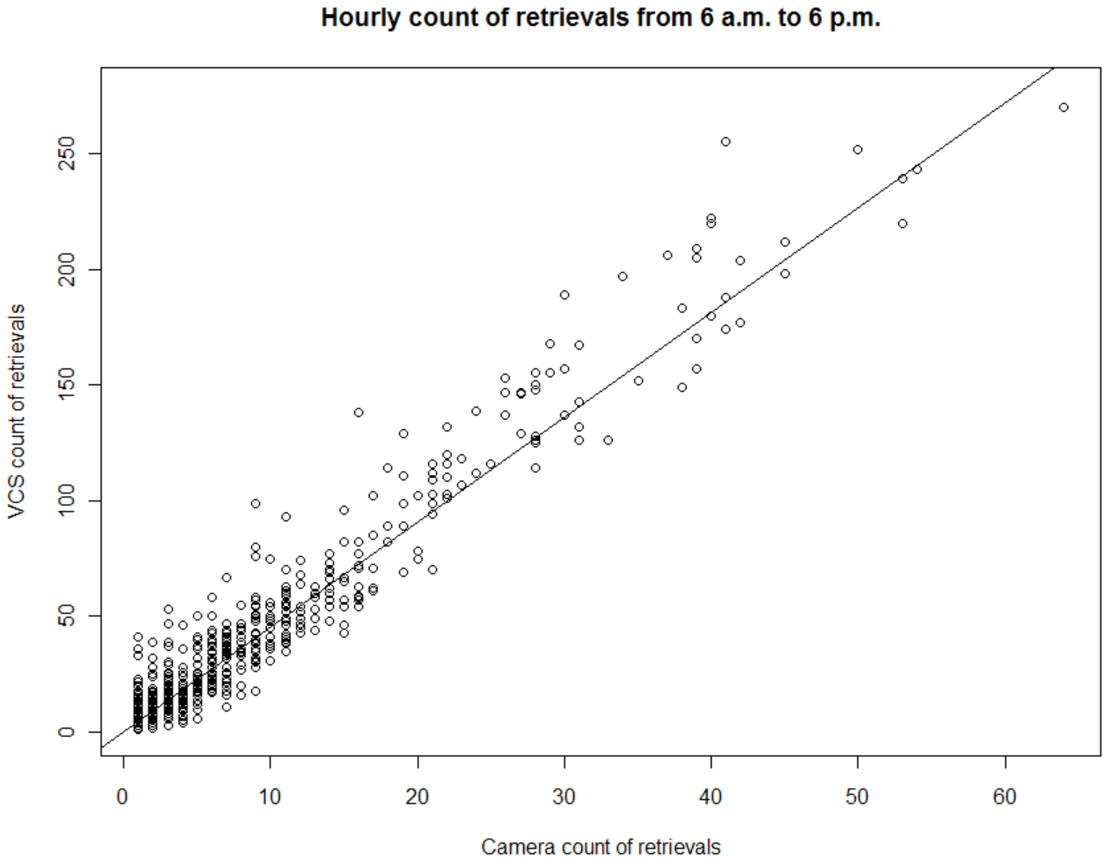

Figure 3.22 VCS count of retrievals versus camera count of retrievals at Hillarys boat ramp.

3.7.4 Estimated total daily boating activity from the Hillarys boat ramp

3.7.4.1 Ramp video camera counts versus camera snapshot counts

Estimates of the boating activity (boat-hours at sea) were derived from both the ramp-based video camera and from the car park camera snapshot counts (Figure 3.23). For the former data, it was assumed that zero boats were at sea at midnight at the start of the 24 hour period. For each boat launch recorded by the ramp camera, one boat was added to the estimate of the number of boats at sea while, for each boat that was retrieved, one boat was subtracted from the estimated number of boats at sea. The total time at sea was then calculated as the sum of the product of the boats at sea and the time period before the next launch or retrieval (or, in the case of the last recording for the day, midnight). Note that negative numbers of boats at sea resulted if boats that were launched from other ramps or on previous days were retrieved at the Hillarys boat ramp. The number of boats launched may also not balance with the number of boats that are retrieved if the vessels launched from the Hillarys boat ramp on a particular day do not return to that ramp on the same day. For the camera snapshot-based car park trailer counts, it was assumed that there were zero trailers in the car park at midnight, and the total boating activity during the day was calculated as the sum of the products of each trailer count and the time period represented by the snapshot, which was taken to extend to midway between the preceding and subsequent snapshots (or, in the case of the first and last snapshots for the day, midnight).

A robust linear regression model, with zero intercept, fitted to the ramp video camera-based estimate of boating activity versus the car park camera snapshot-based estimate produced a very highly significant fit ($P < 0.001$). The estimated coefficient was 1.05 (SE=0.03), with 16 points being considered to be outliers.

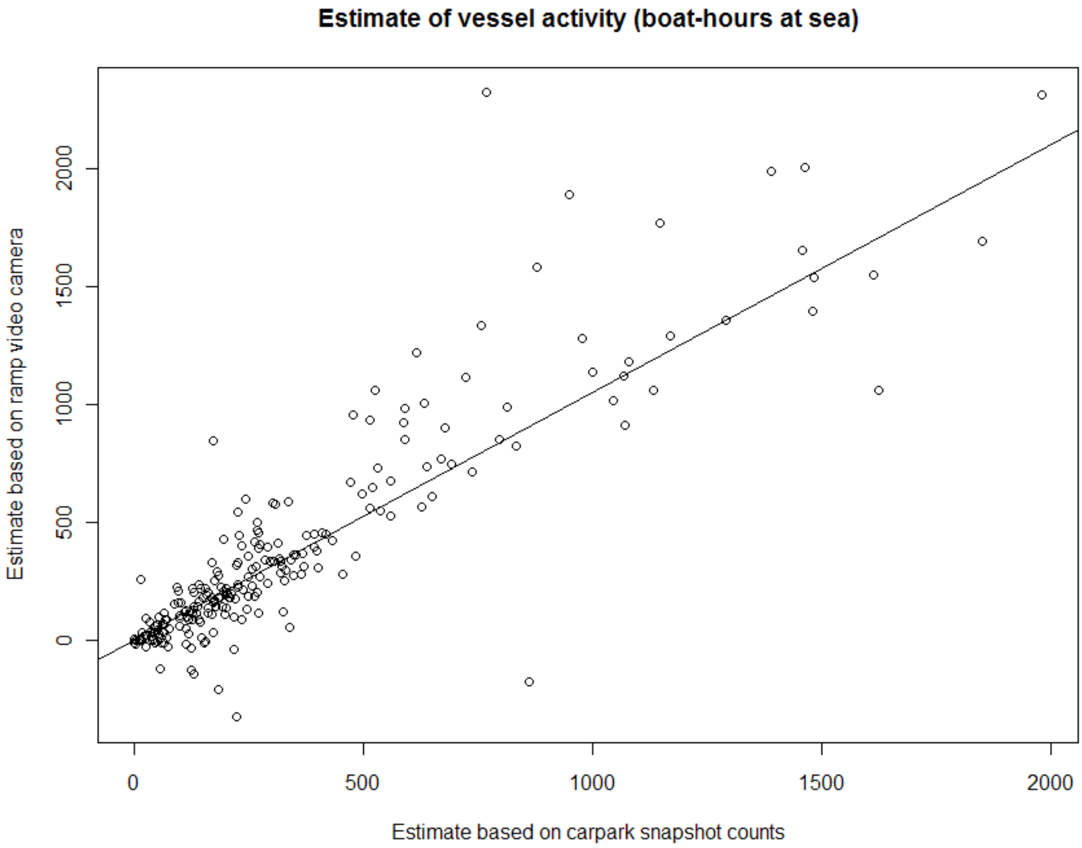

Figure 3.23 Estimate of boating activity from a video camera based on Hillary boat ramp car park versus estimate based on car park camera snapshot counts.

3.7.5 Car park tickets in Hillarys boat ramp car park

3.7.5.1 Monthly car park tickets versus ramp video camera counts

Estimates of monthly retrievals at the Hillarys boat ramp were derived by calculating the total daily retrievals within each month recorded by the ramp for those days on which the cameras operated without event (Figure 3.24). The resulting values were then expanded to produce an estimate of the total number of retrievals for the month. A robust linear regression model was then fitted to explore the relationship between estimates of monthly retrievals and monthly car park tickets. The fitted model was found to be highly significant, with a coefficient of 1.86 (SE=0.10) and with no outliers being identified when fitting. The results suggest that, on average, for every car park ticket that is issued, there will be 1.86 boats launched at the Hillarys boat ramp.

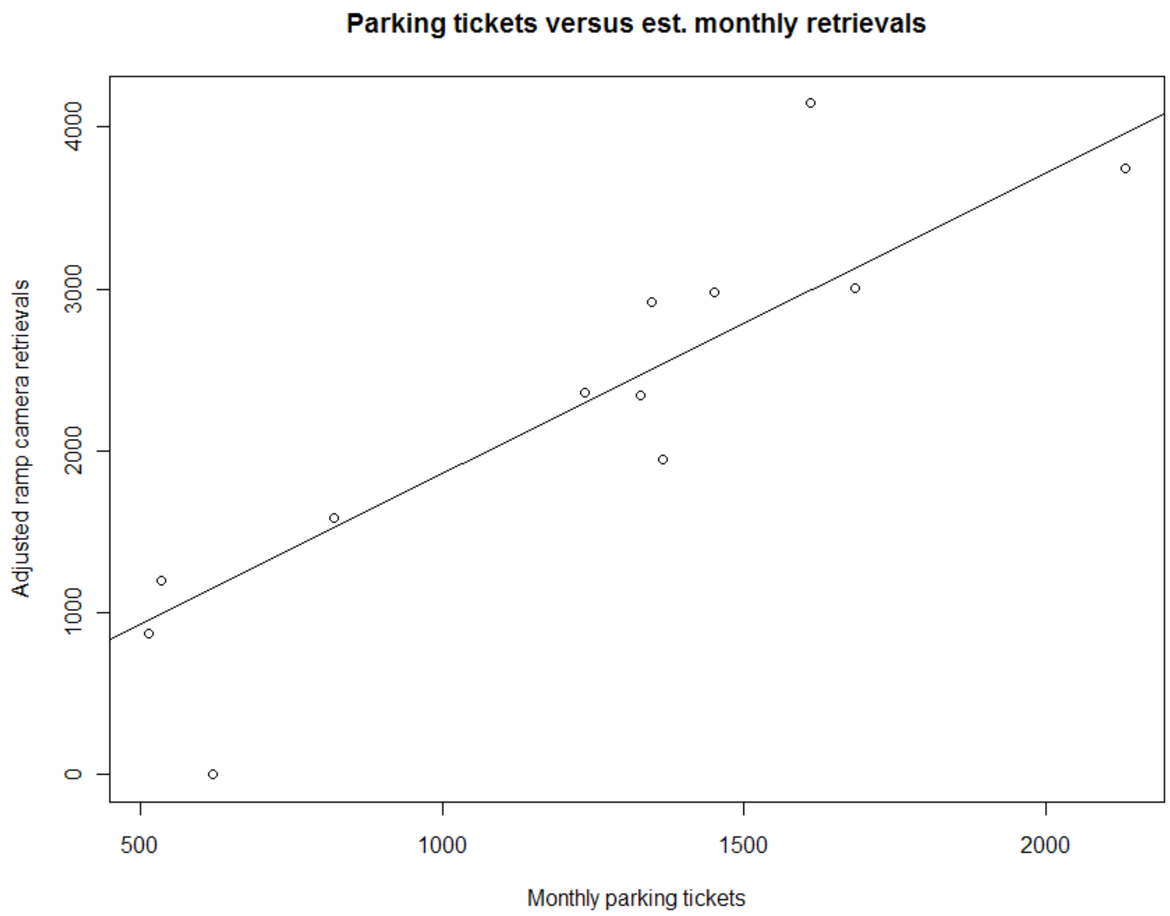

Figure 3.24 Number of monthly parking tickets at the Hillarys boat ramp car park versus adjusted camera retrievals at the ramp.

3.8 Catch, effort and catch rate comparisons

3.8.1 Overview

Catch and effort estimates were only available from boat-ramp based creel and mail-phone-diary survey. Both these surveys provided estimates of catch rates, however, these estimates were also available from the Fisheries and Marine Officer (FMO) recreational fishing survey and Research Angler Program (RAP) logbooks. Each method was constrained by the temporal resolution of data recorded and the quality of the data collected was affected by a variety of factors. Recognising this, however, it was possible to explore the extent to which the different methods employed in this study produced consistent and correlated data and thereby facilitate assessment of the relative effectiveness and value of each method.

3.8.1 Catch and effort comparisons

Estimates of catch and effort for the West Coast Bioregion were calculated from launch and retrieval from boat-based creel and mail-phone-diary surveys. To ensure consistent effort measures, estimates, which were based on launch to retrieval time, were expanded to produce an estimate of the total effort for the West Coast Bioregion (Table 3.18). The very large standard error in the mail-phone-diary survey estimate reflects the high levels of uncertainty.

Two regressions methods were used to compare estimates of catch from both methods; a standard linear regression and a weighted linear regression using the weight function $\frac{1}{\sqrt{\sigma_x \sigma_y}}$ (Figures 3.25 and 3.26). Due to possible issues with species identification with Emperor (Lethrinus species) and redfish species (Bight Redfish, Swallowtail and Yelloweye Redfish), these were aggregated into single groups prior to analysis. The fitted standard and weighted models to kept catches were found to be significant, with slopes of 1.14 (SE=0.15) and 1.37 (SE=0.24), respectively. The results suggested that, on average, the mail-phone-diary survey catch rate estimates were 14–37% higher than those estimated from the boat-based creel survey. The fitted standard and weighted models to released catches was found to be significant, with a slope of 1.07 (SE=0.17) and 1.20 (SE=0.28), respectively. The results suggest that, on average, the mail-phone-diary survey catch rate estimates are 7–20% higher than those estimated from the boat-based creel survey.

Table 3.18 The estimated combined boat-based creel and mail-phone-diary fishing effort (and standard errors SE) between 1 July 2005 and 30 June 2006. Effort (boat hours) is estimated from launch to retrieval time.

	Boat-ramp creel	SE	Mail-phone-diary	SE
West Coast Bioregion	692,861	11,564	649,602	55,045

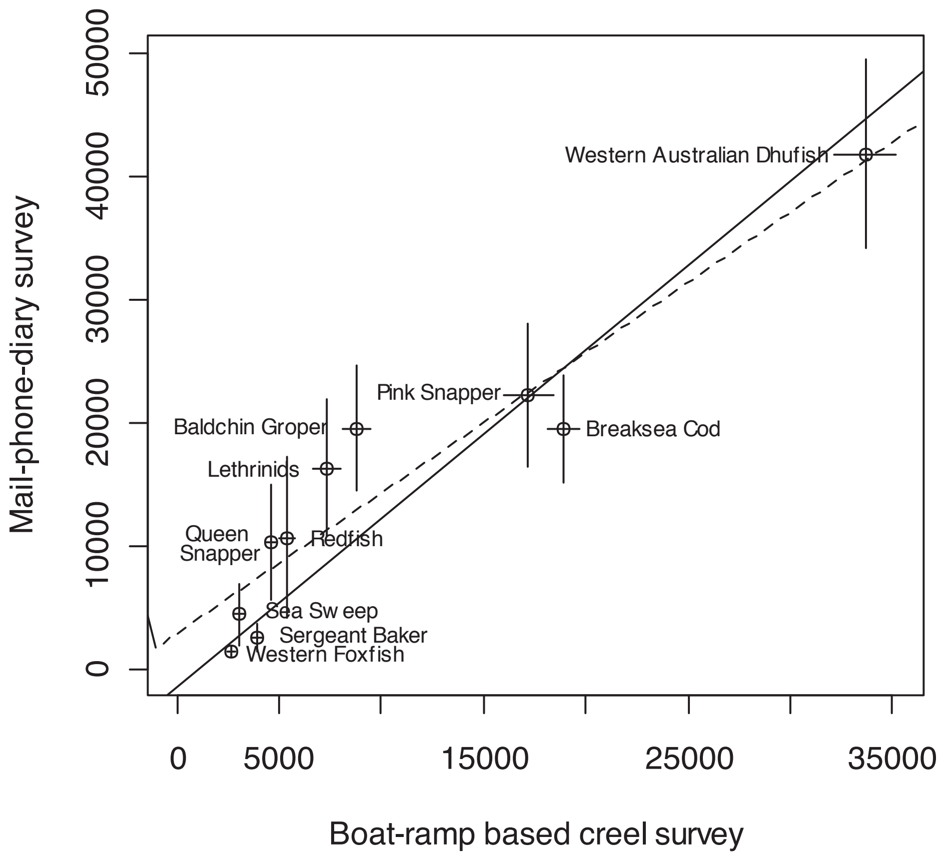

Figure 3.25 Estimates of the total catches (number of individual fish and standard errors) of key demersal fish species kept between 1 July 2005 and 30 June 2006, which were calculated using data from the boat-based creel and mail-phone-diary surveys. Standard linear regression (dashed line) and a weighted linear regression (solid line) with r^2 = 0.87 and 0.78 respectively.

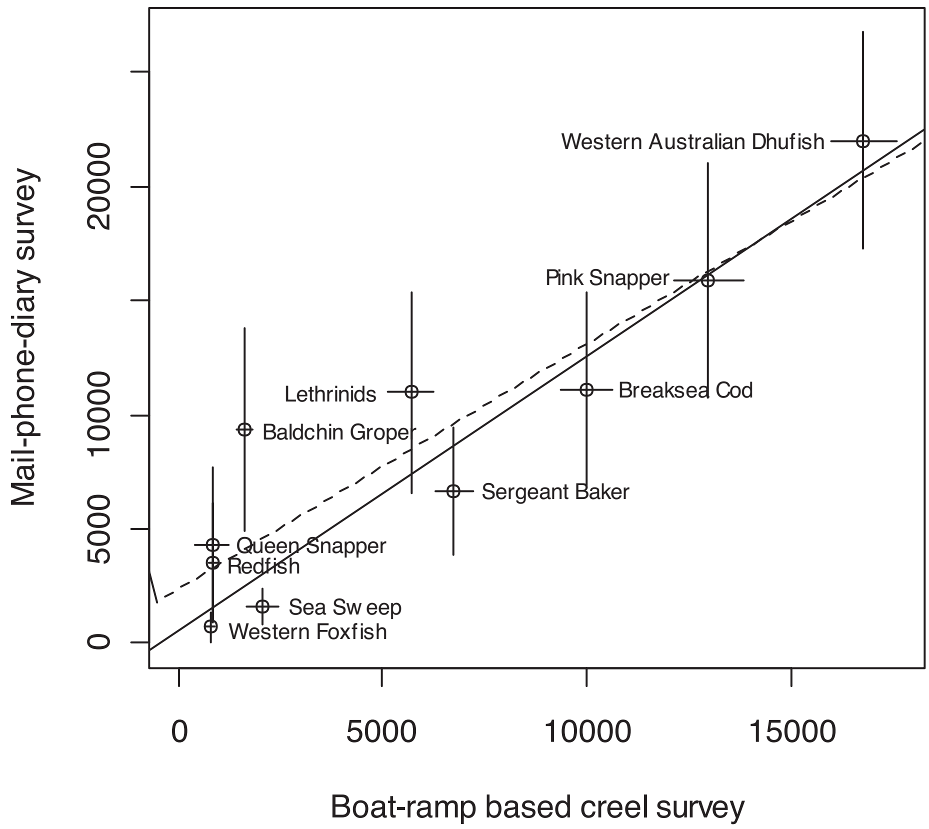

Figure 3.26 Estimates of total catches (number of individual fish and standard errors) of key demersal fish species released between 1 July 2005 and 30 June 2006, which were calculated using data from the boat-based creel and mail-phone-diary surveys. Standard linear regression (dashed line) and a weighted linear regression (solid line) with r^2 = 0.82 and 0.66 respectively.

3.8.2 Catch rate comparisons

Estimates of total catch and total fishing effort for the boat-ramp based creel and mail-phone-diary surveys were used to estimate the overall catch rates for the total fishery. If $\hat{C}$ is the estimate of the total catch and $\hat{E}$ is the estimate of the associated total fishing effort, then

$$\hat{R} = \frac{\hat{C}}{\hat{E}}$$

and

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

The estimated catch rates for the boat-ramp based creel and mail-phone-diary surveys are presented in Table 3.19. For the mail-phone-diary survey, these estimates include values derived using both fishing effort, i.e. time between launch and retrieval, and time actually spent fishing, where values of this latter variable exclude non-fishing time, i.e. time between launch and retrieval that was not spent fishing. The convention adopted for this report was that, unless otherwise stated, fishing effort and catch per unit of effort relate to the time between launch and retrieval, and does not exclude time that was not spent fishing.

Table 3.19 The estimated overall combined boat-ramp based creel and mail-phone-diary catch rates (and standard errors SE) between 1 July 2005 and 30 June 2006. Fishing effort (boat hours) is estimated from launch to retrieval time for boat-ramp based creel and mail-phone-diary surveys and time spent fishing (boat hours of actual fishing time) is estimated for the mail-phone-diary survey.

Common name	Boat-ramp based creel survey catch rates		Mail-phone-diary survey catch rates			
	Catch per boat hour of fishing effort	SE	Catch per boat hour of fishing effort	SE	Catch per boat hour of actual fishing time	SE
Baldchin Groper	0.013	0.0010	0.030	0.0083	0.044	0.0039
Blue Morwong (Queen Snapper)	0.007	0.0004	0.016	0.0073	0.023	0.0021
Breaksea Cod	0.027	0.0012	0.030	0.0071	0.044	0.0039
Lethrinus species	0.011	0.0010	0.025	0.0087	0.037	0.0033
Pink Snapper	0.025	0.0018	0.034	0.0094	0.050	0.0044
Redfish species	0.008	0.0006	0.017	0.0102	0.024	0.0021
Sea Sweep	0.004	0.0004	0.007	0.0039	0.010	0.0009
Sergeant Baker	0.006	0.0004	0.004	0.0017	0.006	0.0005
Western Australian Dhufish	0.049	0.0023	0.064	0.0129	0.094	0.0083
Western Foxfish	0.004	0.0003	0.002	0.0009	0.003	0.0003

Estimates of mean daily catch rates were available for Fisheries and Marine Officer (FMO) recreational fishing survey and Research Angler Program (RAP) logbooks as presented previously, but not for the Volunteer Fisheries Liaison Officer (VFLO) survey. Due to possible issues with species identification for Emperor (Lethrinus species) and Redfish species (Bight Redfish, Swallowtail and Yelloweye Redfish), these were aggregated into single species groups prior to analysis. Given the low sample sizes for some released species, only comparisons of catch rates of kept species were considered. Two regression methods were used to compare estimates of catch rates; a standard linear regression and a weighted linear regression using the weight function $\frac{1}{\sqrt{\sigma_x \sigma_y}}$.

The standard and weighted models, which were fitted to kept catch rates estimated from boat-ramp based creel and mail-phone-diary surveys, were found to be significant, with slopes of 1.14 (SE=0.18) and 1.28 (SE=0.31), respectively (Figure 3.26). These results suggest that, on average, the mail-phone-diary survey catch rate estimates are 14–28% higher than those estimated using data from the boat-ramp based creel survey.

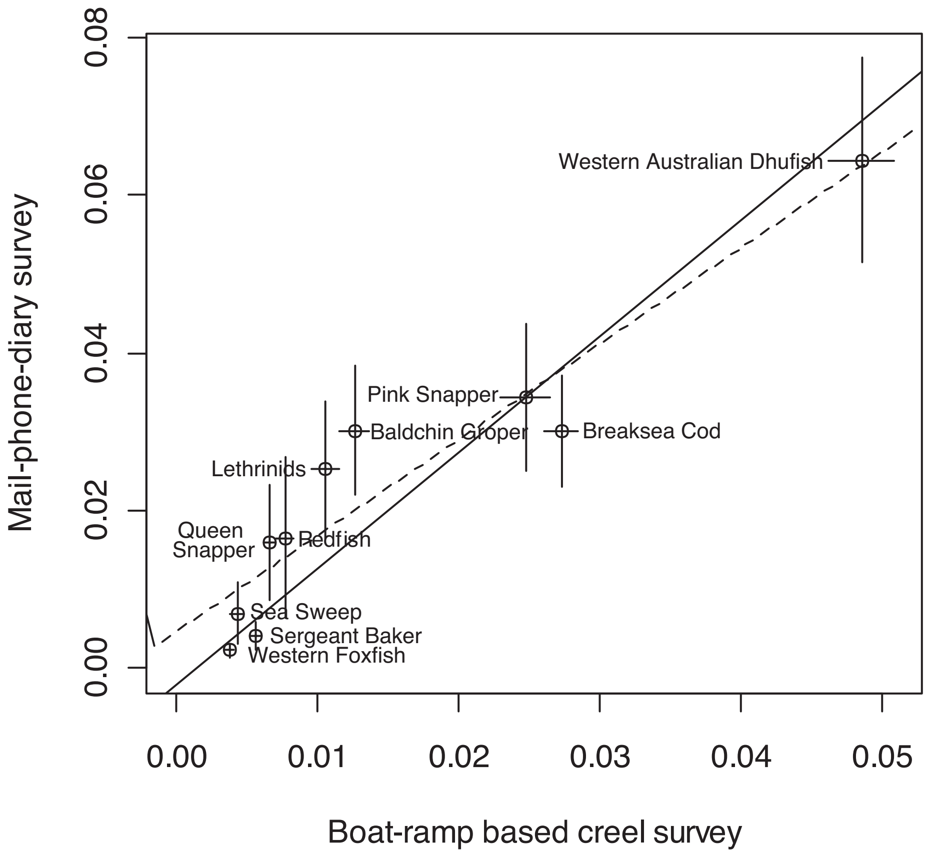

Figure 3.27 Estimates of total catch rates (number of individual fish kept per boat hour and standard errors) for key demersal fish species kept between 1 July 2005 and 30 June 2006, calculated using data from boat-ramp based creel and mail-phone-diary surveys. Standard linear regression (dashed line) and a weighted linear regression (solid line) with r^2 = 0.82 and 0.65 respectively.

The standard and weighted models, which were fitted to the kept catch rates estimated using data from the mail-phone-diary survey and research angler program (RAP) logbooks, were found to be statistically significant, with slopes of 0.41 (SE=0.13) and 0.35 (SE=0.16), respectively (Figure 3.27). The results suggested that, on average, the RAP logbooks catch rate estimates were 35–41% of those estimated from the mail-phone-diary survey. The lower catch rate estimated for the RAP logbook is explained by the calculation of individual fisher catch rate compared to total boat party catch rate estimated in the mail-phone-diary survey. The results demonstrate the high uncertainty associated with the RAP logbook estimates.

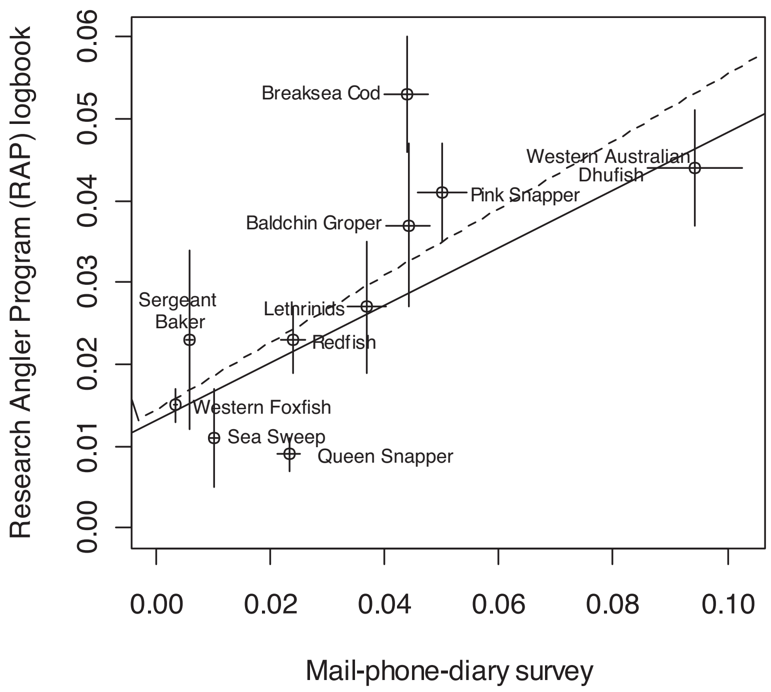

Figure 3.28 Estimates of total catch rates (number of individual fish kept per boat hour fished (i.e. excluding non-fishing time) and standard errors) for key demersal fish species kept between 1 July 2005 and 30 June 2006, calculated using data from the mail-phone-diary survey and RAP logbooks. Standard linear regression (dashed line) and a weighted linear regression (solid line) with $r^2 = 0.5$ and 0.31 respectively.

The standard and weighted models, which were fitted to kept catch rates estimated using data from the mail-phone-diary and FMO recreational fishing surveys, were found to be statistically significant, with slopes of 1.09 (SE=0.13) and 1.05 (SE=0.17), respectively (Figure 3.27). The results demonstrate the high uncertainty associated with the FMO estimates and are limited to four key species.

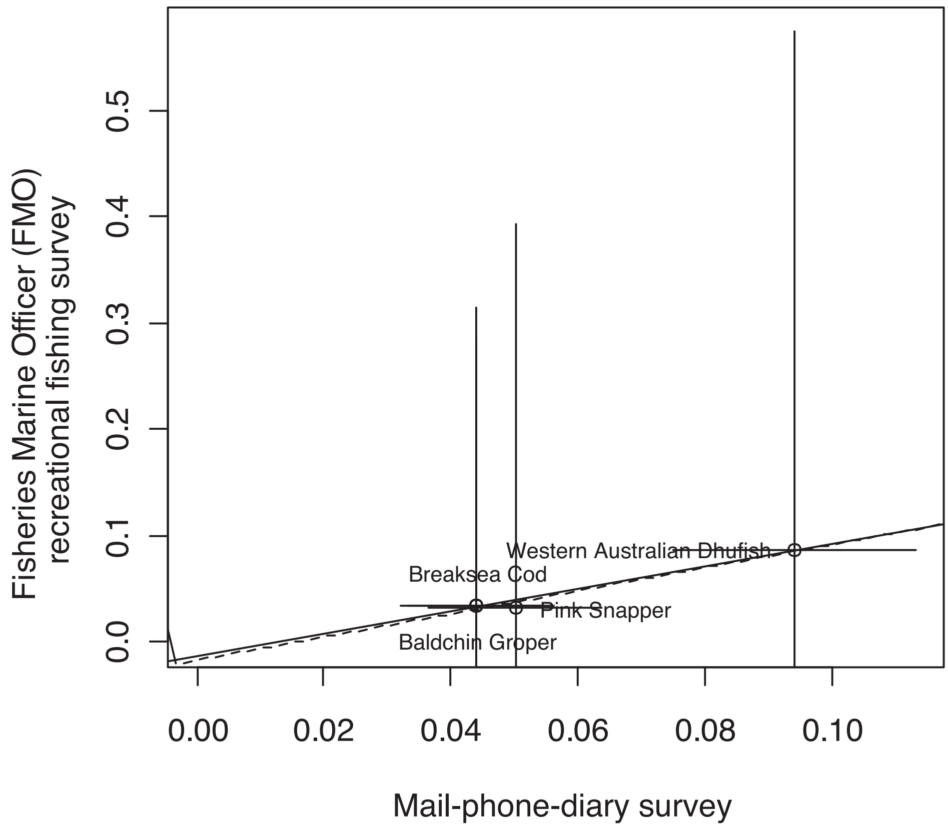

Figure 3.29 Estimates of total catch rates (number of individual fish kept per boat hour fished (i.e. excluding non-fishing time) and standard errors) for key demersal fish species kept between 1 July 2005 and 30 June 2006, calculated using data from the mail-phone-diary and FMO surveys. Standard linear regression (dashed line) and a weighted linear regression (solid line) with r^2 = 0.96 and 0.93 respectively.

4.0 Cost effectiveness of survey techniques

Objective 3. Using cost benefit analysis, produce a series of options to monitor annual catch and effort for a range of precision levels and indicator species

While the estimates produced by the various fishing surveys need to be of spatial and temporal resolutions that are required by fishery managers and stakeholders, it is recognised that broader spatial and temporal resolution may need to be accepted to ensure appropriate precision within an acceptable budget and that past sampling design will constrain the production of comparable estimates to those that are consistent with the sampling frame and protocol.

4.1 Comparison of individual survey techniques

The estimated costs for each survey are presented in Table 4.1. Due to staff and equipment commitments to more than a single survey, costs per survey were based on the estimated proportions of time and resources spent on each particular survey. As presented in chapters 2 and 3, each survey resulted in differing estimates and levels of precision based on spatiotemporal designs and sample sizes limited by the available resources and funds. This means that direct comparison of equivalent surveys was not possible. However, benefits and limitations of each survey are discussed.

4.1.1 Boat-ramp based creel survey

The boat-ramp based creel survey, which cost approximately $550,000, was the most spatially and temporally comprehensive of all surveys conducted in 2005/06. This design produced precise estimates. Given the cost of onsite interviews, however, the survey only included 61 major boat ramps within the West Coast Bioregion and temporal coverage was restricted to eight hours, from 9 am to 5 pm. The survey did not include estimates of catch and fishing effort of boats fishing outside these hours, nor those fishing from yacht clubs, canals, private marinas, moorings, or those launched or retrieved from beaches. In addition, the interviews at the boat ramps are more likely to intercept more frequent fishers.

The use of trained interviewers onsite ensured accurate species identification and length measurements, and that consistent of the catch and effort data were collected.

4.1.2 Mail-phone-diary survey

The mail-phone-diary survey was relatively inexpensive (approximately $90,000) compared to the boat-ramp based creel survey. The survey included only registered powered boats where the owners resided in the West Coast Bioregion. Sample sizes for registered powered boat owners in the northern areas of the West Coast Bioregion were inadequate for estimation of catch and effort in this region. While sample sizes were adequate for the southern areas of the West Coast Bioregion, estimates resulted in lower precision than those obtained from the creel survey. Hence, future surveys would require increased sample sizes before reliable estimates of catch and effort could be produced at a finer scale.

The use of an initial mail survey to encourage participation in the survey resulted in high non-response rates. It was assumed boat owner from the screening survey who reported that their boat was not going to be used for fishing during the next 12-months were correct and that the usage of boats in the phone-diary survey sample was no different to those that were not included. In particular, the usage of boats that dropped out of the survey was assumed to be no different to that of those boats that remained in the survey for the full 12-months.

It was assumed that respondents accurately recalled information from past fishing trips and all fishing from the boats was reported, regardless of whether or not the owner was on board. It was also assumed that recreational fishers correctly identified both kept and released species.

4.1.3 Video camera counter survey

The video camera counter survey provided an accurate census of boat launches and retrievals. Although it was often possible to distinguish motor boats from other boat types such as yachts, jet skis and kayaks from captured video, no information could be ascertained from the video on the type of activity to be undertaken by launched boats or that had been undertaken by retrieved boats. Therefore, it was not possible to obtain estimates of the numbers of boats involved in a fishing activity.

There were some factors that impacted visibility within the video footage, including occasional high intensity glare during sunset, which in some cases made it more difficult for the survey officer to distinguish the type of boats being launched or retrieved. In these circumstances, the boats were classified as “other”. However, when analysing the video data, it was assumed that such a code implied that the boat was not a “motor” boat, and data relating to these boats were excluded from the analysis. While it is recognised that at least a small proportion of kayaks, jet skis and other boat types will be used for fishing, these boats are currently excluded from the analysis. Such exclusion may need to be reconsidered drawing on information from other survey types. The extension of the video camera method to all ramps would make this a very expensive survey, due to the considerable time required to view and record data from each video recording.

4.1.4 Vehicle counter survey

The vehicle counter survey provides a less expensive census method than the video camera counter survey, however, the accuracy of the data is reduced. For example, on a number of occasions (29 and 30 January and 3 February) the pneumatic tubing was pulled from the ground. Footage captured by the video camera revealed that a number of non-retrieving vehicles also used the boat retrieval lane, thus inflating counts of retrieved vessels. This finding was confirmed by field survey staff conducting other onsite surveys.

Typically, the activity recorded by the pair of pneumatic tubes used by the VCS to classify and count the vehicles by their presumed type, based on the number of axles and speed. An initial assessment of the resulting data demonstrated that such classification was likely to be unreliable, at least in part due to the inconsistency of the speed at which vehicles travelled over the tubes, the mixed numbers of axles on the trailers (each of which may or may not have had its axle hit recorded on one or both tubes), and the weights of those trailers when not under load. Thus the data that are produced by the VCS consists of the times at which pulses are recorded by the unit. Accordingly, the frequency of pulses within a specified time interval serves as an index rather than an absolute count of trailers, requiring calibration with other data if absolute estimates of boating activity are required.

4.1.5 Camera snapshot counter survey

The camera snapshot counter survey was used as a less expensive alternative to the video camera counter survey. However, due to the fixed locations at which the cameras were mounted, the counts obtained through this method may not include trailers that were obscured by other vehicles. For some of the cameras trialled, because of the poor resolution of the images and the angle of incidence, it is also possible for the survey officer to conclude that trailers are present in sections of the image where in reality such trailers are not present. Such subjectivity is inevitable when the survey officer is attempting to provide the most accurate count possible, yet image qualitative factors constrain accurate identification of trailers within the images.

4.1.6 Ticketing counter survey

This survey method provided one of the least expensive methods investigated. Although data were available for the key sites of interest, the majority of boat ramps within the West Coast Bioregion do not charge for usage of boat trailer car parks. Therefore, the application of this survey method is subject to data availability. Additionally, the utilisation of a trailer car park is an indirect measure of recreational boat activity and must be used with care as a proxy measure. Again, calibration would be required if the ticketing index was to be related to absolute levels of boating activity.

4.1.7 Fisheries and Marine Officers (FMO) survey

As convenience sampling has been employed in the FMO survey, sampling intensity almost certainly varies throughout each bioregion and is thus likely to have little spatial and/or temporal correlation with fishing activity. While the collection of research catch and effort information by FMOs occurs opportunistically, this would be an expensive method if applied directly to the collection of data.

It should be noted that, because of the nature of the FMOs activities and their responsibility to monitor compliance with regulations, the proportion of the boats contacted that were fishing or intended to fish is possibly a biased measure of the true proportion of boats engaged or likely to be engaged in fishing. However, as the primary focus of these interviews was marine safety it is likely that the proportion of boats sampled was representative of general fishing effort at the time of the patrol, although many contacts occurred prior to fishing.

It was not possible to use the data recorded in the MSI forms employed in 2005/06 to determine appropriate weights that should be applied to the individual observations when assessing the mean catch per boat-day and there was no way of determining the weighting factor by which the total catch or fishing effort might be assessed. No information in the data recorded by FMOs for the individual contacts that allows identification of completed fishing trips. The assumption was made that recreational interviews for which fishing was or is occurring, represent completed fishing trips. If this assumption is invalid, the values of catch rate per boat trip calculated from the selected data will underestimate the true catches.

The target species of the fishing effort expended by the operators of individual boats on the occasions on which they were contacted by FMOs are unknown. Estimates of catch rates achieved by fishers targeting specific species, e.g. demersal fish species, are likely to be underestimated.

4.1.8 Volunteer Fisheries Liaison Officer (VFLO) survey

The VFLO program was primarily an education program, which included opportunistic collection of catch and effort data through interviews with fishers while VFLOs were on patrols.

Due to the unstructured data collection methods (i.e. surveying at opportunistically selected times and days), VFLO data could not be used to calculate estimates of recreational catch and effort, such as in creel or phone surveys. Furthermore, the small number of interviews (77) obtained with recreational boat-ramp based fishers in the West Coast Bioregion in 2005/06 prohibited the calculation of catch rate for any of the key inshore demersal scalefish species.

4.1.9 Research Angler Program (RAP) logbook

The RAP logbook program may provide useful anecdotal information upon which to base the implementation of statistically robust recreational creel or mail-phone-diary surveys. The RAP logbook program is more costly than most volunteer logbook programmes as it attempts to provide incentives to retain the fishers who provide their catch information.

Due to the unstructured data collection methods of the RAP logbook, the collected data could not be used to calculate estimates of recreational catch and effort, such as in creel or mail-phone-diary surveys. In addition due to the lack of a structured design there is no information to explain why estimated catch rates differ among survey types. The catch rates presented in this report should be viewed with caution, as rigorous validation was not an ongoing process and, although care was taken to remove any errors and outliers, the different methods used by the large number of logbook participants may have resulted in some residual inaccuracies.

Table 4.1 Estimated costs for each survey using the following levels and pay scales; Data Entry Officer (L1 $39,047), Data Entry and Validation Officer (L2 $44,890), Research/Technical Officer (L3 $50,538), Senior Technical Officer (L4 $55,393), Scientist/Manager (L5 $64,439) and Senior Scientist/Manager (L6 $75,133).

Survey resource	Cost	Staff Responsibilities
Creel Survey (13 bus routes over 61 ramps)		
Consumables and clothing	$4,000.00	
Lease and fuel for research vehicle	$52,900.00	
Interviewer wages, vehicle allowance	$398,159.00	Interviewing
Data Officer (33%)	$13,015.67	Data entry
Research Officer (100%)	$50,538.00	Planning, implementation, monitoring, validation
Senior Research Scientist (33%)	$25,044.31	Design, analysis, reporting
Total	$543,656.97	
Mail-Phone-Diary Survey (~500 diarists)		
Stationary, Printing and Postage	$4,000.00	
Interviewer wages and phone calls	$43,175.00	Interviewing
Data Officer (15%)	$6,733.50	Data entry and validation
Research Scientist (50%)	$32,219.50	Planning, implementation, monitoring, analysis
Senior Research Scientist (2%)	$1,502.66	Design, analysis, reporting
Total	$87,630.66	
Video Camera Counter Survey (Hillarys ramp)		
Cameras	$1,500.00	
Computers, Storage and Software	$1,800.00	
Internet	$400.00	
Travel and accommodation	$-	
Data Officer (25%)	$9,761.75	Data extraction and entry
Senior Technical Officer (10%)	$5,539.30	Planning, implementation, monitoring, validation
Senior Research Scientist (5%)	$3,756.65	Design, analysis, reporting
Total	$22,757.70	
Vehicle Counter Survey (Hillarys ramp)		
VCS Unit	$1,124.00	
Travel and accommodation	$-	
Technical Officer (5%)	$3,756.65	Planning, implementation, monitoring, validation
Senior Research Scientist (2%)	$1,502.66	Design, analysis, reporting
Total	$5,259.31	
Camera Snapshot Counter Survey (Hillarys ramp)		
Cameras	$1,500.00	
Computers, Storage and Software	$500.00	
Internet	$-	
Travel and accommodation	$-	
Data Officer (10%)	$3,904.70	Data extraction and entry
Senior Technical Officer (2%)	$1,107.86	Planning, implementation, monitoring, validation
Senior Research Scientist (2%)	$1,502.66	Design, analysis, reporting
Total	$8,515.22	

Survey resource	Cost	Staff Responsibilities
Ticketing Counter Survey (Hillarys ramp)		
Research Officer (4%)	$2,021.52	Monitoring, validation
Senior Research Scientist (1%)	$751.33	Design, analysis, reporting
Total	$2,772.85	
FMO Survey (~1000 patrols)		
Numerous compliance staff/FMOs	In kind	Marine safety inspections
Data Entry (15%)	$5,857.05	Data entry
Research Officer (5%)	$2,526.90	Planning, implementation, monitoring, validation
Senior Research Scientist (2%)	$3,756.65	Design, analysis, reporting
Total	$12,140.60	
VFLO Survey (~100 patrols)		
Consumables and uniforms	$10,000.00	
Travel and fuel	$10,000.00	
Volunteers	$-	Interviewing
Data Officer (20%)	$7,809.40	Data entry and validation
Education Manager (30%)	$19,331.70	Volunteer management
Senior Research Scientist (2%)	$3,756.65	Design, analysis, reporting
Total	$40,897.75	
RAP logbook programme (~150 logbooks holders)		
Stationary, Printing and Postage	$1,500.00	
Technical Officer (50%)	$25,269.00	Planning, implementation, monitoring, validation, data entry
Senior Research Scientist (2%)	$3,756.65	Design, analysis, reporting
Total	$30,525.65	

4.2 Comparison of multiple survey techniques

The above comparison of survey types identified the need to examine the entire set of survey methods available. It was concluded that an expert technical workshop to critically examine the strengths and weaknesses of the main survey methods would not only be of value for Western Australia, but would be of great value to other Australian jurisdictions and overseas. A number of workshops were held in 2009/10 to examine these issues.

The Ministry of Fisheries (New Zealand) hosted two workshops in 2009 to improve research methods for generating amateur catch estimates (Hartill *et al.*, 2012). The planned workshops brought together specialists, from a range of disciplines, with expertise in survey design and amateur fisheries research. The workshops involved both local and international researchers (from Australia and the United States) and were an opportunity to establish research networks that can be maintained into the future. The objective was to generate some recommendations on survey techniques at a range of scales with specific examples discussed. These were:

- National scale: An assessment of the credibility and cost effectiveness of large-scale, multi-species catch/harvest estimates from one or more techniques (e.g. telephone, diary, door to door and access point interviews);
- Regional scale: The development of robust amateur catch/harvest estimates for use in the management of the Marlborough Sounds blue cod fishery; and

- Sector scale: Implementation of a successful recreational charter vessel registration and reporting system so that data generated informs management at a range of scales. An outcome of the workshops was an evaluation of the costs and benefits of different approaches to amateur catch and harvest estimation for the New Zealand context. Costs include both the direct financial costs, and the management costs associated with estimates of varying precision (and different potential bias).

Following on from these workshops, the Department of Fisheries, Western Australia hosted a workshop between 22–26 February 2010 to design integrated surveys for the estimation of total recreational fishing harvest, catch and effort. The workshop once again brought together professional experts from Australian and New Zealand, who were involved in recreational fisheries, survey design, fisheries research and management. Emphasis was placed on the design of a phone survey employing the sampling frame from the recently implemented Western Australian boat fishing licence, which was being planned to be undertaken in parallel with a variety of complementary onsite survey methods. The agenda for the workshop can be found in Appendix 8.9.

The workshop also provided an opportunity to continue ongoing regional research networks on recreational angler survey methodology (ICES, 2009; Hartill *et al.*, 2012; Scandol *et al.*, 2009; Tonks *et al.*, 2009). An overview of recreational survey priorities for each Australian State and Territory and New Zealand is presented in Table 4.2. Many of the priorities are common across agencies and there is important synergy in inter agency cooperation. Participants are listed in Appendix 8.10.

A review of the design of recreational fishing surveys was presented as background information on recreational survey design theory.

The basis of the information presented was from reference books on angler survey design (Guthrie *et al.*, 1991; Pollock *et al.*, 1994) and the recent National Research Council review of recreational fisheries survey methods in the U.S.A (National Research Council, 2006). The presentation covered the following topics:

- Introduction, purpose and scope of angler surveys
- Planning, organisation and execution of angler surveys
- Sampling theory and basic survey design
- Questionnaire design
- Angler contact methods
- Charter boat logbooks
- Large scale surveys (phone and phone-access)
- Intermediate scale surveys (bus route and aerial-access)
- Innovations in survey design

4.2.1 Overview of recreational fishing survey design

Recreational fishing surveys are difficult to design in a cost effective manner (Bradford and Francis, 1999; Bradford, 2000; National Research Council, 2006). Ideally, the survey design would match very closely the spatial and temporal scale of the estimates needed by management. For example, if managers and stakeholders seek to manage the recreational fishery using in-season quotas, then a survey with a temporal scale of perhaps a month will need to be implemented, whereas if the regulations likely to be employed will affect fishing activity over a full year, then the temporal scale can be much coarser. Similar issues relating to spatial scale need to be considered when providing estimates at the required precision for individual water body, region, state, or national scales.

In practice, costs dictate the final scale. Where there is a trade-off between quality of estimates and cost, adjustments to the spatial and temporal scales of management are required unless agencies are prepared to pay the higher costs of obtaining precise estimates at finer scales or alternatively imprecise estimates are considered sufficient.

4.2.2 Overview of metrics for recreational fishing surveys

The traditional metrics that are collected in recreational surveys are:

Effort Metrics	
Total Effort	E
Harvest and Catch Metrics (numbers)	
Total Harvest	$C_{Harvest}$
Total Catch	$C = C_{Harvest} + C_{Released}$
Total Removals	$R = C_{Harvest} + C_{Released} * \text{Mortality}$
Biological metrics (weight)	
Average body weight of fish	W

It is typically the weight of the recreational harvest (e.g. in total or for individual species) rather than the numbers that is required for managing sectoral allocations. Weight is normally calculated by applying a pre-determined length-weight relationship to the average size of fish caught, noting that this relationship may vary over time and with geographic location. In turn, this requires that length measurements are collected during the survey. However, many species have not had their length-weight relationship determined, so it may also be necessary either (1) to collect length and weight data so that the length-weight relationship can be calculated, or (2) agree that (a) the relationship for a similar species can be used, or (b) make management decisions based on the numbers caught.

Total recreational removals (numbers and size composition) are important in stock assessments. It must be emphasised how challenging it is to collect information on released catch, as the information relating to released fish is not normally collected in real-time so relies on later recall of the numbers of each species or species group that were released; no useful information on size of released fish can be obtained without length measurements having been recorded at the time of release. Furthermore, information on the survival of the released fish is often unknown and, even in cases where research has been undertaken, there can be ongoing disagreement over the results. Although outside the scope of this workshop, further research may be required to assess the importance of post-release survival rates for many species.

4.2.3 Workshop outcomes

The workshop focused on the design aspects of generating estimates of recreational catch and effort for boat-ramp based fishing in Western Australia, utilizing the sampling frame from the recently implemented Western Australian boat fishing licence. The workshop outcomes show the main elements that need to be considered as part of an integrated recreational survey and identify some of the survey design issues that need to be addressed.

The workshop proposed an integrated survey based on a hierarchical set of linked surveys that could provide recreational boat fishing harvest, catch and effort of important species at a state-wide, bioregional and local area.

State-wide phone-based surveys

- Phone survey over 12-months to provide fishing harvest, catch and effort of important species using the boat fishing licence as a sampling frame. The method requires an initial screening survey and a final follow-up survey of attitudinal responses of participants and non-intending fishers. The survey may require the use of over-sampling to ensure adequate precision of estimates for bioregions or zones outside the Perth metropolitan area but that receive considerable fishing visitors from Perth. This is based on the assumption that people are more likely to travel away from, rather than to, the metropolitan region to go fishing.

Regional/local onsite or remote surveys

- Onsite fishing harvest, catch, effort and biological information collected using a probability based sample of access points throughout the same time period as the phone survey. The harvest, catch and effort data at access points would be used to validate the phone survey data, while the biological data are required to estimate catch weight and provide information for stock assessment. This survey has to be designed carefully and consider both the requirement for spatial and temporal matching with the phone survey and avidity bias, and replicating important data components in each survey.
- Onsite effort from a census or probability based sample of access points using validated counts supplemented with cameras/car counters to increase coverage of the temporal frame throughout the same time period as the phone survey. This survey provides validation and calibration of phone survey estimates.
- Potential use of aerial survey for effort estimates in conjunction with the access-point survey. This survey provides validation and calibration of phone survey estimates.

4.2.4 General survey design issues

The sampling and analyses of timely and scientifically credible data for recreational fisheries is extremely challenging due to the complex nature of survey methods and interview approaches (from self-reported to interviewer-based). This field is well established but is also constantly evolving, resulting in a range of survey designs addressing the range of measurement issues. Improving survey approaches will necessitate a substantial increase in statistical and applied research. The following needs were identified:

- Development of clear and concise survey objectives
- Implementation of surveys on a regular basis to provide ongoing monitoring over time
- Continued refinement of survey methods applied to individual recreational fisheries that address problems and apply emerging techniques in survey design to improve accuracy and precision of estimates
- Undertake research on integrating multiple survey methods to provide a more rigorous overall survey
- Conduct research on the potential application of model-based survey methods for rare or sporadic fishers where traditional design based survey methods are not always adequate
- Exploit new technologies (cameras, etc.) in improving survey design

- Thoroughly reanalyse the data from the National Recreational Survey and other previous surveys to make better use of the data and to inform the design of new surveys
- Collect social and economic information on recreational fisheries (which was beyond the scope of the workshop) to assist in identifying important demographics for survey questionnaires.

4.2.5 Survey design issues of various survey methods

Throughout the workshop, design issues of a range of recreational survey methods were raised and discussed. In general, discussion was based around the following steps in designing a survey (Pollock *et al.*, 1994):

- Starting up
  - survey objectives, survey type/method, timeframe, methods of obtaining auxiliary/supplementary data, cost, legalities, implementation
- Sample selection
  - sampling frame, stratification, sample size, selection of sample (for each method)
- Data collection
  - Preparation: forms, printing, pre-tests, employment, training, databases
  - Operation: data collection, troubleshooting, supervision and quality control, recontacts
- Screening and follow-up surveys
- Data management
  - data receipt and logging, data validation and entry, missing data, derived data
- Analysis
  - analysis plan, software coding, analytical output
  - review of survey design and methods, comparisons with findings of similar surveys, improvements for later surveys
- Reporting
  - extension of results to managers, stakeholders and general community
  - manuscript preparation, manuscript review, presentations and publishing

The important issue of pseudoreplication in recreational fishing surveys was discussed. Hurlbert (1984) defined pseudoreplication as "the use of inferential statistics to test for treatment effects with data from experiments where either treatments are not replicated (though samples may be) or replicates are not statistically independent." In the context of recreational fishing surveys, pseudoreplication arises from the failure to use the probability based structure of the survey design in a statistical analysis or data interpretation. In general terms, pseudoreplication can occur in two main ways. These being whenever: (a) the survey design (i.e. selection probability) is ignored in data analyses or presentations; and (b) the selection of Primary Sampling Units (PSU's) is done inappropriately, resulting in a lack of statistical independence among PSU's.

Analyses derived from pseudoreplicated data will almost certainly be biased. It is possible that these flawed analyses will produce estimates for stratum totals that are inaccurate and that their associated variances are underestimated. Clearly, pseudoreplication should be addressed during all phases of a project. Good survey design alone is not a guarantee that an analysis of the data will be done correctly. The best survey designs can be undone by failing to incorporate the selection probability of the PSU's into the analyses of the data. It is recommended that sound probability based survey designs be used, routinely defining the PSU and documenting how the analyses were constructed to incorporate the probability based structure of their survey design. In this way, fisheries managers, scientists, recreational fishers and the general public can have confidence that the survey results are unbiased and that correct levels of precision have been reported. Little can be said for sampling that is based on samples of convenience or purposive selection. These sampling strategies are not representative of the general population and inferences can only be made about the sample itself.

The following topics were discussed and specific issues were raised including those relating to the use of the boat licence database as a sampling frame. The strategic and operation details are contained in the relevant tables.

Boat fishing licence sampling frame

- The boat fishing licence should improve sampling efficiency for a recreational survey (Ashford *et al.*, 2009).
- The newly implemented sampling frame will be dynamic with the size and content changing markedly over time especially in the initial few years. This will complicate the selection of survey participants.
- More than one person can fish under a license on a boat trip and more than one person on a boat trip may have a license. However, to determine total harvest, catch and effort information is needed from everyone on the boat. For each party trip recorded in a diary, it would be important to collect total party information on: party size, license holders on trip, trip length, harvest and released catch. In the analysis, total party effort and catch would have to be apportioned among the license holders on the trip. For example, if the party consisted of 5 people all fishing on a 3 hour trip then party fishing effort is 15 hours, and if there were 3 license holders then each license holder would be assigned 5 hours of effort and one third of the total catch for the boat. This is compared to the license holder's own effort, which was 3 hours on that trip. To ensure that this information is collected accurately, the diarists and phone interviewers must be instructed properly. Usually diarists only record their own fishing, whereas here they have to record the whole party's fishing. However, it is uncertain whether diarist will always know how many others are licensed.
- Episodic fishers include those who may purchase the licence just prior to fishing and are therefore a challenge to sample. These are fishers who fish (intensively) over only a very short period within the year including very short term opportunists, "grey nomads" and "fly-in/fly-outs". Their fishing activity would not be accounted for in any one month (i.e. the period between contacts by interviewers of diary holders, i.e. survey participants) of the survey period. Retrospective phone-recall surveys will therefore be required to reach this group of fishers.
- Non-compliant fishers i.e. those fishing parties with no recreational fishing licence holder on board the vessel do not form a component of surveys undertaken by researchers but are the subject of ongoing Fisheries Marine Officer recreational contacts.

Phone Surveys (Table 4.3)

The proposed phone survey would be based on the boat fishing licence sampling frame; this will be less expensive than surveys based on a white page phone index, as is used in other states (also see Table 4.2). However, this diary program based on the boat fishing licence frame will differ from earlier diary programs due to ongoing changes in sampling frame (as new participants obtain licenses) and the fact that not all fishers are required to hold boat licences; this system raises a number of unique design issues that must be addressed. There will therefore be a need to conduct a pilot phone survey to provide information that will assist in developing a statistically sound robust survey design for the later full phone survey.

Given the nature of the licence frame and non-license holders, it is important to collect information on the number of other license holders involved in each fishing trip (i.e. to assess dependencies with other license holders). Thus, there is the issue of recording party information and the diaries or memory joggers will have to be modified to record this data. Diarists will have to be asked to do more than in past surveys. It may also be important when selecting diarists during the screening survey to ask for information on fishing locations to facilitate oversampling of small but important spatial areas if these areas can be identified. To reduce the burden on the fishers, it may be necessary to restrict the number of species, especially the species for which data on released catch needs to be recorded. While this would reduce information on rare species, this would only be obtained with very low precision anyway. Such data may need to be obtained from other survey methods.

Access Point Surveys (Table 4.4)

Generally access point surveys can be stand alone or used to augment the results of the phone survey. As such surveys are relatively expensive, the focus here was on augmentation and validation of phone surveys. Thus, annual rotation of the survey though successive bioregions might be appropriate, provided that both the diary and access surveys have sufficient sample size to make a statistically robust comparison of estimates with similar levels of precision.

Workshop participants discussed ways to collect onsite information on the number of licence holders within each angling party without impacting on the willingness of fishers to participate in the survey. The request for such information crosses into the compliance area, and it may be more appropriate that such data are collected by Fisheries and Marine Officers. It was noted by the workshop that, typically, access surveys are limited to public boat ramps and that it is difficult to survey private ramps and marinas. This may not be an issue if total effort arising from public and private access points can be measured at choke points (i.e. entrances to estuaries or protected harbours) and that the assumption that recreational fishers from private and public access points have similar catch rates. This information could be obtained from phone surveys.

Counter Surveys (Table 4.5)

There is potential to employ automated counters (e.g. traffic counters, cameras) to obtain good effort estimates at boat ramps and other access points and increase the spatial scale and precision of surveys. The data from these methods may be integrated with the data from access point surveys using a double sampling, ratio estimation approach. There is a need for more research to determine the relative costs/benefits of this approach. Practical issues relating to missing data due to malfunction/vandalism (the analysis takes into account missing data i.e. it is treated as though it has not been sampled), the time required for data extraction and quality issues still need to be resolved.

Aerial Surveys (Table 4.6)

Aerial surveys could be very useful for regional or local surveys if used in conjunction with access point surveys. There is potential that these could be valuable for surveying fishing activity for boat-ramp based fisheries, such as offshore deepwater fisheries, where aerial surveys could use multiple observers and exploit distance sampling approaches. It is also possible that aerial surveys may be useful for shore-based recreational fishing. Aerial survey techniques can be used to determine estimates of total effort, and offer a useful means of validating and calibrating phone survey estimates.

Compulsory Surveys (Table 4.7)

The requirement that regulations need to be simple may constrain approaches that compel fishers to cooperate in the provision of data. Furthermore, such regulations are likely to be expensive to enforce. Nevertheless, options might be considered for the collection of catch and effort data through compulsory logbooks, or compulsory recruitment to research programmes such as other recreational surveys for estimation of catch and effort. Alternatively, if appropriate hardware could be installed, fishers could be required to use a tag on / tag off system at boat ramps for the collection of effort data and identification of times when, and locations where, they are fishing. It is highly likely that these types of data collection could be subject to a variety of compliance issues.

Surveys for rare species and specialised fisheries (Table 4.8)

Very imprecise estimates of the catch of rare species and fishing effort for specific fishing methods are likely to be obtained from a state-wide phone survey. It would be possible to employ oversampling of the licence frame to locate rare fishers. This would increase the cost of the screening survey component, but cost increases may be offset by gains in precision. Adaptive sampling could be applied to spatial and temporal sampling of rare or clustered species. Respondent driven sampling may provide an alternative method to contact fishers but it is an approach that is, as yet, untried in the fisheries discipline. The method will, however, be tested in some pilot projects later this year. It may be possible to adapt some of these methods for use in recreational angler surveys where rare events may be clustered in space and time. Another obvious solution is the introduction of a special permit for these species and fishing methods if they are viewed of great importance.

Voluntary or Passive Surveys (Table 4.9)

Voluntary or passive recreational surveys (for example through asking anglers to keep volunteer logbooks) are becoming very popular in Australia with recreational fisher organisations. However, these surveys are invariably not representative of the general population of recreational fishers; volunteers tend to be more avid fishers, and cannot be validly used to provide estimates of fishing harvest, catch and effort for the whole angler population.

Without rigorous oversight, the data collected from these programs can be extremely misleading even when used as indices due to large response and non-response errors plus avidity biases which can vary markedly over time. It may be possible to incorporate information from these surveys into scientific probability based survey programs under certain conditions. However, this is a very complex design problem, which would be very costly. The need for intensive quality control for such survey would add to their expense.

Table 4.2 Recreational fishing surveys and priorities.

	Recreational fisheries	Recreational licences	State-wide surveys	Other surveys	Survey priorities
New Zealand	>500,000 recreational fishers with most effort close to population centres	None	Phone surveys in past, but method now under review, with emphasis on concurrent and independent validation	Onsite and aerial surveys of high use boat-based fishing	Workshops to develop survey timeline to 2011/12. Developing a charter boat registry and logbook scheme.
Common-wealth	Commonwealth recreational fisheries occur outside the 3 nm boundary	None	2000/01 National survey using phone-diary survey method utilising white pages – included all Australian States and Territories.	Use of customs aerial surveillance data for estimating fishing effort	Development of survey design for accessing fishers who may be rare in the Australian population.
New South Wales	> 998,000 recreational fishers	General fishing licence, several categories of exempt fishers, contact information incomplete. There is also a licensed recreational charter boat fishery with compulsory log books.	Proposed for 2013	Regional onsite surveys of boat and shore fisheries, and estuarine surveys. Reporting of charter boat catch and effort.	State-wide phone-diary survey proposed for 2011 including a large regional validation study.
Northern Territory	Many areas of low populations with limited key fishing locations - King Ash Bay/McArthur River, Nhulunbuy, South Alligator, Chambers Bay, Darwin and Bynoe Harbours and Daly River. Approximately 24% of Territorians are recreational fishers.	No general recreational fishing licences. There is a licensed recreational charter boat fishery with compulsory log books	Undertaken in 2010 using phone-diary survey method utilising white pages	Reporting of charter boat catch and effort.	Survey of recreational fishing in hotspots. Economic recreational fishing survey. Designing an integrated survey approach.
Queensland	>700,000 recreational fishers	No fishing licences. There is a licensed recreational charter boat fishery with compulsory log books.	Four state-wide surveys between 1997-2005 using phone-diary survey method utilising white pages.	Ongoing onsite surveys to collect biological information from recreational fishers and to assess whether listed and non-listed fishers differ in their fishing. Reporting of charter boat catch and effort characteristics.	State-wide survey commencing in 2010 using the NRIFS approach and sampling the white pages.

	Recreational fisheries	Recreational licences	State-wide surveys	Other surveys	Survey priorities
South Australia	> 220,000 SA residents fish recreationally. Many access sites for both boat and shore fishers. A significant proportion of the recreational fishing population resides in Adelaide metropolitan area, however, higher participation rates occur in rural areas.	No general recreational fishing licence, however permits required for recreational rock lobster pots and recreational gill nets. There is also a licensed recreational charter boat fishery with compulsory log books.	2007/08 state-wide survey using phone-diary survey method utilising white pages.	Periodic surveys of recreational rock lobster pot fishery, using database of permit holders. Reporting of charter boat catch and effort.	State-wide survey proposed for 2012 using phone-diary survey method utilising white pages.
Tasmania	> 120,000 recreational fishers. Many access points and many areas of low populations.	Abalone, rock lobster dive, rock lobster pot, rock lobster ring, scallop dive, grab all net, mullet net, beach seine net and set line (longline and dropline). There is also a licensed recreational charter boat fishery with compulsory log books.	2008/09 state-wide survey using phone-diary survey method utilising white pages.	Periodic to biannual surveys of licensed recreational fisheries. Reporting of charter boat catch and effort.	Proposing another state-wide survey in 2012 using phone-diary survey method utilising white pages.
Victoria	Recreational fishing occurs in the 30 bays, inlets and estuaries with >500,000 recreational fishers.	General fishing licence with exemptions.	2006/07 survey of bays and inlets using phone-diary survey method utilising the Recreational Fishing Licence	Ongoing access point and attitudinal surveys for key fisheries.	Potential use of fishery-dependent monitoring (ongoing access point surveys) and fishery-independent monitoring (pre-recruit surveys).
Western Australia	Large coast line with many access points and many areas of low populations with >600,000 recreational fishers.	Rock lobster, abalone, marron, freshwater, netting, boat fishing licences. There is also a licensed recreational charter boat fishery with compulsory log books.	Onsite creel surveys of West Coast (96/97, 05/06, 07/08–09/10), Gascoyne (98/99, 07/08) and Pilbara (99/00) with intent to rotate surveys through bioregions.	Annual or biennial phone-diary surveys of licensed recreational fisheries. Reporting of charter boat catch and effort.	Integrated pilot boat fishing survey for 2011 and fully implemented boat fishing survey in 2012.

Table 4.3 Phone surveys of recreational boat fishing in Western Australia.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods demonstrated/ published
Starting up	Total harvest, catch and effort estimates state-wide, bioregion or possibly local areas. Estimates used for stock assessment and resource allocation. 12-month phone-diary survey of licensed boat fishers. May require a phone recall survey to collect data for episodic fishers *i.e.* those purchasing licences just prior to fishing. Large Indigenous sector in some areas without licences. Will need pilot survey? Not just for precision as mentioned below.	Cost-effective means of producing state-wide and bioregion estimates. Estimates could be calculated at smaller scales such as metro area; however other remote areas would require substantial screening for participants. Possible small areas identified are Shark Bay, Ningaloo, Abrolhos May be difficult to obtain good catch estimates for remote areas such Kimberley given that most fishers will be Perth or Interstate. Common species in the catch will have higher precision compared to rare species in catches, which will have low precision. Temporal scale and frame top up or oversampling choices must be determined upfront.	H	Lyle *et al.* (2009a, b) Lyle (2008) Jones (2009) West and Ryan (2009) Henry and Lyle (2003) SDWG (2000) Lyle (1999) MRFSS (1997)
Sample selection	Sampling frame is boat fishing licence Monthly data collection to consider dropouts and replacements. Primary sampling unit is person based = licensed fisher Stratify fishers by spatial areas *e.g.* Bioregion. Possible use of white pages for unlicensed fishers Indigenous sector exempt except for those who voluntary take out a licence. No adequate sampling frame to use to remotely contact sector. Suggestion that approach used in the National Recreational & Indigenous Survey could be employed. Initial screening: determine lagged licence frame between purchase of licence and data availability *e.g.* episodic fishers Follow-up survey to determine non-fishers who did fish	Sampling frame is evolving. Pulses of licences taken throughout the year. Exit and re-entry of licensees as licenses fall due for renewal. Cost of licence frame is covered by the licence fee. Need number of active licences during a fishing trip. Need to collect data at the person level and party level for complete coverage of licensed and unlicensed fishers Power analysis of national survey and pilot studies to determine sample sizes for required precision. Generally lose precision with disaggregation of data. Need more than 12-months of licence frame to adequately screen (enough to confirm that initial pool has had a chance to renew – this will ensure that all participants are sure of their licence want, rather than just a knee-jerk reaction to acquire or abstain). Screening critical for surveys of small areas – costs of screening could be very high. Self reported non-fishers who later did fish are likely to be low as licence frame is based on intended fishers.	H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods demonstrated/ published
Data collection	Questionnaire needs to be clear – avoid misinterpretation. Data collected at appropriate levels of disaggregation *e.g.* species, location, gear, month Obtain fishing party information including how many people are in the party, how many have a licence and how many are participating in fishing activities. Initial contact strategy and non-response. Recruitment into diary component of survey.	Be transparent about what constitutes an event *i.e.* location, gear etc. Need to design retention strategies – interviewer and participant rapport important. In-house interview staff or good liaison with reliable external service for training and management of skilled interviewers. Species identification variable quality. Quality levels can be augmented through basic training of survey intents, supplemented though provision of ID books or other aids in memory-jogger/diary tools. Biological information usually not collected.	M/H	
Data manipulation	Requires staff for data editing, entry and filing. Post-stratification *e.g.* avidity?	Validation can be done efficiently with in-house staff to follow-up. Cost efficiencies by over sampling avid fishers – need to determine avidity categories.	H	
Analysis	Automation and diagnostics for analysis done using R module. Comparison with other data (demographics and DPI boat registrations). Validation with onsite data.	Difficult to compare with previous surveys as licence frame is different. Comparison with other surveys depends on availability of data. Replicate data in complementary/validation surveys *e.g.* demographics, avidity and proportion licensed/unlicensed.	H	
Reporting and Communication	Increased awareness and engagement with stakeholders and general community is important throughout the survey.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.4 Complementary onsite/access point surveys of recreational boat fishing in Western Australia.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Total harvest catch, effort and catch rate estimates bioregion and local areas. Estimates used for stock assessment and resource allocation. 12-month onsite survey of boat fishers. Only considering Access (effort)-Access (harvest); Not considering Roving (effort)-Roving (harvest) or Roving (effort)-Access (harvest) surveys May be useful for onsite surveying of Indigenous communities in some areas, as community members are exempt from boat fishing licences.	Expensive means of producing state-wide and bioregion estimates. May be useful for remote areas such Kimberley given that most fishers will be Perth or Interstate. Potential non-coverage issues including private facilities such as jetties, moorings, marinas and night/early morning fishing. Not all ramps may be covered. Common species in the catch will have higher precision compared to rare species in catches, which will have lower precision.	H	Ryan *et al.* (2009) Steffe (2009) Lockwood *et al.* (1999)
Sample selection	Sampling frame is access points where boats launched and retrieved. Primary sampling unit is day Stratify by spatial areas *e.g.* bioregions and districts	Power analysis of previous surveys and pilot studies to determine sample sizes for required precision. Generally lose precision with disaggregation of data.	H	
Data collection	Questionnaire needs to be simple and clear – avoid misinterpretation. Data collected at appropriate levels of disaggregation *e.g.* species, location, gear, month Boat ramp, post code, trip duration vs fishing time, number of persons onboard vs number fishing. Obtain fishing party information including how many people have a licence. Biological information Performance/quality Monitoring	Be transparent about what constitutes an event *i.e.* location, gear, etc. Ask contentious questions at end of interview. Need to collect data at the person level and party level for complete coverage of licensed and unlicensed fishers – Not possible to check licences as not enforcement officers. In-house interview staff or good liaison with reliable external service for training and management of skilled interviewers. Refusals minimised with good interviewers. Good species identification for retained species however variable quality control levels for released species. Need sample of fish lengths or weights that is representative of the recreational catch	M/H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Data manipulation	Requires staff for data editing, entry and filing.		H	
Analysis	Automation and diagnostics for analysis done using R module. Comparison with other data (demographics and DPI boat registrations). Validation with onsite data.	Comparison with other surveys depends on availability of data. Replicate data in complementary/validation surveys *e.g.* demographics, avidity and proportion licensed/unlicensed.	H	
Reporting	Increase awareness and engagement with stakeholders and general community is important throughout the survey.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.5 Complementary onsite/counter surveys of recreational boat fishing in Western Australia.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Total catch, effort and catch rate estimates bioregion and local areas. Estimates used for stock assessment and resource allocation. 12-month onsite survey of boat fishers. Using counter technology to determine effort to supplement effort from onsite surveys.	Expensive means of producing state-wide and bioregion estimates. May be useful for remote areas such Kimberley given that most fishers will be Perth or Interstate. Conversely, it is very cheap for limited spatial scales Non-coverage issues including private facilities Good for providing night fishing effort. Expensive to cover all ramps if operating at a large spatial scale. Counters provide complete temporal coverage Many counter methods will only determine total activity for an access point rather than total fishing effort – this will require use of a complementary/ supplementary survey to determine a proportion of total activity that is fishing	H	Smallwood *et al.* (2011a) Schneider *et al.* (2009) Steffe *et al.* (2008)
Sample selection	Sampling frame is access points where boats launched and retrieved. Primary sampling unit is day or not applicable in the case of a census. Stratify by spatial areas *e.g.* Bioregions and districts	Power analysis of previous surveys and pilot studies to determine sample sizes for required precision. Generally lose precision with disaggregation of data.	H	
Data collection	Need to have expertise to implement, maintain and manage counter technology including hardware, pc, telecommunications and networking. Staff required for image interpretation.	Start-up cost expensive for some counter technology choices but ongoing costs are low.	M/H	
Data manipulation	Requires staff for data editing, entry and filing for some technology choices.	Data extraction from equipment is expensive unless automated.	H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Analysis	Automation and diagnostics for analysis may be possible. Validation with onsite data.	Comparison with other surveys depends on availability of data. Replicate data in complementary/validation surveys *e.g.* demographics, avidity and proportion licensed/ unlicensed.	H	
Reporting	Increase awareness and engagement with stakeholders and general community is important.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.6 Complementary onsite/aerial surveys of recreational boat fishing in Western Australia.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Total catch, effort and catch rate estimates bioregion and local areas. Effort is obtained from aerial surveys. Estimates used for stock assessment and resource allocation and for validation. 12-month onsite survey of boat fishers. Using aerial surveys to determine effort to supplement effort from onsite surveys.	Expensive means of producing state-wide and bioregion estimates. May be useful for remote areas. Good coverage of all boating activity except night fishing effort. Potentially useful for zones where vessels rarely go large distances from shore and are spatially limited (such as the Metro and Ningaloo). It is theoretically possible to use line transect distance sampling here if one wants to go further off shore but not clear how practical it would be.	H	Smallwood *et al.* (2011a;b) Hartill *et al.* (2011, 2012) Vølstad *et al.* (2006)
Sample selection	Sampling frame is area of fishing. Primary sampling unit is day Stratify by spatial areas *e.g.* bioregions and districts	Power analysis of previous surveys and pilot studies to determine sample sizes for required precision. Generally lose precision with disaggregation of data.	H	
Data collection	Need to have reliable aircraft operators.	Consistency in collection can be difficult to maintain with variations in aerial staff Weather limitations are rarely a concern except when vision limiting (such as heavy rain)	M/H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Data manipulation	Requires staff for data editing, entry and filing.		H	
Analysis		Comparison with other surveys depends on availability of data. Replicate data in complementary/validation surveys *e.g.* demographics, avidity and proportion licensed/ unlicensed. Avidity of vessels is unknowable from air and will need to be determined via complementary survey.	H	
Reporting	Increase awareness and engagement with stakeholders and general community is important throughout the survey.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.7 Compulsory surveys.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Statutory logbooks for licence holders would provide total catch, effort and catch rate estimates state-wide, bioregion and local areas. Estimates used for stock assessment and resource allocation. Compulsory tag on and off system for licence holders would provide effort and information on who fished for follow-up by other recreational surveys.	Very expensive means of producing estimates. Requires large number of staff to manage the system and compliance officers to enforce. No point having a compliance system if cannot enforce it. Statutory logbooks provide complete coverage for catch of listed species however it is unknown how much of the data is made up after the fishing event. Non-coverage of catch and effort of non-licence holders who may be fishing under a licence holder. Indigenous communities are exempt from boat fishing licences.	H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Sample selection	Sampling frame is all licence holders. Primary sampling unit is licence holder.	Total licensed population is covered.	H	
Data collection	Logbook needs to be clear – avoid misinterpretation. Data collected at appropriate levels of disaggregation *e.g.* species, location, gear, month Boat ramp, post code, trip duration vs fishing time, number of persons onboard vs number fishing. Obtain fishing party information including how many people have a licence. Clear business rules that are easy to follow for compliance	Be transparent about what constitutes an event *i.e.* location, gear etc. Need to collect data at the person level and party level for complete coverage of licensed and unlicensed fishers – Not possible to check licences as not enforcement officers, although there is the possibility of compliance officer involvement or statutory changes to make this possible. Species identification highly variable quality. Compliance checks can provide good quality data however compliance checks are not random. Need representative sample of fish lengths or weights. Soft refusals are still possible if a licence holder wishes to minimise his/her time/cost.	M/H	
Data manipulation	Requires staff for data editing, entry and filing. Requires compliance officers for enforcement.	Validation and verification issues related to identification apply as per diary/volunteer systems.	H	
Analysis	Need automation and diagnostics for analysis.	Confidential data issues.	H	
Reporting	Increase awareness and engagement with stakeholders and general community is important throughout the survey.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.8 Survey approaches for rare species and specialised fishers.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Objective is to provide cost-effective sample selection and then use another survey method to provide total catch or effort Estimates used for stock assessment and resource allocation. 12-month onsite survey of boat fishers. May be useful for onsite surveying Indigenous communities in some areas who are exempt from boat fishing licences.	Expensive means of producing state-wide and bioregion estimates. May be useful for remote areas such Kimberley given that most fishers will be Perth or Interstate. Common species in the catch will have higher precision compared to rare species in catches, which will have low precision unless the stratification method targets these specific areas.	H	Thompson and Seber (1996) Heckathorn (1997, 2002) Griffiths *et al.* (2010)
Sample selection	Sampling frame is access points where boats launched and retrieved. Primary sampling unit is day Stratify by spatial areas e.g. Bioregions and districts	Power analysis of previous surveys and pilot studies to determine sample sizes for required precision. Generally lose precision with disaggregation of data.	H	
Data collection	Questionnaire needs to be clear – avoid misinterpretation. Data collected at appropriate levels of disaggregation *e.g.* species, location, gear, month Boat ramp, post code, trip duration vs fishing time, number of persons onboard vs number fishing. Obtain fishing party information including how many people have a licence. Biological information Performance/quality Monitoring	Be transparent about what constitutes an event *i.e.* location, gear etc. As contentious questions at end of interview. Need to collect data at the person level and party level for complete coverage of licensed and unlicensed fishers – Not possible to check licences as not enforcement officers. In-house interview staff or good liaison with reliable external service for training and management of skilled interviewers. Good species identification for retained species however variable quality of released species. Need representative sample of fish lengths or weights.	M/H	
Data manipulation	Requires staff for data editing, entry and filing.		H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Analysis	Automation and diagnostics for analysis done using R module. Comparison to other data (demographics and DPI boat registrations). Validation with onsite data.	Comparison with other surveys depends on availability of data. Replicate data in complementary/validation surveys *e.g.* demographics, avidity and proportion licensed/ unlicensed.	H	
Reporting	Increase awareness and engagement with stakeholders and general community is important throughout the survey.	Needs to be costed in survey budgets. Needs good communication skills.	H	

Table 4.9 Passive or voluntary surveys.

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Starting up	Does not provide total catch or effort. Provides fishing information on a specific group of volunteers Information may be useful when designing other recreational surveys.	Can be very cheap to expensive means of obtaining information depending on system and incentives used. Non-random or self-selection of volunteers thus weight up to population size would be inappropriate.	H	Bray and Schramm (2001) Baker and Oeschger (2009)
Sample selection	Sampling is through self-selection	Sample is not representative of any defined sampling frame, and likely to vary temporally. Participants are likely to represent avid anglers.	H	
Data collection	Questionnaire needs to be clear – avoid misinterpretation. Data collected at appropriate levels of disaggregation *e.g.* species, location, gear, month Boat ramp, post code, trip duration vs fishing time, number of persons onboard vs number fishing. Biological information Performance/quality Monitoring	Be transparent about what constitutes an event *i.e.* location, gear etc. As contentious questions at end of interview. Species identification variable quality of. May obtain fish lengths or weights from keen volunteers. Expensive to maintain consistency and quality	M/H	

	Description	Advantages/Disadvantages/Uncertainties (Precision/Biases/Limitations)	Relative importance L, M, H	Methods Demonstrated/ Published
Data manipulation	Requires staff for data editing, entry and filing. Alternatively use online systems with internal validation checks. Still necessitate staff to maintain the system, provide quality control and chase up errors.	Data cannot be expended to the level of the total fishery due to the lack of a sampling frame from which participants are randomly selected. Data likely to be biased by avidity.	H	
Analysis	Automation and diagnostics for analysis could be considered as component of online system.	Validation and verification must be either accepted as unknown or directly managed.	H	
Reporting	Increase awareness and engagement with volunteers throughout the survey to keep them keen.	Needs to be costed in survey budgets. Needs good communication skills in the medium of choice selected.	H	

5.0 Development of cost effective methods

Objective 4. Development of cost effective methods for monitoring the catch of the non-commercial sector

Effective management of exploited stocks requires that estimates of the catch taken by all sectors are available. Estimating the total catch taken by recreational fishers, however, can be logistically difficult and is often relatively costly. These difficulties are especially apparent where there is no licence frame (i.e. list of license holders) to easily identify participants. In these circumstances, the most common recreational survey method is the use of onsite creel surveys. This method has been used extensively by the Department of Fisheries in Western Australia during the last 15 years to estimate recreational catch, especially for boat-based recreational fishing. As with all survey methods, the survey design involves specific trade-offs between available resources and the level of sampling and spatial-temporal coverage.

Significant improvements have recently been made to the analytical processes used by the Department to calculate the creel-based estimates of catch obtained from boat-based recreational fishing. There is now improved robustness, and a consistent approach for estimating catch among surveys has been adopted, thereby reducing time to produce catch estimates from any one survey. These analytical changes do not, however, reduce the acknowledged spatial and temporal limitations of the survey design. These include only sampling public boat ramps and only between 9 am to 5 pm, which means that adjustment factors must be applied to generate estimates of total catch. Consequently, some stakeholders will remain critical of any results produced by creel surveys. Finally, the costs of conducting such onsite (face-to-face) surveys only allows one bioregion to be sampled each year (i.e. each bioregion is sampled once every four years) and there are increasing risks in not knowing the boat-based recreational catch in other bioregions of the state, particularly in the northern and southern marine bioregions.

The introduction of the Recreational Fishing from Boat Licence (RFBL) has allowed consideration of other, more cost effective and comprehensive (both spatially and temporally), survey methods to estimate total boat-based recreational catch. To capitalise on this opportunity, a workshop was held in 2010 with invited technical experts and managers from most jurisdictions in Australia and NZ. The objective of the workshop was to determine the most appropriate method or set of methods for a recreational fishery with a specific licence frame. The workshop concluded that an integrated system that obtained data from several survey methods, utilising the RFBL as the basis for sampling recreational fishers, would provide the most robust approach for future annual estimates of recreational catch by boat-based fishers at the state-wide and bioregion levels.

The new design will enable:

- Total catch estimates to be made concurrently for every marine bioregion in the State, not just one bioregion at a time.
- Include catch taken by all motorised vessels, not just those launched at public boat ramps.
- Cover all fishing times, not just fishing during the main period of the day.

This planned survey will be the most comprehensive of its type ever conducted but comes with a risk of encountering unanticipated problems, which in turn means the project has to be flexible in its application. Consequently, the Department is developing a collaborative research agreement with Edith Cowan University to investigate some of the potential problems and biases that might be encountered. This research agreement will also have a focus on developing human capital in the fields directly relevant to the state-wide survey.

Finally, it must be stressed that, while the new design will provide improved catch estimates, it is still a "survey", and as such, cannot be expected to provide the level of precision that would be available from a true "census".

5.1 Summary of survey design

The key components of the proposed integrated survey and the types of data these will provide are outlined below. More detailed descriptions, including any issues associated with the various types of data collection that relate to some form of sampling bias, are highlighted. This enables each of the various survey components to be examined in the context of their cost effectiveness.

The objective of this survey is to generate annual estimates of the total recreational catch (both retained and released) that is taken by boat-based recreational fishers at state-wide and bioregion levels. The integrated survey includes the following complementary components:

1a. Phone survey using the RFBL as a sampling frame – The main survey will involve a total of 3,000 randomly selected RFBL holders. This will comprise approximately 2,000 residents from the wider metropolitan area and 1,000 residents from country locations. Each participant will keep a diary/logbook of his/her fishing activities for a 12-month period and will be phoned at least monthly to both obtain fishing details for the past month. This interviewer-assisted approach minimises respondent burden, reduces recall bias and maintains respondent involvement in the survey.

1b. Post-enumeration surveys at the completion of the 12-month period will be used to detect and adjust for information of new licence holders, non-respondents and participants who drop out of the survey. These surveys will include a benchmark survey of another 3,000 RFBL holders (to describe the RFBL population for the diary/logbook period and relevant profiles for expansion of data to the RFBL population), a non-intending fisher survey to check for the incidence of fishing among those that weren't intending to fish (i.e. renewed their RFBL after first saying they would not) during the screening survey and a follow-up survey to provide substantive additional information, including socio-economic data.

2. Boat ramp survey – To provide onsite biological information and validation of information collected in the phone surveys, a targeted boat ramp based survey will be undertaken at specific boat ramps and times to carry out onsite face to face interview with 5,000–10,000 boat-based fishers.

3. Remote video survey – Video cameras mounted at key boat ramps will monitor launches and retrievals. This will assist the validation of effort levels over 24-hour periods.

5.2 Detailed description

5.2.1 Background

The Department of Fisheries has conducted broad scale surveys of recreational fishing since 1994/95, with the first application to a specific marine bioregion in 1996/97 for boat-based fishing in the West Coast Bioregion. Further bioregional surveys of boat-based recreational fishing have now been undertaken in the West Coast and Gascoyne Bioregions, and in the Pilbara region of the North Coast Bioregion, with each using a design based on the bus-route method. It was acknowledged that these surveys did not account for the full recreational catch because they were limited to 8 hour survey periods per day (in daylight hours) and only covered vessels launched from public boat ramps.

An external review of the survey methods, as applied to the West Coast Bioregion (and therefore to other similar surveys), was undertaken in late 2008/early 2009. In summary, the review identified that, while the point estimates were valid, (1) the analyses were underestimating the error (or uncertainty) associated with estimates of catch, and (2) the analyses used were only one of several that could be applied to the types of data collected in the survey.

Following the review, an internal process was undertaken to test and implement the review recommendations. This led to a complete restructure of the analytical system used for calculating the estimates of recreational catch, including a full review of the statistical components employed in the analyses and how they relate to the experimental design. Importantly, this process also entailed the successful development of new software that enabled the completion of the analyses and calculations in a substantially shorter time. These analytical changes do not, however, reduce the acknowledged spatial and temporal structural limitations of the survey design used to collect the survey data (as outlined above). Consequently, some stakeholders were likely to remain critical of the results produced by any future creel surveys.

The introduction of the RFBL has allowed other, more cost-effective and (importantly) more robust, survey methods to be employed to estimate total catch. To capitalise on this opportunity, an international workshop was held which included invited technical experts and managers from most jurisdictions in Australia and NZ. The objective of the workshop, which was held on 22–26 February 2010, was to determine the most appropriate method (or set of methods) for estimating total recreational fishing catch and effort for all four marine bioregions given that there was now a recreational "fishing from boat" licence.

The workshop brought together professional experts from Australian and New Zealand who are involved in recreational fisheries surveys and management. The expertise of participants covered survey design and analysis, fisheries research and management. Emphasis was placed on the design of surveys that could employ the sampling frame from the recently implemented RFBL.

5.2.2 Need

Detailed knowledge of recreational catches is required for effective management of fish resources. Despite significant improvements in the system for estimating recreational boat fishing catch since 2008, stakeholders remain sceptical of results produced by creel surveys due to the spatial and temporal structural limitations of the survey design. In addition, because of their expense, there are increasing risks in not knowing the boat-based recreational angling catch in other regions of the state, particularly in the northern and southern marine bioregions.

It is acknowledged that boat-based fishers use numerous access points including harbours, marinas and private docks and from beaches. Their behaviours and fishing patterns vary around the state, and the ability to effectively sample boat fishers also varies. These types of issues mean that there is no single survey method that can be used to accurately and precisely estimate catch and effort from all recreational fishers. Consequently, the expert workshop concluded that an integrated survey comprising a number of complementary components would provide the most robust and cost-effective system for simultaneously estimating total catch and effort at the zone, bioregional and state level.

5.3 Integrated survey design - overview

5.3.1 Key Components

This integrated survey is designed to estimate the total annual and monthly catch (retained and released) that is taken by boat-based recreational fishers at the zone, bioregion and state-wide levels. The survey includes the following complementary components:

1. Phone survey based on the RFBL
2. Boat ramp survey
3. Remote video survey of launches and retrievals at specific boat ramps

5.4 Details of survey components

5.4.1 Phone survey

This is the main component of the integrated survey. The objective of this survey is to provide estimates of the annual catch and effort for boat-based recreational fishing at state-wide and bioregion levels. Highest precision will be achieved for key species at annual and state-wide levels, however, estimates with lower precision may be available at finer scale temporal (monthly) and spatial (zone) levels.

Diaries/logbooks will be provided to a stratified random sample of RFBL holders, selected by a screening process, based primarily on their place of residence (or postcode) at the time of purchasing the RFBL. Strata are required to meet the objectives of obtaining monthly catch estimates for each bioregion and for zones within bioregions (e.g. Metropolitan zone within the West Coast Bioregion) while also reflecting the distribution of RFBL holders throughout the state, which varies markedly due to the considerable spatial variation in population. Each stratum requires an absolute minimum sample size of 150 logbook holders for zones within bioregions, in order to ensure that estimates are of an acceptable level of accuracy and precision.

A total of 3,000 participants will be selected across the strata, with the expected regional breakdown of these participants being 2,000 from wider metropolitan residents and 1,000 from country residents. The large sample size from the Metro zone is based on the assumption (based upon data from previous surveys) that many licence holders are more likely to travel away from, rather than go to, the metropolitan region to go fishing.

There will also be some consideration of the need to specifically account for avid fishers (i.e. fish often) and expert fishers (i.e. catch many fish); these may or may not represent the same group of fishers. The statistical mechanisms to incorporate such strata directly into the calculations of catch and effort are not straightforward and are undergoing further investigation.

Participants will be called at least once per month over the 12-month survey period to provide data that will be entered on a database (once identified, more avid fishers will be called more frequently). These data will form the primary set of data for estimating annual and monthly catches for each zone and bioregion.

5.4.2 Post-enumeration surveys

The objective of this component is to determine, and adjust for, exceptions not fitting the normal distribution of behaviours covered by the phone survey.

Some RFBL holders will only fish irregularly or periodically (i.e. episodic fishers) and of these, some will only buy their RFBL just before they go fishing. These behaviours and new licence holders will preclude them from the initial screening process for the phone survey, especially in the first series of surveys.

To account for these types of biases, a follow-up survey at the completion of the main phone survey will be used to detect and adjust for information of new licence holders, non-respondents and participants who drop out of the survey. This second licence-based survey involving 3,000 randomly selected licence holders will profile and compare their fishing with the main phone participants. In addition, this follow-up survey will include some social and economic questions.

Post-enumeration surveys at the completion of the 12-month period will be used to detect and adjust for information of new licence holders, non-respondents and participants who drop out of the survey. These surveys will include:

Benchmarking survey conducted after the diary/logbook period using a random sample of 3,000 RFBL holders. This survey provides an enumeration of the RFBL population for the diary/logbook period and relevant profiles for expansion of data to the RFBL population.

Non-intending fisher survey to check for the incidence of fishing among those that weren't intending to fish (renew their RFBL) during the screening survey.

Follow-up survey conducted immediately after diary/logbook period to provide substantive additional information, including socio-economic data. This survey will sample from respondents selected for the benchmark survey (3,000 RFBL holders from the diary/logbook period) or a subset of this sample.

5.4.3 Boat ramp survey

The objective of this component is to provide the necessary onsite biological information and validation of information collected in the phone survey.

Information including lengths of fish, catch rates, catch composition and proportion of boating activity that includes fishing will be collected based on the survey methods developed for the creel survey. The locations and frequency will use a probability based sample of state-wide boat ramps that will be covered throughout the same time period as the phone survey. In addition, detailed information will be collected at a number of key boat ramps in the Perth region throughout the same time period as the phone survey.

The duration and time during the day when sampling at these boat ramps will occur is planned to extend beyond the previous 9 am – 5 pm period to help overcome one of the major structural limitations associated with the earlier methodology.

The catch and effort data from these direct, onsite surveys at boat ramps will be used to validate the phone survey data. In addition, the biological data that will be collected are required to estimate catch weight. It is likely that the opportunity will be taken to collect actual biological material for use in the stock assessments for indicator species. Stock assessment staff may also be able to participate in the boat ramp data collection so synergies will be developed between the recreational survey and stock assessment field activities.

5.4.4 Remote monitoring of activity levels of boat ramps

The objective of this survey is to provide validation of phone survey effort estimates. Information gathered will inform the number of launches and retrievals at specific boat ramps which, when combined with the proportion of all boating activity that involves fishing as derived from the boat ramp surveys, will provide further validation of the effort calculated from the phone survey. This information will be collected at a number of key boat ramps throughout the same time period as the phone survey. The exact locations of remote video cameras are determined by infrastructure at the boat ramp and the logistics of transmitting the information.

5.4.5 Fisheries and Marine Officer (FMO) patrols

While not included as a key component of the integrated survey, data from these patrols will provide reliable onsite compliance data on the level of non-compliance both with having a recreational boat licence and in terms of the numbers of under/oversized fish or those in excess to bag limits.

Information gathered will inform the level of non-compliance and provide further validation of information from the phone survey. Onsite information will be collected at major boat ramps throughout the same time period as the phone survey. Data collection on FMO patrols that will help validate the phone survey include species composition and numbers of people on board vessels, time of inspection (usually landing), and a recall estimate of the fishing duration.

5.4.6 Cycle of continual improvement

The recreational fishing from boat license is still in its first year since implementation and will likely have a “settling in” period as fishers settle into longer term usage patterns for the new license. A critical objective of the first integrated survey will be to develop a much better understanding of the types of biases that may be occurring due to potential changes in annual patterns of RFBL usage; by proactively looking for possible biases and behavioural adjustments of fishers we expect to gain guidance as to how to deal with these.

It is very likely that some components of the integrated survey methodology will need to be modified in subsequent surveys to address problems. In some cases it may be necessary to apply emerging techniques in survey design to further improve accuracy and precision of estimates. Furthermore, as the pattern of fishing changes, the survey design needs to be flexible enough to accommodate these changes. The Department is currently developing a collaborative research agreement with Edith Cowan University to investigate some of the potential problems and biases mentioned above. A critical element of the research project is having the expertise across several related disciplines (experimental design, data mining, spatial statistics, temporal statistics, phone survey methodology) to allow real-time development and implementation of changes to the survey if warranted. This research agreement will also have a focus on developing human capital in the fields directly relevant to the state-wide survey.

Finally, the Department will be actively working with RecFishWest (RFW) to ascertain what other types of information might be able to contribute to better understanding the behaviours of recreational fishers to improve catch and effort estimates. Of particular interest is developing a clearer understanding of how avid and/or expert fishers contribute to the overall catches.

6.0 Conclusion

6.1 Benefits

The project was successful in identifying options for future surveys of recreational fishing in Western Australia. The comparison of alternative survey methods carried out concurrently in 2005/06 and workshops attended by national and international experts in the field of recreational survey methods helped demystify myths of recreational surveys being too complex and expensive and ensured a pragmatic approach to the development and implementation of these survey methods in Western Australia.

Determining the most appropriate methods has been made very transparent and the findings from this report have been adopted by the Department of Fisheries in Western Australia to design and implement a state-wide survey of recreational boat fishers currently underway in 2011/12. The results from the survey will be available towards the end of 2012 with a cycle of continual improvement for surveys in the future.

Finding the most appropriate survey method has been made simpler through the development of this report, which can be used to identify cost, capacity and complexity of the specific methods to determine the most suitable options given the local capacity available.

The involvement of the recreational fishers throughout this process has improved the acceptance of methods within the community. Trialling of alternative survey methods including those favoured by recreational fishers (e.g. volunteer logbooks and volunteer programmes) has resulted in the development of a much broader understanding of the benefits and limitations of each survey method.

The numerous workshops held from 2009 onwards have greatly broadened the network of national and international experts who regularly discuss survey methods and improvements. The goal will be to ensure this communication continues.

6.2 Further Development

The results from the initial state-wide survey of boat fishing in Western Australia will be available in 2013. This will provide Western Australia with state-wide catch and effort estimates comparable with those produced by the national recreational survey carried out in 2000/01 (Henry and Lyle, 2003). An assessment of the trade-off in accuracy and precision to cost savings by using the alternate survey methods or combined methods will need to be undertaken to refine methods for subsequent and regular state-wide surveys of boat fishing. Data collected in this project will be managed by the Department of Fisheries in Western Australia according to the State Records Act 2000 and along with all other recreational survey information collected by the department be subject to further analyses, refinements and integration in the future.

There is no equivalent licence frame for shore-based fishers in Western Australia and development of survey methods of obtaining similar estimates of catch and effort for this component of recreational sector is required. Alternative methods include the use of the white pages (Henry and Lyle, 2003), aerial surveys (Smallwood *et al.*, 2011a; 2011b), roving surveys (Smallwood *et al.*, 2011a; Smallwood *et al.*, 2012) or a combination of techniques. However, the cost effectiveness of these methods are yet to be investigated.

There are numerous methods available for carrying out surveys of recreational fisheries, however, there are continuing needs to refine survey methods as experience is gained through their use. Within Australia there a need to develop agreed national standards for survey methods that can be used to provide consistent recreational fishing statistics across all States and Territories. This may alleviate generally unfounded perceptions that recreational fisheries in this region are not well managed and to achieve equitable resource allocations to the sector. The ultimate goal is to determine national estimates of recreational catch and effort, which incorporate the cross-boundary fishing activities of fishers.

6.3 Planned outcomes

This project successfully provided estimates of the catch by the boat-based recreational sector, to assist the IFAAC provide recommendations to the Minister for Fisheries, on the appropriate IFM allocation of access to all sectors of the West Coast demersal scalefish fishery (IFAAC, 2013). These results are therefore, of interest and benefit to the other sectors operating in West Coast demersal scalefish fishery especially the commercial sectors.

The project assisted the Department of Fisheries to establish the most appropriate management methods for the demersal recreational fishing in the West Coast region especially the ongoing recreational monitoring programs. The information generated by these monitoring programs enabled the management of this fishery to rebuild the West Coast demersal scalefish resources to sustainable levels (Wise *et al.* 2007) and moreover, ensures catch by the recreational sector is conforming to their specific allocation as decided by the IFM process (Department of Fisheries 2010, IFAAC 2010, 2013).

Each of the survey methods were or will be published as independent reports. The preliminary results of the creel survey was published in Sumner *et al.* (2008) and reviewed by Steffe (2009). This report provides updated results based on the review recommendations. A detailed description of the establishment of the RAP programme was published in Smith *et al.* (2007), the VFLO programme published in Smallwood *et al.* (2010) and the FMO programme published in Smallwood *et al.* (2012). The results and survey methods presented here are being transferred to the collection of further data for recreational fisheries in Western Australia (e.g. Smallwood *et al.*, 2011a; 2011b).

6.4 Conclusion

Information on fishing effort, catch rates and catch from all sectors are required to evaluate the status of stocks and to manage those stocks. In Western Australia, commercial and charter operators are required to provide catch and effort returns as a condition of their licence. Since there is no mandatory reporting system in place for recreational fishers, surveys must be conducted to determine the catch and fishing effort for this sector.

The traditional methods in Western Australia for estimating recreational catch and effort have been creel, diary and/or logbook based surveys. These methods can have a relatively high cost with each generating estimates that are subject to a number of different biases. Given that allocation decisions for these fisheries are based on the estimates generated from these surveys, all stakeholder groups demand assessments of the accuracy and precision of any estimates produced. Analyses were completed on simultaneously collected data by alternative methods to allow comparisons to be made of the resulting estimates.

During 2005/06 a series of concurrent catch and effort surveys of West Coast demersal recreational boat-based fishers that used a variety of survey techniques were undertaken (Objective 1). The different methods used in this study were:

- Boat-ramp based creel survey
- Mail-phone-diary survey
- Counter surveys of:
  - boat launches and retrievals using video cameras
  - vehicles and boat trailers using a Vehicle Classifier System (VCS)
  - car park vehicles and boat trailers using video cameras
  - car park vehicles and boat trailers using ticketing machines
- Fisheries and Marine Officer (FMO) survey
- Volunteer Fisheries Liaison Officer (VFLO) survey
- Research Angler Program (RAP) logbooks

All methods that are used when surveying recreational fisheries generate estimates that are potentially subject to a number of different biases. This project provided a greater level of understanding of the relative precision and accuracy (Objective 2) of each of the various standard and innovative approaches along with their relative costs, benefits, limitations and interactions (Objective 3).

A series of workshops held in New Zealand and Western Australia with invited national and international experts provided recent advances in survey methods. These workshops proved essential for determining ongoing sampling methods required to provide ongoing monitoring of the IFM outcomes for this fishery (Objective 4). The key components of an integrated survey to estimate the total state-wide catch taken by boat-based recreational fishers include the following complementary components:

- Phone survey based on the RFBL
- Boat ramp survey
- Remote video survey of launches and retrievals at specific boat ramps.

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8.0 Appendices

Appendix 8.1 Intellectual property

This is not applicable to this project.

Appendix 8.2 Staff

The following staff contributed to the various components of this project;

Creel survey

Norm Hall
Peta Williamson
Stuart Blight
Carli Telfer
Karen Santoro
Andy Ajduk
Kim Clayton
Cameron Hugh
Mathew Hutchinson
Clinton Blight
Pat McAuliffe
Gabby Mitsopolous
Richard Nile
Lee Patterson
John Retallack
Ryan Rushton
Emma Samson
Tony Smith
Neil Sumner
Bill Trenow
John Urbanski

Mail-phone-diary survey

Norm Hall
Tara Baharthah
Iris Bennett
Suzanne Doble
Cameron Hugh
Carolyn Midwood
Helen Murray
Julie Valli
Susanne Wakeling
Stacey Walker

Video camera (boat ramp and car park) survey

Norm Hall
Stuart Blight

Michael Tuffin
Ivan Lightbody
Stacey Wells
John Urbanski

Vehicle Classifier System (VCS) Survey

Norm Hall
Michael Tuffin
Stuart Blight

Ticketing Survey

Claire Smallwood
Peter Cook (Harbour Officer, Department for Planning and Infrastructure–Hillarys)
Don Froome (Harbour Manager, Department for Planning and Infrastructure–Hillarys)
Andrew Driver (Ranger, Town of East Fremantle)
Paul Hrovatin (Ranger, City of Joondalup)
Terri Olden (Ranger, City of Wanneroo)

Fisheries Marine Officer (FMO) Survey

Carli Telfer
Tim Green
Teresa Coutts
Rob Humphreys
Barbara Lawrence
Anita Ward
Fisheries Marine Officers

Volunteer Fisheries Liaison Officers (VFLO) Survey

Claire Smallwood
Emma Connelly
Michelle Dyer
Larisa Vanstien
Volunteer Fisheries Liaison Officers

Recreational Angling Programme (RAP) Logbook

Kim Smith
Michael Hammond
Josh Brown
Volunteer Anglers

Survey costings

Michael Tuffin
Selina Cranley
Kevin Carhart
Gail Thomas
Peter Moulder

Appendix 8.3 Creel survey forms

WEST COAST RECREATIONAL BOAT SURVEY
BOAT RAMP FORM 2005 / 06

Interviewers Name: ____________________________

Date: _______________ Start Time (24hr): _____________ Finish Time(24hr): ___________

District_________________________________ Boat Ramp: ____________________________

ENVIRONMENTAL DATA

Wind:

Calm 1	Light 2	Mod 3	Strong 4	Gale 5

Direction

Water:

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

Cloud Cover:

Cloud %

Rainfall:

Nil 1	Light 2	Mod 3	Heavy 4

Boat Launches				Boat Retrievals			
Time	Type	Time	Type	Time	Type	Time	Type

Total Number of Trailers in carpark	
At Start	At Finish
Number of Boats from Moorings / Shore	
At Start	At Finish
Final Count	
At Start	At Finish

Boat Types

P: Power boat

Y: Yacht

O: Other

WEST COAST RECREATIONAL FISHING SURVEY 2005/6
INTERVIEW QUESTIONNAIRE

Date: _________ **Location:** ______________________ **Boat Reg. No.:** ________________

Retrieval Time	Launch Time (include date if different from Today)	Boat (Pwr / Yacht / Other)	Fishing (Yes / No)	Dive / Snorkel / Water Ski / Other	Number of Persons Fishing / Number in Party	Number of Aboriginal or Torres Strait Islanders Descent	Home Postcode of Interviewee	Lenght of Boat (ft / m)	Block Number or Estuary	Crabbing (Yes / No)	Time Spent Fishing (Decimal Hrs)	Number of Lines Used	Number and type of nets - Crab / Gill / cAst / Scoop / Pot
										FISHERS ONLY			

Species (Record Sex for Lobsters and any Tag Numbers for Fish)	Number Kept	Number Released	Number taken by Sharks	Number of Break-offs	Number of Undersize or Oversize Kept	Species Targeted 1.____ 2.____ Measurements (mm)
W.A. Dhufish (male)						
W.A. Dhufish (female)						
Pink Snapper						
Breaksea Cod						
Baldchin Groper						
Herring						

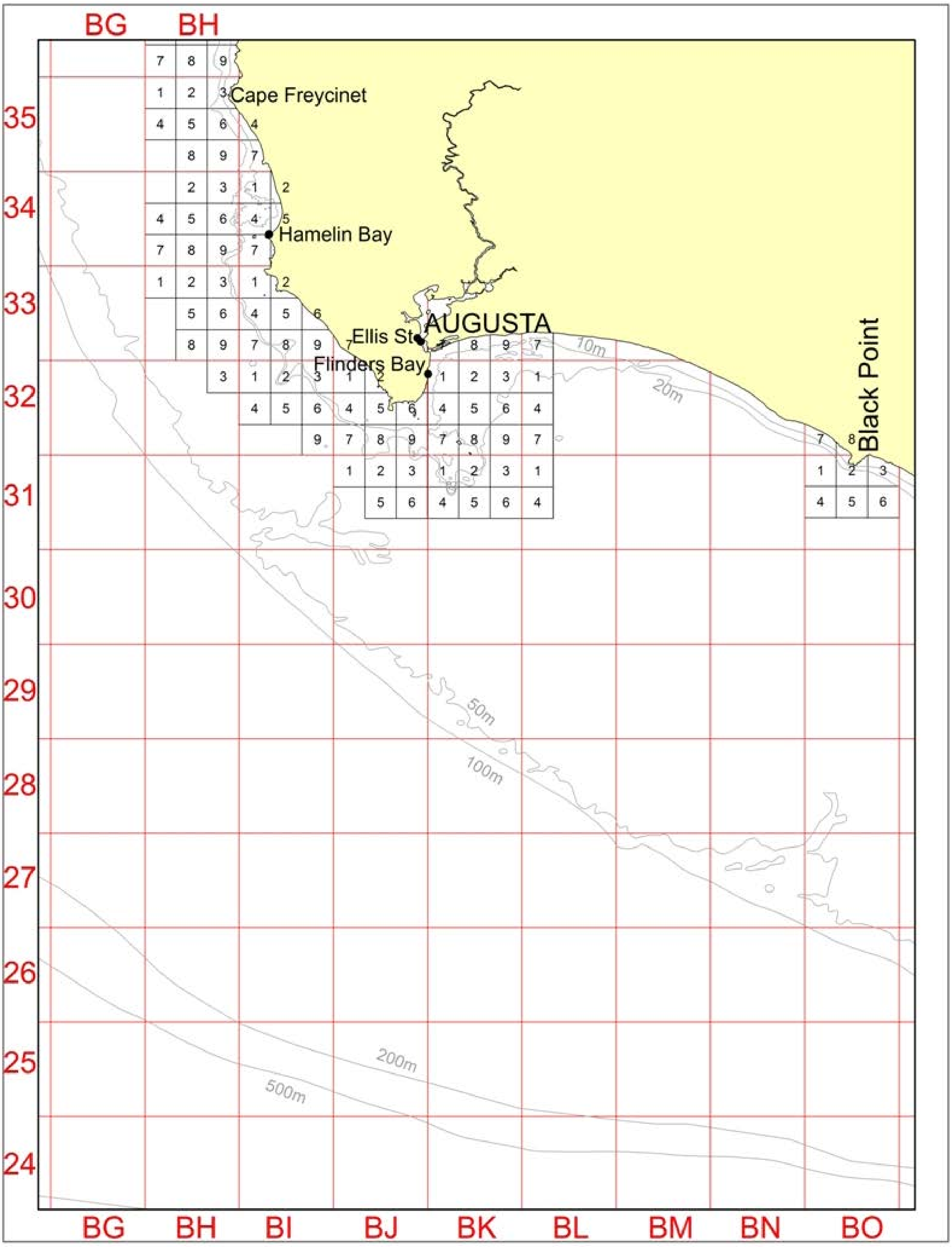
1) What is the bag limit for ______________________ *targeted/predominant species from catch?*

CORRECT	INCORRECT	DONiT KNOW

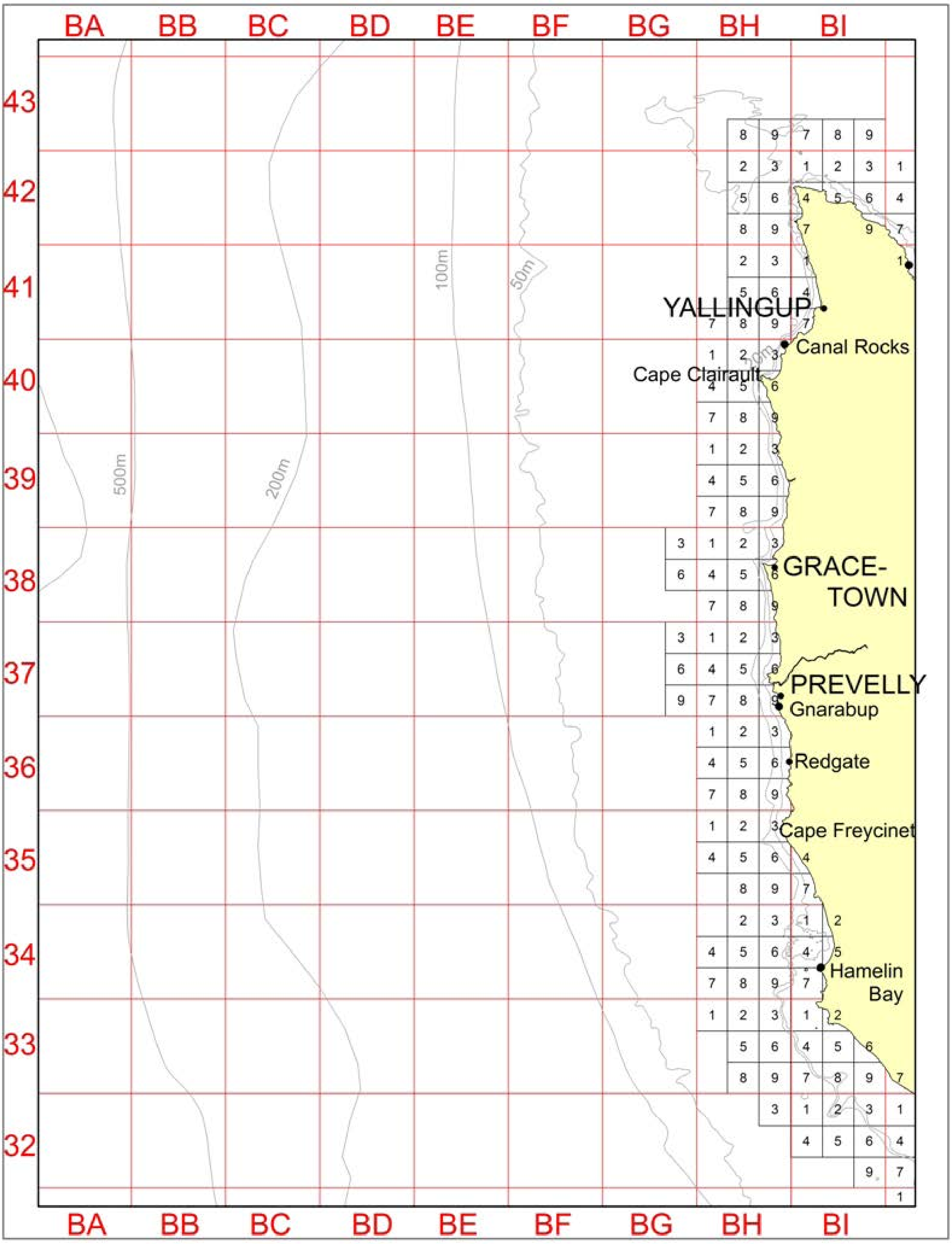
2) What is the size limit for ______________________ *targeted/predominant species from catch?*

CORRECT	INCORRECT	DONiT KNOW

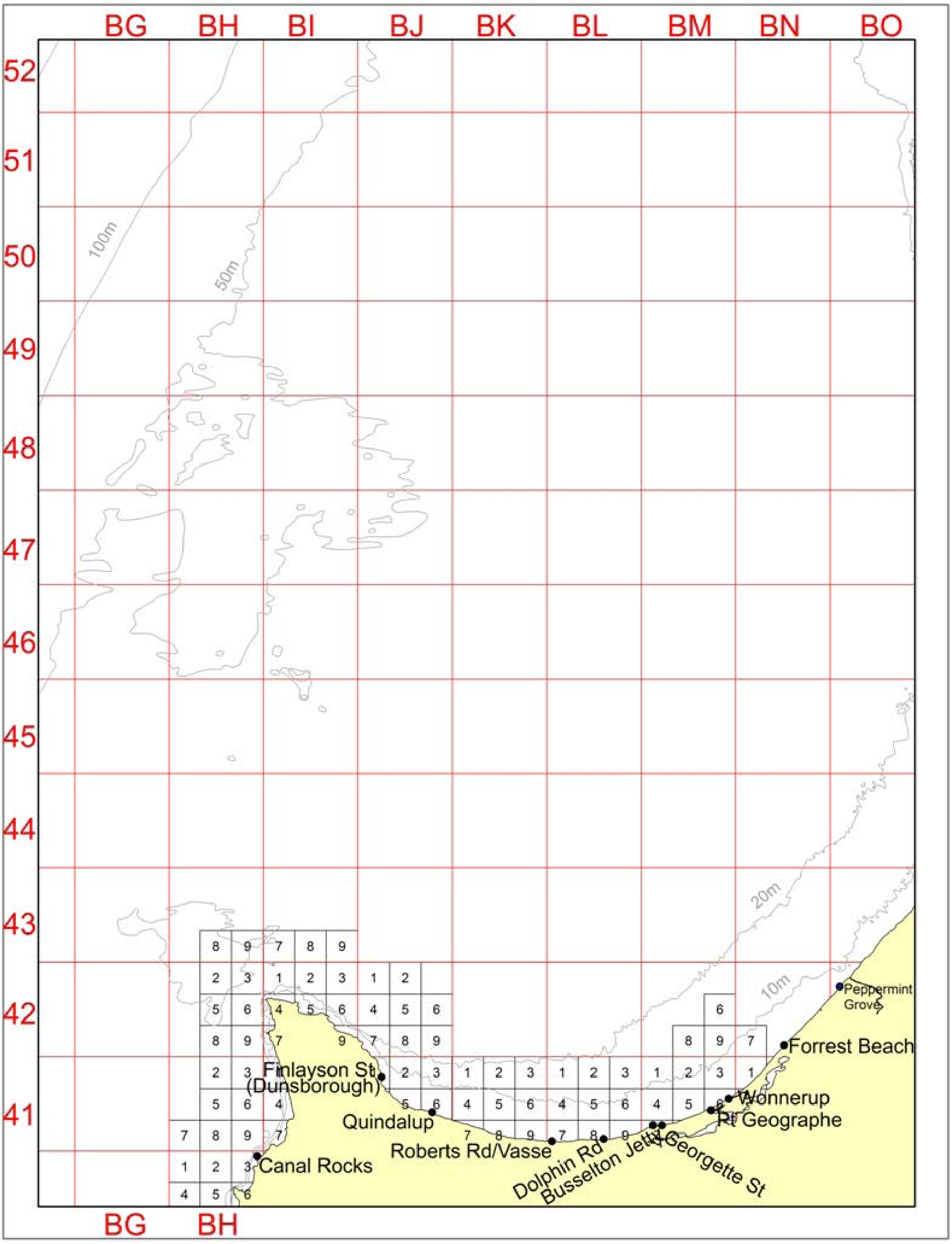
Appendix 8.4 Recreational fishing block sheets



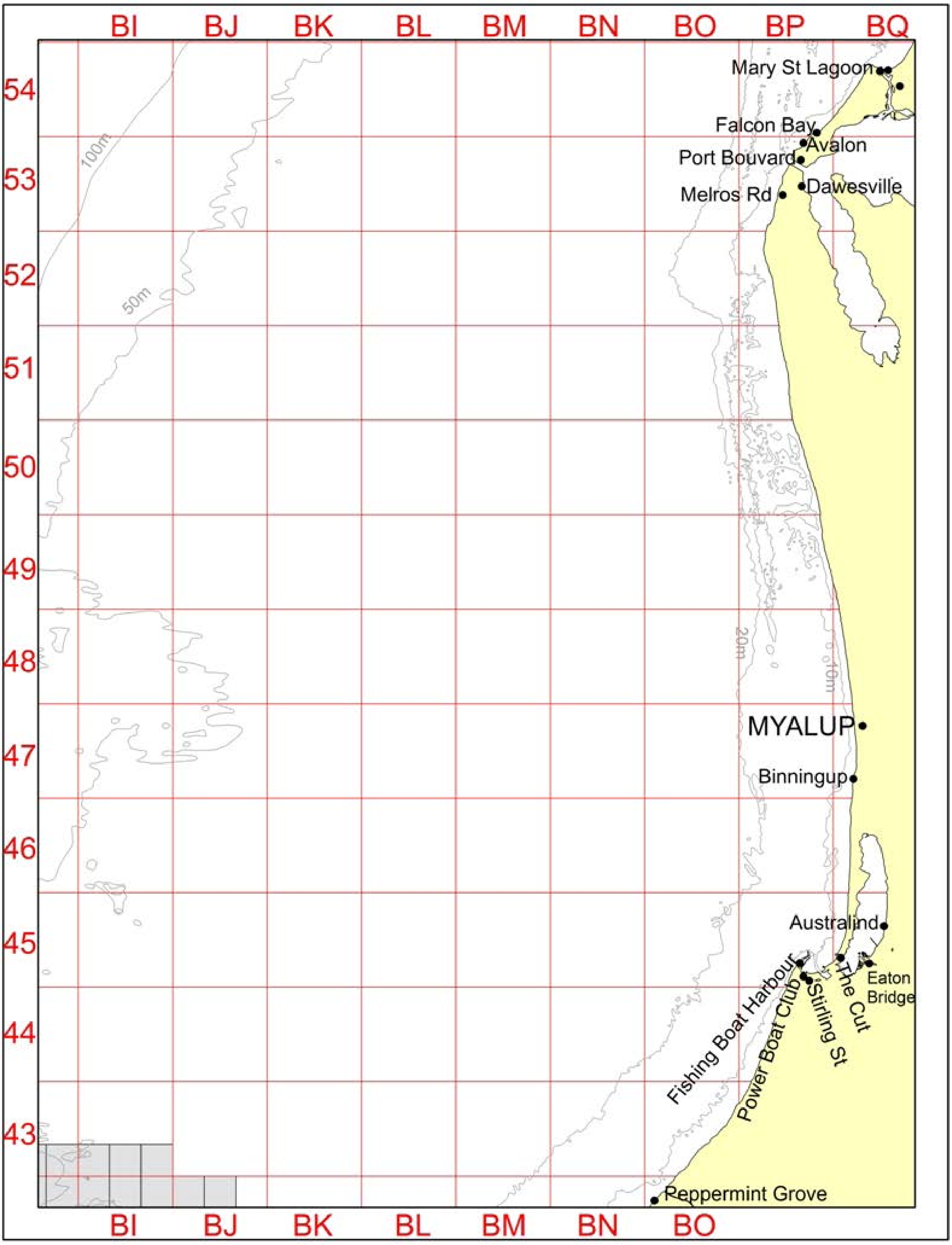
Augusta


BA BB BC BD BE BF BG BH BI
43
42
41
40
39
38
37
36
35
34
33
32
500m
200m
100m
50m
YALLINGUP
Canal Rocks
Cape Clairault
GRACE-
TOWN
PREVELLY
Gnarabup
Redgate
Cape Freycinet
Hamelin
Bay

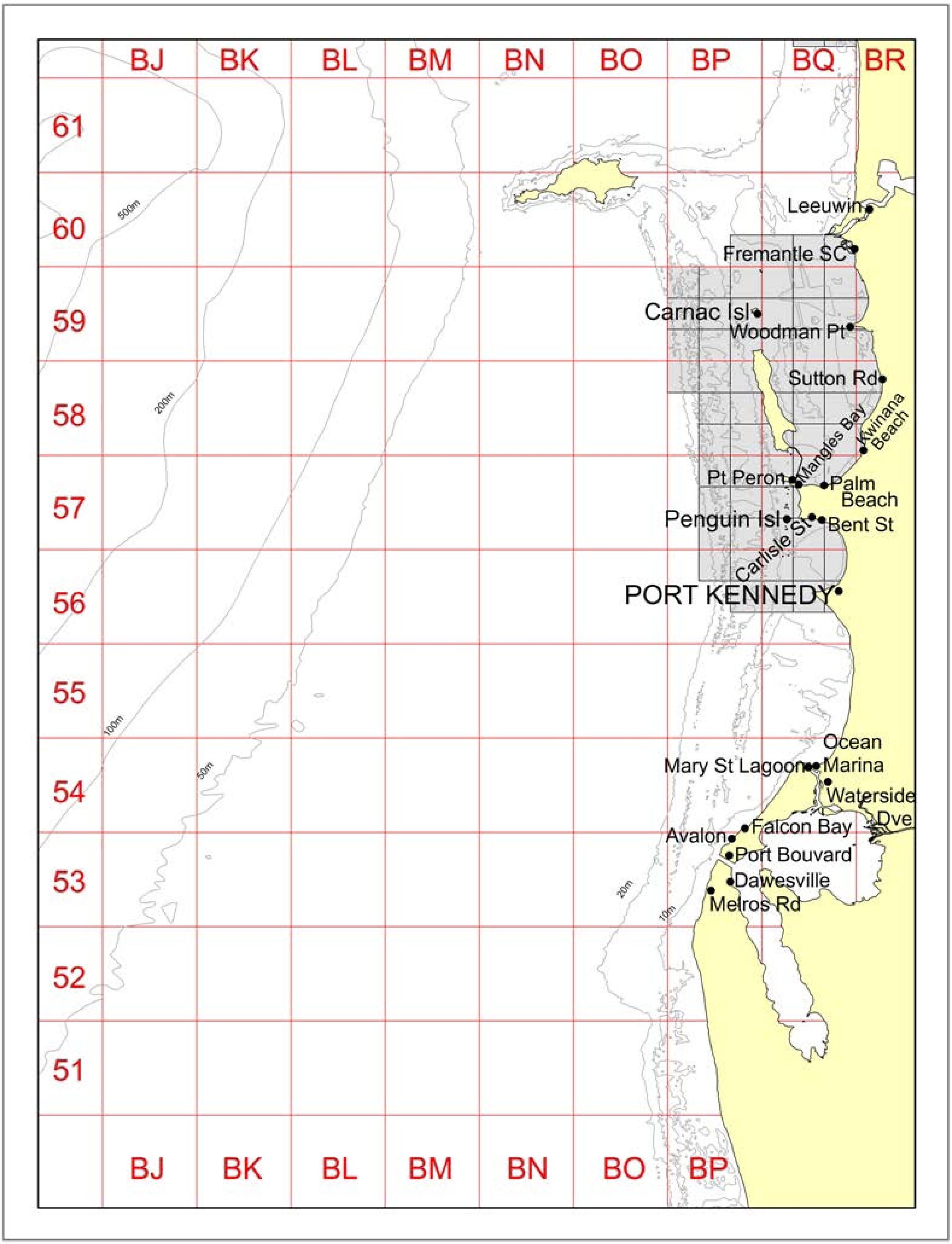
Cape to Cape



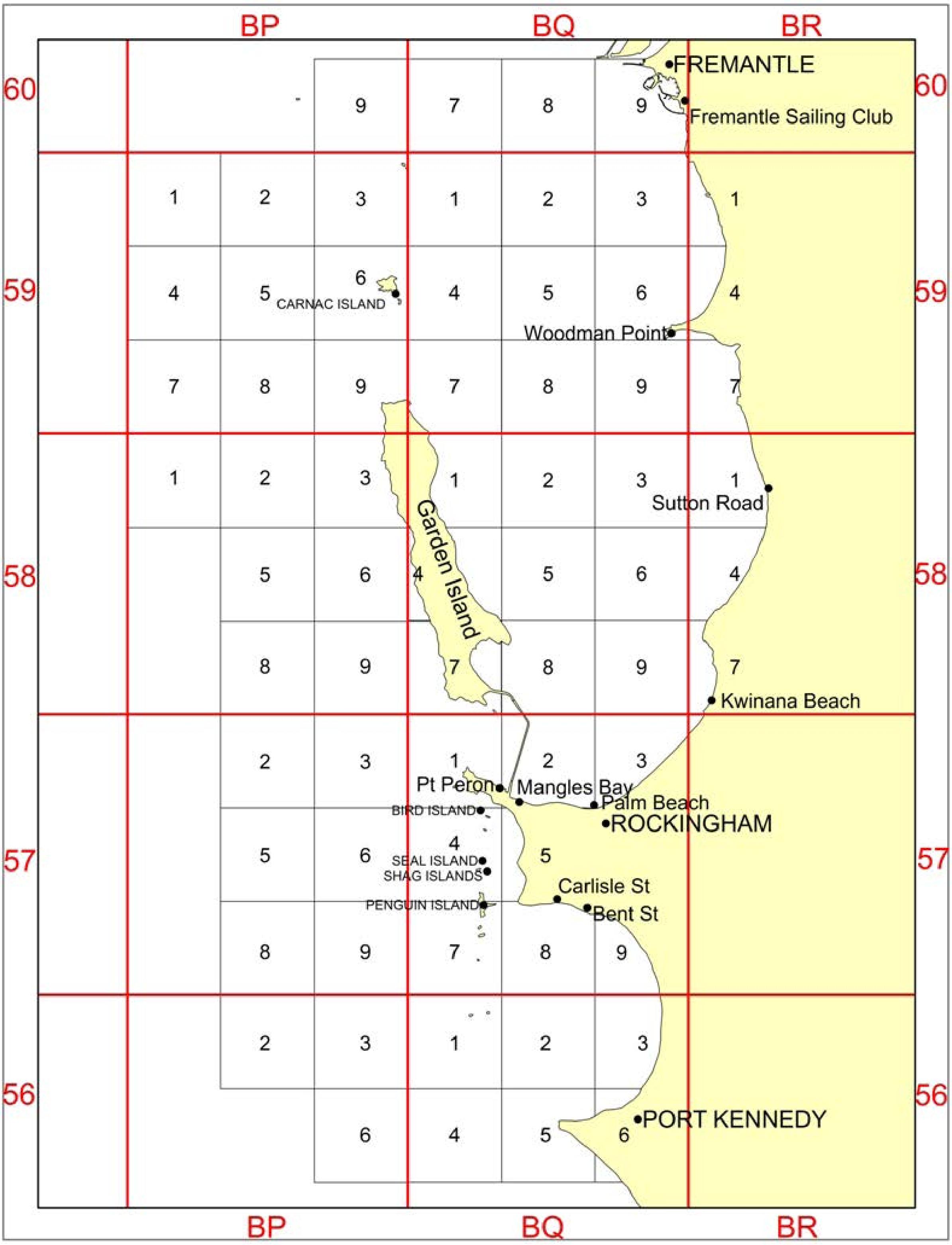
Geographe Bay



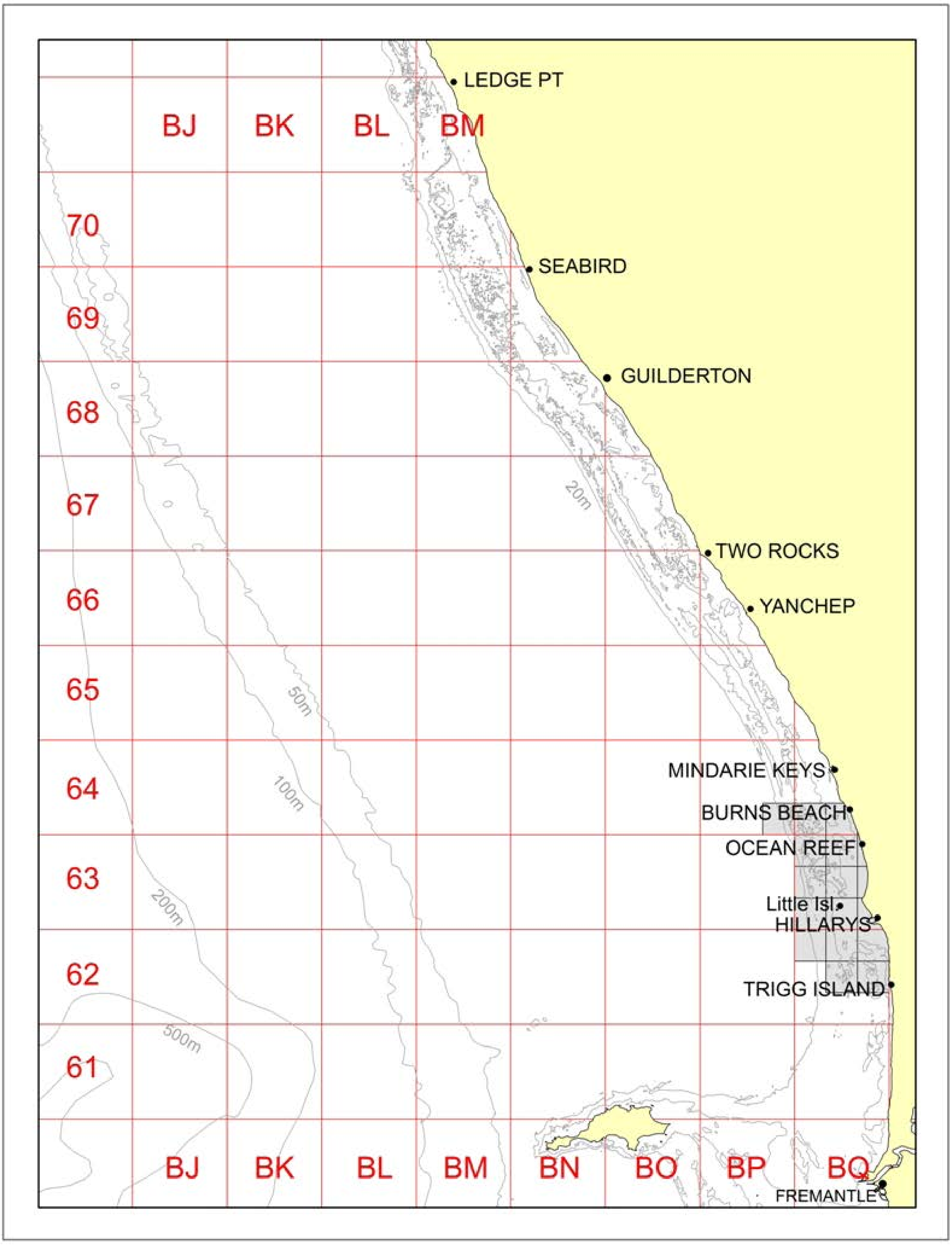
Mandurah to Bunbury



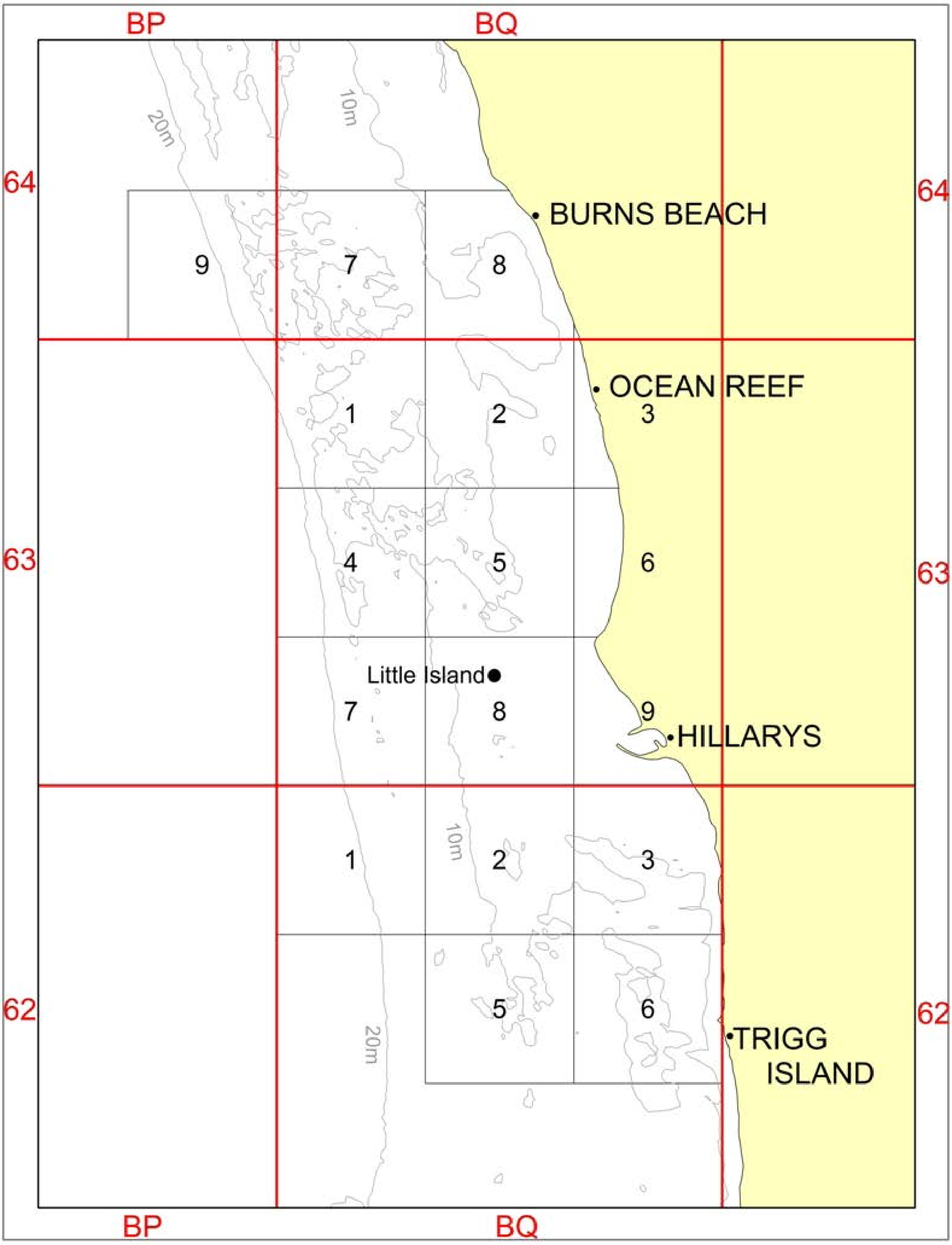
Fremantle to Mandurah



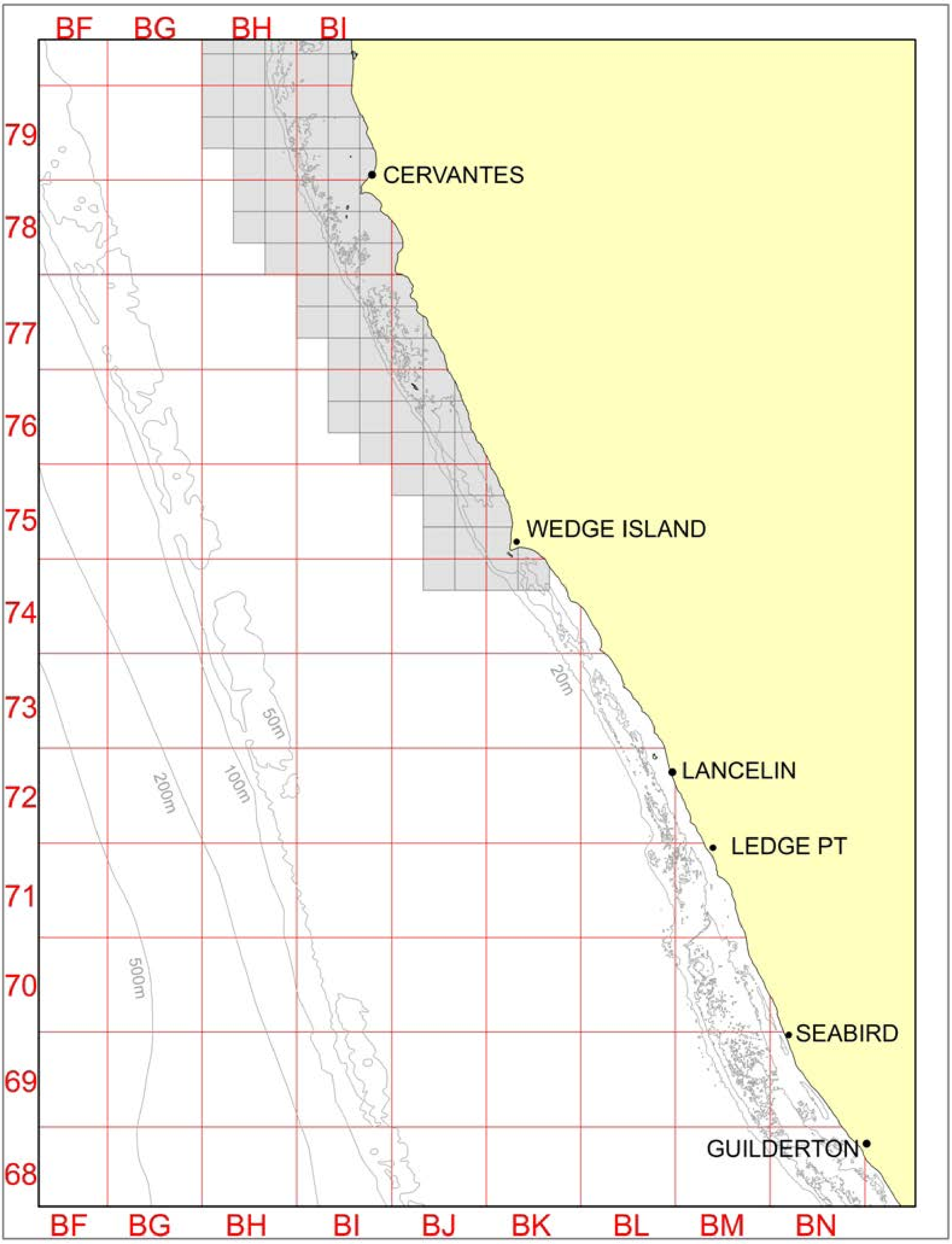
Carnac Island to Shoalwater Bay



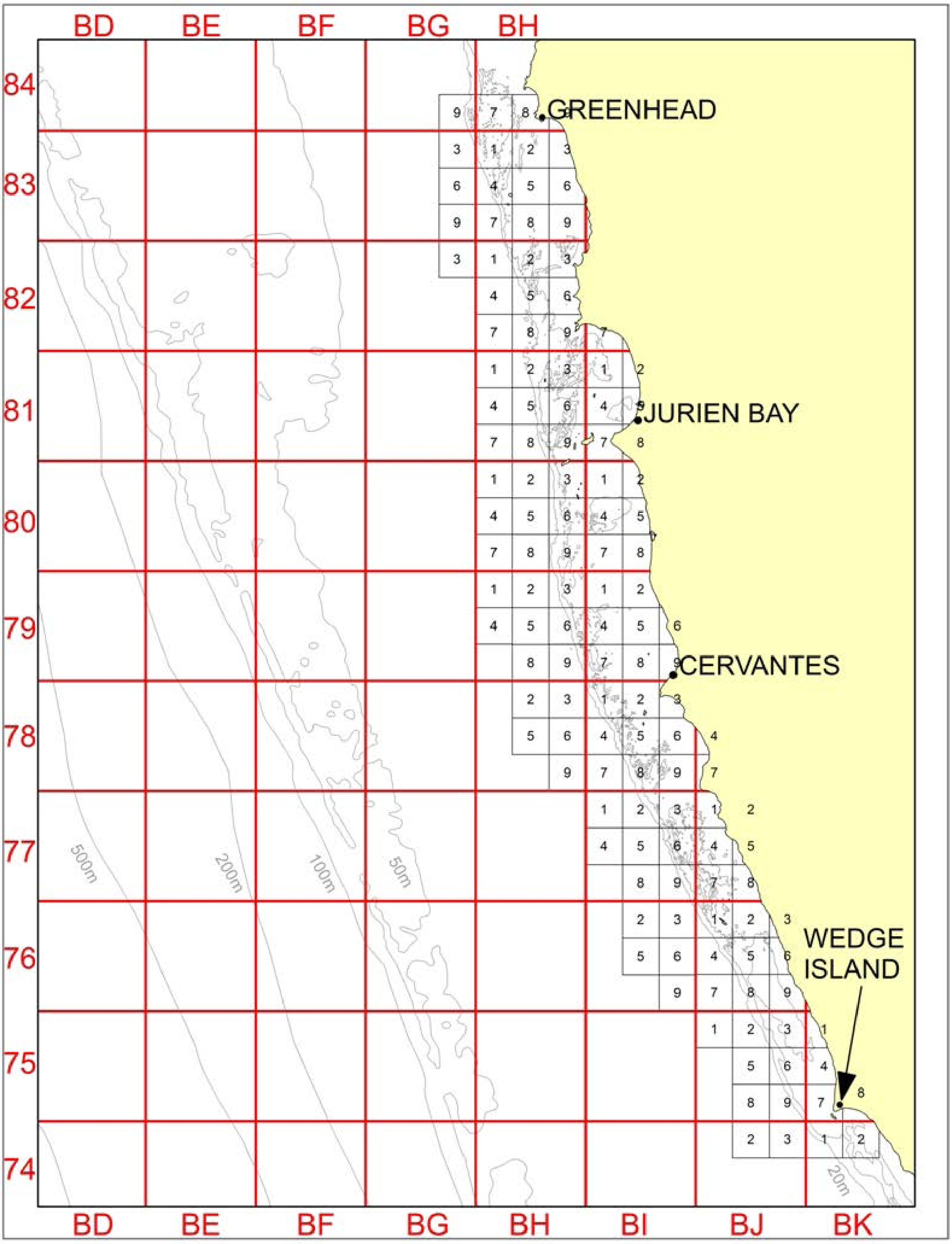
Fremantle to Ledge Point



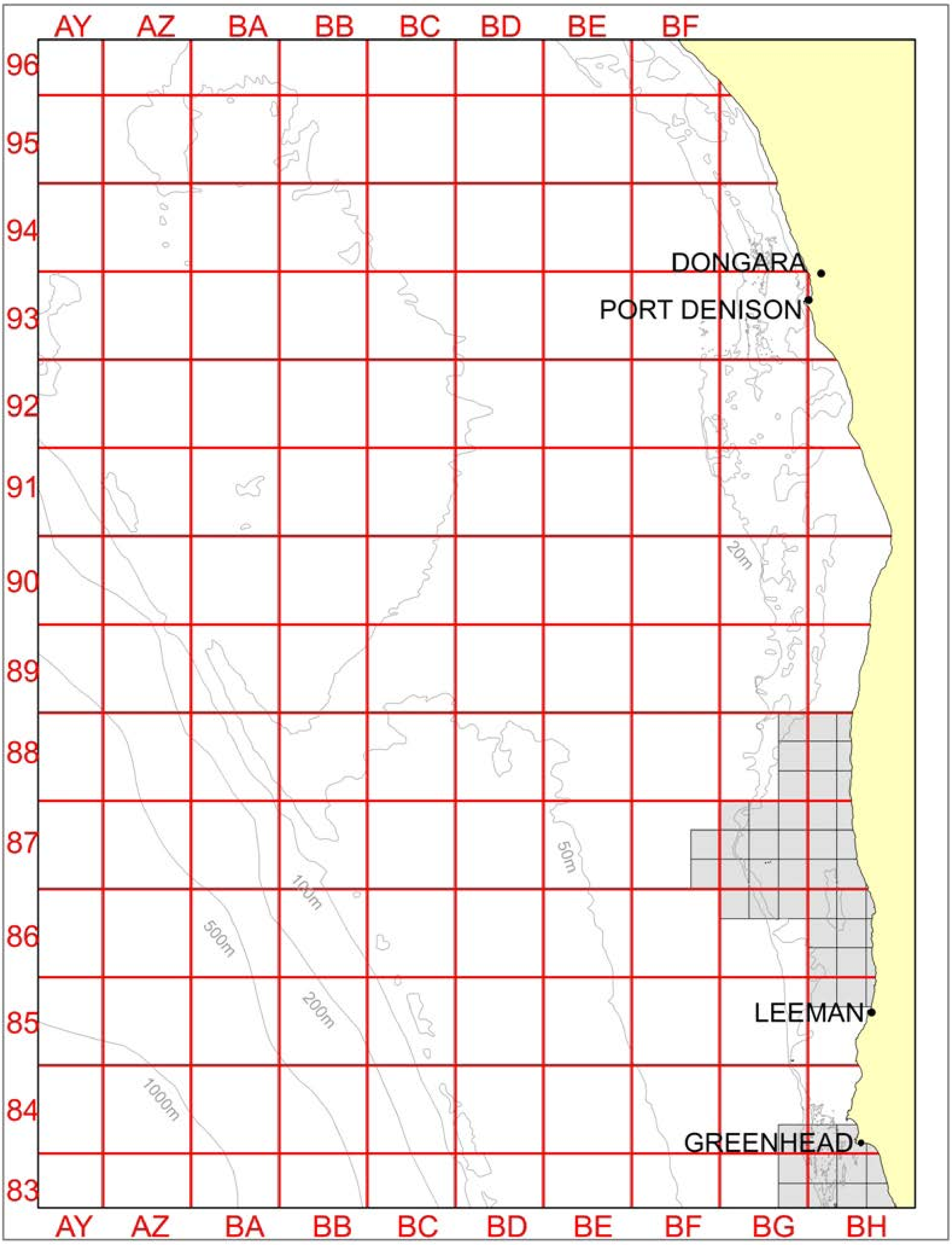
Marmion Marine Park



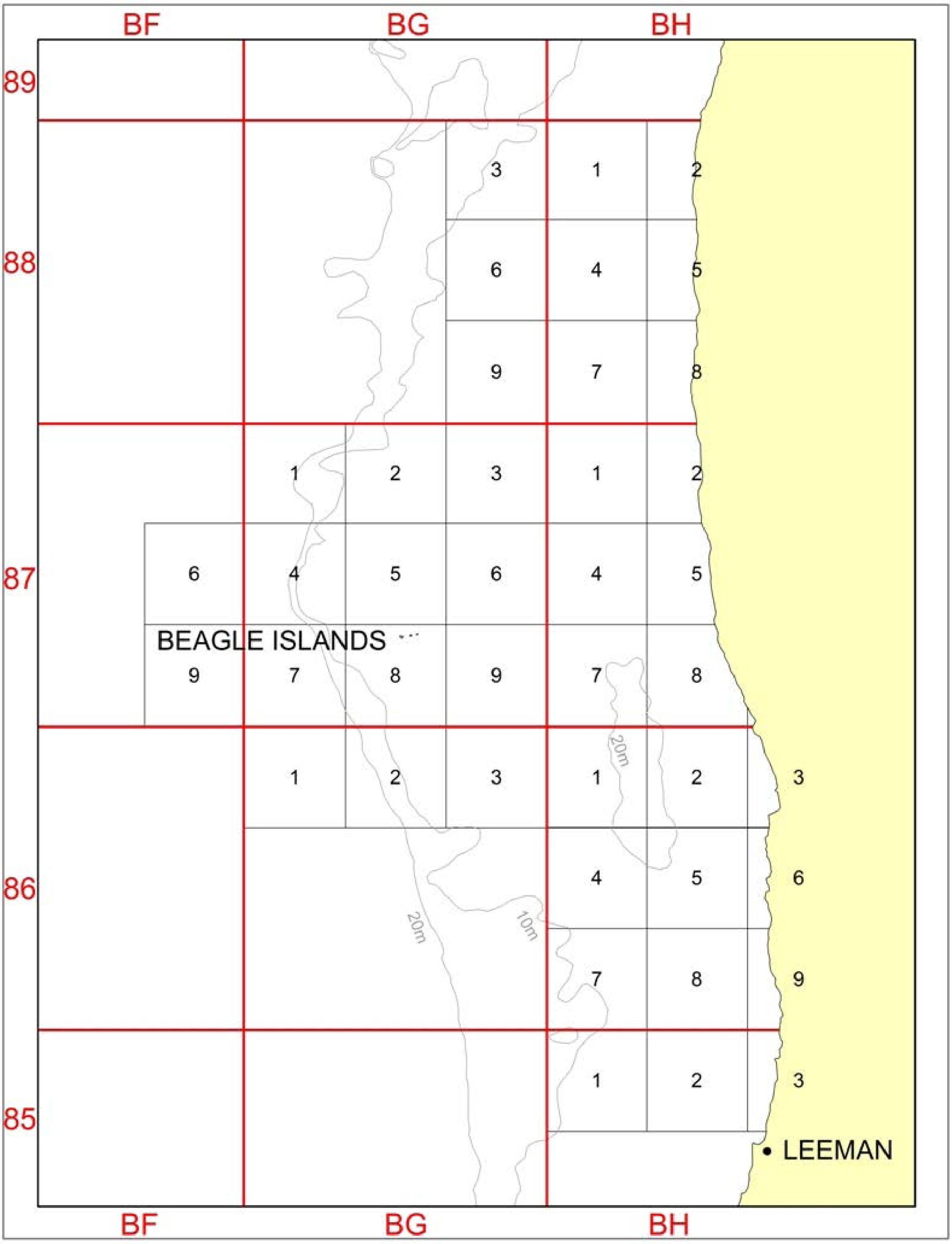
Seabird to Cervantes



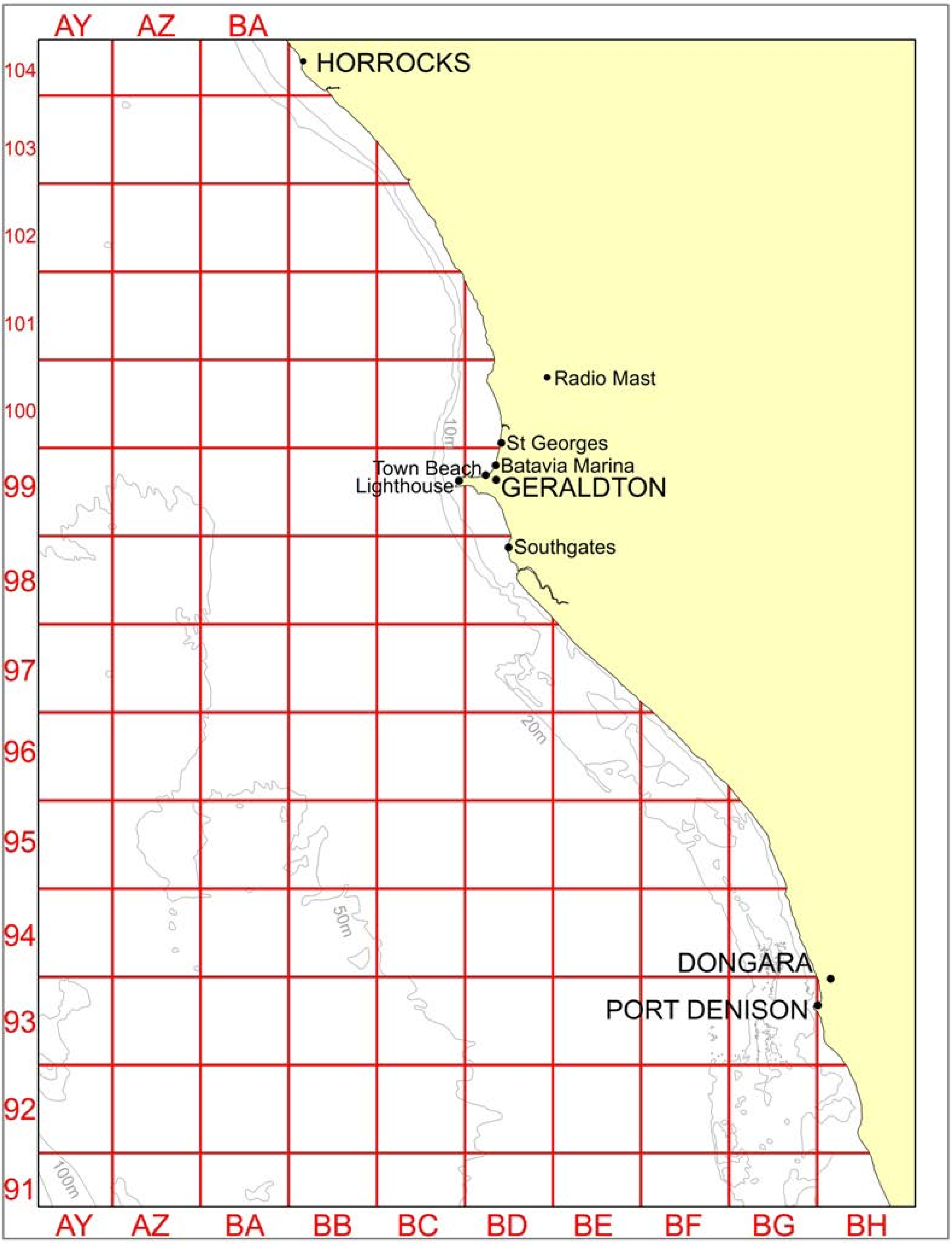
Jurien Bay Marine Park



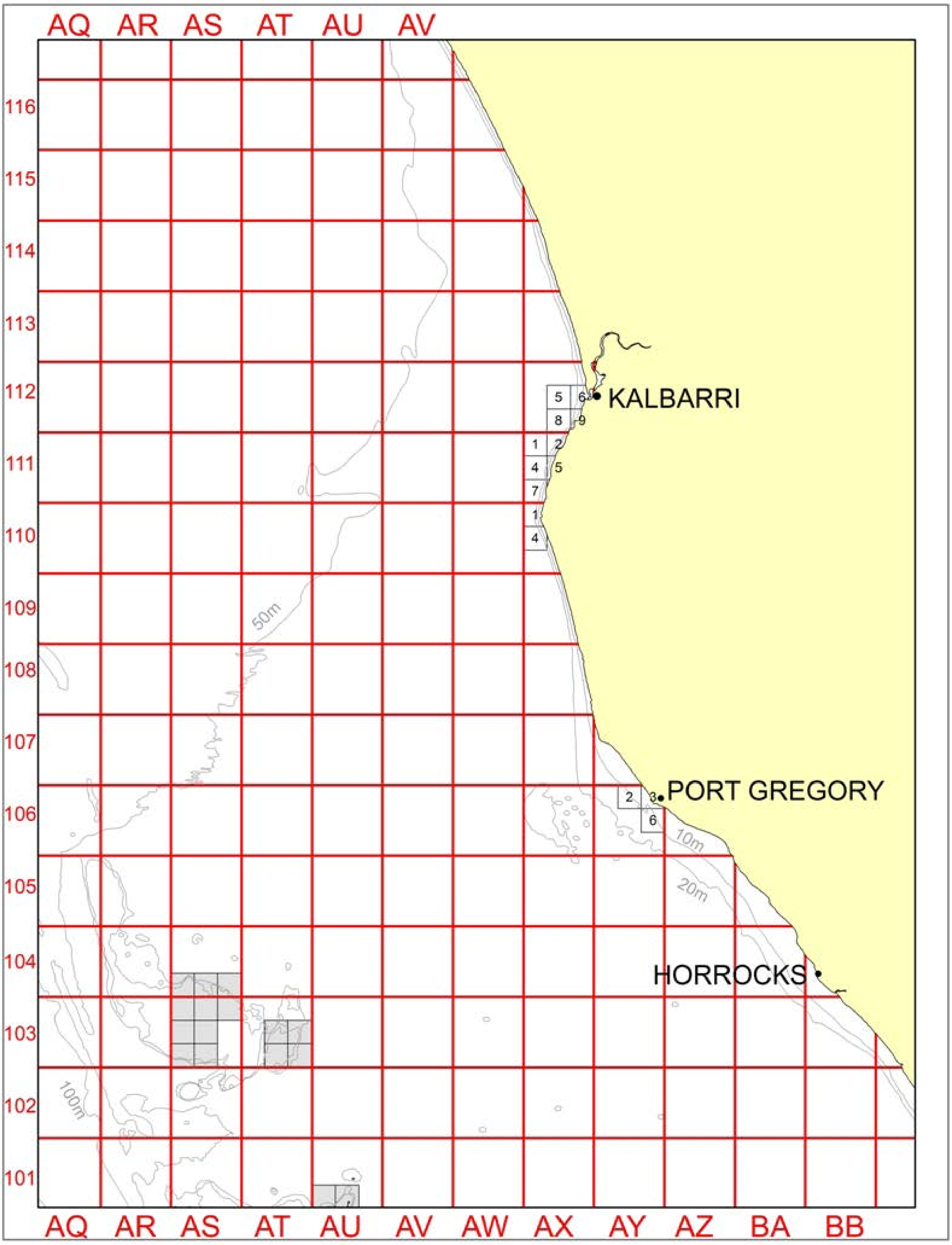
Greenhead to Dongara



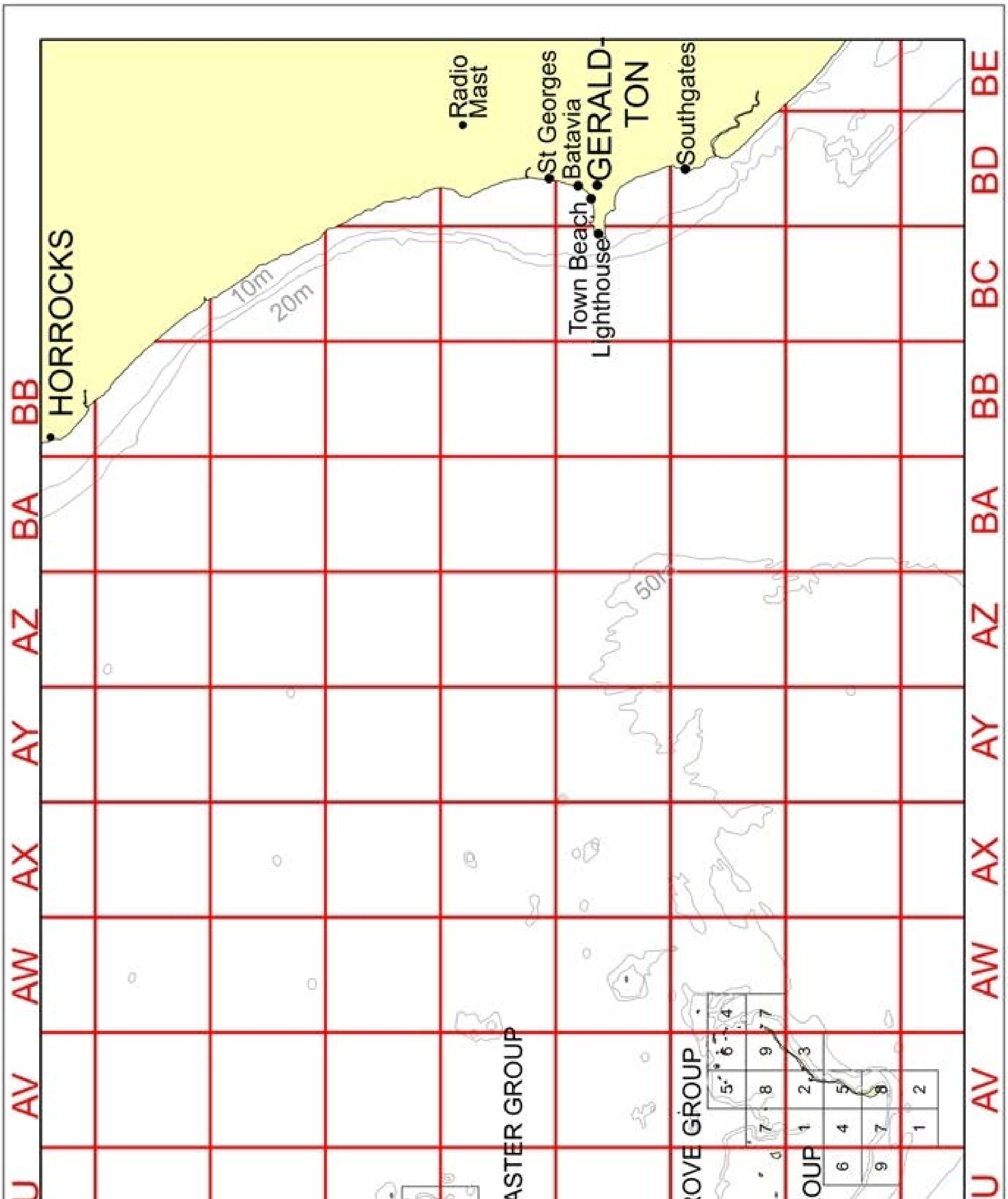
Beagle Islands Marine Park



Dongara to Horrocks



Horrocks to Kalbarri



Geraldton and the Abrolhos Islands

Appendix 8.5 Mail-phone-diary forms

Survey letter

Letter from DPI

<Given Name> <Surname>
<Address>
<Suburb> WA <Postcode>

Dear <Given Name>

Re: Survey of Recreational Boat-based Fishing

I am writing to seek your participation in a survey of recreational boat owners to assist with a research project being undertaken by the Department of Fisheries' Research Division.

The boat <Boat Registration Number> that you have just purchased is currently in the study. It is important that we keep the boats in the study wherever possible.

You will be called and may be asked to participate in a survey of recreational boat-based fishing between Augusta and Kalbarri. The project is seeking to determine the total recreational boat-based catch and fishing effort between Augusta and Kalbarri.

An interviewer from the Department of Fisheries will telephone you soon to conduct the initial interview.

The researchers would appreciate your participation in the voluntary telephone interview, which will take about 5 minutes. Some boat owners will be asked to participate in a 12-month survey.

The Department of Fisheries advises that your responses will be held in the strictest of confidence; no personal information will be given outside of the research team.

Your name, address, telephone number and boat registration details will be released to the Department of Fisheries for the specific purposes outlined above.

If you wish to be removed from this survey sample, please return the bottom of this letter to:

Tara Baharthah, Research Scientist,
Hillarys Research Facility,
PO Box 20,
NORTH BEACH WA 6920 **before close of business <Date>.**

Yours sincerely

Manager Recreational Boating
<Date>

....

<Given Name> <Surname>
<Address> <Suburb> WA <Postcode>
<Boat Registration Number>

Mail-phone-diary: Screening interview.

RECORD ALL DETAILS ON THE BLUE FORM.

Good morning/afternoon, my name is . . . . from Department of Fisheries, Research Division.

May I please speak to . . . (NAME OF REGISTERED BOAT OWNER)?

The Department of Fisheries Research Division is conducting a survey of registered boat owners and their fishing activities on the West Coast during the next 12 months. You would have been sent a letter from Department for Planning and Infrastructure to notify you of this survey.

Just a couple of questions:

Q1) Has your boat (DESCRIBE THE BOAT) been used for an kind of recreational fishing including angling, crabbing, prawning, spearfishing, collecting abalone or aquarium fish [Other Recreational Fishing may include Marron, Netting, Oysters, Rock Lobsters]) on the West Coast (between Augusta and Kalbarri) during the last 12 months?

Q2) How likely will your boat be used for recreational fishing on the West Coast (between Augusta and Kalbarri) during the next 12 months?

Very Likely	1
Quite Likely	2
Not Very Likely	3
Not At All Likely	4
UNSURE	5

IF Q1 = YES OR Q2 = 1 or 2 then:

We will provide you with a diary and we would like you to record brief details in your diary each time you or any other person using your boat goes recreational fishing from your boat on the West Coast during the next 12 months.

It's quite simple and it only takes a minute.

I'll call you every now and then to get the information from you (over the phone).

The diary is to help you remember and we don't see it or get it back from you. Also, you may prefer to use your own codes and abbreviations … really it's whatever works best for you. But please ensure that you record <u>times and daily catch details for each time you or any other person goes recreational fishing from your boat on the West Coast</u> whether or not you catch anything.

The survey starts on the 1st July 2005 and will finish at the end of June 2006. The aim of the survey is to measure what people <u>normally</u> do … so, we don't want you to go fishing any <u>more</u> or any <u>less</u> often than you normally would have done during this time.

If I couldn't contact you on this number, is there another number I could get you on?
(WORK PHONE NOT USED UNLESS REQUESTED).

If for some reason I couldn't contact you (on either of these numbers), could you give me the name and phone number of someone who would know how to contact you?
(EXPLAIN: doesn't happen often, but in surveys covering a period of time, sometimes people move unexpectedly).(CONFIRM MAILING ADDRESS OF REGISTERED BOAT OWNER)

Thank you for your time.

OTHERWISE: that's all I need to know from you. Thank you for your time.

Mail-phone-diary: Diarist forms.

Department of Fisheries

Survey of Recreational Boat Based Fishing on the West Coast of Western Australia 2005 - 2006

Fish for the future

Diary Card For:

- Please record brief details for **each time** your boat is used for recreational fishing on the west coast... whether you **catch anything or not.**
- Your survey period is from 1 July 2005 to 30 June 2006.
- Any questions or problems? Please ask your interviewer next time she/he calls.

2005/2006

July

S	M	T	W	T	F	S
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

August

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

S	M	T	W	T	F	S
30	31					1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

November

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

December

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

January

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

March

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

S	M	T	W	T	F	S
30						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

May

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

June

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

When & Where? • Date • Fishing Location	Times • Launch Time • Retrieval Time • Time Spent Fishing		Fishing Method Line Fishing Lobster Pot Crab Net Other Netting Diving-Snorkelling or With Air	Fishers Number of fishers	Catch anything? Species	Catch from your boat	
						Kept	Released
EXAMPLE 1	Launch Time	Retrieval Time					
10-Jul	10:30	13:30			Australian Herring	5	0
Hillarys		2 hrs	Line Fishing	2	Tailor	2	1
					Whiting - King George	1	0
					Blowfish	0	6
EXAMPLE 2	Launch Time	Retrieval Time					
10-Nov	9:30	12:30					
Peel Inlet		1 hr	Crab Nets	2	Blue Swimmer Crab	3	4
		1.5 hrs	Line Fishing	2	Nil kept / released	-	-
EXAMPLE 3	Launch Time	Retrieval Time					
08-Dec	8:30	10:30					
Jurien		24 hrs	Lobster Pots	2	Nil kept / released	-	-
		1 hr	Diving - With Air	2	Western Rock Lobster	4	2
START HERE	Launch Time	Retrieval Time					
	Launch Time	Retrieval Time					

When & Where? • Date • Fishing Location	Times • Launch Time • Retrieval Time • Time Spent Fishing		Fishing Method Line Fishing Lobster Pot Crab Net Other Netting Diving-Snorkelling or With Air	Fishers Number of fishers	Catch anything? Species	Catch from your boat Kept	Released
	Launch Time	Retrieval Time					
	Launch Time	Retrieval Time					
	Launch Time	Retrieval Time					
	Launch Time	Retrieval Time					
	Launch Time	Retrieval Time					

Mail-phone-diary: Interviewer forms.

SURVEY OF RECREATIONAL BOAT BASED FISHING ON THE WEST COAST OF WA - 2005/06

DIARY SURVEY COVER SHEET

Sample No: | | | | | | Boat Registration: | | | | | |

Boat Owner's Details

First Name: .... Surname: ....

Address: ....

Suburb/Town: .... Postcode: ....

Home Phone: .... Other Phone No.: ....

Best Time to Call: ....

Other (incl. away info): .... Sex: M F

Alternative Contact Person: ....

Relationship: .... Phone No.: ....

Final Response Report

Fully responding	1
Full refusal	2
Part refusal	3
Full non-contact	4
Part non-contact	5

OTHER ....

If not a full response - record last month of data: ....

Are you of Aboriginal or Torres Strait Islander descent?

1 2 REFUSED

Other User's/Owner's Details

First Name: .... Surname: .... Address: ....

Suburb/Town: .... Postcode: .... Phone No.: ....

Boat Details

Boat Type: .... Boat Length (m): .... Material: ....

Licence Expiry Date: ..../........./.........

Other Information

....

....

Call Details

Day/Mth	Time	Result (C/NC/NA)	Day/Mth	Time	Result (C/NC/NA)	Day/Mth	Time	Result (C/NC/NA)
...../	....	....	...../	....	....	...../	....	....
...../	....	....	...../	....	....	...../	....	....
...../	....	....	...../	....	....	...../	....	....
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...../	....	....	...../	....	....	...../	....	....
...../	....	....	...../	....	....	...../	....	....

Appointments

Day/Mth	Time	Other/Fishing plans
...../	....	....
...../	....	....
...../	....	....
...../	....	....
...../	....	....
...../	....	....
...../	....	....
...../	....	....
...../	....	....

PART 1 *IDENTIFICATION OF DAYS / DATES*

Your survey period started… (Last time we spoke was …)

Since then, have you done any recreational fishing from your boat (BOAT NAME) on the west coast, including any days when you didn't catch anything?

IF NO FISHING – GO TO PART 3

IF ONE DAY'S FISHING – GO TO PART 2

IF MORE THAN ONE DAY'S FISHING – ASK THE FOLLOWING:

So where did you go fishing from your boat on these days? Did you fish from your boat anywhere else during this time?

PART 2 *FOR EACH DATE / EVENT*

(CHRONOLOGICAL ORDER USUALLY: What did you do first/next?)

Q1. START DATE: So (that/the first/the next) day was . . .

Q2. PERSONAL / PROXY: ARE YOU SPEAKING TO THE DIARY HOLDER (BOAT OWNER) WHO WAS ON BOARD FOR THE FISHING TRIP OR ANOTHER FISHER ON BOARD OR A PROXY?

Q3. DIARISED DATA: (And) did you fill out your diary for this day? Have you got it there?

Q4. FISHERS ON BOARD: How many people were fishing from your boat that day?

Q5. BOATING TIMES: (And) what time did you launch your boat … (that day)? What time did you retrieve your boat? How long were you actually fishing?

Q6. LAUNCH TYPE: From what structure did you launch your boat from eg: ramp, beach, canal, permanent or temporary mooring?

Q7. FISHING AREA: Were you fishing in the ocean, an estuary or a river?

Q8. FISHING REGION: Where did you go fishing that day? Did you fish anywhere else that day?

Q9. FISHING METHOD: What fishing method did you use that day? Any other methods?

Q10. CATCH: (And) did you catch anything (that day)? Did you catch anything else (that day) that you released?

PART 3 *AFTER LAST EVENT RECORDED*

Q11. COMMENTS: (RECORD ANY COMMENTS)

(And) do you have any fishing trips planned for the next two-three weeks?

Sample No. | | | | | |

Event Number

1. Start Date

Day | Month

End (if diff, plus ...)

2. Personal / Proxy

Diary Holder on board - Personal 1

Fisher on board - Personal 2

Proxy 3

3. Diarised Data

Yes (all) 1

No (incl. Partial) 2

4. No. Fishers on Board

Number of fishers on board

5. Boating Times

Launch Time (24hr clock)

Retrieval Time (24hr clock)

Fishing Time (hrs:min)

6. Launch Type

Ramp 1

Beach 2

Canal 3

Permanent Mooring - Marina 4

Temporary Mooring - Anchorage 5

7. Fishing Area

Ocean 1

Estuary 2

River 3

8. Fishing Region (*SPLIT*)

9. Fishing Method (*SPLIT*)

Line Fishing 1

Lobster Pot 2 — S P

Crab Net 3

Other Netting 4

Diving - Snorkelling 5

Diving - With Air 6

10. Catch

	Kept	Released
Cod, Breaksea (Black Arse)		
Crabs, Blue Swimmer (Blue Manna)		
Dhufish		
Garfish (Gardies)		
Groper, Baldchin		
Herring, Australian		
Rock Lobster, Western		
Salmon, Western Australian		
Snapper, Pink		
Squid		
Tailor		
Tarwhine (Silver Bream)		
Trevally, Silver (Skippy)		
Whiting, King George		
Whiting, Other		

Nil Kept / Released ***x***

11. Comments

Appendix 8.6 MSI survey form used by FMOs

Recreational Marine Safety Inspections
Last modified: 01/01/2006

District:	Date: / /
FMO:	Page ___of___

WEST COAST BIOREGION
Return *ORIGINAL* to: Anita Ward, CSU
PO Box 20, North Beach, WA 6920

Contact Codes:				Equipment Checks:	Rec Survey Notes: Species Codes etc:
0 – Safety check 1 – Speed Checks 2 – Out of ski area 3 – No rego sticker	4 – No rego 5 – Age of driver/obs. 6 – Tied to nav mark 7 – 45 m offshore 8 – Obstr. channel	9 – Poor navigation 10 – Mooring problem 11 – Tow/assist 12 – General skiing 13 – General queries	14 – Other 15 – PWC 16 – Nav. Lights 17 – Rec Survey Only	Tick – correct/present X – incorrect/absent O – not required (or exempt)	Y – has been fishing; W – will be fishing N – will not/has not fished PS – Pink Snapper; DH – Dhufish, BR – Breaksea Cod; BG – Baldchin Groper; HE – Herring; TA – Tailor; SC – Swimmer crabs.; RL – Rock Lobsters. Eg. Y W N | 1 | 1 | | | | | 12

Area	Time 24h	Vessel Number	Contact code	Tick only ONE: PV		Land		Rego & Equipment Checks: Rego	Life Jacket	Flares	Para Flares	Fire Exting	Anchor & Line	Bilge & Bailer	Radio	EPIRB	Officer notes: # of people	Remarks	Rec. Fishing Survey: Fishing?	PS	DH	BR	BG	HE	TA	SC	RL
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
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																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								
																			Y W N								

Comments: ____

Reporting Officer: ________________ (signature)
Date: ____ /____ /____

Supervisor: ________________ (signature)
Date: ____ /____ /____

Appendix 8.7 VFLO survey form

Sheet .... of ....

FISHERIES
WESTERN AUSTRALIA

VFLO Interview Log Sheet

VFLOs: ______________________

____

Date: ____/____/____

Location: ______________________

Start time: ______________________

End time: ______________________

VFLO Boat: ☐

No. of Shore fishers: ☐

No. of Boat Trailers: ☐

WIND

Calm	Light	Mod	Strong	Gale
1	2	3	4	5

Direction: __________

WATER

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

CLOUD COVER & RAINFALL

Cloud %	Nil	Light	Moderate	Heavy
	1	2	3	4

Shore-based contacts (TALLY): ☐

Boat contacts (TALLY): ☐

LENGTHS OF RANDOM SAMPLE (mm)

Species: ______________________
Lengths: ______________________
Species: ______________________
Lengths: ______________________
Species: ______________________
Lengths: ______________________
Species: ______________________
Lengths: ______________________
Species: ______________________
Lengths: ______________________

Fisher Number	1	2	3	4
Time of interview				
Time spent fishing (decimal hours)				
Age group				
Sex				
Postcode				
Member angling club (Y/N)				
Boat/Shore/Dive/sNorkel				
Number in group				
Number of persons fishing				
Number of lines used				
Gear (Number and Type)				
Species 1				
Total number kept				
Number released				
Number undersize kept				
Species 2				
Total number kept				
Number released				
Number undersize kept				
Species 3				
Total number kept				
Number released				
Number undersize kept				
Species 4				
Total number kept				
Number released				
Number undersize kept				
Species 5				
Total number kept				
Number released				
Number undersize kept				
Boat Registration Number				

Gear Types

DR: Drop net (crab or marron)
SE: Set (or gill) net
HA: Haul (or drag) net
CA: Cast (or throw) net
PO: Pot (rock lobster)
SC: Scoop (crab, prawn or marron)
SN: Snare (rock lobster or marron)
HO: Hook (rock lobster or crab)
SP: Spear

Issues/Comments:

____
____
____
____
____
____

NB: Contacts - fishers or prospective fishers spoken to but not interviewed in detail

Appendix 8.8 RAP logbook.

Angler's Log Book

OCEAN EDITION

Department of Fisheries
Government of Western Australia

RESEARCH ANGLER PROGRAM

Fish for the future

RES440/07

By completing this log book, you are providing essential biological information that will be used by fisheries researchers to manage the fish resources of Western Australia in a sustainable manner.

Log book data will be used to monitor changes in the size, structure and distribution of fish and invertebrate populations along ocean beaches and in offshore waters. Data from this log book will be combined with other types of environmental data (e.g. water quality) to better understand the factors that affect the health of fish populations. Fish are near the top of the food web and their health is a useful indicator of the overall condition of the ecosystem that supports them.

Personal details that you provide will remain confidential.

Please return the white pages (originals) at the end of each month to the:

'Research Angler Program'

in the supplied envelopes or post to the following address:

Research Angler Program
Department of Fisheries
PO Box 20,
North Beach, 6920

Keep the yellow pages for your own records.

Instructions

THIS LOG BOOK IS FOR OCEAN BEACH AND OFFSHORE FISHING ONLY. ONLY RECORD YOUR OWN PERSONAL FISHING INFORMATION. DO NOT RECORD CATCHES OF OTHER ANGLERS IN THIS LOG BOOK.

Start a new page for each day of fishing. You can use more than 1 page per day. If you use several pages in one day, make sure you write the date on all pages.

If you went fishing and caught zero fish, record this by ticking the box at top of page. Then record location, depth, start/finish times, gear, tackle and bait used.

Complete a separate line for each fish caught. Record details of all fish and invertebrates caught (including crabs, rock lobster and abalone), whether retained or released, including details of 'trash' fish such as blowfish. Include as many details as possible about each fish.

- **Location** can be recorded as a block number, as a latitude/longitude coordinate or as a well-recognised, precise name (e.g. Halls Head, Mandurah). When fishing at Rottnest Island, or in the surrounding waters, use the block locations map of Rottnest Island.
- Record the **Depth** of where you are fishing in metres.
- **Start time** is when you actually started fishing, i.e. put your gear in the water. When you are setting gear such as crab drop nets or rock lobster pots record the time the gear is set as the start time and the time the gear is pulled as the finish time. Use 24 hour time, e.g. 3 am = 0300, 6:45 pm = 1845, etc.
- Record the code (see inside front cover) for the **Gear** used to catch each individual and the **number** of this gear being used at the time, e.g. if you were using 2 handlines, then write "H 2".
- Record the code for the type of **Tackle** used to catch each individual and the **number** of sets of tackle used on the line, e.g. if you have two sets of ganged baited hooks, then write "BG 2"
- Record the code for the type of **Bait** used to catch each individual.
- Record the **Species** of each fish caught, e.g. "dhufish", "Australian herring", "western rock lobster" etc.
- Record the total **Length** of each individual caught. For finfish, measure from snout tip to tail tip. For crabs, record carapace width. For rock lobster lobsters measure the carapace width from over the ridge between the two spikes at the front of the rock lobster's head to the back of the carapace. For abalone measure across the widest part of the shell. Use millimetres.
- Record whether each individual was **Released** by writing "yes" if released, and "no" if retained.
- If you released the individual, then record the code for the **Reason for release**.

See inside front cover for codes.

CODES

GEAR

R = rod

H = handline

N = set, haul or throw net

D = drop net

S = scoop net

J = jig

PN = prawn net

P = rock lobster pot

L = rock lobster loop

HC = collected by hand

O = other

TACKLE

BS = bait on single hook

BG = bait on gang of hooks

L = lure

LB = lure plus barbless hook

F = fly

BAIT

PR = prawn

PI = pippy

W = worms

M = maggots

F = small fish

C = crab

S = squid

ML = mulie

OC = octopus

LB = live bait

SB = strip bait

MU = multiple

O = other

REASON FOR RELEASE

S = size limit

B = bag limit

R = prefer to release

P = poor eating

Angler's Daily Log Sheet – Ocean Edition

DATE: 5/Oct/2003

BOAT or SHORE (circle)

Zero fish caught today (tick) ☐

use 24 hour time

Location (lat / long)	Depth (in m)	Start time	Finish time	Gear & No. used	Tackle & No. used	Bait	Species	Length (in mm)	Released (Y/N)	Reason for release
West End Rottnest Island (RA04 OUT)	40m	1500	1630	R 1	B 1	SB	pink snapper	550	Y	R
				" "	" "	" "	pink snapper	440	N	-
				" "	LB 1	" "	samson fish	640	Y	R
				" "	B 1	OC	dhufish	400	Y	S
North of Parker Point Sanctuary Zone	5m	1700	1800	L 1			western rock lobster	89	N	-
Rottnest Island							western rock lobster	74	Y	S
(RF 05 IN)							western rock lobster	83	N	
Litttle Island (BQ63)	10m	1530	1700	R 2	BS 1	PR	Australian herring	285	N	-
				" "	" "	" "	Australian herring	276	N	-
				" "	" "	" "	toadfish	180	Y	P
				" "	" "	" "	toad fish	175	Y	P

EXAMPLE

Comments The samson fish recorded had a Fisheries tag - number 0024 - and has been reported.

Angler's Daily Log Sheet – Ocean Edition

DATE: / /

BOAT or SHORE (circle)

Zero fish caught today (tick) ☐

use 24 hour time

Location	Depth (in m)	Start time	Finish time	Gear & No. used	Tackle & No. used	Bait	Species	Length (in mm)	Released (Y/N)	Reason for release

Comments

Please send another (please tick log book required)

☐ **Angler's Log Book – Ocean Edition**

☐ **Angler's Log Book – Estuary Edition**

to:

Name ....

Address ....

.... Postcode ....

Phone ....

I wish to be a registered angler with the Department of Fisheries – Research Division

Please send a (please tick log book required)

☐ **Angler's Log Book – Ocean Edition**

☐ **Angler's Log Book – Estuary Edition**

Name ....

Address ....

.... Postcode ....

Phone ....

Do you belong to an Angling Club? .... Y/N

Please send me information on current bag and size limits. (tick) ☐

No stamp required
if posted in Australia

Research Angler Program
Department of Fisheries
Reply Paid 20
NORTH BEACH WA 6920

Delivery Address:
PO Box 20
NORTH BEACH WA 6920

No stamp required
if posted in Australia

Research Angler Program
Department of Fisheries
Reply Paid 20
NORTH BEACH WA 6920

Delivery Address:
PO Box 20
NORTH BEACH WA 6920

Appendix 8.9 Workshop to design integrated approaches to the estimation of recreational fishing catch and effort

Department of Fisheries, WA and WAMSI
Western Australia Fisheries and Marine Research Laboratories (WAFMRL)
39 Northside Drive Hillarys

22–26th February 2010

Objective: To design integrated surveys for the estimation of recreational fishing harvest, catch and effort. Emphasis will be placed on the design for a phone-diary survey employing Western Australian licence sampling frames that will be undertaken in parallel with a variety of complementary survey methods.

Agenda

Day 1. Monday 22 February

9:00 am Tea and Coffee

9:30 am Workshop Welcome (Rick Fletcher)

9:45 am Workshop Overview (Brent Wise)

10:00 am Morning Tea

10:15 am Introductions:

Current and future directions in amateur catch estimation in New Zealand (Eugene Rees)

Research on Recreational Fishing Surveys in South Australia (Keith Jones)

Recreational Fishing Survey Research in Northern Territory (Hock Lee)

Recreational Fishing Surveys in Tasmania (Rod Pearn)

Recreational Fishing Surveys in Victoria (Karina Ryan)

Recreational Fishing Surveys in New South Wales (Aldo Steffe)

An overview of monitoring and assessment of recreational fishing in Queensland (Stephen Taylor)

Developing innovative and cost-effective tools for monitoring recreational fishing in Commonwealth fisheries (Shane Griffiths)

Recreational fishing creel surveys – time for a new way of thinking (RecFishWest: Frank Prokop)

(WAFIC: Richard Stevens)

Department of Environment and Conservation: Monitoring, Evaluation and Reporting. (Kim Friedman)

Western Australian Universities (Norm Hall)

12:30 pm Lunch

1:30 pm Design of Recreational Fisheries Surveys – core concepts (Ken Pollock)

3:00 pm Afternoon tea

3:15 pm Design of Recreational Fisheries Surveys – designs for a range of spatial scales (Ken Pollock)

4:30 pm Reception

Day 2. Tuesday 23 February

9:00 am	Tea and Coffee
9:15 am	Design of Recreational Fisheries Surveys – designs for large spatial scales and use of phone-diary surveys. (Ken Pollock)
10:30 am	Morning tea
10:45 am	Application of a phone-diary method in recreational fishing surveys (Jeremy Lyle)
	Pseudoreplication (Aldo Steffe)
12:00 am	West Australian recreational boat fishing licence and purpose of breakout sessions (Brent Wise)
12:15 pm	Breakout session to design phone-diary surveys (to 3:30pm)
12:30 pm	Lunch
3:00 pm	Afternoon tea
3:30 pm	Reporting back and general discussion
5:00 pm	End session

Day 3. Wednesday 24 February

9:00 am	Tea and coffee
9:15 am	Phone-diary review
10:15 am	Morning tea
10:30 am	Aerial survey techniques for assessing recreational fisheries (Bruce Hartill)
	Implementing On-site Surveys: a practical perspective (Aldo Steffe)
12:15 pm	Breakout session to design complementary surveys (to 3:30 pm)
12:30 pm	Lunch
3:00 pm	Afternoon tea
3:30 pm	Reporting back and general discussion
5:30 pm	Meet and greet BBQ

Day 4. Thursday 25 February

9:00 am	Tea and coffee
9:15 am	Complementary surveys review
10:15 am	Morning tea
10:30 am	Catching the uncatchable: Use of Respondent-Driven Sampling to obtain representative data and population size estimates from specialised recreational fisheries (Shane Griffiths)
	Novel approaches (Norm Hall)
11:30 am	Breakout session to identify novel surveys (to 2:00 pm)

12:30 pm	Lunch
2:00 pm	Reporting back and general discussion
2:45 pm	Breakout session on integrating surveys (to 4:30 pm)
3:00 pm	Afternoon tea
4:30 pm	Reporting back and general discussion
5:45 pm	End session

Day 5. Friday 26 February

9:00 am	Tea and coffee
9:15 am	Workshop conclusions and thanks for attending
10:45 am	Morning tea
11:00 am	Monitoring recreational fishing effort in QMA 1 (Bruce Hartill)
	Use of Cameras in Western Australian Survey's (Stuart Blight)
	Access point counter surveys in Western Australia (Michael Tuffin)
12:30 pm	Lunch

Appendix 8.10 Workshop participant list

Participant	Affiliation	Location	Email
Bruce Hartill	National Institute of Water & Atmospheric Research	New Zealand	b.hartill@niwa.co.nz
Eugene Rees	Ministry of Fisheries	New Zealand	eugene.rees@fish.govt.nz
Martin Cryer	Ministry of Fisheries	New Zealand	martin.cryer@fish.govt.nz
Aldo Steffe	Department of Industry & Investment	New South Wales	aldo.steffe@industry.nsw.gov.au
Jeff Murphy	Department of Industry & Investment	New South Wales	jeff.murphy@industry.nsw.gov.au
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Participant	Affiliation	Location	Email
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Stuart Blight	DoF – Research Division	Western Australia	stuart.blight@fish.wa.gov.au
Tim Green	DoF – Regional Services	Western Australia	timothy.green@fish.wa.gov.au

Note: Not all participants were present every day – attendance was self-determined, based on own priorities.